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UNIVERSITY OF SOUTHAMPTON

FACULTY OF EDUCATIONAL STUDIES

DEPARTMENT OF EDUCATION

A HERMENEUTIC EXPLORATION OF THE RELEVANCE OF METHOD TO RESEARCH TASK ARISING FROM AN INQUIRY IN TEACHER TRAINING.

A thesis by

Raymond Bury.

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ABSTRACT

FACULTY OF EDUCATIONAL STUDIES

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A HERMENEUTIC EXPLORATION OF THE RELEVANCE OF METHOD TO RESEARCH TASK ARISING FROM AN INQUIRY IN TEACHER TRAINING.

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In this study I have made a philosophical examination of the role of explanatory notions commonly used in educational research, and of the relation of these notions to research method. I have also given an account of specific performances of women student teachers, which, as far as I am aware, have not been reported elsewhere.

The study comprises four inter-related elements. The first is a description of an inquiry, in the empirical science tradition, into the performances of women student teachers on tasks related to Piagetian notions of intellectual development.

The second is an account of events affecting the course of the inquiry. I offer this description because consideration of the personal involvement of the inquirer, an existential commitment, reveals the genesis of the later argument.

The third element is the tracing and examination of assumptions which gave direction to the inquiry. This process led to the belief that certain features of the explanatory notions involved were open to criticism, and reasons are given as to why I came to regard them as unsatisfactory.

The fourth element is a consideration of the nature of explanation in educational research as it is commonly practised. This discussion leads to an assertion of belief in the inevitably personal condition of inquiry in education, with implications for research into human action as distinct from the causes of behaviour.

The study is an interpretation of the experience of exploring a topic and being compelled to reconsider fundamental beliefs.

FOREWORD

My thanks are due to the college students and staff who put up with my tests and questioning; to Mr. R.G. Stansfield, formerly of City University, for helpful comments on test items; to Professor E. Stones, for permission to use parts of his published test material; to many members of the University Staff, who have helped generously at every stage of this study, and to Bill Brookes, who undertook the major part of supervision.
I have heard tell of a student teacher who looked at a child's drawing during a scripture lesson and said, "That's nothing like God - rub it out." The story may or may not be true, but it does remind us of what most of us do, whether we teach infants or graduates. We measure the worth of what our pupils say against what we think they ought to be saying. Bill Brookes is unusual. He actually listens to what his students say, with the intention of trying to understand it as it stands. This allows him to probe, prod, to stop them in their tracks, and to get at grains of truth within errors, as his favourite aphorism from Wittgenstein enjoins. And it allows his students to grow. I thank him for this and for unfailing support and encouragement.

PREFACE

"I kept thinking that I should be able to do it ......
somebody of my age ought to be able to do this ....
we had it drummed into us so often in Child Development
that children of this age can do this and this ....

Student teacher.

INTRODUCTION

The main assertion of this study is that research in education is personal and subjective.

This view is probably unremarkable, and what I try to do in the following chapters is to trace the way in which the practical realisation of what is entailed by the proposition, as distinct from a theoretical acceptance, came about in my own case.

I had found a difficulty in my work as a teacher. In an attempt to describe and explain the difficulty I commenced this study using theories from psychology and their implied methods, as 'frames of reference'. These frames of reference turned out, in my view, to be inadequate, and I was compelled to consider what might count as explanation in educational research. This consideration led to the assertion above, to a statement of preference for a frankly interpretative mode of inquiry, and to the contention that the way in which 'student generated research' is commonly carried out has a teleological form.

The report on the study presented here has, therefore, a subject matter within a subject matter: it is about itself, being simultaneously context and process. Polanyi (1958) argues that this is as it should be:

> .... the process of examining any topic is both an exploration of the topic, and an exegesis of our fundamental beliefs in the light of which we approach it; a dialectical combination of exploration and exegesis. Our fundamental beliefs are continuously reconsidered in the course of such a process, but only within the scope of their own basic premisses.
>
> (p.267).

Reports on educational research do not always make exegesis evident; indeed the protocols of some forms of research preclude an exposition of fundamental beliefs, these being regarded as assumed background knowledge. Thus 'variables' (dependent and independent) may be selected and measured without any detailed statement of what is presumed to be invariant in the situation giving it structure.

In the case of this study the whole point is to attempt to make the process of exploration and exegesis explicit.

It takes the form, therefore, of a personal, 'historical' account of what happened. This raises some literary difficulties, as a logical order of elements in an argument sometimes competes for priority with the chronological order of described actions in a narrative. Where testing is reported, for example, I have included accounts of events which influenced my actions because they happened at the time when the results were being considered.

The study seemed to go through four phases. The first was the period of the original difficulty mentioned above; then a period during which I carried out a programme of testing within the 'psychometric' field. This was followed by an attempt at 'qualitative' description and explanation of material with reference to Piagetian theory. The final phase was a period of retrospective examination of the course of events, and a re-orientation of view.

This report follows the four phases in order. Chapter One describes the work I was engaged in from which the teaching difficulty emerged, and the process of registration for research degree candidature which led to the commencement of a particular style of inquiry. This is the first phase.

Chapter Two gives an account of the second phase, and takes the form of a section of a 'quantitative' research report; the statement of the problem, a review of literature, description of measuring instruments and procedures, and a limited statement of the results of testing, with some comment on these results.

Chapter Three describes events and influences which produced a change of emphasis and direction, and Chapter Four contains an analysis and interpretation of material related to Piagetian theory. This is the third phase.

Chapters Five, Six and Seven represent the fourth phase. Chapter Five traces the reasons why the two lines of inquiry in phases two and three were adopted and later abandoned, and develops the reasons why the explanations they offered were unsatisfactory. Chapter Six contains a discussion of the nature of forms of explanation in educational research, and leads to the proposition that the process of arriving at an explanation is necessarily personal and subjective. Chapter Seven reviews arguments for a purposive explanation of human action and relates these to the particular circumstances of this study.

Introduction to the Green Pages.

Pages coloured green are inserted at several points in this thesis. The following introduction explains their function.

A 'hermeneutic' study professes to interpret, to make clear, to make sense of a topic. This particular thesis can, on reading, have several appearances, indeed perhaps as many as there are readers obliging enough to stick with it to the end. One appearance can be of a fairly lengthy description of an empirical inquiry attempting to get at what is 'inside' a group of 'subjects', followed by a philosophical disquisition which gives reasons why the empirical study should not have been attempted in the first place. On this reading one might object that criticisms can be made of the techniques and procedures used in the empirical work, and, perhaps more importantly in view of the title, that matters are not conspicuously clearer in the end in respect of the observations that set the whole thing off.

On this reading there are two outcomes: a set of <u>findings</u> and an <u>argument</u>.

The findings can be described quite briefly. A number of women student teachers were given a paper-and-pencil test composed of items loosely based on Piagetian problems. Many of the students appeared to have difficulty with the problems. Some of these students discussed the test items in groups, and their comments reinforced the impression that they held misconceptions about the situations described in the test items. When some of the more 'primitive' notions implied by the test items were examined in relation to Piagetian theory, a defensible case could be made out that the students concerned functioned in these limited areas on the lower levels of cognitive ability as described by Piaget.

The reactions of the students to the test suggested that their difficulties in these matters would be a considerable hindrance to them in any work they were required to do on Piaget.

The findings are 'impressionistic' but 'suggestive'.

The argument is a theoretical commentary on what happened. The main thrust of the argument is that there is a dominant mode of educational research, and that the criterion of validity of this mode is in terms of method: does the technique used allow the observer to be independent of his own being and of those of the people he studies?

This raises questions of legitimacy if studies are proposed based upon other criteria.

But expectations define problems, and expectations arise from the dominant explanatory sytems which form an unquestioned 'way of life' for education and educational research. Research is personal because the researcher himself is inescapably part of the problem he studies. His prior commitment is <u>the</u> independent variable in the inquiry he carries out.

Human action, the argument goes on, may not be susceptible to explanation in terms of cause and effect (although behaviour may). There is a legitimate form of inquiry which interprets purposes and the meanings that situations have for participants in the situations. This form of inquiry deals with a range of human experience inaccessible to measurement and the analysis of numbers.

I see these arguments as completely convincing, and their development came as a revelation to me.

I am aware that a personal revelation is rarely news to other people, especially when stated in the terse style of communication one tends to adopt when setting out to be 'factual' or to present an argument. Thus, a reading of this thesis which detects only findings and arguments may miss what I hope is the point. As I said in the main Introduction, the assertion that research in education is personal is not particularly remarkable, at least not for some people. But there is another appearance which a reading of this study might give rise to and which I hope would be its main point and its claim to be hermeneutical. This reading would include, as a third outcome, what I will call illustrations. These illustrate intuitions in a transformation in modus vivendi.

It is these illustrations of intuitions which may resonate with the intuitions of a reader and thereby give the study its 'permissible degree of generalisation'.

The purpose of the green pages is to parenthesize these intuitions. While the bulk of the study, on white pages, represents an attempt to set out, as honestly as I can, the things that occurred and the products of thinking, the green pages comment on the process of transformation: they represent pointers to a meta-description.

I said earlier that the argument, the products of thinking, came as a revelation. This is strange, because I 'knew' previously that scientific and other theories are part of the general cultural context. I knew, to use a crude example, that it is not entirely surprising that America produced Watson and Britain produced Galton.

It is not only possible but common, I think, to know something as an intellectual object and yet not to know it in such a way that it informs one's action. Wittgenstein commented on this:

> We must begin with the error and bring out the truth in it. That is, we must uncover the source of the error; otherwise hearing what is true won't help us. It cannot penetrate when something else is occupying its place.
> To convince someone of what is true, it is not enough to state it; we must find the road from error to truth.
> I must plunge again and again in the waters of doubt.
>
> (Remarks on Frazer's "Golden Bough")

The hard thing about Wittgenstein's remark is that it applies to itself. Although the words may make sense, until you have done what he is talking about you don't really know what he means. How do you uncover the source of the error if you don't know what the error is until you have uncovered its source? Hearing that it is an error won't help. This circle is probably the central dilemma of all attempts to educate.

This study is an account of one road from error, not to truth, but to the shedding of some illusions, and illusion is error which is rooted and expressed in one's actions.

Trying to find explanations of what I thought was puzzling was rather like trying to walk in a straight line but finding that I was moving in circles. Breaking out of a circle and groping round the edges of the outside merely revealed another circle, perhaps enclosing the former, perhaps not. Smaller circles presaged larger ones.

The green pages are mostly to do with circles.

A list of green page references is shown after the main Bibliography.

CHAPTER ONE

Background.

CHAPTER ONE

Background.

In 1968 I commenced work as a lecturer in the Education Department of a college of education. There were about five hundred students on roll in the college following courses leading to a Certificate in Education or a B. Ed. Degree. Most of the students were young women, apart from seventy to eighty members of a two-year shortened Certificate course for mature students which included older women and a number of men. For the first three years of my appointment I worked with the young women members of the normal three or four year courses, and after this with the mature students.

Students' work in the normal three or four year courses was arranged in four parts; Education, an individually chosen 'main subject', professional subjects and an interdisciplinary study. Part of the work of the Education Department was concerned with the so-called 'four disciplines' of the history, psychology, sociology and philosophy of education, and part with the students' work in schools.

Each Education tutor was responsible for two 'Education Groups' of anything from twenty to thirty students, preparing them for work in schools and generally overseeing their theoretical work, conducting seminars and discussions and supervising individual special studies of educational topics.

Each tutor also took part in one of the 'four disciplines' courses.

I shared the work on the psychology of education with a colleague. A succession of about twelve weekly timetable periods was allowed for this work in the first and second years of the course. The teaching procedure was to present material in mass lectures, specified reading and films, and to require the students to write an essay of about three thousand words towards the end of the group lectures. The topics dealt with in this way were arranged under headings such as "Learning", "Social Development", "Intellectual Development", "Creativity" and so on.

After working in this way for some time it seemed to me that students often appeared to find work dealing with the affective domain to be interesting, understandable and useful in their professional lives; but work in the cognitive areas seemed to be regarded as being of little interest. Consideration of Piaget's work was less than popular. Essays written on this topic frequently showed signs of a general lack of understanding, and subsequent group discussion usually confirmed this.

I believed that Piaget offered a valuable description of how a person becomes intelligent, and while acknowledging its partial and provisional nature, I thought it to be a pity if intending teachers failed to grasp the description sufficiently for it to become a useful intellectual tool.

There are, of course , innumerable possible reasons and combinations of reasons for the students' lack of benefit from the time and effort used up on these topics; the inherently difficult nature of Piagetian theory, the sophistication necessary to relate the theory to day to day teaching events, the capabilities possessed by the students, the students' habits, attitudes and values (and those of the teachers), the quality of teaching techniques and materials, the time available to students, the relations between teachers and taught and so on. But it was necessary, at least, to examine some of the more accessible of these.

There were difficulties in the recommended readings. These were mainly from Brearley and Hitchfield (1966). A passage selected at random may illustrate their nature:

> What we would suggest is that non-conservation of length is attributable to the absence of an independent reference system to provide a spatial framework for moving objects. Children who fail to establish paired relations between the two extremities of a moving object, will also be unable to link objects to reference elements.
>
> (p. 33)

This is from an introductory text intended to prepare students for more difficult reading. In view of Black's study of the ability of student teachers to understand what they read (Black, 1953), it was likely that my students would have to study passages of this kind for some time in order to derive meaning from them.

The book was replaced by Phillips (1969).

There were several films which set out some of the important ideas quite clearly and simply, and lectures and supplementary duplicated papers were revised and, we hoped, improved.

I had doubts about the value of essays as exercises for exploring this range of topics. After consultation, my teaching colleague and I arranged a different type of exercise for the next time the work on intellectual development and Piaget came round. The students had various days and half-days set aside for them to visit the schools in which they would work during teaching practice and two of these fell within the time allocated for 'intellectual development' work. On these visits the students were provided with copies of part of a schedule of questions devised by King (1961) which were apparently based on Piaget's work on concepts of causality and sought to explore children's scientific concepts and interests. The students were asked to work through these questions with a group of children and subsequently to write a report on the children's reactions. The report would count instead of an essay.

On reading the completed reports I became aware of a distinct possibility that in many cases the students themselves did not understand the questions in the schedule. Children's responses which were clearly wrong had been accepted as correct, comments in the 'discussion' sections of the reports indicated that the content of the questions was not fully understood, and there was the same use of apparently unconnected excerpts from the given text (in this case, King's article) which in my opinion had made the essays unsatisfactory. It was possible that many students lacked basic notions which may be thought of as pre-requisite for understanding Piaget's work (and much else). This put the efforts to improve the teaching material in a rather different light.

Communication with the students about the reports was necessarily by means of written notes, which rarely drew a response from the recipients, who were accustomed to take back their essays, note the grade given and, I suspect, sigh with relief and say, "Thank God I've 'done' Piaget (or Learning or whatever)". As it happened I did not have a tutorial group in that particular 'year' and therefore had little opportunity to discuss the reports personally with the writers, except for odd encounters in corridors.

Soon afterwards, in Autumn 1971, I was appointed tutor in charge of the shortened course for mature students, working in premises two miles from the main college site.

This work was different in character from the work with younger students. The time available was shorter by one third; the students, between them, had a vast experience of life and a wide range of expertise; many were men and most had families of their own; personal crises were common, indeed the very act of joining the course indicated a crisis of some degree, if only one of changing career.

At this time it was advantageous for the future prospects of the college to have as many students as possible and the shortened course attracted candidates fairly readily. At one point in my early time in the job I had forty-four second year students and thirty-six first year students. Working without assistance, I was busy for some time.

I had, however, freedom to develop the work in Education as I thought it would best suit the students.

It was possible to arrange for students to spend one to two days in each week of the first two college terms actually working in the schools where they would later carry out their formal teaching practice. Besides allowing them to become, to some extent, part of the working team in the school, this arrangement also provided opportunities for them to carry out small studies related to their work in college. Each student, for example, worked with two or three children learning to read, and with another two or three learning number, and wrote accounts of this work after the teaching practice. They therefore had the best part of half a school-year's experience on which to draw, in addition to related work in college, when they embarked on 'essays'.

My intention was to include in these studies of small groups of children, one based on Piagetian 'experiments' which would give the students some base in reality to which they could relate college work on intellectual growth.

Having at the back of my mind the results of the exercise with the younger students, I thought that it would be useful to make sure that none of these mature students had similar difficulties. This required care since the group included ex-officers of the three armed services, engineers, hospital ward sisters and the like, who might wonder what was happening to them if they were asked to answer questions on an apparently infantile level.

I put it to the students that, just as some accomplished people were none too sure about mathematical notions, there were perhaps some who had a similar problem when dealing with ideas from elementary physics (there were murmurs of agreement at the mention of physics) and that a short 'quiz' might help me in preparing a section of their work which was to come. There was ready agreement to this. I then asked sixteen questions orally, drawing illustrations on a blackboard as necessary. The students wrote their answers on papers which, it was agreed, would be unsigned and anonymous. Afterwards the answers accepted as correct were read out, the students marked their papers andthen gave them to me. Tables 1 and 2 show the questions and illustrations, the responses accepted as correct and the results. There were forty students present in the group.

Table 1

Questions presented informally to Mature Students.

	Question	Responses Accepted as Correct.
1)	Estimate time between two taps on table. (15 secs.)	12 - 18 secs.
2)	Estimate height of room. (10 ft.)	8 - 12 ft.
3)	Indicate the angle at which a hose pipe should be held to make the water go the greatest distance.	Any drawing or statement which suggests 45 deg.

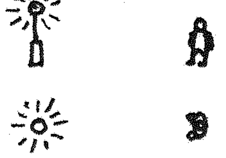
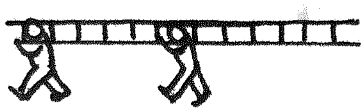
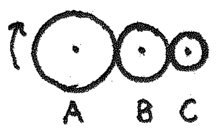
4)	A jar contains some water. A stone is added. Is the water level now higher, lower or the same?	Higher.
5)	A jar contains some water. Some sand is added. Is the water level now higher, lower or the same?	Higher.
6)	Two jars have bases of the same diameter but one has straight sides and the other has sides sloping outwards.  The water in the first jar (A) is poured into the second jar (B). Will the water level in jar (B) be higher, lower or the same?	Lower.
7)	Similar to (6) but with the diagram 	Higher.
8)	Two balls of plasticine, both the same size and weight. One is rolled into a sausage. Have they now the same volumes?	Yes (The same).
9)	Has the sausage in (8) the same surface area as the ball, or less, or more?	More.
10)	Two drawings, plan and elevation, of a man standing near a street lamp. Show where his shadow should fall. 	Any drawing or description indicating shadow on side away from lamp.
11)	Drawing of a seesaw and two children. Show where the boy should sit to balance the seesaw if he is twice as heavy as his sister. 	Any drawing or description showing point about half way between end and fulcrum.

Table 1 (cont.)

12) Two men carrying a ladder. Which carries the heavier load, or are the loads equal? — Any statement indicating the man in the middle.

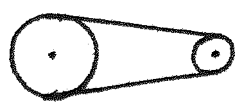


13) Three cog wheels. Which wheel turns in the same direction as (A)? — C



14) Drawing as in (13). Which wheel turns fastest? — C

15) Drawing of two wheels connected by a belt. Does (B) turn in the same direction as (A)? — Yes (The same)



16) Drawing of two wheels connected by a twisted belt. Does (B) turn in the same direction as (A)? — No. (Opposite)

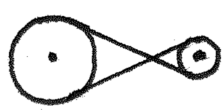


Table 2

Results of Informal Test, Mature Students, 1971.

N. 40.

Item No.	No. Correct.
1	22
2	24
3	35
4	40
5	29
6	38
7	37
8	39
9	29
10	34
11	40
12	32
13	36
14	37
15	40
16	35

Table 3

Results of Informal Test, Mature Students, 1972.

N. 32

Item No.	No. Correct.
1	19
2	27
3	16
4	32
5	21
6	Omitted
7	29
8	31
9	18
10	22
11	32
12	23
13	31
14	29
15	31
16	30

Responses to Question 10 were particularly interesting. They included drawings which showed shadows extending towards the light, and others which showed shadows in various positions around the drawings of the objects.

After this procedure there was a considerable amount of laughter, argument and discussion. Knowledgeable members of the group set out to convince other members of the validity of some of the correct answers. This discussion, and in particular the variety of counter-arguments presented by the doubters, was most instructive. Some students, for example, argued that if you put sand in water, some of the water will be soaked up by the sand and the level of water will not rise.

The procedure was repeated with a later group of mature students. The results of this are shown in Table 3.

The study of children's responses to Piagetian type 'experiments' was carried out later. Students chose six exercises from a selection taken mainly from Fogelman (1970) and I discussed them with each student before work commenced to make sure that their content and purpose was understood. During these discussions it was noticeable that the exercises intended for older children were less popular than the 'simpler' ones. Deformation of plasticine balls was often chosen, for example, whereas exploration of a pendulum was not, even among students who were dealing with older children.

The reports, in general, were satisfactory, but a feeling of unease arose from these small sections of day to day work. There seemed to be, among some students, signs of confusion about what I had regarded as basic general knowledge. Indeed the circumstantial evidence from the reports written by the young women students and from the rough and ready test given to the mature students suggested that the confusion may even involve concepts commonly thought to be acquired in infancy or childhood.

If this was so a number of questions suggested themselves. Were the confusions genuine or only apparent? If genuine, in what particular contexts did they occur? In what proportion of students? In what ways might the confusions affect students' academic work (prevent an understanding of Piaget, for example)? In what ways might the confusions affect professional competence (primary school teachers, for example, are normally expected to introduce work with a scientific bias at some time or other)? Would instruction remove confusions? How did people pass through an extended schooling without taking in these elementary notions? If they had, in fact, done this, what were the implications for developmental theory? What were the characteristics of the students who were confused?

By this time I was being assisted by other members of staff and had more time available, and I decided that some of the implications of these tentative findings were worth following up.

A preliminary scanning of the literature revealed several studies which pointed out limitations in the capabilities of the average student teacher (e.g. Black, 1954, and Chapman, 1973, on reading comprehension; Buckland, 1969, on mathematical background; Hopkins, 1972, on 'general culture') but none that was obviously related to the field in which I was interested.

In order to make a serious study of the matter, under supervision, I inquired about part-time M. Phil. candidature at the University in late 1973.

At a preliminary interview I was asked how I might account for the students' difficulties that I described, and how I thought a study of them would achieve the breadth of interest normally associated with research degree work.

After some thought about this I decided that the argument pursued in the study should be set within a generally recognised theoretical frame of reference, and that, in order to provide the necessary breadth of interest necessary for research degree work, I should start from the original problem of the frequently unsatisfactory results of certain parts of a course in the psychology of education, rather than a direct treatment of the questions raised by students' misconceptions of everyday phenomena.

Since I was concerned with the abilities possessed by students to perform certain 'scholastic' tasks, and since a great deal of information was available about the measurement of abilities of one kind or another, I conceived of the problem as one of ascertaining and comparing the strengths or weaknesses of abilities in students which had been defined by authorities in factorial studies, or which could reasonably be related to them.

The ability to profit from the sections of a course in the psychology of education dealing with 'intellectual development' was to be compared with certain other abilities deemed to be connected to this ability in some way.

Responses to the item dealing with shadows in the 'quiz' given to the groups of mature students interested me greatly. A grasp of the relationship between a light source, an object and the shadow cast by the object is not unreasonably thought to be one of the notions gradually built up by the vast majority of people in childhood. Terman and Merrill (1961, pp. 126, 236) suggest the twelfth year as an appropriate level for its achievement; Piaget's subjects (Piaget, 1930, pp. 180, 194) dealt successfully with shadows at about nine years; yet here were six adults in a group of forty, and ten in another group of thirty-two, apparently confused when asked to display this understanding. Furthermore, although I could not be sure because of the haphazard nature of the test, confusion about shadows seemed to go with confusion about other items.

I was in the habit of describing the mature students as accomplished people, as indeed they were. It occurred to me that the accomplishment which they all most obviously possessed was the ability to use words and to fit in to a social context with ease. All the students were fluent and articulate, yet quite a high proportion in two 'year groups' had trouble with shadows, and Piaget comments (1930), "The explanation of shadows is purely geometrical". In order to understand shadows one must grasp a geometry of spatial relations. Perhaps undeveloped spatial abilities (relative to verbal abilities and 'general abilities') might account for lack of success in understanding some notions presented in psychology work.

I submitted to the University an outline which proposed a study of relationships between the results of tests of spatial ability, 'general' ability, verbal ability, achievement in psychology, and a test of students' understanding of some of the basic notions from physics used by Piaget in his experiments, a questionnaire to investigate students' interests and attitudes to school subjects and activities, and G.C.E. results.

This seemed to me to place the proposed work within the respectable and well documented area of psychometric studies of human abilities, and at the same time to allow my observations of students' difficulties with shadows and so on to be related to them.

During subsequent discussion of the proposal with University tutors I was asked if I knew of empirical evidence or a body of theory which suggested a link between spatial ability and my observations.

Since a search of the literature had not revealed any reports of observations similar to mine, and Piagetian theory suggested that the observations were unlikely to occur anyway, I could only refer to the general argument of Macfarlane Smith (1964) who maintained that tests of spatial ability were good predictors of success in school science. This was not felt to be a sufficiently strong basis for my planned study.

As a variable in a correlational study of abilities the test of basic notions from physics had become an embarrassment. I revised the study plan, leaving out the physics test and the school subjects and interests questionnaire.

The revised outline was accepted, proposing an investigation of the relationships between spatial abilities and the acquisition of certain concepts within a course in the psychology of education in a women's college of education. I registered as part-time M. Phil. candidate in April, 1974, with one of my interviewers, Tutor A, undertaking supervision of the study.

Starting work in a college of education was stimulating in many ways, not least in the prospect of dealing day-to-day with ideas which informed educational practice. I had found the literature of educational psychology fascinating and absorbing and thought that students, with allowance for their lack of teaching experience, would at least find it interesting.

I found that I had to be an Infants teacher in disguise. Students got most from lectures when I resorted, almost in desperation, to telling stories. Few people can resist a story, and using stories to illustrate the general idea of what I wanted to get at, I found that I could then deal less awkwardly with more orthodox material.

The literature of educational psychology is not noted for its gripping narratives, and I used stories from my own experience and adapted others from published work. For example, on the topic of 'Creativity' I used a story told vividly by Konrad Lorenz in "Man Meets Dog" about how dogs might have become domesticated, bits about Newton culled from Bronowski's "Science and Human Values", stories about children I had known, and then introduced notions from Koestler, Guilford and the creativity testers.

It was not difficult to illustrate ideas from social psychology in this way.

This strategy seemed to work. Students at least seemed to catch a general idea. But the stories one can tell about Piagetian notions are quite limited. It was here that the procedures used faltered most noticeably and where the question, "What are we trying to do?" became most urgent. I spent whole holidays reading essays large numbers of which hardly provided any starting point for a constructive message to the student.

The feeling was of being on a treadmill which turned without apparently affecting anything.

CHAPTER TWO

The Planned Study.

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Statement of the Problem.

I believed that a proportion of each year's intake of students into the college where I worked gained little of value from those parts of their course in psychology which dealt with intellectual development. There were a number of references in the available literature to dissatisfaction with psychology courses in colleges and departments of education, but while there appeared to be continuing effort to improve the courses there were few reports of investigations into the particular abilities which may be necessary in students for understanding of the content of particular courses.

The study set out to examine the relationship between spatial abilities in students and the degree of understanding achieved by students of the contents of parts of a college psychology course dealing with intellectual development.

By spatial ability was meant the ability to represent space mentally - "The capacity to perceive and hold in the mind the structure and proportions of a form or figure, grasped as a whole." (Macfarlane Smith, 1964).

The parts of the psychology course with which spatial abilities were expected to have a special relationship were those elements to do with cognition and cognitive growth. A more specific definition is provided by Stones and Anderson, (1972). Stones and Anderson carried out a cluster analysis on the choices of teaching objectives made by tutors in colleges and departments of education teaching educational psychology. The tutors were asked to select from a list those teaching objectives which they considered to be most important. One of the 'coherent patterns' of choice (Cluster 3 in the analysis*) that emerged was "more theoretical and mainly concerned with cognitive matters".

The objectives were as follows:

That the students should

> have knowledge of Piaget's model of cognitive development, and the ability to relate this to classroom situations,
>
> be able to replicate Piaget's experiments,
>
> be able to outline experimental studies on the intellectual development of children,
>
> be able to describe the main elements in concept formation and strategies involved in concept attainment,
>
> be able to outline views on the nature of thinking,
>
> be able to describe how a child learns to preceive the world,
>
> be able to outline social influences on learning.

Traditionally, formal education has valued verbal-literary abilities more highly than the abilities sampled by spatial tests.

In general, the means of assessment of students in colleges and departments of education favour students with an 'Arts' (i.e. verbal-literary) background.

Some courses in colleges and departments of education may, however, require an understanding of abstractions which are most easily grasped through 'spatial thinking'. Topics denoted by 'Cluster 3 Objectives' are a case of this.

An understanding of certain mathematical, scientific and mechanical notions is a pre-requisite for a basic understanding of Cluster 3 work, particularly Piagetian theory, and it is necessary to think abstractly and analytically and to form difficult general concepts if the central ideas of Cluster 3 work are to be grasped.

Macfarlane Smith (1964) has shown that high spatial ability (relative to verbal) is associated with success in mathematical, scientific and mechanical work, and with the ability to think abstractly and analytically, to form general concepts and to solve problems.

---

* To avoid unnecessary repetition these objectives will be referred to as "Cluster 3 objectives" in the rest of the text.

The hypothesis to be tested in the study was that a spatial test makes an independent contribution to the prediction of students' achievement of Cluster 3 objectives beyond the contributions made by tests of general intelligence and verbal ability.

Review of the Literature.

I took the 'British' hierarchical view of abilities as a frame of reference. This is often represented diagrammatically as an inverted tree-like structure (e.g. Vernon, 1961, p. 22) with 'g' (a fundamental general ability associated with all problem solving) subsuming other abilities grouped under two main headings, 'v:ed' and k:m'. 'v:ed' refers to performances which are verbal, numerical and affected by educational processes. 'k:m' refers to performances which are thought to be related to processes of a spatial-perceptual-mechanical nature.

The adoption of this scheme seemed justified by persuasive arguments from authorities such as Vernon and Butcher.

Vernon (1961) sets out a list of reasons why the general ability-plus-group-factor description of intellect was superior to the multiple-factors favoured by some American theorists. There were technical advantages in the British usage of methods of analysis. They avoided, for example, the danger of exaggerating communalities which was present in Thurstone's technique (p. 129). American criteria of statistical significance were said to be lax (p.130). American writers such as Guilford and Michael admit that no test measures a single factor and that it is usually necessary to use statistical devices to suppress 'g'. As Vernon asks (p.133), "Why not admit then that all tests do involve 'g' instead of artificially removing it by means of rotation?" Finally, the British view simplifies the task of the vocational or educational psychologist. A short battery of 'v:ed' and 'k:m' tests "will cover most of the ground in educational or vocational prediction that can be covered by tests" (p.134). Butcher (1968) recommended the hierarchical view for purposes such as mine:

> The hierarchical theory has major advantages over almost all other models of human abilities.
> ...... for particular families of skills and for greater accuracy in a more limited area (where 'fidelity', in the language of communications specialists, is more important than

'bandwidth') it may well be necessary to use tests that measure a major or minor group factor.

(p. 50).

Vernon (1961) made it quite clear that in his view the term 'ability' should not be construed to mean some kind of organ of the mind or of the nervous system.

> We now know that traits and abilities are not located in particular parts of the brain ....
>
> (p. 1).
>
> ..... factors should be regarded primarily as categories for classifying mental or behavioral performances rather than as entities in the mind or nervous system.
>
> (p. 8).
>
> (The term 'ability') implies the existence of a group or category of performances which correlate highly with one another, and which are relatively distinct from (i.e. give low correlations with) other performances.
>
> (p. 4).

Butcher (1968), in similar vein, warned against the reification of words such as intelligence (P. 22) and went on later to say, "It is a big jump from observing a pattern of co-variation to claiming that this pattern indicates a significant psychological function," and quotes Burt, "factors as such are only statistical abstractions, not concrete entities." (p. 43).

However, among many attempts to relate abilities, as revealed by factor analysts, to other findings, McFie (1972) reviewed research by himself and others in which tests of ability had been given to people who had suffered localized cerebral lesions. He felt that he had demonstrated that "the main factors of intellectual ability have a neurological reality" and that "abilities are organised in specific regions of the brain". He was confident enough to suggest that there may be "an opportunity for using psychological tests in neurological diagnosis".

Macfarlane Smith (1972) summarized papers by Bogen on the implications of research on brain bisection. Bogen had postulated two different modes of thinking, both equally important, one being propositional and associated with the left hemisphere of the brain, and the other 'appositional' and associated with the right hemisphere. According to Bogen verbal and spatial abilities tend to lateralize in the left and right hemisphere respectively, while general intellectual ability must be distributed, not necessarily equally, between the two.

Macfarlane Smith (1964) was explicit about what he meant by 'spatial ability': "The capacity to perceive and hold in the mind the structure and proportions of a form or figure, grasped as a whole". Early in his career Smith had been impressed by the fact that some people produced drawings of objects such as Bunsen burners which were grossly out of proportion, and yet seemed to see nothing wrong with their drawings.

> Thus from the outset of the investigation, the writer had the theory that the special aptitude that he sought to measure, if it existed at all, would be manifest in an ability to perceive and reproduce shapes correctly, i.e. with their dimensions and their relations in due proportion ..... The sub-tests of the spatial test proper were constructed largely on this principle, i.e. that the items should depend <u>critically</u> for success on the perception of the correct proportions of a figure or pattern. This has been the writer's guiding principle in his subsequent researches.
>
> (p. 55).

Smith devoted a large part of his work to associating scores on spatial tests with psychological functions: a constitutional tendency for visual processes or images to persist, a capacity for selective inhibition of experience leading to the 'good Gestalt', low motor perseveration and a natural ability for mirror writing.

In Smith's work and in the studies cited in his comprehensive review, women were consistently less successful in their performance on spatial tests than were men.

Smith argued that spatial ability may contribute in a significant degree to success in examinations in mathematics, art, science, engineering and technical subjects, and that it becomes increasingly important when greater emphasis is placed on analytical and abstract thinking and on problem solving.

> Until fairly recently tests of verbal ability or verbal reasoning were called intelligence tests and were believed to provide measures of 'abstract intelligence', whereas tests of spatial ability were regarded as measures of a specialised mechanical aptitude or of 'concrete intelligence'.
>
> (p. 272).

Smith's survey of work on spatial ability related to various performances led him to believe that this view was mistaken, and that "spatial tests may be better measures of ability to think abstractly or to form general concepts than verbal tests".

The implications of this were that selection procedures in education, which in general were biased in favour of verbal abilities, should seriously take into account the importance of spatial abilities.

The view that education systems tended to favour verbal abilities and to underestimate the importance of spatial abilities and performances thought to be related to them was shared by educational writers. Rowland (1968), from the point of view of the visual arts, described a verbal-literary bias in formal education, so that in modern Western cultures words are necessary before experience can be given a form acceptable to the mind.

Balchin (1972) distinguished four basic modes of communication between human beings, articulacy, literacy, numeracy and, a term he coined, graphicacy. The potential for all four modes is inborn in the brain of a human being, but none can come to fruition without education. The term 'graphicacy' denotes the educated counterpart of visual-spatial ability, and refers to the communication of spatial information that cannot be conveyed adequately by verbal or numerical means; for example, the plan of a town, the pattern of a drainage network or a picture of a distant place. Balchin argued that since graphicacy was a fundamental aspect of human intelligence and communication, and since geography depends upon graphicacy, geography should rank with English and Mathematics as a foundation subject in schools instead of some kind of optional extra. It is only in geography, he maintained, that the possibility exists in schools of a wide and rigorous training in graphicacy. Arts teachers had abdicated their responsibility in this respect because of their commitment to 'free expression'.

Eysenck (in Suddaby, 1965) argued strongly that spatial tests should feature prominently in the selection procedures used in education systems, their lack having led to a shortage of candidates for science and engineering courses in higher education.

Warburton, Butcher and Forrest (1963) tested a hundred graduate teachers in training in the Department of Education of Manchester University, on measures of ability, values and general culture. The test of general culture was described as "prima facie, a rather crude measure of extent of reading", and consisted of a hundred items made up of titles of books and plays, musical compositions and paintings for which the testees were required to furnish the names of authors, playwrights, composers and painters. Warburton and his associates reported that the test of general culture emerged as a better predictor or results in the final Theory of Education examination and Final Certificate Award than any other single test. The authors comment "For success on the theoretical side of the course, culture and vocabulary are important, suggesting that Art Students, with their literary and verbal background, have an advantage in this respect".

Lomax (1969) made a comprehensive survey of the characteristics of successful student teachers in a college in the north of England. By means of a large battery of objective tests, questionnaire and individual interviews, Lomax obtained measures of predictor variables and criteria of success as a student teacher.

He found that, in a college where importance is attached to academic attainment, general intelligence, verbal ability and G.C.E. 'A' level results were good predictors of academic success, vocabulary tests promised well as selection instruments, and general intelligence was a useful predictor of all-round success.

He also found, however, that it may be that different college courses demand different patterns of ability.

> The intercorrelations between the intelligence test results, and between these results and various criteria of student success, suggest that a more detailed investigation might profitably be conducted into the relationships existing between different abilities and different criteria of success within colleges. Profiles of student abilities might be developed.
>
> (p. 517).

Lin and McKeachie (1973) related student characteristics to achievement in introductory psychology courses at the University of Michegan. They found measures of motivation, interest and personality did not contribute significantly beyond measures of intelligence to the prediction of psychology grades for women.

King (1963) studied relationships between age, sex, scores on tests of verbal and non-verbal ability, and a test of 'knowledge of science concepts' in a sample of 801 children in primary and secondary schools. The test of verbal ability predicted success in science more successfully than the non-verbal test. The non-verbal test was Raven's Progressive Matrices, however, and Macfarlane Smith, commenting on a different study, maintained that the Progressive Matrices have been shown to have a low 'k' loading and should not be regarded as a spatial test.

King's findings did not, therefore, run counter to the argument in my study.

The Sample.

Lomax (1969) maintained that, "Not only student teachers but in-service teachers may be regarded as being relatively homogeneous groups, when judged in terms of intelligence, interest, personality traits and scholastic achievement".

Nevertheless, because the mature students with whom I worked formed an unusual and relatively small group in the student teacher population it seemed advisable to carry out the study with students following the normal college course.

The sample consisted of 115 women students entering a college of education in the south of England in late September, 1974. The majority came from the southern counties of England, but a substantial minority came from Wales and the northern counties, and a small number from Scotland and Northern Ireland.

Appendix I lists the ages of students in the sample.

The mean age of the group on October 1st. (approximately two weeks after entering college) was 19.2 years.

The distribution of ages is shown in Table 4.

Table 4

Ages at Oct. 1st. of students entering college in 1974.

19th year	68	students.
20th "	28	"
21st "	12	"
22nd "	1	"
23rd "	2	"
24th "	2	"
25th "	1	"
33rd "	1	"

Appendix I lists the number of G.C.E. examinations passed by students in the sample. There were in total, 566 passes at 'O' level and 136 at 'A' level. Means are shown in Table 5.

Table 5. Distribution of G.C.E. Passes at 'O' and 'A' Level.

	Students	Passes at 'O'	Mean	Passes at 'A'	Mean
Students with 'O' passes only.	41	221	5.4	-	-
Students with 'O' and 'A' passes.	74	345	4.7	136	1.8

Measuring Instruments.

Scores on tests of general, verbal and spatial ability, and records of standing at school as reflected in G.C.E. examination results, were to be compared with a measure of the students achievements in 'Cluster 3' work, and analysed by multiple correlation.

Tests to be used were as follows:

1) The Cattell Culture-fair Intelligence Test, Scale 3, Forms A and B.
2) The Moray House Verbal Reasoning Test (Adult) 1, 1970 Revision.
3) The N.F.E.R. Spatial Test 3.
4) A 'Cluster 3' Psychology Test, to be constructed.

The following abbreviations of the test titles are used in this study:

1) C.C.F. (Cattell Culture-fair Intelligence Test, Scale 3).
2) M.H.V. (Moray House Verbal Reasoning Test, Adult 1).
3) S.T.3. (N.F.E.R. Spatial Test 3).
4) C3P ('Cluster 3' Psychology Test).

The Cattell Culture-fair Intelligence Test, Scale 3.

This was chosen as a suitable measure of 'g'. Cattell and Cattell (1959) distinguish two forms of general ability:

> 1) a fluid general factor showing itself in culture-fair tests, speeded situations, an earlier growth plateau and a clear age decline, high hereditary performances involving adaptability to new situations:
>
> 2) a crystallized general ability showing itself more reliably in acquired cultural achievements and skills, manifesting a steeper and longer up-curve over the school years and exhibiting no age decline in later life when measured by unspeeded (power) tests, liable to more specific area losses through brain injury, and less correlated than fluid ability with adaptability to new situations.
>
> (p. 37).

The Culture-fair Test aims to measure the fluid general ability factor.

> The test .... deals with the core of general 'relation eduction capacity' which many researchers have shown to be (a) largely inborn, (b) a relatively constant characteristic for the individual, and (c) operative in quite different fields of content, e.g. verbal, numerical, spatial and social skills.
>
> (p. 7).
>
> (The test aims to) seek a radical freedom from contamination by accidents of social, educational and racial background in estimating the real potential of the individual.
>
> (p. 9).

Scale 3 is intended for use with adults of above average intelligence and is said to be "especially suitable for spreading out finely the ability differences of university undergraduate and graduate students".

Use of a combined score from forms A and B (equivalent versions of the test) is recommended by the authors.

<u>The Moray House Verbal Reasoning Test (Adult) 1</u>.

The test manual states that the test was constructed from items found too difficult for the average child of 13 years, and standardisation was based on scores obtained from young people in their fifteenth year. Norms were extrapolated to age 17:6. The authors assume that no age allowance is necessary beyond 17:6 years.

The test had been administered "for many years" to graduate and non-graduate teachers in training in colleges of education in Scotland, and was a well-established measure of 'v:ed.'

A table showing the score distribution of teachers in training was provided in the manual.

<u>The N.F.E.R. Spatial Test 3</u>.

Since my argument was based upon Macfarlane Smith's view of spatial ability it seemed appropriate to use his test.

The Spatial Test 3 was originally intended for use in the allocation of 11 year old pupils to technical courses.

Inspection of the test revealed that it followed closely the principles set out in Smith's (1964) book. There were six sub-sections. Section 1 consisted of 'sections of solids' in which testees were asked to match 'three-dimensional' drawings of objects with end-views and middle-sections. In Section 2 testees were to match drawings of 'block buildings' with plans. In Section 3 items (described by Smith as 'surface development' in his book) three-dimensional drawings of folded paper objects were placed next to 'opened-out' versions of the objects. There were shaded areas on the three-dimensional drawings. Testees had to mark the equivalent areas on the opened-out versions. Section 4 consisted of matching mid-sections with three-dimensional drawings of objects. In Section 5 drawings of solids were to be copied on to a framework of points. The last section required testees to state the number of times plane surfaces were used in building up solid objects.

Each sub-section of the test was separately timed.

Correspondence with the N.F.E.R. Test Division revealed that the test had been used with revised time limits with engineers and builders in colleges of further education. There was a large difference in time allowance.

Table 6. S.T.3 Test: Time Allowances for Children and Technical Students.

Sub-test	Children	Technical Students
1	4 min.	2 min.
2	$3\frac{1}{2}$ min.	2 min.
3	$6\frac{1}{2}$ min.	3 min.
4	5 min.	2 min.
5	16 min.	8 min.
6	4 min.	2 min.
Total Allow.	39 min.	19 min.

Norms were given for engineering and building students aged 15 - 18 years. The two occupational groups differed significantly in their performance.

Table 7. S.T.3 Test: Norms for Engineers and Builders.

Age	N	Mean	S.D.	
15:0 - 15:11	151	66.9	15.9)	Engineers
16:0 - 18:0	145	72.3	16.2)	
15:0 - 16:11	400	60.5	18.7)	Builders
17:0 - 18:0	193	65.3	19.8)	

As this was a 'closed' test I obtained permission from the Local Education Authority for its use.

The 'Cluster 3' Psychology Test.

The construction of the psychology test is described on Pages 37 - 41

A Supplementary Test.

I was reluctant to discard completely the observations which had originally made me believe that an inquiry was warranted.

Before actually commencing the study I had virtually completed the preparation of a test ('Everyday Phenomena') which was intended to reveal misconceptions of everyday phenomena such as shadows.

As this line of inquiry had led to my interest in spatial ability in the first place I decided to use the test with the sample as a supplementary source of information which might provide interesting evidence when discussing the data from the main areas of testing.

The results were not to be included in intercorrelations.

The test is described later.

The Programme of Testing.

At the beginning of the academic year 1974 - 5 my intention was, in the course of the year, to

a) complete the Everyday Phenomena Test

b) administer the Everyday Phenomena Test to the main sample

c) try out the three standard tests

d) administer the three standard tests to the main sample and

e) construct the 'Cluster 3' Psychology Test.

In the following year, 1975 - 6, when students in the sample had finished the relevant parts of their psychology course, I intended to administer the completed Cluster 3 test.

The timetable for this work was as shown in Table 8.

Table 8

Timetable for the Administration of Tests.

	Student Year Group	Autumn Term	Spring Term	Summer Term	
ACADEMIC YEAR 1974 - 1975	1	Everyday Phenomena Test	M.H.V.1 Cattell C.F. 3 Spatial	→	Main Sample
	Year 2	M.H.V.1 -Cattell C.F. Spatial Test	Try out Psychology Test (try-out)	→	Pilot Group
	Year 3	Preliminary Psychology test. (try-out version) Everyday Phenom.			Pilot Group
ACADEMIC YEAR 1975 - 1976	Year 1				
	Year 2			Psychology Test,	Main Sample
	Year 3				

Procedures.

Permission from the college Principal and the agreement of the Students' Union and Education Group Tutors were obtained to proceed with testing.

I was allowed a short time at the beginning of mass lectures to speak to students, asking them for their co-operation in a small scale survey which aimed to understand some of the possible difficulties which students encounter when they take part in the college course in the psychology of education. I also repeated this at the commencement of each testing session before explaining the purposes of the particular test and describing the administrative procedures of the test.

I used the existing Education Group structure as a convenient arrangement for testing, each group of approximately 25 students meeting in the room normally used by that particular group, usually in time set aside for Education Studies. In effect this meant that each Group Tutor relinquished his students, room and one of his timetable periods to me for each of the standard tests.

All sessions in which the C.C.F. Test, the M.H.V. Test and the S.T.3 Test were used were conducted by myself. The C3P Test and the 'Everyday Phenomena' test were administered by Group Tutors.

Try-out Testing of the Three Standard Tests.

To enable me to be sure of the administration procedures and to gain a preliminary idea of the probable pattern of scores for the main sample, I tried out the three standard tests with students who in 1974 were in the first term of their second year in college ('Year 2 Pilot Group' on the Testing Timetable). For this work, alternate names were taken from an alphabetically arranged list of the whole 'year', producing a group of 62 students.

I administered the tests according to the standard instructions, marked the scripts and calculated means and standard deviations of the scores.

The average score of my pilot group on the C.C.F. Test was considerably lower than that given by Lomax (1969) of students in a north of England college (Table 9).

Table 9.

Scores on C.C.F. Test: Pilot Group and Lomax (1969)

	Lomax	Pilot Group
N	46	55
M.	60.17	53.38
S.D.	6.24	6.6

The average score of the pilot group on the M.H.V. Test was slightly below that of the non-graduate teachers in Scottish colleges shown in the test manual (Table 10).

Table 10.

Scores on M.H.V. Test: Pilot Group and Scottish Teachers.

	Scots. Teachers	Pilot Group.
M	65.7	63.2
S.D.	13.0	13.3

(Scots. Teachers N. not available)

The scores on the N.F.E.R. Spatial Test were unexpected in some respects. I had timed the sub-tests in accordance with the instructions for male technical students. If women generally did less well on tests of spatial ability it might have been expected that women students would be hard pressed to complete the items in the time allowed. This was not so, however, and the majority of students in the pilot group had time to spare, particularly in sub-tests 2 and 6.

Scores tended to be high compared with male technical students.

Table 11.

Scores on S.T. 3 Test:

Student Engineers, Builders and Pilot Group.

	Engineers	Builders	Pilot Group
N	145	193	54
M.	72.3	65.3	87.74
S.D.	16.2	19.8	9.3

The three standard tests appeared to discriminate well enough for my purposes.

The "Everyday Phenomena" Test.

As part of the more theoretical aspects of Educational Studies in the college where I worked, students were required to consider some of Piaget's work; in particular his clinical experiments through which he intended to examine children's ways of thinking, and from which he derived evidence for 'stages of intellectual development.'

I suspected that in each intake of students there were some who would themselves have considerable difficulty in understanding the problems which Piaget put to his child subjects, and that consequently the conclusions which Piaget drew from the experiments would have little meaning for these students.

The Everyday Phenomena Test (Appendix IX) was intended to provide data which would be helpful in establishing whether or not there were students who were likely to have this kind of difficulty. The test's function was to "screen" a whole student year-group.

With the exception of two items (Nos. 15 and 17), which were connected with Macfarlane Smith's notions of spatial ability, all the items in the test were based on well known elements of Piaget's work.

The test was tried out with 71 students in the first term of their third year in college.

The fact that the test dealt with ideas of the kind that are supposedly basic general knowledge made me uneasy about the way the test might be received by some students, who could possibly regard it as an insult to their capabilities. I therefore added a short appendix to the try-out version asking for opinions on the content and form of the test. If veterans such as students in their third college year found the style and level of difficulty acceptable, then other students were likely to accept it too.

In the appendix the students were asked to choose, from statements about the test, those statements they agreed with and to add comments where necessary.

Responses to the statements were as follows:

1)	"The questions were so easy that they were ridiculous."	0
2)	"The questions were generally easy, but some of them made me think for a moment."	61
3)	"Some of the questions were quite hard."	39
4)	"The method of answering (choosing ready-made answers and putting crosses in boxes) was	
	easy to follow	51
	difficult to follow	1
	convenient and time saving	47
	frustrating and restricting	2
5)	"The questions were too frivolous and were put in a childish setting."	0
6)	"The setting of the questions was mildly amusing making a pleasant change from the usual formal work."	63

The generally favourable responses to the questions suggested that third-year students regarded the test as a suitable challenge to their abilities and that the exercise of completing the items was not beneath their dignity.

Considering the nature of the items, their facilities supported this conclusion (Table 12).

Table 12.

Try-out, Everyday Phenomena Test, Item Facilities. N.71.

Item No.	f%	Item No.	f%
1 (i)	76	7	44
1 (ii)	91	8	99
2	41	9	55
3	73	10	93
4 (i)	90	11	55
4 (ii)	48	12	27
5 (i)	99	13	75
5 (ii)	89	14	59
6	65	16	73

(Items 15 and 17 were not scored)

Trying out the test suggested that its use with the main sample would be worth while.

I had registered as a research student so that I would be likely to do the job of inquiry properly, to "make a serious study of the matter". It seemed clear that there were accepted ways of doing a proper job, procedures one <u>ought</u> to carry out involving selecting an appropriate experimental design, choosing variables, suitable methods of analysis and so on.

The choice of variables was worrying. How could all the many influences that common sense indicated would affect a student's performance be left out of account? Lomax (1969), in what seemed a particularly admirable study, had measured social, emotional and other 'non-intellective' variables. On the other hand, there were very many studies which dealt with only a few 'intellective' factors. Burroughs (1971) gave advice on this. Looked at in one way, he said, variables can be of three kinds:

> Those variables which, being relevant to the problem, are going to be consistently measured in the proposed experiment.......
> Those which, although possibly relevant, are not going to be measured...... The important thing here is to recognise that there are other variables which may affect the outcome and thus to recognise the possible limitations of the study......
> Those variables, existing in large numbers, which have negligible effect on the outcome of the experiment and are therefore irrelevant. The collection of data under these headings should be sternly resisted. Data should be collected because they serve the foreseen research purpose and not because they might come in useful some time.
>
> (P. 5.)

There was still a problem. How do you know, before you start, which are relevant and which are not? The answer, implied in the phrase, "because they serve the foreseen research purpose", was that <u>previous research has shown</u> their relevance or otherwise.

This fitted in well with the feeling of 'ought'. The choice was not quite a matter of personal judgement. It was reasonable, given a suitable sample, to choose a limited number of 'intellective variables' and ignore the whole range of others if I accepted the limitations on any conclusions drawn.

The 'Everyday Phenomena' observations seemed to be among the class of data that I should sternly resist collecting. But my own teaching work regularly produced reasons why I should not resist. Many of my own students intended to work with infant children. All said that they believed in the value of sand and water play, cardboard box modelling and so on. The benefits to be derived were such things as "learning to co-operate", "co-ordination" and "learning liquid measure". I asked successive groups of students actually to play with water and make box models themselves, and to note interesting points. When, during these activities, I showed students objects such as a syrup tin with holes punched in a vertical line down the side, no-one could predict what would happen if the tin were filled with water, and there was much surprise and discussion when these things were actually done. Lists of interesting points included such things as the discovery that cutting a toilet roll centre intended to be a chimney on a model house to fit the slope of the roof produced an oval shaped end.

These were mature students; mature enough to 'lower themselves to children's level'. In doing this they were, apparently, noting as discoveries the kind of thing that, given suitable opportunities, it might be thought that young children would notice during play.

There was nothing to connect this kind of anecdotal material to the test I had put together, but it contributed to the feeling that many of us, as adults, do not know the things that infants are presumed to learn about. If I wanted to know something about the students in the sample, the 'Everyday Phenomena' test might come in useful as a start, even if it did not contribute in any strict sense to the foreseen research purpose.

<u>The 'Cluster 3' Psychology Test.</u>

I intended the test to sample students' understanding of selected explanations of, or theories about, intellectual development which were relevant to 'Cluster 3' objectives.

The test would need to fulfil several requirements:

1) It should provide a measure which is technically suitable for comparison with measures of other capabilities.
2) Its contents should reflect the information available to the students in lectures, a set text and supplementary materials.
3) It should sample the 'higher abilities' of 'application' and 'evaluation' as well as 'knowledge' (Bloom et al 1956).
4) Its form should reduce the effects of literary capabilities on the students' performance as far as possible.
5) It should be simple to administer.
6) It should be capable of fitting conveniently into the students' normal timetable.
7) Because it dealt directly with part of the students' work its results should be capable of forming part of the college assessment of students' work on the psychology course as a whole.

The well-known difficulties associated with essays as means of evaluation*, and my previous dissatisfaction with essays I had had to read made this type of exercise inappropriate. Also, if spatial abilities as opposed to verbal abilities were in question it was important that students with high spatial ability (relative to verbal) should not be handicapped by a need for highly developed literary skills.

An 'objective' test with multiple-choice items seemed to be the most appropriate type.

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* Difficulties of marking objectively and 'reproducibly': the small number of questions that can be set and the consequent inadequate coverage of topics: difficulties in assessing the relative 'facility' of individual questions: difficulties in assessing what is being examined.

This is not to say that strong verbal capabilities are not needed for success in completing multiple-choice items in objective tests, even when the wording is reduced to a minimum and much use is made of diagrams and pictures, but at least the multiple-choice format removes the need for some of the literary skills involved in producing answers in connected prose.

Because of timetabling considerations the test had to be completed by the whole 'year' of students at the same time. This made it necessary for Group Tutors to administer the test to their own group of students. The test had to be arranged so that nothing was required of the tutors other than to give out the papers, ask for test conditions to be observed and collect the papers when completed.

A total of 35 items, untimed, but with an average working time of about 45 minutes, seemed suitable.

In devising the items a difficulty arose from the fact that I did not take part in teaching the students who were to be tested. I had some trouble in making sure that the items would only deal with what students could reasonably be expected to know about. In descriptions of the course, aims were expressed in broad statements and topic headings which could denote a wide variety of content.

After discussions with the tutors concerned and an examination of the set text (Hilgard, Atkinson and Atkinson, 1971) I produced several papers containing questions which required short written answers. These papers were given to students in their third year in college (that is, who had completed the psychology course) and the responses obtained were used in writing the 'distractors' in items for the try-out version of the test proper.

This try-out version was administered to the 'pilot group' of students in their second college year after they had completed the relevant part of their work in psychology.

The further development of the test was made somewhat difficult for two reasons. Firstly, the tutor who dealt with the Cluster 3 work left to take up another appointment. The tutor who replaced her changed the set text (which became Child, 1973) and the ideas considered to be important.

Secondly, the results of the first try-out test seemed to surprise and disconcert some Group Tutors, who produced impromptu tests of their own. This surfeit of tests led to a noticeable hardening of attitudes towards testing among students in the 'pilot' groups of years two and three.

I again discussed the probable content of lectures, the parts of the Child text to be used and films and video-tapes with the staff concerned. It seemed to me that two broad theoretical views were to be emphasised to introduce notions of intellectual development to students, namely Learning Theory and Cognitive Theory. I defined these two views as follows:

<u>Learning Theory</u>.

Those explanations of intellectual development which regard developmental change as a special case of behavioural change; regard development as a large collection of gradual changes in specific performances; regard changes that take place in one period of a child's life as no different, qualitatively, from the character of changes that occur in any other period; and regard current environmental circumstances and the results of previous learning as the important factors in intellectual performance.

<u>Cognitive Theory</u>.

Those explanations which regard intellectual development as a gradual process which proceeds through a series of qualitatively different stages, each of which is characterised by a different type of cognitive structure. The structures are seen as setting limits to what a child can or cannot learn at a particular stage. Each succeeding stage is seen as incorporating the cognitive structures of the previous stage, and at the same time opening up new possibilities for learning and thinking. The child himself is the source of change in cognitive structure, in dynamic relations with his environment.

I made a list of generalisations and principles which I thought to be important for the understanding of explanations proposed in the two views set out above, and discussed the list with the tutor in charge of the course.

The list was as follows:

Learning Theory.	Cognitive Theory.
Discrimination.	Developmental Stages.
Generalisation.	Adaptation - Equilibration.
Reinforcement.	Semiotic Function.
Extinction.	Schemata.
Successive Approximation.	Cognitive Structures.
Inhibition-Punishment.	Insight.
Description and measurement of Behaviour.	
Hierarchies of Types of Learning.	

Taking these topics which could be assumed to be introduced to the students through the various media, I re-wrote test items.*

The object of the test was to try to assess students' understanding of some aspects of theories of intellectual development, and I took the view that 'understanding' should involve seeing the possible relevance of the theories to work in school or to connected children's activities. Wherever possible the items were set in a context of children's behaviour rather than, say, experimental work with animals, although one or two items had to refer directly to theories.

In this way I hoped that many of the problems presented in the test would be 'novel' to the students, in that they were required to apply to the problems principles learned in different contexts. In order to do this they would have to 'understand' the principles.

I classified the items in broad categories based on Bloom, et. al. (1956). Details of the classification are shown in Appendices III and IV and in Table 13 below.

Table 13. C.3p Test Items Classified According To Bloom's Taxonomy.

	Learning Theory Items	Cognitive Theory Items.
Knowledge	7	4
Comprehension	5	-
Application	3	9
Anal./Syn./ Eval.	1	6
	16	19

* Three items, Nos. 2, 21, 27, were taken from the post-test to Stones' (1968) "Learning and Teaching", with the permission of the author.

Because of the change of tutor and teaching material and the proliferation of tests mentioned earlier, trying out the items had to be done with interested individuals and small groups, mainly mature students, who had access to the ideas but through different means. The small numbers and the fact that the people concerned had received a different pattern of instruction made a conventional examination of the test's reliability and validity extremely difficult to achieve before the time when it must be administered.

Meanwhile my supervisor had gone abroad for an extended visit. I needed the opinion of a competent judge as to the content validity of the test.

In the absence of a supervisor I was referred, in the Autumn term of 1975, to a senior member of the University's Education Department, Tutor B, who had recently been appointed, and who was well known as a writer on Piagetian matters. In his opinion the test represented 'Cluster 3' objectives satisfactorily for the purposes of my inquiry. A copy of the final version of the test is shown in Appendix II.

At the beginning of January, 1976, Tutor B agreed to act as supervisor of the study.

The test was administered to the main sample of students on completion of the relevant sections of their psychology work.

Results.

By the end of the summer term, 1976, I had administered to the main sample the three standard tests, the Cluster 3 Psychology Test and the supplementary Everyday Phenomena Test.

The inevitable process of students withdrawing from the course resulted in only 93 of the original 115 students having completed the three standard tests and the Cluster 3 test. I believed that, if necessary, this difficulty could be met by adopting the device used by Warburton, Butcher and Forrest (1963), that is by assigning to a student who had missed a test the mean score of the whole group on that particular test.

Individual scores on the M.H.V, C.C.F., S.T.3 and C3P tests are listed in Appendix VII. Distributions of scores on the four tests are shown in Appendix VIII.

Taking the results of the 93 students who had completed all the tests, the means and standard deviations of the raw scores on the three standard tests were as shown in Table 14.

Table 14.

M. and S.D. of Three Standard Tests (raw scores).

N.93.

	M.H.V.	C.C.F.	S.T.3
M.	55.9	57.1	70.7
S.D.	12.5	7.2	16.2

The distribution of scores on the N.F.E.R. Spatial Test was bi-modal.

The Cluster 3 Psychology Test.

I carried out an item analysis of the Cluster 3 Test following the procedure recommended by Pigeon and Yates (1968).

The item facility and discrimination indices were computed, and, using very broad criteria for acceptance of an item (facility between 20% and 80%; discrimination .30 or over) only 16 of the 35 items could be considered adequate (Table 15).

Table 15 C3P Test: Item Facility and Discrimination Indices.

Item No.	f%	D.	Item No.	f%	D.	Item No.	f%	D.
1	84.9	.19	11	43.0	.48	17(vi)	63.4	.41
2	7.5	.19	12	85.0	.26	18	16.1	.07
3	66.7	.56	13	37.6	.22	19	22.6	.33
4	37.6	.37	14	49.5	.30	20	14.0	.22
5	44.1	.19	15	22.6	.07	21	67.8	.56
6	63.4	.59	16	66.7	.56	22	87.1	.33
7	59.1	.41	17(i)	38.7	.11	23	4.3	*
8	6.5	.08	17(ii)	52.7	.56	24	89.3	.22
9	26.9	.30	17(iii)	65.6	.07	25	72.0	.44
10(i)	31.2	.30	17(iv)	69.9	.22	26	18.3	.22
10(ii)	49.5	.26	17(v)	58.1	.30	27	33.3	.26
						28	30.1	.30
						29	10.8	.04

Application of the Kuder-Richardson formula 21 to the results of approximately 27% of students scoring high and 27% scoring low, as recommended by Pigeon and Yates, produced a reliability coefficient of 0.62.

With a possible score of 35, the mean for the test was 15.7, standard deviation 4.5

On these figures no reliance could be placed on the test as a stable criterion measure, and scores on the test could hardly be predicted by scores on any other test. It might have been possible to go ahead with correlations using the sixteen 'satisfactory' items of the psychology test, but although this might inflate the index of reliability of the shortened test, its validity would have been very much in question. The result would have been merely an exercise in arithmetic.

Yet it was hard to ignore a feeling that if students had even a limited grasp of the ideas dealt with by at least some of the items, they would have had little difficulty in choosing the preferred responses.

Responses to distractors were interesting (Appendix V).. Item No. 2, for example, was taken from the post-test to Stones' (1968) programmed text, "Learning and Teaching", and with Item No. 1 was intended to serve as an easy 'starter'.

2. A child enters a classroom noisily. If you wish to end this pattern of behaviour by 'extinction', which of the following courses of action would you choose?

   (A) Send the child out again and make him enter quietly.

   (B) Ignore his entrance.

   (C) Punish him.

   (D) Explain that he is causing a disturbance and ask him not to do it again.

   (E) Refuse to admit him until he enters quietly.

Responses were as follows:

A	53	D	14
B	7	E	17
C	2		

It would seem that tradition and 'common sense' classroom practices were the guiding principles for most of these choices rather than the general notion of extinction in Learning Theory.

Similarly in Item 20 responses seemed to stem from staffroom lore rather than an appreciation of the principles of behaviour modification. The idea of positive reinforcement did not fare well in Items 5 and 10(ii).

In these and many other items it seemed that students tended to ignore the part of the question which required them to take into account the point of view of Learning Theory. Rather they appeared to choose courses of action which most resembled what staffroom tradition might recommend.

Item 18 was an apparently straightforward matter of recalling the hierarchy of learning types proposed by Gagne. Only 15 students recalled correctly.

Items 9, 15, 22, 24, 28 and 29 required students to evaluate

Children's responses to questioning in Piagetian type 'experiments'. The distractors in these items were taken from published works (e.g. Brearley and Hitchfield, 1966) or from the reports on work done with children by my mature student groups. Students appeared to find most of these difficult. For example, in Item 15, although 68 students chose the preferred response, A, 47 of these also chose one or more of the distractors.

> Some children are shown a glass of water and a heaped tablespoonful of sand. They are asked, "If I put this sand in the water, will the water level go up, go down, or stay the same?"
> Which answer/answers shows/show understanding of the problem?
>
> (A) It will go up because the sand takes room up.
>
> (B) It will go up because the sand will not dissolve.
>
> (C) It will stay the same because the sand will soak up a lot of the water.
>
> (D) It will go up because the sand is heavier.
>
> (E) It will stay the same because the water is lighter than sand.

In general, the performance of students on the test was low, assuming that the items did represent the ideas considered important in the instruction they had received.

Low facility and discrimination on items such as No. 2 suggested that many students were unfamiliar with the ideas involved. The test failed as a criterion measure to some extent because students had not learned some of the things that their tutors said they set out to teach.

Reflection on what emerged during my attempts to construct the test makes this understandable.

The extent to which students were willing to concentrate their effort after meaning towards the topic was powerfully affected by their total work load. At any particular time, demands were made on students by work in main academic subject, subsidiary subjects and 'combined studies', as well as Education.

Education as a whole, including professional studies and preparation for practical work in schools, represented only a third of their commitment. The 'theoretical' work in Education took up less than half of the Educational commitment. At any particular time there were at least two major strands of 'educational theory' work in progress. The 'Cluster 3' topics were merely one part of one of these strands.

The main source of information on the topic available to students was the set text (Child, 1973). This was eclectic in character, and students were required to read 'relevant' sections, the reasons why they were relevant being largely left to the students. Lectures and films were intended to elaborate on ideas from the reading and to present supplementary material.

Students were not accustomed to being asked to attend to the detail of particular topics. Instead, their expectation was that they should write essays assembled around general statements taken from their readings, and be rewarded with 'literal grades'.

Tutors taught with the assumption that the outcome of teaching would be an essay, and that even in a weak essay something would be found which would serve as its saving grace. It would have been very unusual for a student to be required to return to a topic for further study of particular ideas. The need to get on to the next topic and grading exercise precluded this.

Because of all this, the tendency for students to seek a general impression of a topic, and for tutors to teach so that a general impression might be available to students, was pronounced. The principle was a basic, if unspoken, assumption about what everybody was trying to do.

The only valid criterion of achievement in this process was therefore an essay, a form which I had avoided because of its association with strong verbal abilities.

The 'Everyday Phenomena' Test.

Students' responses to the Everyday Phenomena Test were intriguing (Appendix X). If responses other than the preferred responses were regarded as errors, the results suggested that a significant number of students held some quite remarkable beliefs about relations between elements in everyday situations. The responses are described at length later, and a few examples may serve as illustrations at this point.

In Item 4(i), which described an olive placed in a cocktail-type drink, eight students apparently thought that the size of the olive would determine whether or not the level of the liquid rose. Nine thought that the liquid level would remain the same.

In 4(ii) which described the addition of sugar instead of an olive, twenty-nine students thought that the height of the level of liquid would depend on whether or not the sugar dissolved, and forty-nine thought that the liquid level would remain the same.

Item 6 described two people of the same height carrying a ladder, one in the centre of the ladder and the other at one end. Six students thought that the person at the end carried a heavier load, and twenty-three thought that both people carried about the same load.

In Item 11, twenty-eight students thought that the weight of an object placed in water determined the amount by which the water level would rise.

Item 16 required students to draw lines to indicate a level of liquid on drawings of tilted glass containers. Twenty-two students drew lines which were at various angles to the horizontal.

Even in Item 8, which was a version of Piaget's cows-in-a-field conservation of area problem, five students apparently thought that the particular disposition of objects on a surface affected the area left exposed.

Perhaps the most remarkable responses were to Item 14, which required students to indicate, by drawing, where a shadow would fall on two views, plan and elevation, of a light source and an object. The responses of forty-nine students could not be counted as correct. They included drawings in which the shadows extended towards the light, others which showed shadows going in different directions in the two views, responses which indicated (sometimes in writing) that the object in the plan view would produce no shadow, and others.

My attempt to be an independent observer, to look in on the actions of other people engaged in their own affairs, had run into some rather nasty snags. People would not hold still for a moment to be measured. The member of staff who taught the students, a key figure, disappeared and another with different ideas took her place. Other members of staff, who were not supposed to be among the variables, made themselves into key figures by making up their own tests and requiring the students in their own 'Education Groups' (my 'try-out subjects') to complete them. Students who did the try-out work became restless under the spate of tests.

Originally it had not been thought necessary to consider Education Groups separately because all students, on the face of it, received the same tuition. It now looked as though results from the main sample would need to be tested for 'Education Group effect'.

Besides going about their own affairs, people were reacting to my interference. I wondered how this kind of runaway cussedness was avoided in the research situations neatly described in the literature.

The students in the main sample inconveniently produced a distribution of scores on the spatial test which did not need Geary's test to show that it was far from normal. Most inconvenient of all was the circle of lectures, reading and essays which would not allow the essay to be replaced by a different kind of test. In effect I was back where I had started, with the difference that then I was inside what I saw as a treadmill trying to break out, and now I was trying to break in from the outside.

CHAPTER THREE

Re-direction of the Study.

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The testing procedure, including try-out work, had gone on for two years, demanding a great deal of negotiation with staff and students about my intrusion into their affairs, and time and effort expended in organising suitable conditions for the many testing sessions. Testing within an institution such as a college of education can disturb not only routines and timetables but also the composure of students, who may feel that some sort of psychical voyeurism is going on, and staff, who may feel with some justification that their work is being subjected to a rather impertinent inspection.

There were clearly limits to what I might do in addition to the programme already carried out.

A further disturbing feature appeared during the year when it was made known that the college was among those which were to close after the academic year 1977-8 as part of the general 'cut-back' in teacher education.

My two home-made tests, in their different ways, had brought about a growing personal dissatisfaction with the study as planned.

I had had the results of the Everyday Phenomena Test since the Autumn term, 1974, and they appeared far more interesting, even as testing went on, than a comparison of measurements of abilities.

I decided to carry out individual interviews, as soon as the planned testing programme was complete, with students who had made what seemed to be unusual responses. In the interviews I hoped that students would be willing, in spite of the unfavourable climate, to talk about what they had in mind when confronted with the Everyday Phenomena items.

My attempts to construct a 'Cluster 3' test technically suitable for correlation had also led me to think again about the usefulness of a study of correlations between scores on tests of 'abilities' on the one hand, and a criterion of achievement on the other.

There was the difficulty of establishing a criterion measure. It was not clear how a suitable achievement test could be constructed without breaking what I saw as a closed circle centred on the writing of essays.

I had also begun to wonder about my hypothesis. It demanded that the students should be seen as instruments whose function was to register the relative strengths of abilities. There was something wrong with this.

I consulted my supervisor, Tutor B, again.

He agreed that the Everyday Phenomena results were of interest, particularly as a possible indicator of levels of intellectual functioning, and suggested the test should be administered again to the same students with the aim of examining changes, if any, in the performance of students after approximately two years in college.

The Brimer cluster analysis (Brimer, 1968; Satterly and Brimer, 1971) was suggested as suitable technique for qualitative analysis of the results.

Shortly afterwards, Tutor B left to take up an appointment abroad.

At the beginning of the Autumn term 1976, Tutor C undertook supervision of the study.

After consulting available written descriptions of the Brimer analysis and examples of its use (Brimer, 1968; Satterley and Brimer, 1971; Wallace, 1972; Carter, 1975) I understood the technique to be capable of assembling data into clusters which were not dependent upon pre-conceived notions as to why they should be so grouped.

These clusters could then be inspected and qualitative relationships proposed between elements in each cluster.

The technique would allow students to be grouped according to their pattern of response to the various items of the Everyday Phenomena Test, and these patterns could be interpreted as levels of response to the test. Students' 'levels' on the earlier and later administrations of the test could be expressed in diagramatic form, as in Inhelder, Sinclair and Bovet (1974). Interest would be in students' movement, or lack of movement, from one level to another, and in the relation of the levels to characteristics of Piagetian stages.

I negotiated with staff and students for their agreement to another administration of the test and this was completed in the Autumn term. Results closely resembled those of the first administration (Appendix XI).

My supervisor referred me to another member of staff, Tutor D, would would advise on the application of the Brimer analysis through a computer programme.

As part of the process of preparing the results for processing Tutor D examined several examples of completed test papers. He persuaded a lady he knew well to complete a paper and was surprised to find that she too produced unusual responses to some of the items. He thought that the test results were interesting material, but that before subjecting the data to computer processing I should re-examine the assumptions on which my proposed procedure was based, particularly assumptions about students' interpretations of the test items.

In order to do this it was essential to attempt to get students to talk about the test items in spite of the unfavourable climate generated by a surfeit of testing, students' heavy timetable commitments and the growing uncertainty about prospects of employment for students as their time in college approached its end.

Apart from the constraints mentioned above there was not a great deal of time remaining when the students would be available. I decided to choose students so that most types of response on the second administration of the test would be represented, and to ask students to meet in small groups for discussion.

Thirty-one papers seemed suitable. The groups were asked to meet after normal timetable hours. There were five groups, the number in each group varying between three and eight members. The size and composition of the groups was determined by the particular occasions when students were able to attend.

The identification numbers of students who took part in the discussions are marked by asterisks in Appendices I and VII.

I was somewhat surprised to find that all the students invited actually attended.

In each group discussion students sat around a table on which there was a tape-recorder microphone and the students' completed test papers. I asked each student to take her own paper and explained that I would be glad to hear comments on the items which would be helpful in interpreting responses.

I asked if students would agree to the ensuing conversation being tape-recorded. After I gave assurances that no speaker would be identified in any way, four groups gave permission for recording. One group, Group 5 in the written accounts of the discussions, would not allow recording. I took written notes of this discussion. In each group, discussion commenced with Item No. 12 as the distractors seemed to provide good openings for contributions. Some care was necessary in persuading the groups to comment freely at first, and I abandoned any attempt to use a schedule of questions, relying on the opportunities of the moment to shape my approach.

Transcriptions from the tapes of the four recorded groups, and notes from the fifth group, are shown in Appendix XIII. Cassette tapes of the discussions are submitted with this thesis.

I had produced a 'flow-chart' (Appendix XIV) to try to make clearer how I might assess the material and make use of the results of the Brimer analysis, but I was now unsure of what a statistical analysis might achieve.

Application of the Brimer analysis produces classes of data. The production of the classes is said to make no greater assumptions about the nature of the data than that they are binary events whose frequency of occurrence and co-occurrence are subject to the laws of probability. The content of the classes or clusters is inspected to find something which will fit in with an hypothesis about the 'meaning' of clusters.

Although the theory of the classificatory technique itself may involve only statistical assumptions about the nature of the data, use of the technique on data such as responses to the Everyday Phenomena test makes the quite considerable assumption that all testees who choose a particular item option do so for the same reason. If this were not assumed there would be no grounds for hypotheses. But different students may well have had different reasons for choosing the same pattern of item options.

If, in a hypothetical case, three students X, Y and Z, chose Option A in, say Item No. 4 (i) and also Option B in Item No. 9, reasons for the choices such as those given below are possible.

Student X chose 4 (i) A because she forgot that the question was about whether or not the level would rise, and proceeded as though it was about how much the level would rise. She chose 9B because, although she felt she knew very little about bicycles, there was something different about the one in the illustration and it was likely to do the opposite of what one would expect of a bicycle.

Student Y did not bother to 'think' anything, but put crosses at random throughout the test.

Student Z thought that there must be a catch somewhere in Item No. 4(i) and chose A because it seemed non-committal.
In Item No. 9 she chose B after tracing her pen round the drawing of the belt and deciding that the rear pulley must turn in the opposite way to movement of the pedal.

The responses, crosses made in boxes on the test paper, all look alike, but their 'meanings' are potentially diverse. It is a fairly long step to read meanings into the responses by virtue of the fact that particular combinations of choices are revealed by cluster analysis, even though the odds on their appearance are 'better than chance'. The test reduced the situations that the items dealt with, merely by describing them. The 'multiple-choice' answer options reduced possible response still further. Connections were already established between the situations by their inclusion in the test. The only bond between combinations of responses produced by cluster analysis that could be inferred with confidence was the fact that all the students had taken the test. Pursued to the end, this line of argument meant that I, the compiler of the test, was the bond holding students, items and responses together producing the context.

I was at a loss for some time about the best course of action to take, and other matters intervened. The college was closed and I took up another course of study. These events are briefly described in Chapter 6.

On returning to the dilemma presented by the Everyday Phenomena material, it seemed best to try to describe students' test responses and contributions to discussion in as much detail as possible and to relate them to Piagetian theory in a way which was frankly interpretative, rather than to produce findings from a statistical analysis of one part of the material.

Chapter 4 which follows represents an examination of test responses and contributions to discussion in respect of each test item, and their interpretation with reference to Piagetian theory.

I thought I was setting out to find out something about a group of people. I had chosen variables and found ready made instruments to take measurements. The events of the period of testing brought about a shift of viewpoint. I saw the test papers not as measuring instruments but as the calibrated dials on which the real measuring instruments made marks. The instruments were the students themselves, and their function was to register the relative strengths of abilities. The people I wanted to find out about had become sets of initial conditions in which something operated. This reversed view of things led to an appreciation of the recursive and conservative nature of psychometric theory.

The inside-out impression returned when I was considering what to do about the 'Everyday Phenomena' results. When I put together the items of the test, the idea was that they would indicate whether there were students who might have difficulty in understanding Piagetian 'experiments' because of some lack of a basic general knowledge. The test was not intended to provide answers to questions of why this general knowledge might be lacking. Any approach to these questions in respect of most of the items would require much more refined procedures.

When, as I described in Chapter Three, students' difficulties and apparent misconceptions in these areas returned to the forefront of attention, I had in mind the possibility of individual interviews with students, in which some of the requirements of 'clinical method' might be met. Most of the test item topics would make the Geneva School procedures necessary, that is, presenting materials and a problem, obtaining a response, re-arranging the materials and posing the problem in a different way so that the steps in the 'subject's' reasoning could be demonstrated.

By this time, however, the emotional climate was not ideal for further overt testing. It is not easy at the best of times to persuade adults voluntarily to lay themselves open to more judgements of their capabilities than seems to them to be strictly necessary. When students have read and heard about Piaget's work, believe that it largely refers to children, and find themselves asked to go through the same procedures, they are likely to feel even more threatened. What one ought to be able to do is important. As a student later remarked (Preface and Page 306), "....somebody of my age ought to be able to do this..... we had it drummed into us so often in Chid Development that children of this age can do this and this...."

There was also a limited amount of time available, and individual interviews take a great deal of time to arrange, prepare and carry out. I had seen a description of procedures said to allow Piagetian testing of large groups (Shayer and Wharry, 1974) but the affective difficulties remained, and in any case, I thought there were objections to be made to the group procedures if they were to be regarded as 'clinical' in the Piagetian sense.

When I consulted Tutor B he offered a pragmatic solution to what he saw to be my problem, that is, how to finish the study. The solution was a 'qualitative' method of analysis of the results that I had. But in the process of applying this method another influence appeared. Tutor D persisted in asking questions about what I thought I would get from a cluster analysis. After an uncomfortable period of trying to find answers I felt that the analysis presented a circle similar to the one I saw in psychometric testing.

CHAPTER FOUR

Reactions of Students to a Test based on Piagetian Problems.

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Reactions of Students to a Test based on Piagetian Problems.

(1) Examination of Test Responses and Students' Comments in Discussion.

The marks that students made on the Everyday Phenomena* test papers as responses to the items could signify a variety of kinds of response. Students may have believed that their response was the most suitable answer, and arrived at this decision through reasoning and use of the knowledge they had. In the multiple-choice items students may have guessed, either blindly or by elimination of some of the distractors. Students may have interpreted the items in ways different from the way I intended them to be interpreted. Because of the content and style of presentation of the items, a contemptuous or flippant treatment of the test by students was possible.

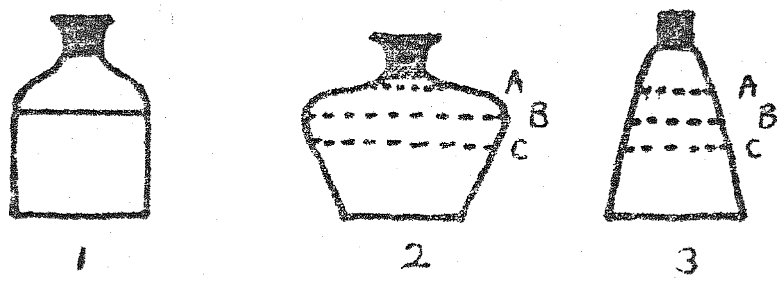
Possible reasons for the different responses are discussed in the examination which follows of students' reactions to each item of the test.

* The abbreviation E.P. is used for the title "Everyday Phenomena Test".

Examination of Results, Item by Item.

Item No. 1

Fig. 1. E.P. Item No. 1.



These are scale drawings of bottles in which a certain brand of perfume is sold. Each bottle is round. Which of the dotted lines (A, B or C) on Bottles 2 and 3 show where the perfume should come up to in order to have the same amount as Bottle 1? Put a cross in the appropriate boxes in the answer column.

Table 16. E.P. Item No. 1. Results:1974. N.115.

i) (Bottle 1.)	A	1	ii) (Bottle 2.)	A	100
	B	22		B	15
	C	92		C	-
	N.R.	-		N.R.	-

(N.R. = No response)

I expected that most students would follow the line of reasoning:- The bases of the bottles are the same diameter. The sides of the second bottle slope outwards, so to compensate for the greater width the surface of the liquid must be lower. Therefore, C. The sides of the third bottle slope inwards, therefore A.

In (i) 23 students (20%), and in (ii) 15 students (13%) apparently did not.

There was little change in the results of the 1976 administration E.P. Item No. 1.

Table 17. E.P. Item No. 1.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

i)	1974	1976	ii)	1974	1976
A	-	1	A	77	79
B	19	22	B	9	6
C	67	63	C	-	1
N.R.	-	-		-	-

Leaving aside idiosyncratic responses for the moment, arriving at the preferred responses (C in (i) and A in (ii)) depends upon seeing the bases of the bottles as equal in diameter. The term 'scale drawings' in the item stem was intended as a cue to this, and the lines representing the bottle bases are approximately equal in length, although how these are seen may be affected by the lines representing the sides of the bottles.

Students' contributions to discussion of the items indicated possible ways leading towards the choice of a particular answer.

(Group 1) The B line on both of them is the same as the first one, so that couldn't be right. The second bottle was bigger so it should be lower down, and the third bottle was smaller, so it should be higher up.

For this student at least, it was a straightforward problem of the conservation of continuous quantity. One would imagine that the correct responses were based on this kind of approach, deducing a necessary conclusion from a known principle - seeing the 'structure' of the problem. Some correct responses could, of course, have been arrived at by other means.

Other comments suggested uncertainty and some confusion:

(Group 4) ...... on thinking back I wasn't so sure. With the sides being wider would it really go higher, or would it be the same if it was that bit lower?

One reason why a student might look for the structure of the problem and fail to find it, is that the item stem does not spell out explicitly that the bases of the bottles have the same diameter. But a student confident in sorting out the relations involved would ask, at the outset, "<u>Are</u> the bases equal in diameter? If so such-and-such will follow", and check the cues available. Students who reported feelings of confusion on this item also said that it had not occurred to them to check the bases. No student commented on being unable to arrive at an answer because of lack of information. It is possible that some students knew that there should be a logical procedure available to them, but did not know what to look for - the relation between the three elements on which to base deductions.

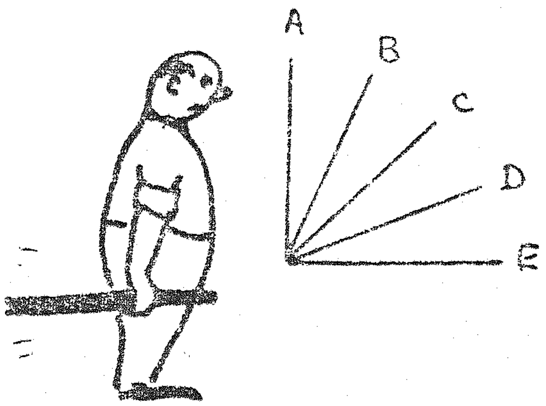
This view is supported to some extent by the fact that, in both administrations of the test, the total number of errors on Bottle 2 was greater than the total on Bottle 3. A deductive process should have made Bottle 2 no harder to deal with than Bottle 3.

Comments from Group 5 suggest that some students used the general appearance of the illustrations as the data on which to base choices:

> I imagined the straight bottle placed over the top of the others.
>
> I looked at the amount of white paper inside the lines and thought about how much there was.

Item No. 2.

Fig. 2. E.P. Item No. 2.



Fred wants to water the far end of his garden, but the hose-pipe is pulled as far as it will go. How should he hold the hose-pipe to make the water go farthest (A, B, C, D or E)? Put a cross in the appropriate box in the answer column.

Table 18.

E.P. Item No. 2 Results. 1974. N.115.

A	2
B	-
C	42
D	51
E	18
None	1
N.R.	1

I anticipated reasoning such as - You need to raise the nozzle in order to give height, otherwise the water will soon touch the ground because of gravity, but unless the nozzle points forward the water will not reach far; therefore a compromise between vertical and horizontal:- C.

A sophisticated testee, however, may remark on unstated conditions; the question of air resistance, the factors which determine when the water jet will eventually break up into drops (size and shape of the nozzle, etc.) and so on.

She may point out that the hose-jet is unlikely to be a parabola and that rules (to do with the angle of elevation for a parabolic trajectory under constant downward acceleration and fixed projection velocity to give maximum travel) would be inappropriate.

In short, from the point of view of formal physios, the item is very hazy. Answers B, C, or D must be accepted as possibly correct.

It is all the more interesting that 22 students (19%) did not pick B, C, or D. Two chose the vertical, eighteen chose the horizontal, one chose "None" and one did not respond.

Results in 1976 were similar.

Table 19. E.P. Item No. 2.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions). N. 86.

	1974	1976
A	-	-
B	-	-
C	30	31
D	40	38
E	14	16
None	1	1
N.R.	1	-

Contributions to discussions indicated that, at least among the students taking part, there was more of an attempt to remember from experience how a jet of water behaved, rather than an appeal to 'laws'.

(Group 1) I was standing with a hose pipe .... the height the water reached and .... how far it would go.

(Group 5) I imagined myself looking at the place where the water had to go, and chose the middle one.

Most students thought A very unlikely. When asked which of the answers could be eliminated easily:

(Group 2) A! (Laughter)

(Group 3) A, straight away.

(Group 1) A can go out .... I thought it was between C, D, and E.

No student, in 1974 or 1976, chose B. This may have been because B is next to A, and A is clearly out (except for two students in the first administration):

(Group 3) I'd say E was a possibility, but not B; it's not much difference from A to B really.

Rejection of A was the starting point for another student who chose E:

(Group 5) If you point the hose-pipe straight up, it comes down next to you, so the furthest away from that must be the one that goes furthest, so I chose 'hose-pipe level'.

E was attractive to a number of students in the discussion groups:

(Group 5) I picked D because it was the nearest to E. I thought that there must be a catch in it so I didn't put E.

(Group 1) .... said to ... about putting E, but somebody said that was wrong because it was C. But if you put your finger over the end of the hose ....
(What made you choose E in the first place?)
Just seemed to me that if you stuck it out in front it should go further .... if you chose C it would have to go up, but if you pointed it directly it would just have to go straight.

Some students did not want to hold water-pressure as a given constant:

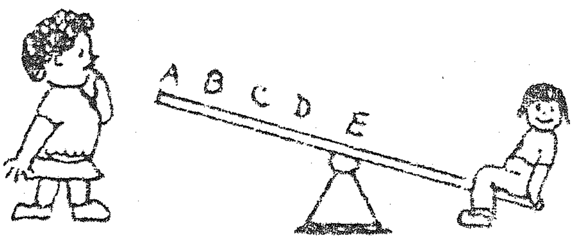
(Group 5) It depends on the pressure of the water.

(Group 1) Doesn't it depend on how much water is coming out of the hose-pipe in the first place?

(Group 2) Course, it does depend on the force of the water.

Item No. 3.

Fig. 3 E.P. Item No. 3



Jill is twice as heavy as her brother Jack. Where should Jill sit on the see-saw (A, B, C, D, or E) to balance Jack?

Put a cross in the appropriate box.

Table 20 E.P. Item No. 3.

Results. 1974. N.115.

A	-
B	1
C	85
D	21
E	3
None	4
N.R.	1

I expected that most students would have an intuitive grasp of the relation between weight and distance from the pivot, since see-sawing involving experimentation is a common play experience.

30 Students (26%) did not choose C.

The 1976 results showed a slight increase in 'correct' responses:

Table 21. E.P. Item No. 3.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	-	1
B	1	1
C	59	67
D	19	10
E	3	2
None	3	5
N.R.	1	-

Comments in discussion indicated that experience of see-sawing was drawn upon rather than learned 'laws':

(Group 5) I thought about see-sawing when I was at school. One of us sat at one end and two of us would work our way up from the middle till we balanced.

(Group 3) I went back to childhood.

(Group 1) I remember see-sawing last summer ... that's what I related this to. I was always one of the heavier ones and I always had to sit next to the middle bit ...

Most students were aware that there was some principle which described the relations involved, but no-one felt comfortable about it:

(Group 1) There's something vaguely reminiscent of physics lessons in that as well.

(Group 5) I kept thinking about the word 'fulcrum'.

(Group 2) There's a rule to this, isn't there, the distance from the fulcrum or something ...

(Group 3) I related it to science - we used to try to get rules to balance ...

(You were thinking of a general principle?)

Yes.

(Is it one you could put into words?)

No.

(Group 2) The work at school was confusing in these questions. We had to remember so many different factors that affected something.

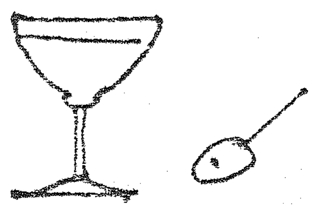
(Group 1) .... as she was twice as heavy as her brother she'd be in the middle .....

That's what put me off - as soon as I saw it was 'twice' I thought, Oh, it's got maths in it; that's me out for a start.

Choice of E or None might be taken to mean "It can't be done". Choice of B or D could reflect doubts about where the centroids of mass of Jack and Jill might be.

Item No. 4 (i).

Fig. 4. Item No. 4 (i).



i) An olive is put into a drink. Is the level of liquid then higher, lower or the same? Choose one of the following and put a cross in the appropriate box

A. It depends on the size of the olive
B. The same
C. Higher
D Lower

Table 22. E.P. Item No. 4 (i):

Results. 1974. N.115.

A	8
B	9
C	97
D	1
N.R.	-

I expected that virtually all students would choose the preferred response, C, on the basis of everyday experience, stories such as Aesop's Raven and so forth, if not from formal rules learned in school physics lessons. Yet 19 students (16.5%) did not. This figure had reduced to 7% in 1976.

Table 23. E.P. Item No. 4(i).

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	8	2
B	8	4
C	69	80
D	1	-
N.R.	-	-

Some of the comments in discussion were as surprising as the choice of anything but C.

(Group 3) You really had to think about this.

The uncertainty of some of the 'correct' students was exemplified by comments such as:

(Group 5) I put C, but A could be right.

There was certainty that the liquid level would not be made lower, but a feeling that the other options could not be dismissed lightly:

(Group 2) It won't go lower.

(Jumbled conversation)

It depends on the size of the olive too.

A possible reason for choice of A may be confusion about what depends on the size of the olive, some students perhaps forgetting that it was whether or not the level would rise and thinking instead that it was how much the level would rise. No one, however, mentioned this in discussion.

A hint of why A may have been chosen in some cases came from Group 5:

Do olives float?

A floating olive may only produce a very slight change in the level of the liquid. One could therefore say, in that case, that the change would be imperceptible; the fact that the level must in principle, rise by some amount being forgotten, or left out of account because general rules were not appealed to, or, conceivably, not fully grasped.

Other students had recollections of what they thought the law to be:

(Group 4) I thought of the theory of the weight of something going into the container and the amount of water being displaced being the same as the weight of the object that was placed into it.

This lack of, or partial grasp of a principle was also indicated by the results of a relevant item in the C3 Psychology Test (No.9.)

> Some children are shown a glass half full of water and a ball of plasticine. They are asked, "If I put the ball of plasticine in the water, will the water level go up, go down, or stay the same?" This is followed by the question, "Why?" The following are answers given by the children. Which answer/answer shows/show understanding of the problem?
>
> (A) It will stay the same because the ball is little.
>
> (B) It will go up because the ball is heavy and makes the water go up.
>
> (C) It will stay the same because the water can get under the ball.
>
> (D) It will go up because the water is lighter.
>
> (E) It will go up because the water can't get into where the ball is.

Table 24

Results. Item No. 9 C3P Test. N.93.

(Preferred response) -	E	25
	B	9
	B & E	30
	B & D	9
	B, D & E	14
	D & E	4
	A, B & C	1
	A & C	1

Statement A resembles "It depends on the size of the olive".

Statements B and D have the same confusion of weight and volume as that indicated in the comment (above) by the students in group 4.

68 (73%) students accepted A, B, or D as statements which displayed "an understanding of the problem".

Item No. 4 (ii).

Fig. 5. Item No. 4(ii).

ii) A spoonful of sugar is added to a drink. Is the level of liquid then higher, lower or the same?

A. It depends on how much sugar.

B. It depends on whether the sugar dissolves or not.

C. Higher

D. Lower

E. The same.

Choose one and put a cross in the box.

Table 25. E.P. Item No. 4(ii).

Results. 1974. N.115.

A	1
B	29
C	34
D	-
E	49
N.R.	2

A very sophisticated testee might point out that it is not physically impossible for some substances to contract in solution due to unusual strengths of inter-molecular bonding forces.

However, the substances involved are sugar and (one would be fairly certain) alcohol, and the answer must, in principle, be C. The amounts indicated in the illustration also suggest quite a substantial (perceptible) rise in liquid level.

A less sophisticated testee might be expected to draw on experience in cookery, as well as such activities as sand-and-water play in childhood, and formal school science, particularly in the primary school.

81 students (70%) did not choose C.

A high proportion did not choose C in 1976.

Table 26. E.P. Item No. 4(ii):

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	-	-
B	21	18
C	24	39
D	-	1
E	40	27
N.R.	1	1

Discussion in Group 1 indicates the uncertainty produced by this item:

> Oh, this one with the sugar .....
> A body in water displaces its own weight ..... I remembered that but got confused when we got to the sugar..... if you put in half a ton of sugar it's bound to go up, isn't it ..... unless it dissolves ..... oh dear. If it dissolves it must dissolve in something, mustn't it? Therefore there must be more of something than there was before .....
> I put "The same".
> I didn't put anything.

The question arose of whether a change in liquid level could be seen or not, again suggesting that for some students it was a matter of what could be observed in particular circumstances rather than what must necessarily follow from an established principle:

(Group 5) If it dissolves, how can you see a difference?

A student in Group 2 suggested a conflict between what is known and what one thinks may be seen:

> ..... experience as against reason. Reason says that when it goes in it's displacing something, but if it's being dissolved it must be adding to the liquid .... it must be a fraction higher, you know, it's not really perceptible.

The results of Item No. 15 of the Psychology Test seem to support the impression of considerable uncertainty in students about this problem.

> Some children are shown a glass of water and a heaped tablespoonful of sand. They are asked, "If I put this sand in the water, will the water level go up, go down, or stay the same?" Which answer/answers shows/show understanding of the problem?
>
> (A) It will go up because the sand takes room up.
>
> (B) It will go up because the sand will not dissolve.
>
> (C) It will stay the same because the sand will soak up a lot of the water.
>
> (D) It will go up because the sand is heavier.
>
> (E) It will stay the same because the water is lighter than sand.

Table 27.

Results. Item No. 15. C3P Test. N. 93.

(Preferred response) -	A	21
	B	3
	C	9
	D	1
	E	6
	A & B	24
	A & D	9
	B & D	3
	A, B & D	12
	B & C	1
	A & C	2
	C & E	1
	D & E	1

B implies that if the sand would dissolve the level would not go up.

C involves a similar idea of one substance taking in the other without an increase in volume.

55 (59%) students accepted B or C as statements which displayed "an understanding of the problem".

Items Nos. 5(i) and (ii).

Fig. 6. E.P. Test Items Nos. 5(i) and (ii).

The drawing shows three cog-wheels, A, B and C. Cogwheel A turns in the direction shown by the arrow.

i) Which wheel/wheels turns/turn in the same direction as A?

ii) Which wheel (A, B or C) turns fastest?

Put a cross in the appropriate box in the answer column for i) and ii).

Table 28. E.P. Item No. 5 (i).

Results. 1974. N.115.

B	7
C	102
Neither	5
N.R.	1

This item seems straightforward and less open to different interpretations than others, but 13 students (11.3%) did not choose the preferred response, C.

In 1976, 5 students (5.8%) did not choose the apparently obvious C.

Table 29. E.P. Item No. 5 (i).

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
B	6	3
C	76	81
Neither	3	2
N.R.	1	-

Table 30. E.P. Item No. 5(ii).

Results. 1974. N.115.

A	14
B	5
C	93
N.R.	3

22 students (19.1%) did not choose C. The proportion was slightly less in 1976, 13 students (15.1%).

Table 31. E.P. Item No. 5(ii).

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	10	6
B	5	5
C	69	73
N.R.	2	2

The few comments on both (i) and (ii) in discussion were mainly concerned with the general difficulty of imagining what would happen:

(Group 1) I remember playing with things like clocks - but again I couldn't remember which one went which way. I was trying to remember what it did used to do. I expect it was .... a child's .... plastic cogwheels .... tried to sit and think, if I turned that one which way did that one go. I played for hours with it but couldn't visualise it sufficiently well to actually see it. I put down the first thing that came into my head because I haven't the faintest idea, simple as that really.

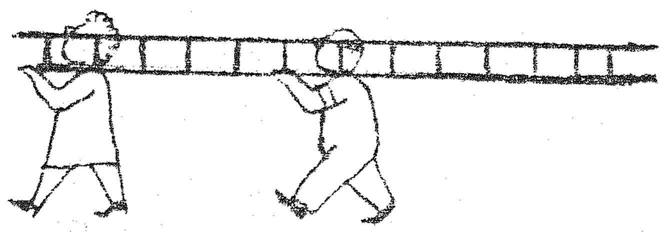
(Group 5) Circular lines are difficult to see.

(Group 2) I was trying to think of a watch .... you know, what you find in a watch with the back off, wheels going round. For some reason I thought that if one goes round one way the other must go round the opposite way, so the other one, the tiny one, will go the same way as B.

This last comment is particularly interesting since it indicates that a student may recall or abstract a principle correctly, and express it in words, but somehow fail to apply it.

Item No. 6.

Fig. 7. E.P. Item No. 6.



Fred and his wife are the same height They are carrying a ladder so that Fred can mend a window Which of the following is most likely to be true? Put a cross in the box.

A. Fred's wife is carrying a heavier load than Fred is carrying.

B. Fred is carrying a heavier load than his wife is carrying.

C. They both carry about the same load.

D. It depends on their relative strengths

Table 32. E.P. Item No. 6

Results. 1974. N.115.

A	6
B	70
C	23
D	16
N.R.	-

45 students (39.1%) did not choose the preferred response, B. In 1976, 38 students (44.2%) did not choose B. The question appears, superficially, to have become 'harder'.

Table 33. E.P. Item No. 6.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	6	6
B	50	48
C	16	24
D	14	8
N.R.	-	-

If the testee notices that Fred is under the centroid of mass of the ladder and can draw upon recollections of school maths and science lessons, or upon experience of carrying long objects, choice of B would seem to follow without many complications. For those students who took part in the discussions and knew what to look for, this appeared to be the case:

(Group 4) (In deciding between A, B and C)

Well, Fred was really the balancing point ....

It was not at all a straightforward matter for other students. A member of Group 1 noticed for the first time the significance of Fred's central position and a lively argument followed as she tried to persuade other group members that because Fred was in the middle of the ladder he would bear the heavier load:

> Oh, I've just noticed, Fred is actually dead in the middle of the ladder. Therefore it should balance on his shoulder. So in that case Fred's carrying a heavier load than his wife.
>
> Not necessarily ......
>
> Not necessarily if his wife is carrying all the first bit.
>
> Well, if it balances it might just be leaning on her shoulder.
>
> How do you know that? How do you know that she's not carrying a heavier load than him - he might just have his hand on it?
>
> But he's dead in the middle ......
>
> Yes, but she might be just as strong as him, so she might pull heavier so she'll be carrying more than him.

...... equal weight on each side so that he's carrying virtually all the weight of the ladder.

No, I don't agree.

Yes, if his wife wasn't there, he'd still balance the ladder on his shoulder.

It would drop down at the front ......

...... if you count the stiles on the ladder ......

I don't think it makes any difference to it.

If you put a pencil on the middle of your finger it balances, doesn't it?

It depends on how much they <u>were</u> carrying, doesn't it?

No. (Demonstration of pencil balanced on one finger with another finger near the end).

I think they both carry about the same weight.

One, two, three, four .... (counting steps of ladder).

Well, I've got that Fred's carrying a heavier load but I couldn't tell you why I got that in the first place because I definitely didn't think of what I just said.

Another student noted Fred's position but thought that this would make it easier for him:

(Group 5) He is balancing the ladder so he's not taking so much weight - if you balance something you're carrying it's easier to carry. His wife's taking the weight.

This argument seems to have behind it a comparison of two people carrying separate loads, one person balancing his load while the other does not.

A student gave a novel reason for suggesting that Fred might carry less than his wife:

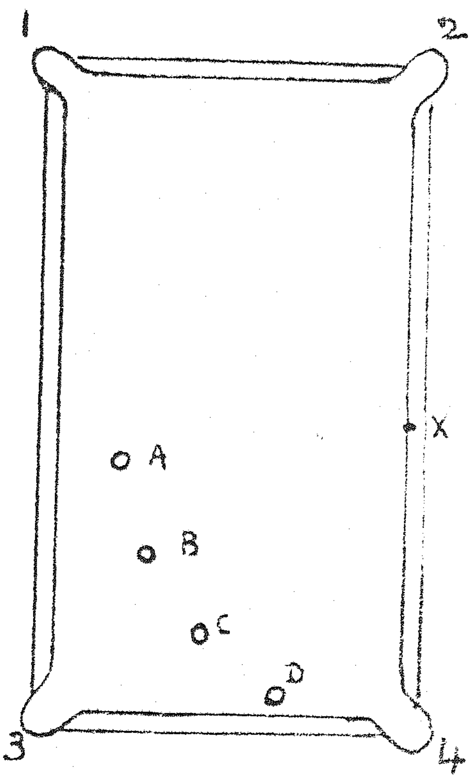
(Group 1) Now I see a different answer to this one. The person behind is always the worse off - I mean, is better off than the person in front, because they can't see how much the person behind is carrying, can they? The person behind might only have his finger tip on it as far as you know ...... like on a tandem - yes.

An argument developed in Group 2 about whether precise measurements were needed in order to arrive at an answer:

I put that they both carry about the same load.
(What sort of argument did you have to ...?)
I can't really remember .... I didn't like the question .... because .... er .... I didn't think there was enough information. Because I think it depends on their height ....
I mean if Fred is ....
(It says they are the same height ....)
Yes.
Fred is half way along the ladder so there's half of the ladder over his shoulder, and he is balancing on the ....
(Interruption - person coming into the room)
.... I took it that he was half way along the ladder so you've got half of it in front of him with his wife holding it, and half behind, er .... now you could be more definite, er .... certain about the answer if you knew the length of the ladder and what position on the left and where his wife was ....
Yes, but it tells you.
She's holding the end of the ladder there ....
Yes, precisely, it's just an approximation: it could be ....
.... but then you've got to sit down and measure it, haven't you ....
Well, er ....
.... to make sure that whoever's drawn it is accurate.
That's what you assume.
.... not enough information given.
I thought there was enough information to answer the question, but then ....

Item No. 7.

Fig. 8 E.P. Item No. 7.



This is a plan of a billiard table with four pockets, numbered 1, 2, 3 and 4. If each of the balls (A, B C and D) is hit with the right amount of force, exactly in the centre of the ball, and bounces off the cushion at X, which ball is most likely to go into Pocket 1?

Put a **cross** in the appropriate box

In the Piagetian experiment which made Item No. 7 necessary (Inhelder and Piaget, 1958, p.3), children's understanding of the equality between angles of incidence and reflection was investigated through their use of "a kind of billiard game".

> Balls were launched with a tubular spring device that can be pivoted and aimed in various directions around a fixed point. The ball is shot against a projection wall (with a rubber buffer) and rebounds to the interior of the apparatus. A target is placed successively at different points, and subjects are simply asked to aim at it. Afterwards, they report what they observed.

Inhelder and Piaget were interested in the way in which children noticed and interpreted regularities in the behaviour of the ball, and although they required children to formulate a law by induction, they did not need to be too concerned about the niceties of the situation. However, when a multiple-choice item is devised, set in what was hoped would be an 'everyday' situation and intended for adult subjects, problems arise, even when the purpose is merely to gain some idea of whether students are already familiar with the idea of equality of angles of incidence and reflection rather than to explore the subtleties of how the law is discovered.

A physical scientist commented on Item No. 7:

> It depends on the resilience of the cushions, i.e. the age of the billiard table and how recently warmers were put on the cushions - or should I say, we're not told the coefficient of restitution of the cushion at X. The coefficient of restitution is always less than 1: the lower the coefficient of restitution, the more the angle of reflection of the ball will be greater than the angle of incidence. But acting against that, the ball will be given spin by the cushion; kinetic energy of motion parallel to the cushion will be converted into kinetic energy of rotation, so this means that the angle of reflection will be substantially less than the angle of incidence. These two effects act in opposite directions. We are not told the coefficient of restitution, and we are asked which ball is "most likely", so we have to make a guess between the possible ones (A is clearly 'out') - let's plump for C.

If a testee knows the principle involved, and all the qualifications that may be necessary, she still must be able to judge the angles by 'eye', perhaps helped by drawing lines. However, it seems to me that A and B would clearly be implausible to anyone knowing the general principle, and a little care would lead to choice of C rather than D.

In the event 58 students (50.4%) in 1974 did not choose C.

Table 34. E.P. Item No. 7.

Results. 1974. N.115.

A	11
B	21
C	57
D	26
N.R.	-

The result was much the same in 1976, when 45 students (52.3%) did not choose C.

Table 35. E.P. Item No. 7.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	7	6
B	14	18
C	43	41
D	22	21
N.R.	-	-

In discussion a few students were confident about the principle involved:

(Group 4) There's a principle.
(What was the principle?)
Angles of reflection - it had to be the same angle going on as going off.

When one student mentioned the principle in a tentative way it was thought highly unlikely by other members of the group:

(Group 1) I'd got some idea that it had to bounce off at the same angle that it bounced on .....
(general laughter)

Some students thought that a right-angle came into it somewhere:

(Group 3) I was under the impression it should make a right-angle with the line the ball travels to X.

(Group 1) ..... I was trying to remember what I'd seen on television I was trying to work out what I'd seen, but I couldn't ... the principle that any ball that bounces off the side bounces off at a right-angle. So therefore you drew a right angle from where you ... make a right angle with X.

Others relied frankly on intuition:

(Group 5) I drew lines and chose the one that looked right.

I've played pool, but I don't understand the geometry.

As in the other items, many students tried to abstract principles from what they could remember of actually carrying out or watching the actions concerned, e.g. Group 2, Appendix XIII.

Some students, basing their reasons on recollections, maintained that any of the balls could go into pocket X:

(Group 5) It depends on where you stand. You can hit X from anywhere.

(Group 3) When you play pool you can hit them from all angles.

(But it says "exactly in the centre of the ball with the right amount of force ....")

It depends on where the actual ball you're hitting is being hit from.

(Group 1) Really, any of them could have gone in.

(It (the test item stem) says, "If each of the balls is hit with the right amount of force ... (etc.)" I believe that in order to put spin on a ball you have to hit it at the side ....)

Yes, but we're not to know that, are we?

The impression of uncertainty is confirmed by the results of Item 28 in the Psychology Test.

> The diagram shows a plan view of a board surrounded by a rubber-lined buffer. Targets are placed on the board (1, 2 and 3). Balls can be shot at the targets from a spring-gun at one corner (4), but the targets can only be hit by bouncing the balls off the buffer (5).

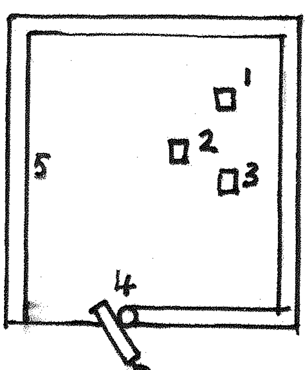


Fig. 9

> Some children play with the apparatus. They are then asked to find a rule for hitting the targets. Which answer/answers shows/show understanding of the problem?

(A) There has to be a right-angle between the angle of incidence and the angle of reflection.

(B) The angle of incidence has to be the same as the angle of outsidence - it has to come off the buffer at the same angle as it went on.

(C) You have to make the ball come off the buffer at a right-angle - you have to point the gun so that you get a right angle.

(D) When it misses by four inches, you have to hit the buffer four inches back - and the same for other inches.

Table 36

Results. Item No. 28 C3P Test. N.93.

A	17	A and D	6
B	28	A and B	1
C	16	A and C	10
D	10	B and C	2
N.R.	1	B and D	1
		C and D	1

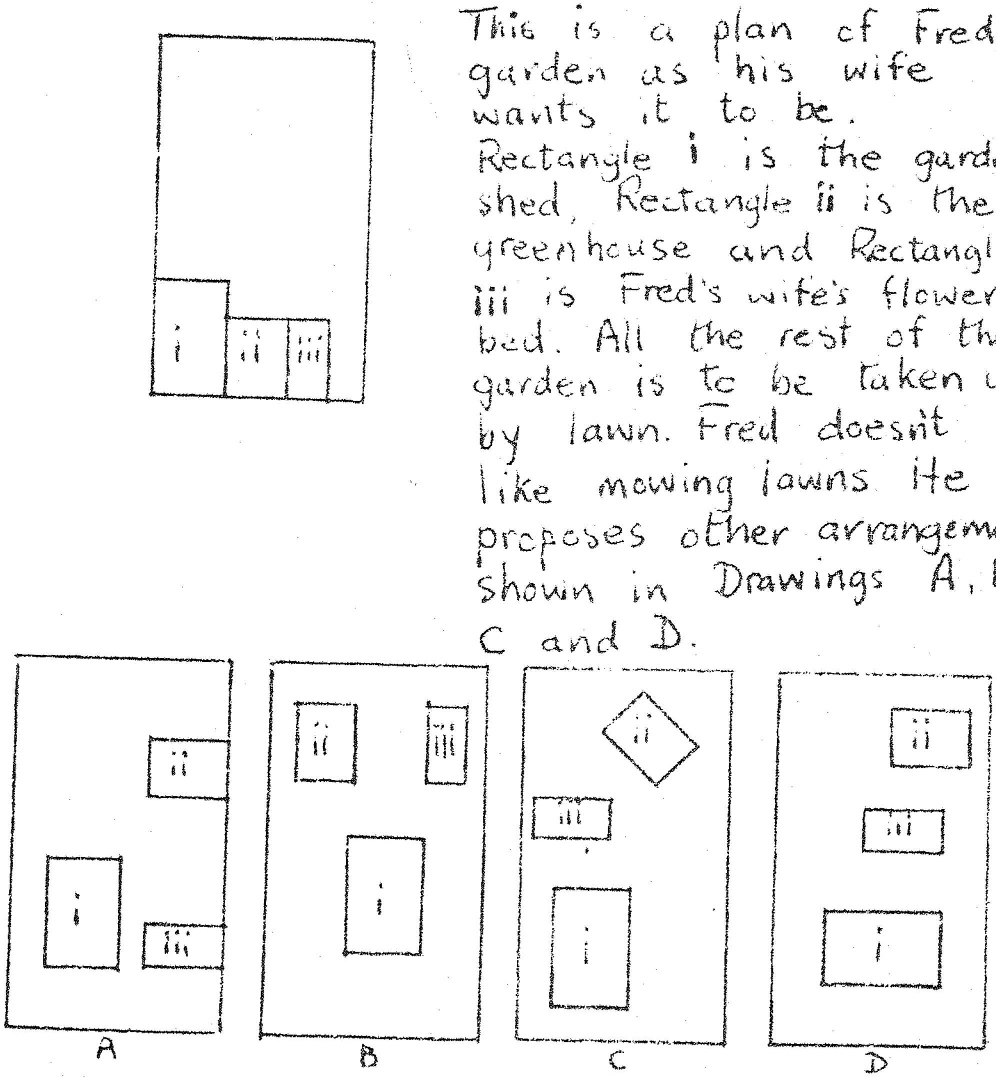
Statements A and C closely resemble those made by some students who believed that a right-angle was involved somewhere in the principle.

Statement D implies an unawareness of the importance of taking angles into account.

64 students (68.8%) accepted A, C or D as statements which "show understanding of the problem".

Item No. 8.

Fig. 10. E.P. Item No. 8.



This is a plan of Fred's garden as his wife wants it to be. Rectangle i is the garden shed, Rectangle ii is the greenhouse and Rectangle iii is Fred's wife's flower bed. All the rest of the garden is to be taken up by lawn. Fred doesn't like mowing lawns. He proposes other arrangements shown in Drawings A, B, C and D.

Which, if any, of these arrangements would give him less grass to cut? Put a cross in the appropriate box/boxes in the answer column.

The question could be taken to mean "Which arrangement involves less work?" and, for people familiar with grasscutting, attention focussed on the total length of edge to trim in each case. The answer must still be "None of them".

In 1974, 6 students (5.2%) for some reason did not come to this conclusion.

Table 37. E.P. Item No. 8.

Results. 1974. N.115.

A	1	B,C and D	1
B	1	A, B, C and D	1
C	1	N.R.	1
D	-		
None	109		

In 1976, 3 students (3.5%) did not choose "None of them".

Table 38. E.P. Item No. 8. Results 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	-	1
B	1	-
C	1	1
D	-	-
None	84	83
B, C & D	-	1
N.R.	-	-

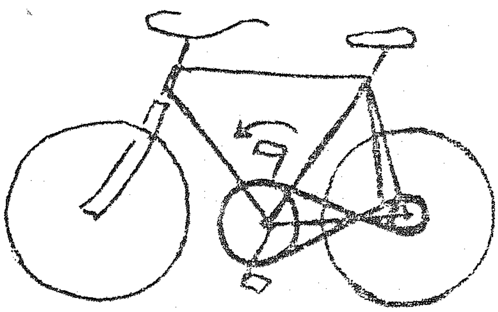
Only one comment emerged from the discussion groups:

(Group 1) I immediately thought of the psychology we did - what was it - conservation of space or something, where the children knew all the funny answers .... it's sort of the same.

The cows-in-fields problem was evidently close enough to be recognised. It is just conceivable that a few students lapsed momentarily into non-conservation of area under the special conditions of testing.

Item No. 9.

Fig. 11. E.P. Item No. 9.



This drawing shows a bicycle which has a belt instead of a chain. The belt is twisted into a figure-of-eight. If you pushed the pedal in the direction shown by the arrow, which way would the bicycle go?

Choose one of the following and put a cross in the box.

A. Forward
B Backward
C. Not enough information given.
D. it depends on the amount of pressure

Apart from the students described in this report, a number of people have examined the items both before testing when the test was being prepared, and afterwards, until quite recently. These people have included scientists of various kinds, technicians and mechanical engineers. With one exception Item 9 seems to have been interpreted as something like the following: "This is a specialised bicycle having instead of the normal gear-wheel, chain and free-wheel, a large pulley-wheel, a belt and a small pulley-wheel fixed rigidly (that is, not on a ratchet) to the rear road-wheel. The question is about what happens when a rider mounts the cycle and pushes the pedal".

In short, people knowledgable in mechanical matters have made the assumptions that I wanted to be made when producing the item. The typical answer to the question was "It's B, obviously." Apart from the exception mentioned above, no-one has suggested that A, C, or D could be entertained as reasonable choices.

But a difficulty arises if the testee does not assume that the rear pulley is a 'fixed' wheel. In everyday life 'fixed' rear cogs are rare; bicycles usually have 'free-wheels' (ratchet-wheels) which allow 'free-wheeling'. If the bicycle in Item 9 had a free-wheel pulley attached to the rear road wheel, pushing the pedal as described would not move the bicycle. This occurred to me only when trying to imagine reasons for some of the students' choices of answer. The item-stem should mention a fixed-wheel pulley but does not: C could therefore be a reasonable response.

A second difficulty also arises from an omission from the item-stem. In order to produce a simple and reasonably clear drawing I did not include a rider in the illustration as the legs would have obscured the belt and pulley-wheels arrangement. Some testees may not assume that the bicycle is to be mounted before the pedal is pushed forward.

It was pointed out to me* that if an ordinary everyday bicycle is not mounted but merely supported so that it does not fall down, with a pedal placed at the bottom of its turn, and the pedal is pushed backwards, the bicycle will roll backwards.

If the bicycle in Item 9 (assuming a fixed-wheel rear pulley) were held as described above, and the pedal pushed forward the whole machine would roll forward. The item-stem should have read, "If you <u>sat on the bicycle</u> and pushed the pedal ...."

A and possibly D could therefore be reasonable responses if supported by this argument.

In 1974 51 students (44.3%) did not choose B:

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* By Mr. W.M. Brookes.

Table 39. E.P. Item No. 9.

Results. 1974. N115.

A	20
B	64
C	26
D	3
N.R.	2

In 1976 38 students (44.2%) did not choose B.

Table 40. E.P. Item No. 9.

Results. 1974 - 1976 (responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	16	21
B	48	48
C	19	13
D	2	1
N.R.	1	3

The points about the free-wheel and the mounted rider had not arisen when the group discussions took place, and no-one mentioned them during any of the sessions. While they remain possible reasons for some of the responses, the assumption throughout the discussions was that the rear pulley was 'fixed' and that the rider was mounted when pressing the pedal. This can be inferred from most of the contributions.

There were many comments expressing a general uncertainty:

(Group 3) I think what put me off, I can't ride a bicycle, I don't know anything about them.

(Group 2) I haven't even a vague idea about bicycle chains or anything like that. I just couldn't figure it out.

(Group 1) It's like that cog-wheel (No. 5), you can't really remember.

The arrow in the illustration indicating the way the pedal was to be pushed confused some:

(Group 2) (Where did it start to get difficult?)

Well, it wasn't .... I mean if you .... could just put A, saying it was going forward .... because, to me the

arrow is pointing that way, it's almost biased.
(Oh, you mean that's acting as a cue to make you say, "Yes, it's going forward?")
(Unintelligible)
(It's necessary to mention it (the direction of the push) isn't it, otherwise ....)
But surely, if it pointed backwards, you'd go backwards.
Yes, but surely, if that's going round that way .... you'd go forward .... no .... twisted .... the push comes .... That's where you've got the push, and the wheel will be going backwards.
(Unintelligible comments)
Then the pull bit would go round under ....

.... pushing at the top which will start the wheel in motion backwards, and then the pull .... underneath which continues .... in other words, it's going backwards.
Yes.
Well, I don't know. I've just looked at it again; it would break; I mean it's silly.
I thought of it going forward, but I wrote backwards; looking at it now I'd say forwards.
(What would make it go forwards, did you say?)
Because of the arrow and this little thing ....

The feeling that the belt would snap because of opposing forces came up in each group except Group 4.

(Group 2) (Did you say that the belt would snap?)
_I_ thought so. I put that ....
I don't know - that would make that one turn backwards and it couldn't turn .... so ....
(so one wheel would be going one way and the other would be going the other way, and therefore the belt would snap?)
Yes.

(Group 3) I think I decided that would be pulling against that and the belt would break. If you pushed the pedal forward

that would go back and it wouldn't work at all ....
That would go forward (gear-wheel) that would go backwards (rear road wheel) therefore it wouldn't work at all.

It would depend on the amount of pressure. The bike would stay still and the belt would eventually snap or something.

(Group 5) I think the belt would snap.

(Group 1) I tried to work it out .... if the band was going like that .... oh, I don't know what I thought now, but I remember thinking that if you turned the pedal forward which presumably you could do with that, if you forced the pedal forward then what would happen to the band? It would snap.

Two other comments expressed the idea of opposing forces:

(Group 5) I don't think the bike would move at all. Surely the wheels would go in different directions and prevent movement either way. If you pedal forwards this gives a slight forward momentum to the bike, but it wants to go backwards - you would fall off.

Several students had traced with a finger round the line representing the belt, but found that the help that this provided ceased at the point where the belt crossed or at the rear pulley:

(Group 4) (When does tracing your finger round cease to help?)
When it comes back the other way.

(Group 3) I couldn't answer it. I got half way and couldn't get back.

(Group 1) It (the arrow) makes you think that its going to go backwards.
(Why should it do that?)
What?
(Go backwards)
Because the chain is on a twist and it probably won't do what it normally does.
(But you actually traced it round with your finger, didn't you?)

Yes.

It's one of those things you just can't visualize in your mind.

(Is it the fact that you are trying to imagine movement?)

(Murmurs of assent)

Once you've worked out one stage, you've forgotten one stage.

It was the same with the cogs .... got so far round .... but then I got confused and I couldn't remember what the first one was doing, in relation to the second one, when I came to the third one.

(Which was the confusion point on this one?)

It was the twist ....

(In spite of your finger going round?)

Yes. If it had been a three-D picture I might have been able to .... but because I couldn't actually go round it properly ....

With Group 2 discussion returned to Item 9 after the other items had been dealt with,

Why does it go backwards? I've written it but I don't know why.

(I attempt to demonstrate the path of a point on the belt as it travels round the two wheels)

But then, if you're pushing that way, going like that, you're going forwards this way but your back wheel's going backwards.

(But it's only your leg that goes forward, isn't it, the machine itself wouldn't go forward.)

(Unintelligible)

This seems stupid to me, you pedal it one way and it goes the other.

A quite revealing comment was thrown into Group 1's discussion:

I thought it would be a pretty useless bike if it didn't go forward anyway.

Piaget (1930, Chap. 9.) got children to explain how a bicycle works, and from their explanations inferred "a gradual progression from irrational dynamism to .... a genuinely mechanistic view of causality". In item 9 testees are asked to imagine what would happen if part of the chain of causality took an unusual course. The discussion reported above hints at an inability to let go of the idea of what a bicycle normally does.

Post-script to Item No. 9.

The tendency, brought out in discussion, of students to cling to 'what normally happens', the subjective dwelling upon what one does rather than the objective consideration of principles, seems at first thought to be a fairly clear indication of a difference in the levels of thinking between the students and those whose response to Item 9 was "B, obviously."

However, the following argument was put to me to consider, by Mr. W.M. Brookes. When a normal bicycle is mounted and ridden, the rider first gives a 'push-off' in some way with his leg. This gives a forward motion to the machine which is reinforced and sustained by pedalling. It is not pedalling itself which produces the forward motion of the bicycle from a stationary position, but the 'push-off' followed by a combination of the addition of the weight of the rider and the action of pedalling, all timed by the rider to operate at the appropriate moment.

In the case of the bicycle in Item No. 9 this argument raises complications in addition to the ones discussed on Pages 88-89 In which direction would the initial 'push-off' be made? If backwards, presumably the motion of the machine would be reinforced by pedalling forwards. If the 'push-off' was forwards, pedalling forwards would produce an opposing backwards force the results of which would be best established by experiment.

It is possible that some students had this in mind, but the general drift of the discussions makes it more likely that, rather than any coherently worked out argument, they were convinced that the question was about a person acting upon a machine, but could not work out the implications. Whether or not these students became entangled in a mass of imagined movements as they tried to follow the action through the mechanism of the machine is of less importance for the point which emerges here than is the question. Were they not, in fact, nearer to the reality of the problem than I was in devising the item, and nearer than the scientists, engineers technicians and others who were knowledgeable about mechanical principles, who unhesitatingly said that the bicycle would move backwards?

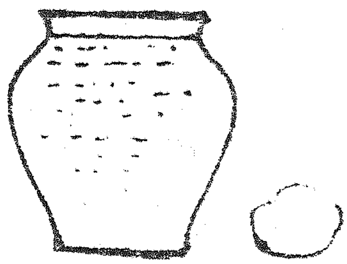
What is revealed is the readiness of those 'in the know' to idealise a situation. Leaving the rider out of consideration reduces the situation to an idealised system of pulleys abstracted and isolated from the whole, which, in reality would be dominated by the rider's complete action, and not merely by his pressing the pedal.

To argue that pressing the pedal forwards must make the machine move backwards is to use reasoning which is adequate for pulleys but not for the bicycle. A rider riding the bicycle is the context which includes the mechanism of pulleys. In 'centering' (to use Piaget's term) on the pulleys the larger context is ignored. 'Centering' is one of the characteristics of the earlier Piagetian stages.

Abstracting from human action and the isolation of idealised situations are discussed in Chapter 7.

Item No. 10.

Fig. 12. E.P. Item No. 10.



Fred's wife put a ball of plasticine in a flower vase to hold a pin-holder for flower arrangement. She found that the water over-flowed. Fred said, "Why don't you squash the plasticine flat, then the water level won't rise as much?"

Was Fred's idea useful? Which of the following do you think is correct? Put a cross in the appropriate box.

A. It depends on how much she squashed it.

B It wouldn't make any difference

C. The water level would rise more

D. The water level would rise less.

In 1974 20 Students (17.4%) did not choose the preferred response, B.

Table 41. E.P. Item No. 10.

Results. 1974. N.115.

A	10
B	95
C	2
D	7
N.R.	1

In 1976 10 students (11.7%) did not choose B.

Table 42. E.P. Item No. 10.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions.) N.86.

	1974	1976
A	9	3
B	69	76
C	1	1
D	6	5
N.R.	1	1

Students in Discussion Group 2 dismissed Item No. 10 lightly:

(Did any of these answers seem to be completely useless?)
Yes, "It depends on how much he squashed it".
(Laughter)
(What sort of considerations did you have in mind in getting rid of the others?)
Piaget.
(General hubbub)
I just thought of the Eureka thing ....

Others were much less confident:

(Group 5) All I could think of was a story the teacher told at school - "When a body is immersed in water the telephone bell rings".
I'm not sure whether the surface area would make a difference.

The suspicion that the surface area of the plasticine would be important came up in Group 1's discussion, along with the suggestion that the preferred response, B, should be the first option to be eliminated as unlikely to be correct, and that the plasticine might soak up water and thereby affect the water level:

(You all know what a pinholder for flower arrangement is?)
Yes.
Depends on the size of the plasticine. Is that what it's supposed to be, in relative size to the jar?
(Well, it's the change in shape that's in question really. It says (item stem read out)).

I didn't think about that.

I thought, again in physics, the man displacing the water ....

(Comments on the term "mass")

(So you would be able to get rid of one of these?)

B

C and D.

Yes, but that was the point of the question, D, would it make any difference .... because I was thinking it was B or D ....

But surely if you put anything in the water it would rise ....

I took it to mean that it had risen before .... if you squash it, it would rise less than if you put it in as a ball.

But they're still the same .... oh, I dunno.

.... the plasticine hasn't got any smaller, it's still got the same amount, mass or whatever it is .... just because it's been squashed ....

You see, I immediately thought it would be B, then I thought perhaps it wasn't.

.... it's the surface area ....

The only way to find out is to do it to prove it .... we've all got different ideas so the only way you can prove like that is to try it .... it's difficult to see it in your mind .... I sat there and sat there and sat there .... but then I thought that the water would have gone into the plasticine .... like paper .... what's the word, it ....

(Absorbs?)

Yes .... the only way you could really do it is to try it. Some people can do it in their minds but I can't, I have to do it. I haven't got that sort of mind ....

Item No. 24 in the Psychology Test dealt with similar content.

Some children are shown two glasses of water and two balls of plasticine. The children agree that there are equal amounts of water in the glasses and that the balls are made of equal amounts of plasticine. One of the balls is placed in a glass of water and the effect on the water level is noted. The other ball is flattened into a disc. The children are asked, "If I put this flat plasticine in the other glass, will the water still rise by the same amount?" Which answer/answers shows/show understanding of the problem?

(A) It won't go up as much because the ball has been spread out sideways.

(B) It will go up as much because the disc might stand on its edge, leaning against the side of the glass.

(c) It won't go up as much because the disc is lighter than the ball.

(D) It will go up as much because the disc used to be a ball.

Table 43.

Results. Item No. 24 C3P Test. N.93.

A	1	D	83
B	1	B & D	6
C	2	N.R.	-

Statements A and B suggest that the shape of the plasticine will affect the water level.

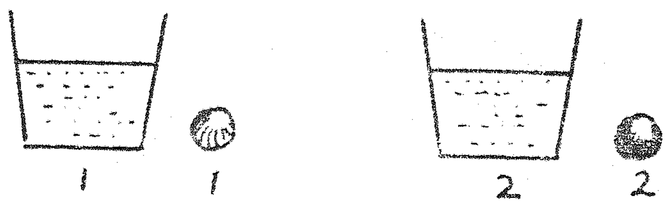
Statement C suggests that the shape of the plasticine affects its weight, and the weight affects the water level.

10 students (10.8%) accepted A, B, or C as statements which displayed "an understanding of the Problem".

There are possible difficulties. A testee could imagine the plasticine disc standing on end with part of it exposed above the water level. It may be that some merely looked at the part of the option which indicated "will/won't go up as much" without considering the reasons.

Item No. 11.

Fig. 13 E.P. Item No. 11.



The drawing shows two beakers with water in them, and two balls. Ball No.1 is made of plasticine and Ball No.2 is made of lead. The balls are exactly the same size, but the ball of lead is much heavier than the plasticine ball. Beaker No.1 is exactly the same size as Beaker No.2. and both beakers have exactly equal amounts of water in them.

If the plasticine ball is placed in Beaker 1 and the ball of lead is placed in Beaker 2, which of the following would be correct?

A. The water level in Beaker 1 would be higher than the water level in Beaker 2.
B. The water level in Beaker 2 would be higher than the water level in Beaker 1.
C. The water level in both beakers would be lower by the same amount.
D. The water level in both beakers would be higher by the same amount.

In 1974 30 students (26.1%) did not choose the preferred response, D.

Table 44. E.P. Item No. 11.

Results. 1974. N115.

A	1
B	28
C	-
D	85
N.R.	1

In 1976 17 students (19.8%) did not choose D.

Table 45. E.P. Item No. 11.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
A	1	2
B	21	13
C	-	-
D	64	69
N.R.	-	2

Again students in Group 2 were confident in discussing this item (Appendix XIII).

Others grappled with half remembered notions from school work:

(Group 1) This one, I immediately thought, "Ah he's trying the cup of lead is equal weight to the cup of sugar type ... Again I tried to remember the theory about mass displacing the water, and then I couldn't decide whether the mass was the weight or the size or what ... was the mass the weight or was it the size of the ball?

(You remembered the formula, the words, but one of the words, mass, you were having trouble with it?)

Yes.

If it had been "Which ball would sink to the bottom quickest?" that would have been the weight, therefore it couldn't be anything to do with the weight, and it would be something to do with the size ......

(Which of these, then, could you get rid of pretty easily?)

A.

C.

So it must be D.

You've still got B left.

No, it's not likely to be B.

(Group 5) These words, mass, weight, are confusing weight was used when I was at school, not mass.

The more you think, the more possibilities there are.

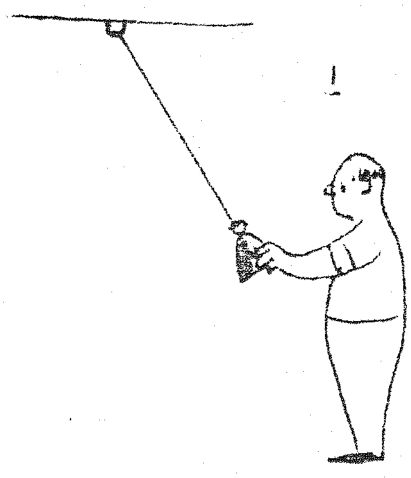
I have doubts about my answer now.

Item No. 11 was presented in a 'straightfaced' manner, with conditions stated quite formally. This gives it something of the character of a legal document. Statements from one part of the text must be kept in mind while dealing with other statements in other parts of the text. There is a need to check on what bits of statements mean as the whole statement is taken in. The resultant cognitive strain which arose for some students was summed up by a student in Group 5:

You get bored reading this one half way through.

Item No. 12.

Fig. 14. E.P. Item No. 12.



Drawing 1 shows Fred about to swing a pendulum made from a piece of string and a weight.

Fred wants to make the pendulum swing faster which of the following would affect the rate of swing (number of swings per minute) of the pendulum, making it faster?

A. Replacing the weight by a heavier one.

B. Replacing the weight by a lighter one

C. Giving the pendulum a harder push.

D Giving the pendulum a gentler push

E Shortening the string.

F. Lengthening the string.

G None of them.

Put as many crosses as you think are needed in the boxes in the answer column.

The well known 'Piagetian pendulum experiment' (Inhelder and Piaget, 1958, p.67) is described by the authors as follows:

> We have just seen how the subject goes about separating out factors in order to determine their respective effects in a multi-factor experimental setup. The present chapter takes up the reactions of the child and adolescent in an analogous situation, with the difference that only one of the possible factors actually plays a causal role; since the others have no effect they must be excluded after they have been isolated. Such is the case for the pendulum. The variables which, on seeing the apparatus, one might think to be relevant are; the length of the string, the weight of the object fastened to the string, the height of the dropping point (= amplitude of the oscillation), and the force of the push given by the subject. Since only the first of these factors is actually relevant, the problem is to isolate it from the other three and to exclude them. Only in this way can the subject explain and vary the frequency of oscillations and solve the problem.

Devising a multiple-choice item for the purposes of the Everyday Phenomena Test raised difficulties which Inhelder and Piaget were able to ignore in their 'clinical' work.

As a physical scientist pointed out, options A, B, C and D are not as implausible as might be assumed at first thought:

> A and B: Is the replacement-weight heavier because it is <u>larger</u>, or because it is <u>denser</u>? If larger, it probably makes the pendulum effectively "longer" (how is the length measured?); if denser, the pendulum would swing faster because of the slowing effects of the bouyancy of the air on the pendulum and of the inertia of the air entrained by the pendulum. But the air-effects are small ....
> C and D: .... would take a little time to work out what happens if the approximation in the theory is inadequate because the amplitude of swing is increased by a harder push. I seem to remember that D is correct.....

These were informal comments, but illustrate that in addition to the preferred response, E, choices of A, B and D might be given some support by a knowledgeable testee.

Keeping in mind the purposes of the test, however, I took E as the acceptable response.

Table 46. E.P. Item No. 12.

Results. 1974. N.115.

E	15
Others	98
N.R.	2

Table 47. E.P. Item No. 12.

Results 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
E	12	25
Others	74	61
N.R.	-	-

In discussion there was no hint of the arguments set out above, but, as in other items, there were attempts to remember previous instruction, e.g.

(Group 1) I was thinking about the experiment we did on this.

(Group 2) I was trying to remember a theory we did in maths.

(Group 3) I remember reading problems like it in books, something to do with Piaget's stages of thinking.

(Group 4) We'd been doing something in maths. like this just the week before we did this.

Two students illustrated the difficulty of disentangling rate of swing and amplitude:

(Group 5) The obvious answer is E. But a harder push would give a faster rate of swing initially, although this would slow down, so you should keep pushing every now and then.

(Group 2) (Which (option) went first?)
Gentle push.
(Why?)
If you only push it gently it won't go fast. Then I thought it wouldn't be A because if you put a heavier weight on, it would slow down. If you think of a swing, someone light, it's easy to push and it goes further, but with a heavier person it doesn't go so far.

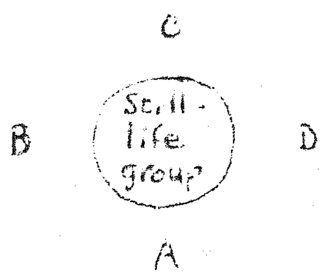
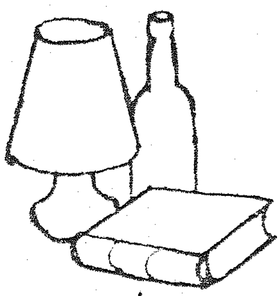


Fig. 15. E.P. Item No. 13.

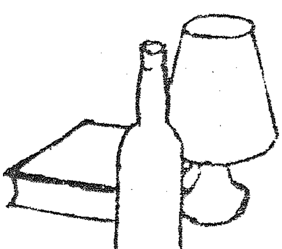
The above plan shows the positions of four art students (A, B, C and D) who are painting a 'still-life' group of objects placed on a table in the centre.



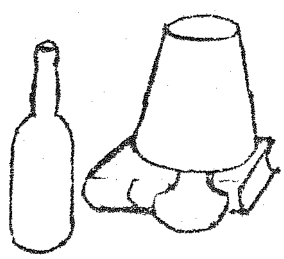
1

Drawing 1 is the view of the still-life group painted by Painter A.

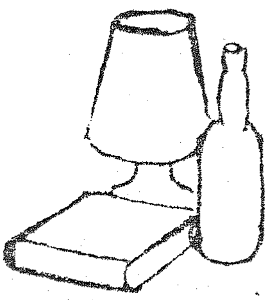
From the views shown below, choose the views that each of the other three painters would have, then put the numbers of the drawings in the appropriate spaces in the Answer Column.



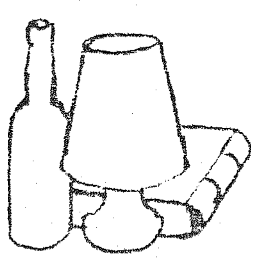
2



3



4



5

Item No. 13.

Table 48. E.P. Item No. 13.

Results. 1974. N.115.

B5, C2, D4.	66
Others	46
N.R.	3

Table 49. E.P. Item No. 13,

Results. 1974 - 1976. (Responses of those students who completed the test on both occasions) N.86.

	1974	1976
B5, C2, D4.	46	55
Others	38	29
N.R.	2	2

This item was intended to relate to the 'three mountains problem' by means of which Piaget and Inhelder (1956) investigated the development of children's ability to imagine objects from another person's perspective.

Comments on the item in discussion groups were limited.

One student said that she imagined a plan-view of the group of objects and derived her answer from that image (Group 4).

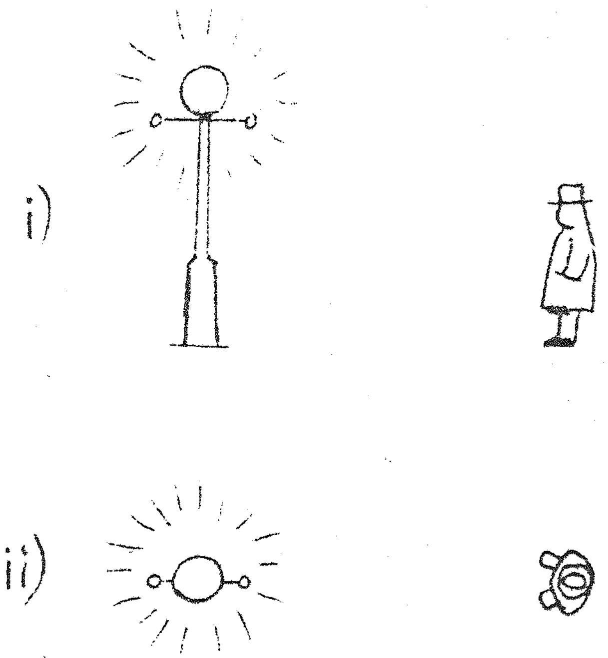
Most commented on the difficulty of the exercise without specifying the nature of the difficulty.

People other than the students described in this study, who found Item 13 relatively easy, appeared to adopt a systematic analysis. A mechanical engineer commented:

> I go for the one opposite to A first, and that must be the one with the positions of the lamp and the bottle reversed, so it's 5. The chap on the left (B) will have the bottle to the left of the lamp and the book to the rear, so that's 2. 3 is rubbish, so D must be 4.

Item No. 14.

Fig. 16. E.P. Item No. 14.



Drawing (i) above shows a side-view of Fred waiting for his wife by a lighted street-lamp.
Drawing (ii) is a plan-view of the scene.
Indicate, by drawing on the two views, where Fred's shadow would be

The requirement for a response to be counted as 'correct' in this item was that a line or a mark of some kind should be made on both views, with the following conditions:

a) on Drawing (i) the line of mark should extend from near Fred's feet more or less horizontally to the right, for anything from half an inch to the edge of the page.

b) on Drawing (ii) the line or mark should extend to the right from near the back of Fred's figure, more or less in line with the lamp, for about the same distance as the line in Drawing (i).

In marking the item "about the same distance" came to mean any pair of marks where one was not at least double the length of the other.

In 1974 49 students' responses (42.6%) did not meet these requirements.

Table 50. E.P. Item No. 14.

Results. 1974. N115.

Correct	66
Others	45
N.R.	4

In 1976 31 students' responses (36.1%) did not meet the requirements of the item.

Table 51. E.P. Item No. 14.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions). N.86.

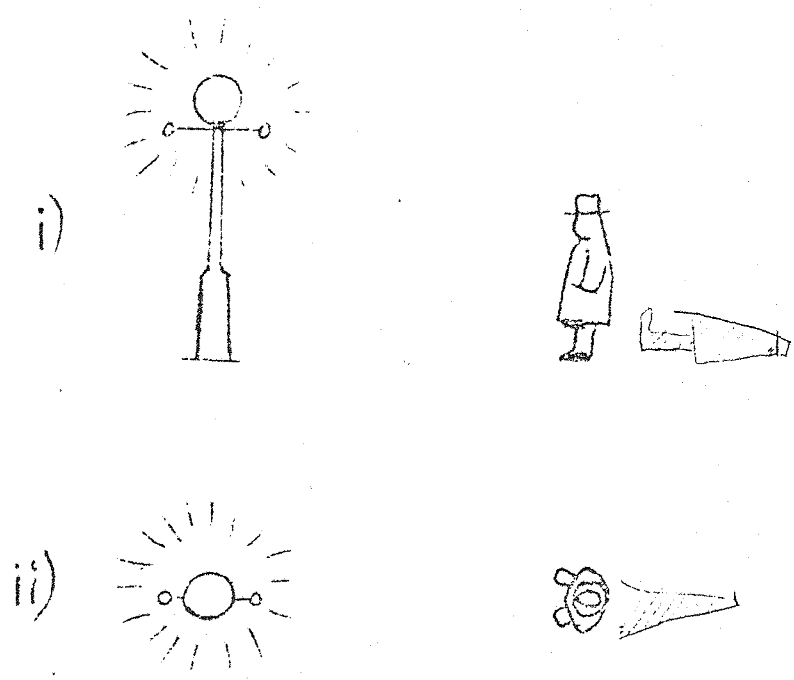
	1974	1976
Correct	49	55
Others	33	26
N.R.	4	5

In order to deal successfully with Item 14 the testee must know the simple principle that a shadow will always fall to the side of an object away from the light source. She would also need a very basic knowledge of, and skill in carrying out, Western cultural conventions to do with the graphical representation of spatial relations, including the idea that Drawing (ii) shows the same arrangement of objects as Drawing (i) but represented as from a different viewpoint.

There was considerable variety among the responses to the item.

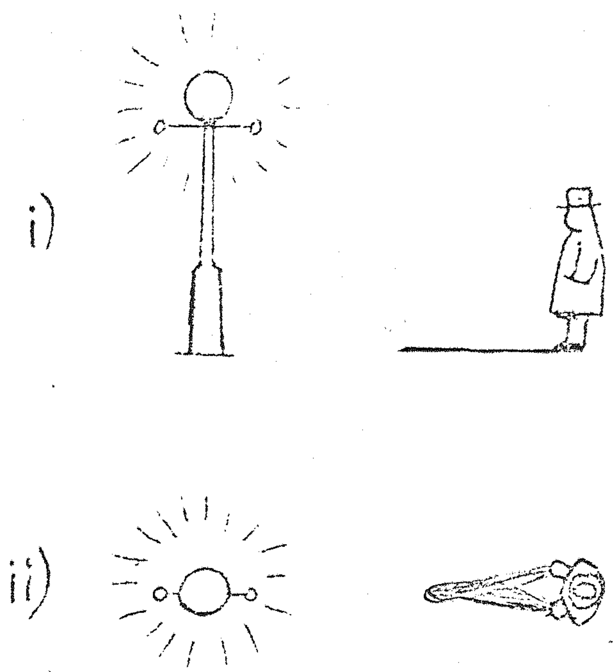
Responses judged to be correct ranged from simple lines, through drawings such as Example 1, to quite elaborate carefully drawn projections.

Fig. 17. Example 1



The following examples illustrate the kinds of response which were judged to be incorrect. The number of times the particular kind of response occurred is shown after each illustration.

Fig. 18. Example 2.



1974(N.115) / 8

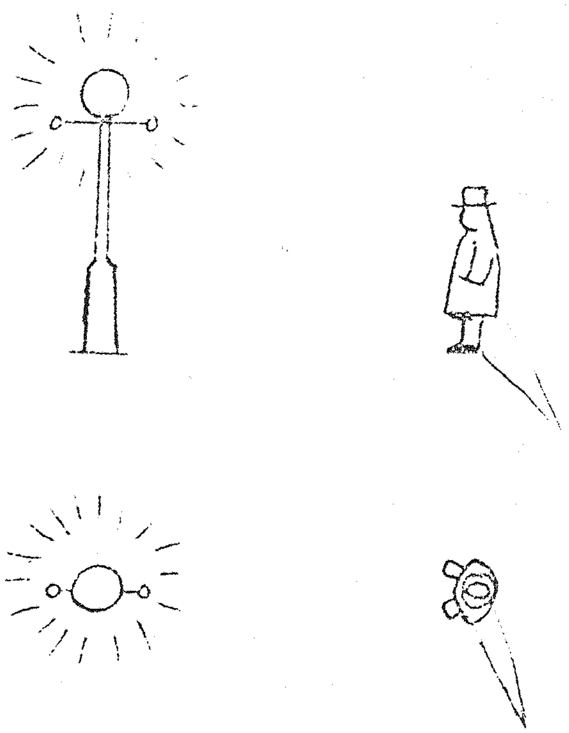
1974 (N.86) / 7

1976(N.86) / 10

Fig. 19. Example 3.

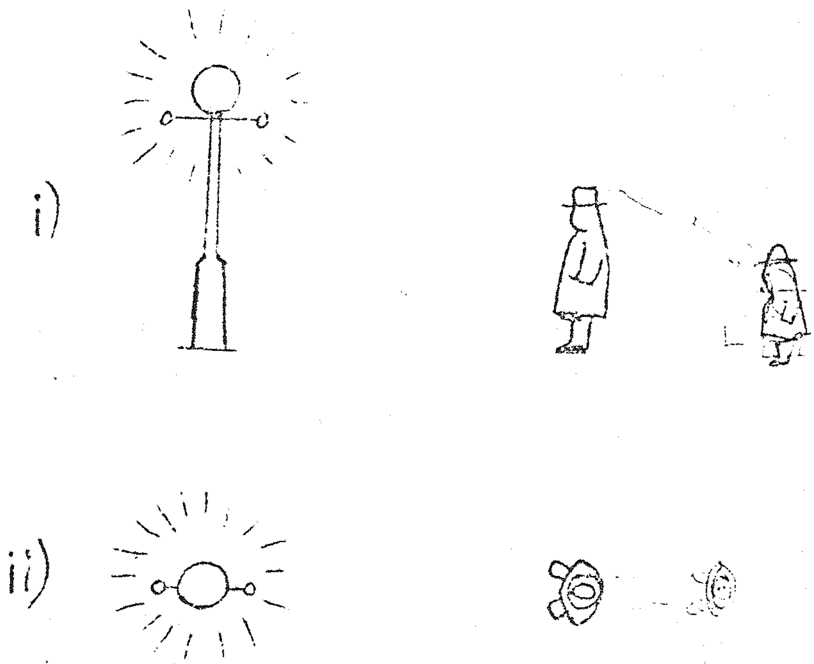
i)

ii)



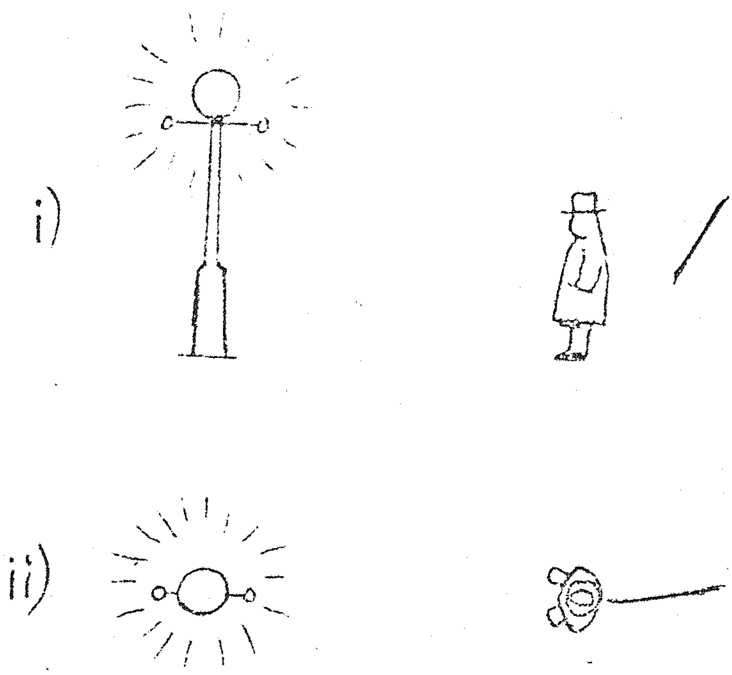
1974(N.115)	1974(N.86)	1976(N.86)
2	2	0

Fig. 20. Example 4.



1974(N.115)	1974(N.86)	1976(N.86)
1	1	0

Fig. 21. Example 5.



$\frac{\underline{1974(N.115)}}{1.}$ $\frac{\underline{1974(N.86)}}{1}$ $\frac{\underline{1976(N.86)}}{0}$

In the first four examples (Nos. 2 - 5) there is agreement between the two views (i) and (ii).

In example No. 2 the conventions of drawing are clearly well understood but, apparently, the shadow principle is not.

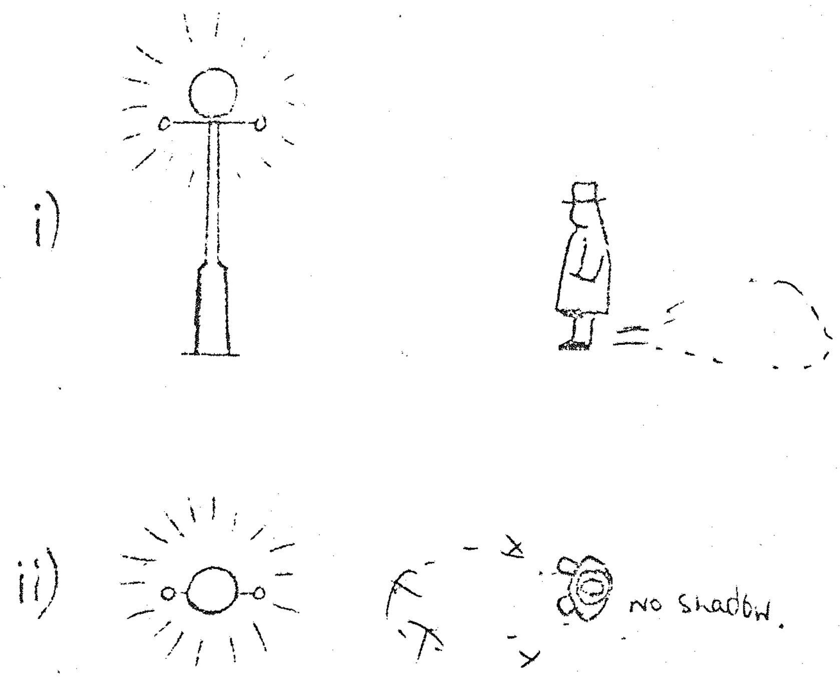
In example No. 3 the two views are seen as the same event (the shadows are about equal in length) but appear to extend to the side of the figure. In Drawing (i) this could be because a shadow has no 'thickness' and its representation on the flat plane of the paper poses problems. This is not so in (ii).

In Example No. 4 the shadow-principle is accounted for, and in a sense the two drawings are consistent, since both shadows are about the same distance from the figures, but it is difficult to imagine how the shadows may have been conceived. It almost seems as though the student was saying, "I know where the shadows should be but I can't make them lie down". They appear as three dimensional replicas of Fred set back roughly to where the shadows might reach. The same kind of representational problems arose in Examples 17, 18, and 19, but with additional complications.

Example No. 5 suggests an understanding that the two views are of the same event, but there seems to have been another difficulty of representation.

Examples Nos. 6 - 16 (below) all treat the two views, (i) and (ii) as representing different and quite separate events; in each case the shadows indicated in Drawings (i) and (ii) are inconsistent.

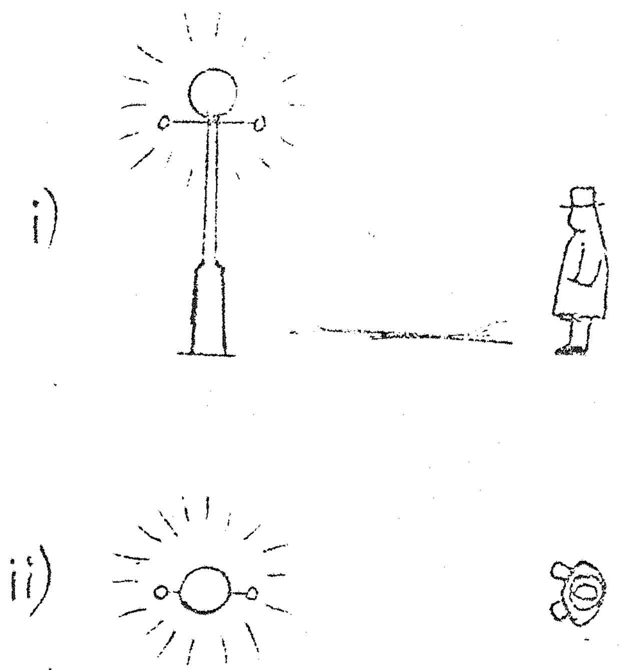
Fig. 22. Example No. 6.



In this illustrated example the shadow in (ii) was first drawn extending towards the light, then crossed out and "No shadow" written by the figure. Other responses of this kind showed the shadow in (i) correctly, but no shadow in (ii)

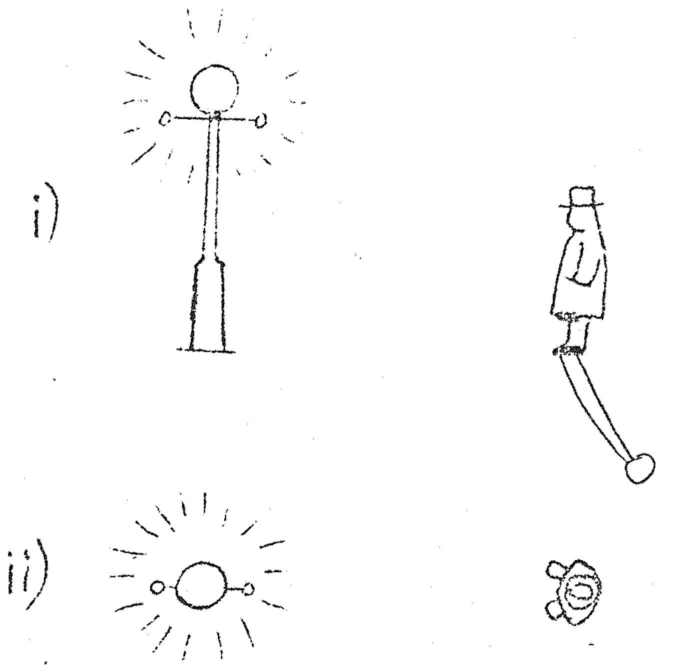
1974(N.115)	1974(N.86)	1976(N.86)
8	3	0

Fig. 23. Example 7.



1974(N.115) / 1	1974(N.86) / 1	1974(N.86) / 1

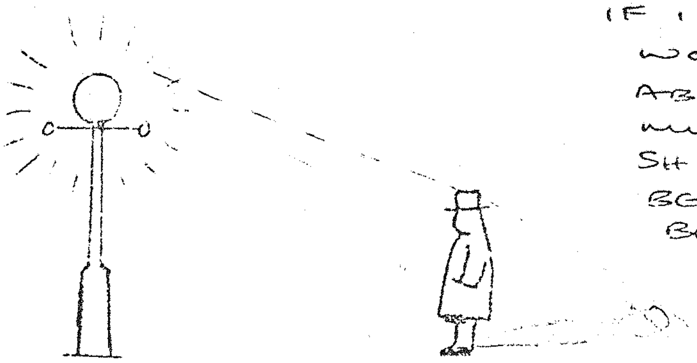
Fig. 24. Example 8.



1974(M.115)	1974(N.86)	1976(N.86)
1,	0	0

Fig. 25. Example 9.

i)

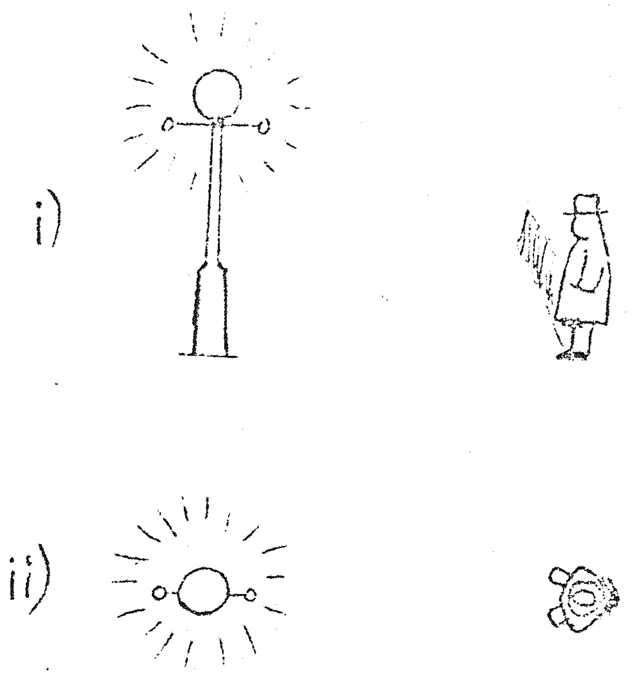


IF IT WAS DARK
WOULD NOT BE
ABLE TO SEE
MUCH OF ACTUAL
SHADOW AS IT WOULD
BE TOO DARK
BEHIND FROG

ii)

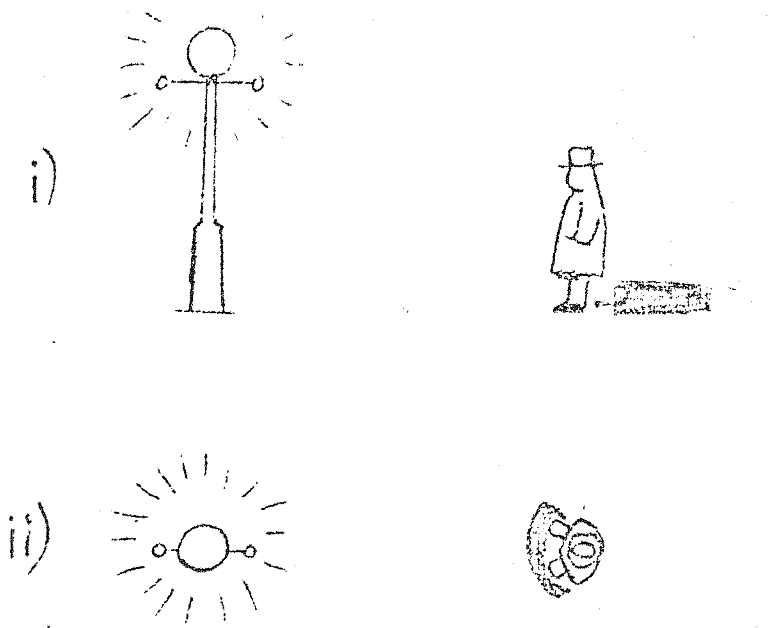
1974(N.115)	1974(N.86)	1976(N.86)
11	9	9

Fig. 26. Example 10.



$\frac{1974(\text{N.115})}{1}$ $\frac{1974(\text{N.86})}{1}$ $\frac{1976(\text{N.86})}{1}$

Fig. 27. Example 11.

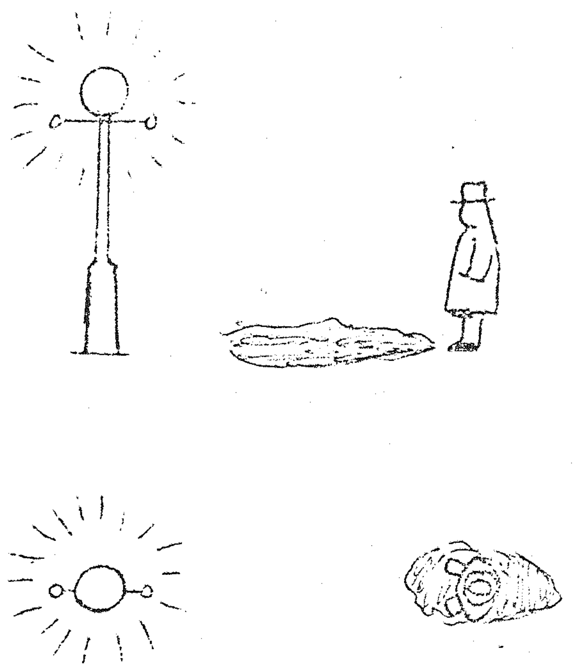


1974(N.115)	1974(N.86)	1976(N.86)
1	0	1

Fig. 28. Example 12.

i)

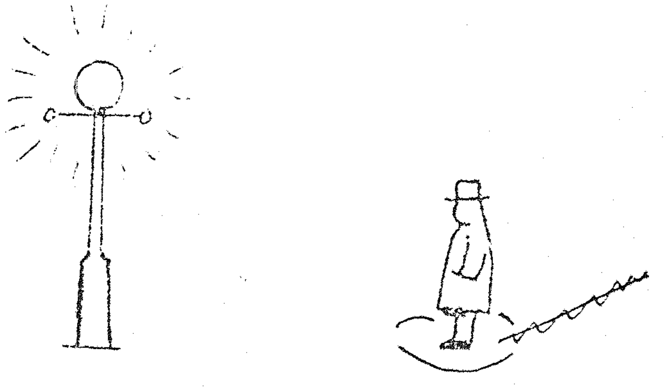
ii)



$\frac{1974(N.115)}{1}$ $\frac{1974(N.86)}{1}$ $\frac{1976(N.86)}{2}$

Fig. 29. Example 13.

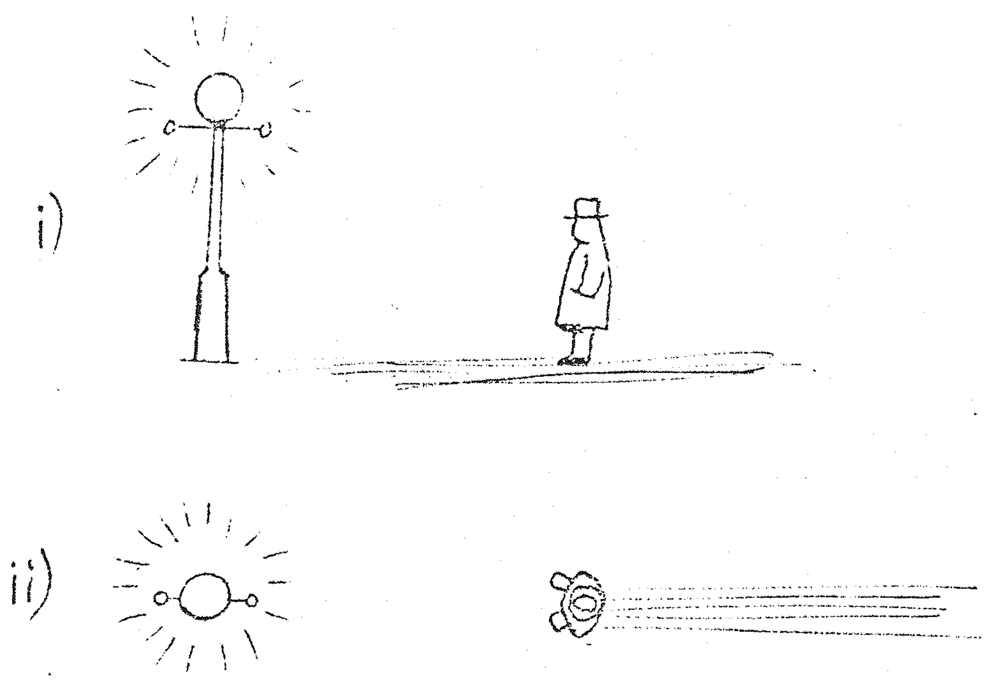
i)



ii)

$\frac{1974(N.115)}{1}$	$\frac{1974(N.86)}{1}$	$\frac{1974(N.86)}{0}$

<u>Fig. 30. Example 14.</u>

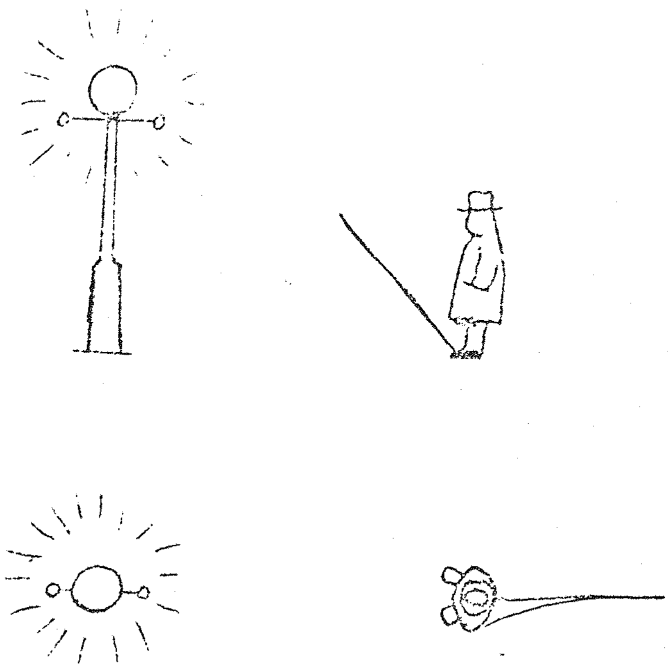


<u>1974(N.115)</u>	<u>1974(N.86)</u>	<u>1976(N.86)</u>
1	1	0

Fig. 31. Example 15.

i)

ii)



1974(N.115)	1974(N.86)	1976(N.86)
1	1	0

Fig. 32. Example 16.

i)

ii)

$\frac{1974(N.115)}{2}$ $\frac{1974(N.86)}{2}$ $\frac{1976(N.86)}{2}$

Eight of the above ten examples (Nos. 6 - 16) include a shadow cast towards the light or to the side.

In Example No. 10 it seems as though the student has said to herself, "If Fred is facing the light his shadow must be behind him", and then gone on to draw the shadow 'behind' the figure from her point of view.

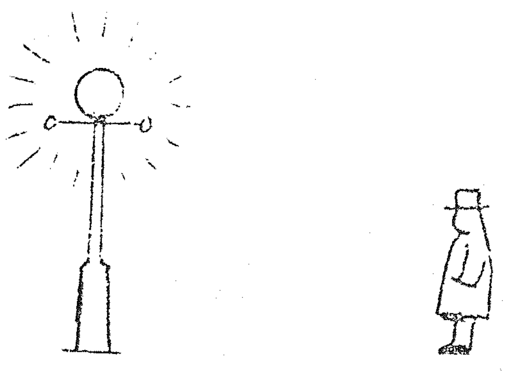
Confusion about viewpoints seems to be the probable reason for the very small shadows, or lack of shadow in Drawing (ii) in Examples Nos. 6, 7, 8, 9, 10, 11, 12 and 16. The students, as observers of the scene depicted in Drawing (ii), appear to have transferred the source of light from the lamp to their own viewpoint (it is interesting to recall the ancient Greek notion of light issuing from the eyes rather than being received by the eyes).

Example No. 13. goes a step further in complication. The position is reversed and in Drawing (i) Fred stands in a 'puddle' of shadow.

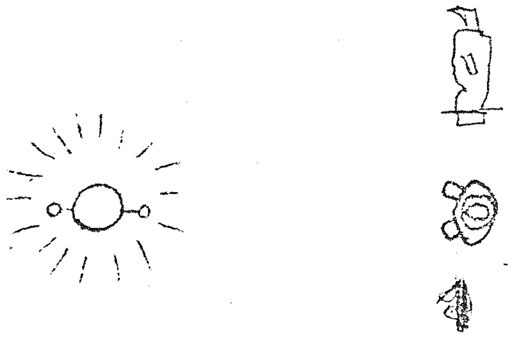
Drawing (i) in Example No. 14 has Fred's shadow extending both towards and away from the light.

Fig. 33 Example 17.

i)

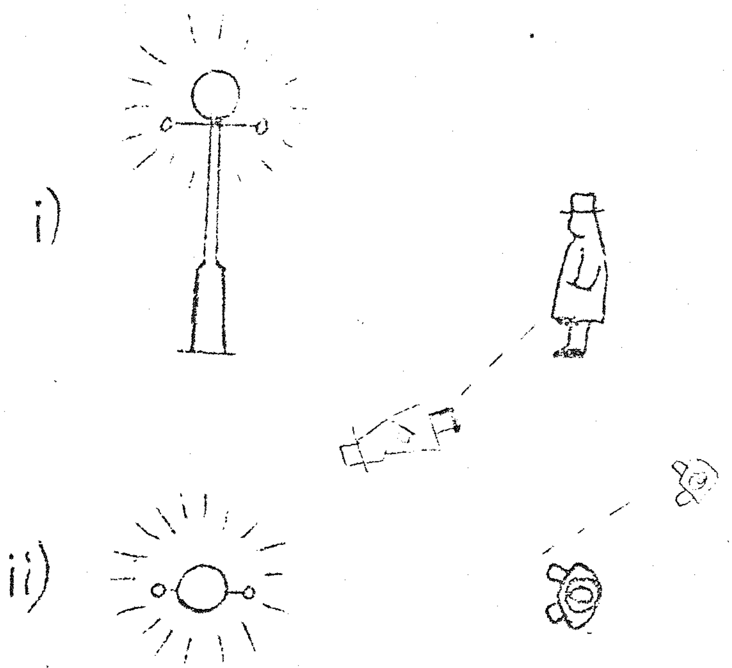


ii)



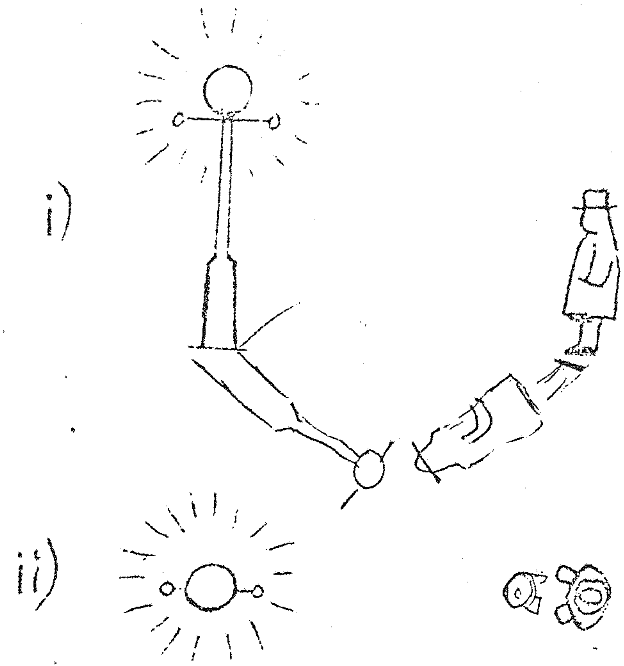
1974(N.115)	1974(N.86)	1976(N.86)
1	1	0

Fig. 34. Example 18.



1974(N.115)	1974(N.86)	1976(N.86)
1	1	0

Fig. 35. Example 19.



1974(N.115)	1974(N.86)	1976(N.86)
2	0	0

In these last three examples, Nos. 17, 18 and 19, the idea of a shadow as a replica of what can be seen of the object casting the shadow seems to have dominated the responses. The drawings suggest the same difficulty as in the previous examples of keeping in mind the idea that the top-view of Fred implies his whole body 'underneath'. The shadows are replicas of the drawing, not of the implied Fred. Also, apart from having the shadow-principle to contend with, these students seem to have found it particularly difficult to find an organising principle to help them express the spatial relations in a way that would be coherent to another person.

In the discussion groups there was much uncertainty about the principle which would enable the prediction of the orientation of shadows.

(Group 1) I went on the basis that if the light was in front of me the shadow went behind me, because you are stopping the light .... you know.

I didn't have any theory to work on.

I seem to remember doing, goodness knows what, something at school to do with light and an object ....

I felt I ought to know the answer ....

Yes, and there ought to be some sort of theory that you could put into practice and get the answer right ....

(Group 3) It was just a guess, I think.

It was very hard to visualise where the shadows would be.

(Group 2) I remember doing these things at school and being told that I was an utter idiot because I didn't know where the shadows came.

(Group 4) You don't really think about where a shadow is when you're standing under a light.

I just couldn't visualise this one at all.

I just can't remember where it should go.

One student explained shadows as follows:-

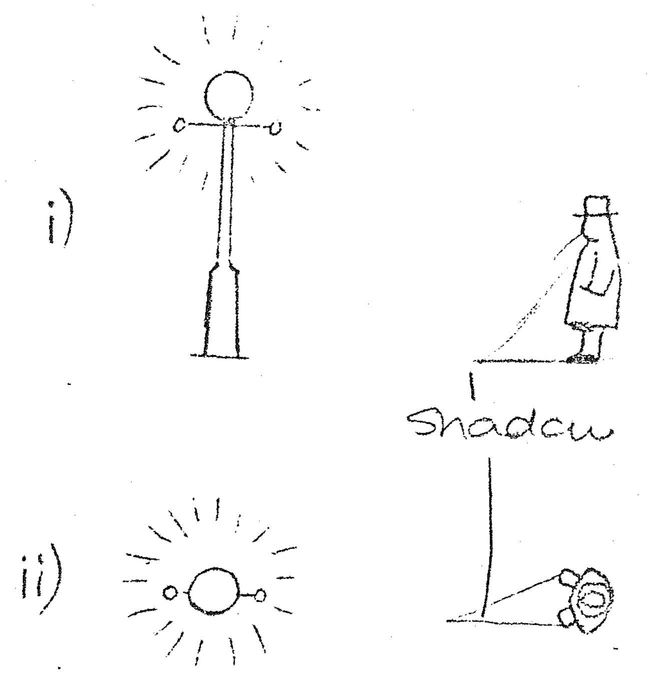
(Group 5) Fred takes up space and blocks the light rays and creates a mass of darkness in front of him.

(In front of him?)

Er .... yes.

This seems like a slip of the tongue, in spite of the request for confirmation, but responses to Item 14 such as the following (of the same type as Example 2 shown earlier) make it possible that the comment from Group 5 actually represents some students' conception of the orientation of shadows.

Fig. 36. Example 20.



I attempted to get other students to spell out the principle.

(Group 3) (When .... you were going to make a mark on the paper, can you remember why ....?)

I think you mentally take a line from the light to the man.

(That's because of something you know, isn't it?
Is it possible to put that into words?)
I think it's imagining actually.

(Group 1) (Could you put a principle into words? etc.)
(Long pause)
I just came to the conclusion that I wasn't very observant. I've never noticed which way shadows have fallen.

(Group 4) (Do you think it would be possible to put the principle into words?)
Yes I think so.
(Can you do it?)
No.

(Group 2) (Could you go in imagination to the point where you are just going to put your pencil to the paper, you know if you were doing it now, what would be going through your mind?)
I'd say that the light's there, the man's there, the shadow's going to be behind.
(So it would be a verbal formula, so to speak?)
Yes .... and I sort of drew lines from the top of the lamp-post, by the head, down to the ground, then back to where he stands, and said "That's the length of it". I'm not sure that's right but that's what I thought, anyway.

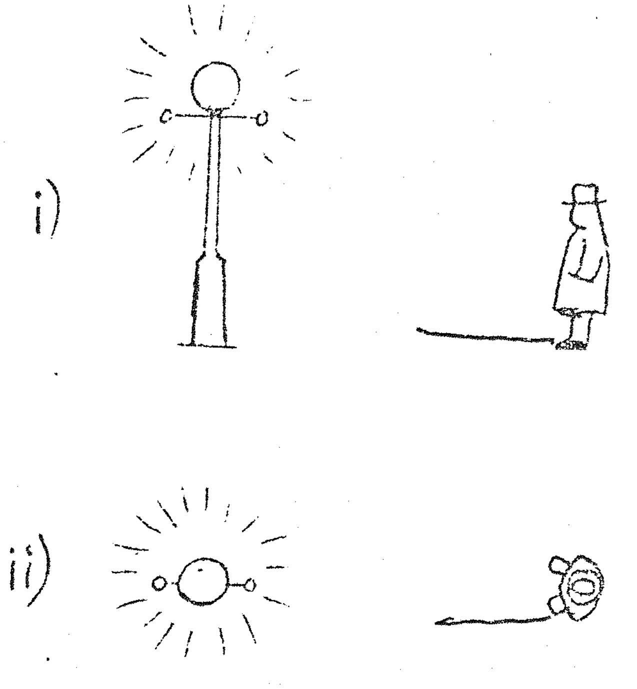
This at least implied a tacit knowledge in dealing with Drawing (i). Drawing (ii) was more difficult. The conversation continued:

(And how about the other one?)
I wasn't sure on this one whether to draw shapes ....
I wasn't sure what shape he would be.
(So on the first one you actually drew a line and that determined where the shadow would be?)
Yes.
(But on the second one it was a different thing altogether .... there was no help from drawing lines?)
Yes .... (Murmurs of agreement from other students).

There was general agreement in all groups that the two drawings, (i) and (ii), were representations of the same event as seen from two different points of view. Students could describe (i) as "looking directly from the side" and (ii) as "looking down from above".

There must have been at least one different interpretation of Drawing (ii) however. An inspection of Drawing (ii) in Example 20 above shows that, in addition to the error in the orientation of the shadow, it suggests strongly that the drawing has been interpreted in a somewhat strange way. The lamp is seen as lying on the ground. So is Fred, lying on his side facing the lamp. The shadow is a line on the ground with, as in Drawing (i), a 'projection line' leading to it from the highest point of Fred's figure. The line with "Shadow" written across it indicates that the lines, and not the triangular areas, represent the shadows in both drawings. It appears to have been a 'how-to-do-it' trick, used without discrimination on both drawings. The same interpretation of Drawing (ii) appears to be clearly indicated in Example 21 below:

Fig. 37. Example 21.



In Group 2 the discussion returned to Item 14 after the other items had been dealt with. I attempted to explain:

(.... the principle is that if you have a light source and an object near the light source, the shadow will be on the side away from the light source,; and the principle would apply wherever you were looking at it from - you know, wherever your view of the thing was, the same principle would apply. And because these (i and ii) are identical events, so to speak, you know it's still the same fellow standing there and it's still the same light shining there, and the shadow would be the same length .... it's the same shadow ....)

It would still be the same? It wouldn't come out like that?

(Other expressions of doubt from members of the group, not intelligible on tape).

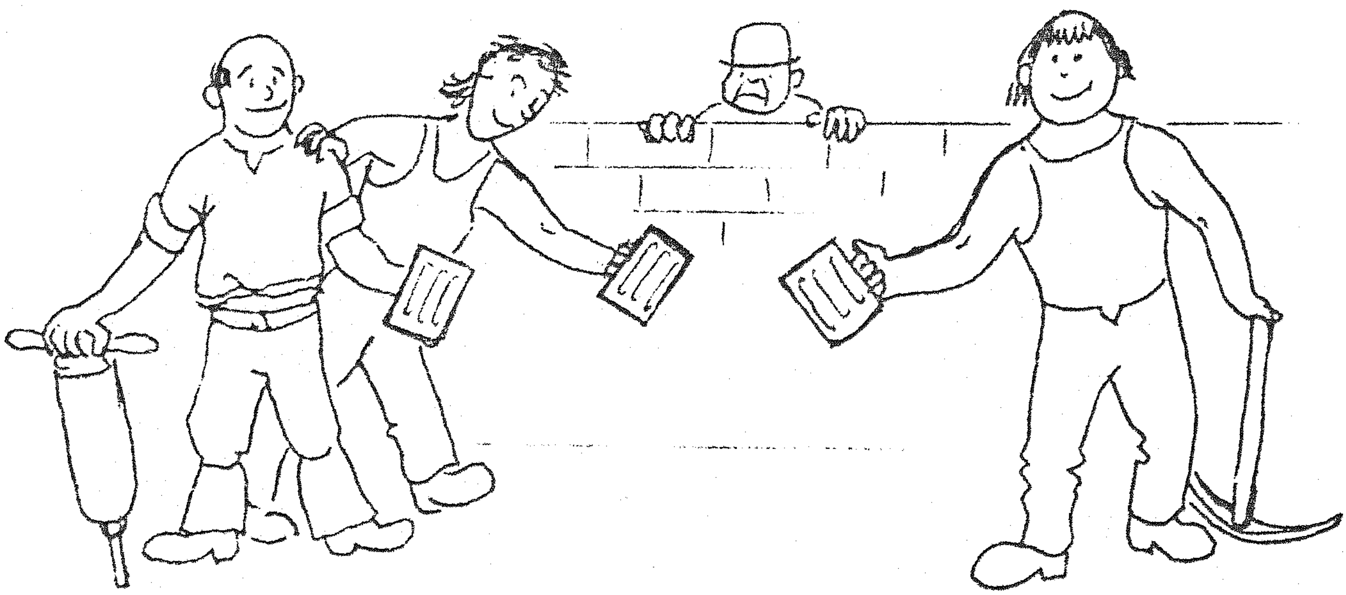
Although some students could agree that Drawings (i) and (ii) depicted the same event, from different viewpoints, they could not agree that the shadows on the two drawings must be the same length (irrespective of whether or not they were correctly oriented).

There was general agreement in the groups about falling back on recollections of standing near lights when a 'rule' could not be brought into play. No one mentioned experimenting with the light that was present in the room at the time of completing the test. It may be that some students thought that the rule might vary according to the kind of light:

(Group 1) .... But there again it could be quite a few things; the light is falling all around, it's not like a spotlight. And I've put my shadows more like a spotlight.

Item No. 16.

Fig. 38. E.P. Item No. 16.



Draw lines across each of the pint glasses to show the level of half a pint of beer.

Piaget and Inhelder (1956) investigated children's construction of Euclidean space. In one experiment the children were shown a glass bottle quarter full of coloured water, and a second similar bottle without the water (or outline drawings of these). The empty bottle was tipped off the vertical and the child asked to indicate where the water line would be if the water from the first bottle were poured into it.

The youngest children 'centred' on the configuration of the bottle and drew the water line as it appeared in the vertical bottle. In mid-childhood there was a conflict between taking reference cues from the form of the bottle on one hand, and on the other hand using the more stable horizontal and vertical features of surrounding objects, so that the water line would sometimes be shown vertical. Piaget and Inhelder found that it was not until the age of nine or ten years that children showed the water line as invariably horizontal.

Lines expressing this invariance were all that was demanded in Item 16. Strong cues were provided by the top and bottom of the wall in the illustration, and by the word 'level'.

In marking the responses any three lines which were more or less horizontal were counted as correct. No account was taken of whether or not the lines indicated half a pint.

Typical examples of responses counted as incorrect are shown below.

Fig. 39. Example 1

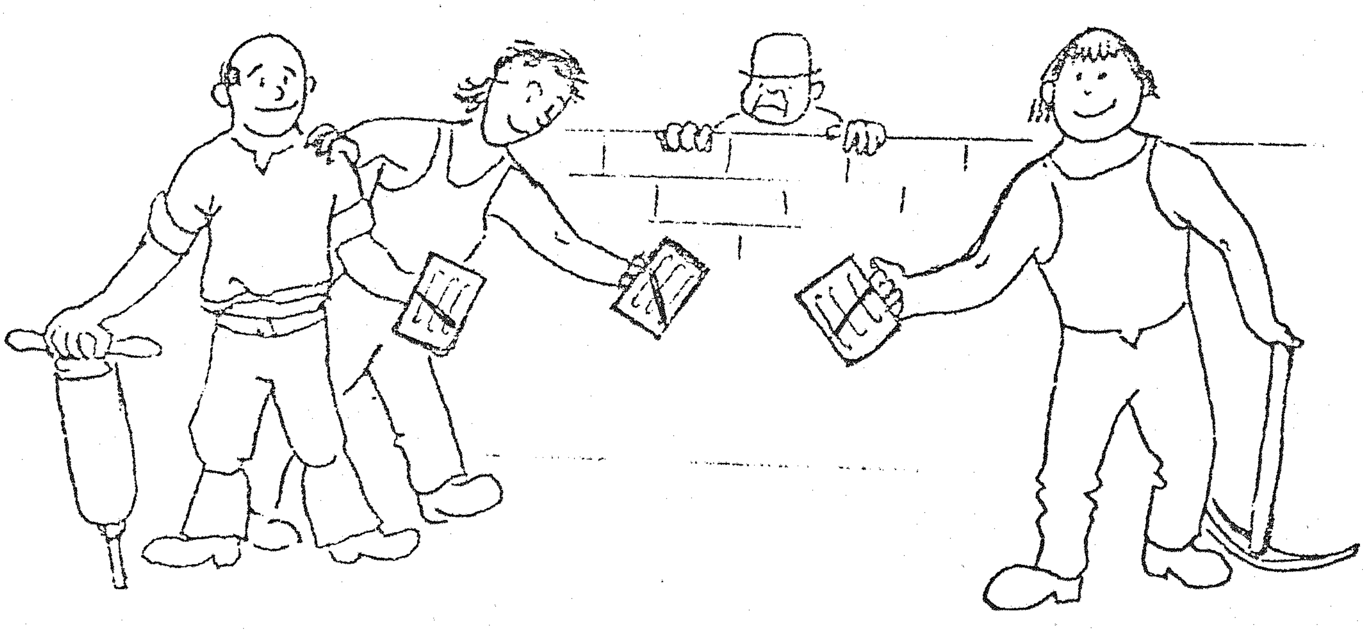
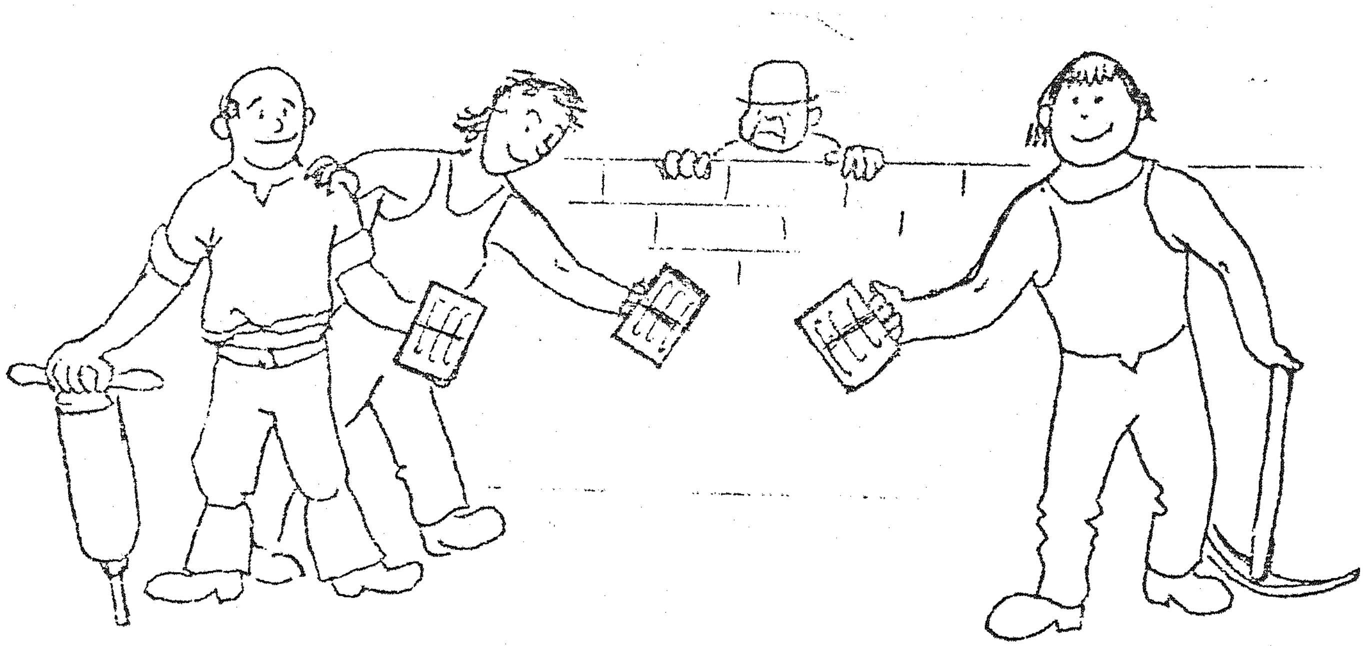


Fig. 40. Example 2.



In 1974 27 responses (23.5%) did not meet the requirements of the item.

Table 52. E.P. Item No. 16.

Results. 1974. N.115.

Correct	88
Others	22
N.R.	5

In 1976 14 responses (16.3%) were incorrect.

Table 53. E.P. Item No. 16.

Results. 1974 - 1976 (Responses of those students who completed the test on both occasions) N.86.

	1974	1976.
Correct	62	72
Others	19	14
N.R.	5	-

There were few comments in the discussiongroups on this item (see Appendix XIII).

It was interesting that students were looking at their own completed papers as the item was considered, and students whose responses were of the kind shown above saw nothing wrong with their drawings even when 'levels' were discussed.

CHAPTER FOUR

(2) Students' Reactions to the Test related to Piagetian Theory.

The foregoing examination of reactions to the test shows that students often found quite fundamental difficulties in understanding the relations in the situations described in the items. The remainder of this chapter relates these difficulties to notions of levels of thinking, particularly those described by Piaget.

In the work of Piaget and its extension by others, subjects in general have shown an understanding of the conservation of volume, the workings of a balance beam, pendulum, projectile and so on, at a fairly late stage. It may not be surprising if some adults were uncertain about explanation in these topics, although prediction of what ought to happen in the problem situations might be expected.

Students' difficulties in dealing with apparently more 'primitive' notions, such as those of shadows and simple mechanical relations, were less to be expected and the following discussion concentrates on these.

The most surprising results, to me, came from Item No. 14, the 'shadows' item.

The examples illustrating types of error on Item 14 show that six of the error types, Examples 2, 7, 11, 12, 14 and 16, include a clear and quite unambiguous indication of shadow extending towards the light. Table 54 shows the number of students making these responses in the two administrations of the test.

Table 54. Frequency of Shadow-towards-light Responses, 1974-76.

Example No.	No. of Responses in 1974.(N.115).	No. of Responses in 1974 by Students who took part in both Administrations.	No. of Responses in 1976.
2	8	7	10
7	1	1	1
11	1	0	1
12	1	1	2
14	1	1	0
16	2	2	2
	14 (12.2%)	12 (14%)	16 (18.6%)

It seems striking that this group of errors appeared more frequently in the second administration. This in spite of a considerable amount of attention being focussed on the content of the test items in the intervening period.

When the relation is examined between the responses of individual students who made these types of error in either administration of the test (Table 55), only three students 'improved', two changing from Example 2, and one changed from Example 16, to an acceptable response in 1976. At the same time four students change from a correct response in 1974 to either Example 2 or Example 16 in 1976. Four students produced Example 2 responses on both occasions and one student Example 12 responses on both occasions.

Two students produced shadow-towards-light drawings in 1976 after they had made Example 4 and Example 9 responses respectively in 1974.

Others changed from one type of shadow-towards-light response to another.

Table 55.

E.P. Item 14. Shadow-towards-light Responses. Responses of Individual Students in the Two Administrations of the Test.

1974		1976	No. of Students.
Example 2	----------------	Example 1	2
" 16	----------------	" 1	1
" 1	----------------	" 2	3
" 1	----------------	" 16	1
" 2	----------------	" 2	4
" 12	----------------	" 12	1

Table 55 (Cont'd)

1974	1976	No. of Students.
Example 4	Example 7	1
" 9	" 12	1
" 7	" 16	1
" 14	" 2	1
" 16	" 11	1
No. Res.	" 2	2
Example 2	No. Res.	1

This serves to underline the confusion expressed in the discussion groups.

Knowing that a shadow will invariably fall to the side of an object away from the light source, and being able to express this simply in words, is the requirement of an item in the Third Revision of the Stanford-Binet Intelligence Scale (Terman and Merrill, 1961). In this task (Item No. 3, Picture Absurdities II, p. 126), children are shown a drawing of a boy walking in a field with the sun prominent in the sky and the boy's shadow incorrectly oriented. The children are asked, "What's foolish about that picture?" If the response is ambiguous, the question, "Why is that foolish?" follows. Replies such as the following are acceptable:

> His shadow's shining against the sun.
>
> When the sun is there his shadow would be in front.
>
> It's the shadow - it would be away from the sun.

Replies such as the following are not acceptable:

> Because your shadow is always in back of you on a hot day.
>
> The shadow, because it's facing a different way than he is.

The item is regarded as being on the twelve-year-old level. Users of the Terman-Merrill test expect normal twelve-year-olds in a Western culture to be able to recognise in a drawing an instance of an incorrectly oriented shadow, and to be able to explain in a simple sentence the necessary relations between a light source, an object, and the shadow cast by the object.

This, in essence, was what was asked of students in the discussion groups. There is a gap between what one would expect in view of the

Terman-Merrill norms, and what emerged from the test papers and discussion groups.

In an early work, Piaget (1930) described the growth of understanding of shadows in children. According to Piaget this understanding goes through three stages before "Finally, during fourth stage (of which the average age is nine years) the correct explanation is found".

During the first two stages 'substantialist' explanations are given (in which shadows are regarded as substances which emanate from objects) and the children are unable to predict the orientation of shadows correctly. In the third stage, at about eight years, correct predictions are made but there is still 'substantialism' in the explanations given by the children. "It is only once the necessity for a luminous source has been noticed that the substantialist explanation, having become useless, is replaced by the correct explanation" (in the fourth stage).

Later, Piaget elaborates on this achievement:

> .... to explain the phenomenon of shadows is, at bottom, to rely upon judgments of geometrical relations; it is to place oneself in imagination behind the object which acts as a screen and to grasp the fact that from that position the light is hidden. As soon as you have succeeded in handling these relations of perspective, you will understand why shadows vary in shape and orientation according to the position of the source of light, and in this way alone the substantialist explanation will be rendered useless. To explain a shadow is therefore to ascertain by means of the logic of spatial relations to what extent you can or cannot see the light if you walk round the object which acts as a screen. The explanation of shadows is purely geometrical.
>
> (p. 191).

Piaget argues that once the child has noticed that shadows are conditioned by daylight, he is able to predict their orientation. In discovering the law, logical processes are set in motion:

> The discovery of the law is marked by the fact that the child can say; the shadow hides the daylight. After that, it will be sufficient for the child to continue reasoning by means of geometrical relations

> for him to say: the shadow hides the table, not only from us, but above all, from the light itself; and at last, reciprocally: the object hides the daylight. Once these consequences of the primitive relation have been liberated, the correct explanation is found.
> This explanation results from a deduction starting with law and operating without the introduction of any new elements. What is new is the possibility of deduction, the possibility, that is to say, of changes of point of view which will condition the establishment of new relations.
>
> (p.193).

Piaget appears to say that once a child has noticed a connection between the light and the shadow, deduction through a series of propositions about spatial relations will be set in motion: "it will be sufficient for the child to continue reasoning ...." This in line with the notion of equilibration as the 'mechanism' of development which he works out in later writing. Logical structures are rendered unstable by newly appreciated factors in experienced phenomena and must accommodate, giving a twist to the spiral of development. In the examples cited by Piaget manifestations of this change always appear, and within fairly well defined time limits.

In the case of the students who were the subject of the present study, this 'sparking-off' of deduction did not seem to have occurred.

Judging by their comments in discussion, students producing shadows-towards-light responses did not entertain 'substantialist' notions. One student wrote on her drawing, "If it was dark would not be able to see much of actual shadow as it would be too dark behind Fred", (Example No. 9). This reads almost as though the student thought that the shadow continues to exist, as Fred's shadow, even when 'surrounded by darkness' - as shadows did in the story of Peter Pan. There were also indications that some students thought that the rule governing the orientation of shadows might vary according to the kind of lamp or light or other conditions, but it seems clear that the students were fully aware of a causal connection between the lamp, Fred and his shadow.* They knew that the three elements were related in a systematic way, but were unable to "continue reasoning" in the way that Piaget appears to suggest would follow almost as a matter of course.

Students producing shadows-towards-light responses were apparently unable to make the imagined shifts of view-point that are necessary to predict the orientation of shadows.

Other responses counted as errors, those which show a discrepancy in the length, and in some cased the orientation of shadows in the two views(i) and (ii), reveal clearly the difficulties experienced in imagining different points of view. These errors are types illustrated by Examples 6 - 19.

Table 56 shows the number of students making these responses in the two administrations of the test.

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* Bridgman (1927) asked, "Can we separate into cause and effect two phenomena which always accompany each other?" Phenomenally at least, shadows always appear with lights and objects, except in very unusual circumstances such as the lights arranged for surgical operations.

Table 56. Frequency of Responses showing Discrepancy between Drawings (i) and (ii), 1974 - 76.

Example No.	No. of Responses in 1974 (N.115)	No. of Responses in 1974 by Students who took part in both Administrations. (N.86)	No. of Responses in 1976 (N.86)
6	8	3	0
7	1	1	1
8	1	0	0
9	11	9	9
10	1	1	1
11	1	0	1
12	1	1	2
13	1	1	0
14	1	1	0
15	1	1	0
16	2	2	2
17	1	1	0
18	1	1	0
19	2	0	0
	33 (28.7%)	22 (25.6%)	16 (18.6%)

Although it appears from this table that some errors have disappeared in 1976, an examination of the responses of individual students in both administrations of the test shows that this does not necessarily indicate an 'improvement'.

Table 57 shows that eleven students 'improved' (changed from an error in 1974 to an acceptable response in 1976), six 'regressed' and the rest changed from one error type to another, did not respond, or gave the same incorrect response on the second occasion.

Table 57.

Responses showing Discrepancy between Drawings (i) and (ii). Responses of Individual Students in the Two Administrations of the Test.

1974		1976	No. of Students.
Example 6	----------	Example 1	2
" 9	----------	" 1	6
" 13	----------	" 1	1

Table 57 (Cont'd.)

1974		1976	No. of Students.
Example 16	----------	Example 1	1
" 17	----------	" 1	1
" 1	----------	" 9	5
" 1	----------	" 16	1
" 9	----------	" 9	2
" 12	----------	" 12	1
" 6	----------	No. Res.	1
" 18	----------	No. Res.	1
" 7	----------	" 16	1
" 9	----------	" 12	1
" 10	----------	" 9	1
" 14	----------	" 2	1
" 15	----------	" 10	1
" 16	----------	" 11	1
" 4	----------	" 7	1
" 5	----------	" 9	1

Example No. 6 is useful for initial discussion as it shows a change of mind and an explicit statement in words. In Drawing (i) the placing of the shadow is correctly predicted. The student, as observer of the scene from the familiar, everyday view from the side, has no difficulty in seeing the light shining past Fred and leaving a patch of darkness on the opposite side of him. In Drawing (ii) however, she is, as it were, moved bodily in space to look down on the scene; a rotation of herself through 90 deg. In the process she has somehow forgotten that the source of light is still the lamp - that she must still keep the scene "from the point of view of the ray of light" distinct from her own point of view. As she looks down on the scene the point of view of the ray of light has become her own. At first she holds her head slightly to the right of the drawing, and 'sees' the light shining down, literally from her eyes (her point of view) past Fred and leaving a patch of darkness in front of him. Reconsidering this, she recalls that a 'plan-view' is a view from directly over an object so that she must move her head to the left. The 'law of shadows' then demands that Fred's shadow should be underneath him, out of sight from above. She therefore crosses out the shadow and writes "No shadow" instead.

Similar processes seem to be the likely reason for the responses represented by the other examples in this group.

Examples 7 and 12 combine an erratic expression of orientation in Drawing (i) with taking over the light's point of view in Drawing (ii). In Example 10, Drawing (i) there is quite sophisticated graphical expression of Fred's shadow behind him, but 'behind' from the point of view of the student as observer. In this case the everyday 'side-view' has led the student to substitute her own point of view for that of the ray of light. Words may have some role in this; for example, the student having in mind something like, "The shadow will be <u>behind</u> Fred" and then expressing this on her drawing as from her own point of view.

Being misled by apparently relevant words which might occur to students does not, however, give sufficient reason for the variety of examples of confusion of view-point. In Example 6 it is difficult to imagine a verbal mis-cue that would shift an apparently 'objective' conception in Drawing (i) to a personal, egocentric view in Drawing (ii).

In these discrepancy errors the two versions of the shadow are seen as special cases; in one the shadow extends to the right (at least in those cases where the student had grasped the 'law of shadows') because the light shines from the side; in the other there is no shadow (or very little) because the light shines from above; yet the students agree that the two views are of the same event.

This is, in Piaget's terms, "juxtaposition of special case reasonings without generalisation" - transductive reasoning - moving from particular to particular regardless of contradictions. It occurs, says Piaget (e.g. 1930, p. 294.) because of ignorance of the logic of relations, and is characteristic of pre-operational thinking.

Piaget and Inhelder (1971) investigated the role of imagery in thinking and their work is relevant to the students responses. It is necessary to attempt a brief summary of Piaget and Inhelder's argument before relating their findings to the results of the Everyday Phenomena test.

Piaget and Inhelder reject notions of the image as a prolongation of perception. It is part of accommodation:

> .... the mental image is an active and internalised imitation (and) there is a more or less close relationship between the mental image, the imitative gesture, and the graphic image.
>
> (p. 3).

This allows the authors to cope with the vexed question of how mental images are to be got at for investigation. If images are regarded as being part of the imitative processes described by Piaget in his general theory, they become accessible to an 'outside' observer through related 'external' imitations.

In the investigation, data were obtained from typical 'clinical' interviews in which children were asked to imagine displacements and transformations of shapes and objects and to convey their imaging by means of drawing, gesture, choosing from prepared drawings and, to a lesser extent, verbal description.

The conception of images as part of Piagetian imitation also leads to a classification of images which is different from those generally used by other workers in the field (at least those in the English speaking tradition), who have been, in the main, concerned with the sensory modality, 'controlability', vividness, and so on, of images. Piaget and Inhelder base their classification upon structure, which in this case seems to mean, in effect, what an image 'does'. Images may be said to reproduce something, or anticipate something; so the main division is between 'reproductive images', which evoke objects or events already known, and 'anticipatory' images, which, by figural imagination, represent events that previously have not been perceived.

The authors distinguish between two aspects of cognition, the figural and the operative. The figural aspect includes perception, various forms of imitation, and the mental image proper. The operative aspect includes sensori-motor actions (excepting imitation), internalised actions and the operations of the representational intelligence ("reversible internalised actions which organise themselves as a set of structures or as transformation systems").

The figurative aspects are concerned mostly with the 'states' of reality. The operative aspects relate particularly to transformations.

These two aspects of cognition interact in the higher flights of thinking, but the figurative is necessarily subordinate to the operative, since only the operative aspect is dynamic.

Before the development of operational thinking in an individaul, images are static and "just not equipped to represent even the simplest physical or geometrical movements or transformations". In the absence of the operations, images and the figurative treatment of states govern thought.

It is only with the development of the operations, which allow transformations to be thought about, that images can be anticipatory. Even then they are still static, in the sense that they represent beginning-states and hypothesized end-states, and not the movements or transformations themselves, although intermediate states may be be imagined.

Nevertheless, the image plays an important part in the higher reaches of cognition, particularly in 'geometric intuition':

> In the first place, the representation of a perceived or perceptible datum does not constitute a cognition, and it does not become a cognition until it is based on an operational comprehension of the transformations accounting for the datum. But, in the second place ... once the functional interaction of the figurative and operative functions is assured, the images symbolic role is by no means as negligible as the extreme reaction to classical associationism might have suggested. The image ensures finer analysis of 'states', and even aids figural anticipation of 'transformations', in spite of the irreducibly static character of such a figuration. This makes the image an indispensable auxiliary in the functioning of the very dynamism of thought - but only as long as it remains consistently subordinate to such operational dynamism, which it cannot replace, and which it can only express symbolically with degrees of distortion or fidelity varying according to circumstances.
>
> (p. 390).

Three features of this argument are of particular interest in my examination of Item 14 responses:

1) Reversible, dynamic thinking can only occur when figurative representations are subordinate to the operational structures.

2) Where operational structures are undeveloped, images dominate thinking.

3) Images are necessarily static (they can only represent states).

I can now return to the possible role of images in Item 14 responses, Examples 6 - 19.

In discussion, students had no difficulty in conceiving of the two drawings (i) and (ii) as being representations of the same event, "looking directly from the side" and "looking down from above" respectively. They understood, in other words, the graphic images of the two end-states of a transformation. In drawing the shadows, however, they were required to co-ordinate the two; to imagine how one configuration related to the other. There are some clues as to why they found this difficult.

Throughout the discussions students reported their difficulties with the items in phrases such as:

"It was very hard to visualise ...."

"I just couldn't visualise ...."

".... trying to picture in my mind ...."

"It's difficult to see it in your mind ...."

These comments, and others suggesting kinaesthetic or other imagery. constantly recurred in discussion of practically all the items. The role of visual imagery was emphasized in Item 14, as indeed may be expected.

Now, if Piaget is correct, images are essentially static, and only aid an understanding of movement and transformation when they become anticipatory, that is, when they are co-ordinated by operational structures.

The operations are the sole means of apprehending transformations. Images by themselves are inadequate. If, as the evidence seems to indicate, students who made the type of errors under discussion relied almost entirely upon imagery, it would follow that they could produce logically inconsistent drawings in (i) and (ii), two separate 'states', since operational thinking, in addition to imagery and dominating it, is required to 'map' the elements of one configuration on to the other.

In Example 6 particularly it is evident that somewhere in the transformation process the source of light has been transferred from the lamp to the eyes of the student, contrary to all logical considerations. This, by definition, amounts to 'egocentrism', another aspect of Piagetian pre-operational thinking, as opposed to the 'decentred' thinking made possible by the development of operational structures, in which a person's body and actions assume objective relationships with other objects and events.

The role of images in an egocentric, pre-operational view of objects and events is central:

> As the subject has as yet no operational functions at his disposal, he thinks in terms either of configurations, or states, as opposed to transformations, or in terms of assimilations to his own actions. In both cases the part played by imaginal representation is considerable, and, so to speak, out of place, in the sense that it is not yet subordinate to the operational functions (hence non-conservations, etc.)
>
> (p.9).

Accepting Piaget and Inhelder's view, then, it may be said of Example 6 that:

a) Imagery has dominated thinking because, at least in this context, operational structures were not available. If they had been they would have been brought into play (since in operational thought, the image is subordinate to the operations).

b) Imagery, because of its static character, was inadequate for the task.

c) Because the means of co-ordinating the relations in the two configurations were inaccessible, the student thought "in terms of assimilations to her own actions", incorporating the 'point of view of the light' in her own rotation of point of view through 90 deg., this action being necessary to 'look down on' the scene.

Examples 4, 9, 17, 18 and 19 are, at first sight, puzzling to say the least. The 'shadows' in these drawings are merely reproductions of the drawings of the objects, distributed around the reference points in various ways. The placing of the replicas is evidently the result of some deliberation, Examples 4 and 18 showing 'projection' lines.

It might be said that these students merely found it difficult to draw what they had in mind; the problem being one of drawing ability rather than understanding. This, however, does not take the argument very far. Questions remain about the possible reasons why these students found graphic representation so peculiarly difficult.

In Example 4, Drawing (i), the projection lines indicate that the student has applied the 'law of shadows' to place Fred's shadow on the side opposite to the light, but they also show that she has carefully calculated his height, as though the shadow would appear rather like a holograph. Drawing (ii) confirms this.

In Example 18 orientation is incorrect but the shadow in (i) is made to 'lie down'. The lines in this case appear to be not so much 'projection lines' as symbolic representations of movement.

It seems clear that what has already been said about points of view, the role of imagery and the need for operational structures applies to these cases, but Piaget and Inhelder's description of what they term 'pseudo-conservation' adds more interest.

> Pseudo-conservation arises .... when a subject retains certain characteristics of an object which he considers typical or exemplary, and which he clings to even at the expense of other apparently more important characteristics.
>
> (p.362).

Examples quoted by the authors include those in which the subjects hold an idea that there is a necessary isomorphism between the shape of a figure and the shape of its constituent parts. For young children the cutting up of a square or triangle into the smallest possible parts will produce square or triangular 'points'. Children also found difficulty in conceiving of a square as made up of triangles; the belief being that the component parts of a figure should be the same shape as the complete figure. Triangles have no apparent visual link with the complete square and the children believe that they cannot be used to reconstruct it. Deductive or operational relation processes as opposed to figural representation, must govern thinking for successful reconstruction to come about.

An exercise reported by Piaget and Inhelder is particularly interesting. After a description of children's drawings which displayed "jumbles of view points" the question was posed:

> Can subjects capable of dissociating viewpoints in this fashion also anticipate by means of an image the result of unfolding cardboard tubes, cylinders and cones, so that all the elements are rotated into the horizontal plane?
>
> (p.349).

Following up this question the authors observed three stages of development:

> During the first (stage) the child is not yet able to imagine a genuine rotation; he simply draws the object as it is without transformation.
> During the second stage the child makes unsuccessful attempts to imagine the rotation and the drawings translate these attempts into symbolic form. For instance, the sideof a cube to be rotated is shown along with a stroke indicating the direction of the rotation ....

At the third stage (from 7 to 8 years on) the child can imagine and draw the rotation, but in stages according to the difficulty of the objects in question. The authors argue that although spatial transformations have a figurative aspect that can be evoked by the image, where static images are dominant (as in Stages 1 and 2 above) "they give rise to systematic errors deriving from the 'pseudo-conservation' characteristic of all imaginal figuration".

Returning into the shadows and Example 4, the image of Fred has been 'conserved' and merely displaced to the right in both drawings. The students appear to have believed in a "necessary isomorphism" between the shape of Fred and the shape of his shadow. There are striking similarities between this solution and those said to be typically employed in Stage 1 described above.

Stage 2 is exemplified in Example 18. The shapes are retained by 'pseudo-conservation' and unsuccessful attempts to imagine the rotations are symbolised by lines which indicate the direction of rotation.

In a similar way, 'pseudo-conservation' is evident in Examples 9 and 19.

It would appear, then that "difficulties in drawing" amount in the end to difficulties of conception.

Item No. 16 of the test also involved drawing and a brief discussion of what emerges from the results of this item can conveniently be included here.

Errors on this item were all straight lines drawn at various angles to the horizontal. There was therefore less information to be derived from the responses than in Item 14, and there were few contributions to discussion. However, errors on Item 16 may be considered in the light of what has been said about figurative representation in the discussion of Item 14 above.

Taking the responses of individual students who completed both administrations of the test, 15 students 'improved' their response in 1976, going from an incorrect to a correct response, 9 students were incorrect on both occasions and 5 'regressed', going from a correct to an incorrect response (Table 58).

Table 58.

Item No. 16. Responses of Individual Students in the Two Administrations of the Test.

1974		1976	No. of Students.
Incorrect	----------	Correct	10
No Responses	-------	Correct	5
Incorrect	-------	Incorrect	9
Correct	----------	Incorrect	5

As can be seen in Examples 1 and 2, some students drew lines which were at right angles to the sides of the glasses, while others drew lines at a variety of angles, often varying between the glasses. A comment from discussion in Group 1 (Appendix XIII) suggests a figurative approach:

> You try and tilt the glass upwards as you look at it and see where your line is going to level out to.

Piaget and Inhelder (1971) commented on similar responses from children:

> The natural systems of co-ordinates (horizontal and vertical) are elaborated only at about 9 to 10 years. It is thus not until this age that the child attains correct imaginal representation of the level of a liquid in a jar tilted in various directions ....
>
> (p.350).

In another work (1969), the authors emphasize the argument that an inability to assemble the elements of a drawing according to logical considerations indicates a lack of operational structures. Referring in a footnote on p. 68 to the tilted jars experiment among others they say:

> Thus we see that the evolution of drawing is inseparable from the whole structuration of space, according to the different stages of this development. It is not surprising, then, that the child's drawing serves as a test of his intellectual development.

In general, if the foregoing examination of errors on the two items which required drawing is correct, the students who made errors experienced the same kind of difficulties in comprehending the spatial relations involved that Piaget has described in the thinking of children. In the case of Item 14 errors, these difficulties were on the Piagetian pre-operational level.

The remaining items of the test were of the 'multiple-choice' type, and interest is mainly in the comments made by students during discussion.

In Item No. 13 (bottle, book and lamp), an approach apparently dominated by figurative considerations, described by students who found the item difficult, can be contrasted with the description given by a twenty-year-old male mechanical engineer, whose method of dealing with the transformations is 'operational' in the Piagetian sense.

(Group 4) I thought about being in place .... thinking of an artist's impression.

I tried to look at them as though I was standing (in each of the places).

I took a plan view (stood in one place and 'bent over' the objects).

(Group 1) When I found that I couldn't visualise it I did it from one of the objects, the bottle.

(Group 2) One of them didn't fit in with my mental picture.

(Engineer) I go for the one opposite to A first, and that must be the one with the positions of the lamp and the bottle reversed, so it's 5. The chap on the left (B) will have the bottle to the left of the lamp and the book to the rear, so that's 2. 3 is rubbish, so D must be 4.

There was a considerable amount of comment on Item No. 9 (bicycle with twisted belt) in discussion, and the test responses of individual students who did not choose the preferred response in one of the administrations of the test indicate uncertainty (Table 59). 14 students chose the same option in both administrations, 14 changed from a distractor or no response in 1974 to the preferred response in 1976, 14 changed from the preferred response in 1974 to a distractor or no response in 1976 and 10 changed from one distractor in 1974 to another or no response in 1976.

Table 59

Item 9. Responses of Students who did not choose the Preferred Response in One or Both Administrations.

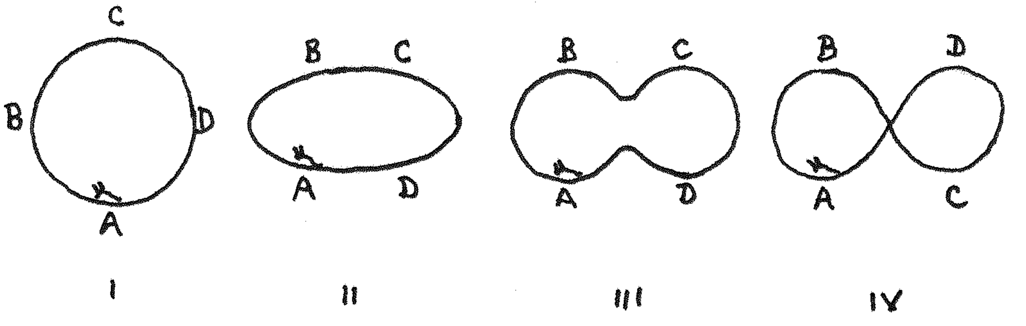
Option 1974	1976	No. of Students.
A	A	7
C	C	7
C	B	6
A	B	7
N.R.	B	1
B	A	7
B	C	5
B	N.R.	2
C	A	5
A	D	1
D	A	2
A	C	1
C	N.R.	1

Several features of the discussion of this item are of particular interest - comments on the difficulty of 'visualising', the little help that tracing round the belt on the diagram provided, the contention that the belt would break and the distracting effect, for some students, of the arrow in the illustration.

Piaget and Inhelder (1971) again offer some basis for the interpretation of these difficulties. The authors reported an exercise in which children were presented with a task similar to that in Item No. 9.

Children were shown four metal strips shaped as a circle, a regular oval, a concave oval, and a figure-of-eight, as in Fig. 41.

Fig. 41.



In each case the children were required to imagine a model snail (placed at position A) move along the strip, and to place a replica of the snail at positions B, C, and D. In doing this the children were asked to predict: the orientation of the moving body in relation to the direction of its path (determined by the position of the head), the general position of the moving body in relation to the frame (outside or inside, above or below), and local positions of the moving body in relation to the frame (foot and not shell against side, etc.)

This is analogous to imagining the movement of a point on the belt in Item No. 9 as it passes round the two pulleys.

The authors found that children often did not follow the curve of the metal path with their eyes, but jumped directly from points A to B, from B to C, and from C to D, "thus delineating a rectangle in the case of the oval and a quadrilateral with its long sides intersecting in the case of the figure-of-eight". The children appeared to be incapable of following the metal strip through, either with the eyes or mentally. Piaget and Inhelder comment:

> The image consisting as it does of internalised imitation, this deficient motricity is translated into a static image of the distance covered, and the snail's situation and orientation remain unchanged accordingly. Here we are at the heart of what is probably the chief reason for the 'pseudo-conservations' of the static image .... which in the present instance leads to conservation of positions.
>
> (p.92).

Semi-static configurations were also distinguished, these due to the fact that children's eyes succeeded in following only part of the metal strip, for example where a child was successful as far as point C on the figure-of-eight but then jumped to point D, 'conserving' the snail's point C position.

These 'pseudo-conservations' and the general inability to deal with movement arise, according to the authors, from the dominance of imagery and the lack of operational structures.

> The image is ill-equipped to grasp the dynamism of a continuum, be it a question of the continuity of movement, a change or a decomposition process .....

> This discontinuity of the image in contrast as it is to the dynamism of the operational continuum, is again no doubt due to the figurative requirements of imagery. It is impossible for a drawing to represent movement except by a series of motionless positions, clear as the symbolism of such indications may be. But the mental image cannot do much better. Try, for instance, imagining a cyclist's leg movements. One can visualise slight displacements as the foot goes down, round and up again. But one thinks one has got the continuity only to realise that one has prolonged the image in thought, and that one is no longer actually 'seeing' the whole in motion.
>
> (p.363).

Students discussing Item No. 9 made comments suggesting that their difficulties were connected with an unsuccessful use of imagery. The points at which the belt crossed and as it changed direction passing over the rear pulley caused confusion. This is essentially the same problem as that presented by Piaget and Inhelder's snail on the figure-of-eight track. A moving point on the belt (represented by a finger tracing the movement) has a 'head' and a 'tail' which have to be correctly oriented. If thinking dominated by visual imagery reduces the movement of a point on the belt to a static configuration representing the distance covered, and this is shaped by 'jumps' from one point to another, then 'pseudo-conservation' of the position of the point is likely to occur and comments such as the following become more understandable:

> (When does tracing your finger round cease to help?)
> When it comes back the other way.
> I couldn't answer it. I got half way round and couldn't get back.
> It's one of those things you just can't visualise in your mind.
> Once you've worked out one stage you've forgotten one stage.
> (Which was the confusion point on this one?)
> It was the twist .....

For some students, who got as far as realising that the rear pulley would turn in the opposite direction to the large pulley (gear-wheel), a problem arose because they forgot, or were not aware of, the fact that it was the twist in the belt which brought about the reversed motion of the rear pulley, and proceeded as though the belt had somehow lost its twist. Opposing motion was then thought to lead eventually to the belt snapping. This conclusion can be accounted for if students are assumed to rely mainly upon figurative representation of the two pulleys, one supplied with an arrow to indicate the direction in which it will turn and the other ready to be supplied with an imaginary arrow, the product of a partially successful tracing of movement round the pulleys. Concentration on these two images, and a far from perfect understanding of the phenomenon of the twist, would lead to an impression of opposing forces.

The many arguments such as the following are highly suggestive of a process similar to the above:

(Group 3) .... that would be pulling against that and the belt would break. If you pushed the pedal forward, that would go back and it wouldn't work at all ....
That (gear wheel) would go forward, that (rear road wheel) would go backwards, therefore it wouldn't work at all.

Some students successfully worked out that the twist in the belt would result in the rear road wheel turning backwards, but then went on to argue that this would conflict with a forward motion of the whole machine. Belief in this forward motion was associated with the fact that the 'gear wheel' moved forward as on a normal bicycle. In Group 2, for example, attempts to explain and demonstrate were resisted:

Why does it go backwards? I've written it but I don't know why.
(Attempt to demonstrate the path of a point on the belt as it travels round the two wheels).
But then, if you're pushing that way, going like that, you're going forwards this way but your back wheel's going backwards.
(But it's only your leg that goes forward, isn't it, the machine itself wouldn't go forward.)

Hubbub .... This seems stupid to me, you pedal it one way and it goes the other.

Again in Group 3:

> It would depend on the amount of pressure. The bike would stay still and the belt would eventually snap or something.

Some students thought that the machine would move forward because of the arrow on the diagram, for example, in the sequence of exchanges in Group 2 including

> If you .... could just put A, saying it was going forward .... because to me the arrow is pointing that way, it's almost biased.
>
> But surely, if it pointed backwards, you'd go backwards.
>
> (What would make it go forwards, did you say?)
>
> Because of the arrow and this little thing.

The difficulty seems to take the form:

> Because you push the gear wheel forward, the whole bicycle will move forward.
>
> But, because of the twisted belt, pushing the gear wheel forward turns the rear road wheel backwards.
>
> This must produce opposing forcesL- the belt will snap.

When Piaget (1930) asked children to explain the mechanism of bicycles, he found four stages of understanding. In stage one (4 - 5 yrs.) the 'how' of the movement was not analysed. In stage two (5 - 6 yrs.) "each piece is mentally isolated and thought of as necessary. But the cause of the movement is still synthetic, for the action of the pieces upon one another is in no way made clear, and when the child is asked to make it more definite, he takes refuge in a series of vicious circles which do not trouble him in the least". During stage three "the action of the pieces is sought for, but the correct explanation has not been completely discovered". Finally, in stage four, the complete explanation is given.

Piaget calls the accounts of 'cause' given by children in the first and second of these stages 'synthetic', by this he means that perception is "global, confused, proceeding from the whole to the part," and tends, as far as causality is concerned, "to find together all the elements of a given whole, but does not bring out the analysis of particular sequences".

The following is of particular interest:

> The child has the impression that each element 'goes with' all the others or is 'made for' all the others but does not enquire as to the 'how' of the phenomenon. In the case of the bicycle, this stage is very definitely marked. The child of 4 - 5 explains the movement of the bicycle by a sort of general forward impetus (élan d'ensemble) which is supposed to be released as soon as the cyclist moves his legs. If the child is asked to state things more clearly he explains the movement by bringing in "the mechanism", "the engine", the lamp, the pump, etc., in short any particularly striking piece which seems sufficiently charged with efficacy to account for the whole of the movement.
>
> (p. 200, my emphasis.)

There is a remarkably close fit between this and the arguments of students - the front part of the bicycle must be impelled forward because the rider pushes the pedals forward; the arrow is "charged with efficacy" and suggests forward movement in a powerful way. The fact that there is no intermediary link between the pedals and the front wheel, except through the back wheel, does not occur to the students.

Piaget and Inhelder (1971) did not comment on Piaget's earlier work on causality. I think that, if they had, the 'synthetic' explanations given by children in the early stages of dealing with the mechanism of bicycles would have been related by the authors to imagery. Children who could "find together all the elements of a given whole" but fail to "bring out the analysis of particular sequences" would be said to do so because of the dominance of figurative representation in their thinking, in the absence of operational structures which alone are capable of dealing with the movement involved.

If, for a moment, one assumes that students' thinking was dominated by imagery in this way, their difficulties become more comprehensible.

The drawing of the bicycle as a whole looks familiar. The unusual feature, the twist in the belt, is a minor part of the configuration in <u>visual</u> terms. If I cover the rear wheel, the picture is of a normal bicycle and this impression is reinforced by the arrow, which 'tells' (in a compelling way exploited in many forms of non-verbal communications) that the pedals are to be pushed forward in the normal way. If the shape of the belt is ignored there is an image of a normal cycle, which, because of the arrow, is about to move forward.

Students were asked to analyse the relations of the parts to each other. As was shown in Piaget and Inhelder's snail experiments, there are difficulties about this, and the attempt has the effect of separating the rear wheel (which is likely to behave in a peculiar way) from the rest of the configuration. The result is two images, one of the front part of the bicycle, which will do one thing, and another of the rear part, which will do the opposite. Unlike Piaget's children, the students are able to voice their disturbance at this contradiction.

Irrespective of whether or not this is so, it would seem that when forced to analyse mechanical relationships (in a situation where the degree of complexity is increased as compared with Piaget's tests) the students came up against the same kind of difficulties as the children in Piaget's pre-operational phase.

If Piaget is right, the fact that some students claimed complete ignorance of bicycles and their workings does not remove this impression. The two outstanding characteristics of the 'primitive stages' of causality according to Piaget are immediacy of relations and absence of intermediaries, "But such features are completely absent from children of 11 - 12 years in subjects of which they know nothing," children of this age having developed operational structures.

> Thus it is more or less impossible for a child of 10 to understand how a motor car works, nevertheless the child presupposes pipes, cog-wheels, chains and belts to act as intermediaries between the petrol and the wheels.
>
> (p.268.)

Comments by students in discussion of Item 5(i) and (ii) of the test support the impression of difficulties arising from an over-reliance on figurative representation in thinking. Students reported difficulty in imagining what would happen in the case of the three cog-wheels:

(Group 1) I played for hours with it (plastic cog-wheel toy) but I couldn't visualise it sufficiently well to actually see it.

(Group 2) I was trying to think of a watch .... you know, what you find in a watch with the back off; wheels going round.

Following the hypothetical movement of the cog-wheels in 5 (i) resembles the problem of the twisted belt; the three cog-wheels become a figure-of-eight with an added loop.

A comment from Group 1 illustrates this

> It was the same with the cogs .... got so far round .... but then I got confused and I couldn't remember what the first one was doing, in relation to the second one, when I came to the third one.

This kind of 'cognitive strain' seems to be accounted for by the dominance of imagery in thinking, and this occurs, according to Piaget and Inhelder, when operational structures are not available.

C H A P T E R   F I V E

Interpretation of Events during the process of inquiry.

Most of the material in Part One of Chapter Four can do no more than suggest that in the group of students considered, some are likely to have had difficulties in dealing with, and may entertain misconceptions about, the topics used in the test. No actual number or proportion of students can be proposed and no specific difficulties can be ascribed to particular students, except in the case of one item. The original aims of the test were modest and interpretation of the test responses depends on whatever supporting or refuting evidence maybe drawn from students' oral statements. But because of the emotional climate mentioned earlier I could not arrange matters so that the comments of particular students in discussion could be linked to the appropriate test responses. Also, again largely because of the need to appear not to threaten students, the process through which the oral comments were obtained is open to criticism. A 'post-mortem' discussion, between participants, of how it was to complete a test, is considerably less disturbing than a follow-up test more penetrating than the original one. Indeed, anyone listening to the tapes might agree that there was often an eagerness to exchange admissions of ignorance, and a readiness in students to lay themselves open in quite heated argument. Students often enjoyed the discussions and found some reassurance in them. But this does not constitute a careful teasing out of lines of reasoning, and it is a commonplace in social psychology that certain forms of the dynamics of group discussion lead to a 'me-too' atmosphere, the so-called regression to the mean, while a slight shift may produce a polarization of expressed opinions which may or may not be firmly held.

Nevertheless, I think that the work is worth reporting in its own right, as it appeared at the time. It conveys a general feeling of misgiving, uncertainty, and even bewilderment and guilt among women students who were pressed into dealing with a particular set of topics. This may be of interest to teachers who deal with these and related topics in schools, and to teachers further along the schooling process whose work depends upon a taken-for-granted grasp of the topics.

The material may be suggestive enough to prompt further inquiry by someone who wishes to get at the 'why' of the matter and is ingenious enough to overcome the difficulties of putting 'childish' problems to adults without defeating his own purposes in the process. I suspect that this may best be done in a teaching rather than a testing setting, as, for instance, when my mature students played with water and cardboard boxes, not to reveal their ignorance, but to find out what might make up the 'stimulating environment' so often talked about after Plowden.

The material in Chapter Four may stand in its own right, as I suggest above, and it is essential for the subsequent argument in this study. In Part Two I think that, if certain assumptions are allowed, I have proposed a tenable argument that some students operated on the lower Piagetian levels in limited areas of content. The material dealt with here is rather different from the rest. It still suffers from the fact that written and oral responses cannot be linked through particular persons, but, on the other hand, all the students but one who took part in the discussions had made unusual shadow responses. The nature of the tasks is different from the rest and, particularly in the case of the shadows, there is more to be had from the marks made on paper.

I found it difficult to see how some aspects of the shadows topic could be taken further by 'clinical method'. It is true that students could be encouraged to play with lights, objects and shadows, perhaps in the teaching setting that I have mentioned above, and questioned in Piagetian style as to the 'law' operating. As a testing process, however, there have long been objections to this kind of questioning, from the general criticisms of Susan Isaacs to those based on specific studies (e.g. Garner and Plant, 1972). These usually assert that leading questions or hints in procedures prompt the testee into particular kinds of response, and I spent some time considering how one might develop acceptable procedures. It seemed possible that Michotte's techniques might be adapted to suit a study of shadows. Michotte (1963) claimed to have demonstrated, in spite of Hume, conditions under which causation is directly perceived. He devised an apparatus which displayed moving coloured shapes. These shapes could be arranged so that, for example, a moving square would appear to an observer (the 'subject') to approach another square which on 'contact' would appear to take on the motion of the first square. If the first square stopped moving on contact, observers would report that the first square "pushed" the second square. Effects such as "entraining" and "launching" were described as actually having happened. Observers insisted that they saw one shape causing another to do something. The argument about whether or not this amounted to a direct perception of causality was interesting although not directly relevant, but I believed at one point that Michotte's methods were.

Michotte pointed out that he had two sources of information, first the stimulus conditions which he controlled and which were capable of being defined in physical units; colour, size, speed and so on could be specified with precision. The second source was the verbal response of 'subjects'. Of this he said:

> It should be made clear....that I have never asked my subjects to adopt the 'attitude of introspection'.....
> Their instructions were: "Say simply what is going on in the apparatus" or some equivalent wording such as, "Say what you see in the apparatus". When we wished to obtain fuller information the only questions we allowed ourselves to ask were ones such as, "Could you not put it another way?" (etc.) with all traces of suggestion carefully avoided.
> Now the responses in these conditions given by the subjects always relate, of course, to the physical 'world', except when they mentioned, for example, the degree of certainty attached to their observations. But the physical 'world' in question here is no longer the world of physical science as revealed by measuring instruments, it is the world of things, as it appears to the subject on simple inspection, his 'phenomenal world'.....
>
> (P. 305)

Michotte argued that the verbal responses provide the basis for hypotheses about the structure of what the 'subject' sees. These are then tested by a study of the concomitant variation between changes in the stimulus conditions and changes in the 'subject's' responses.

This seemed to offer a possible model. There is a difficulty in asking questions about lights, objects and shadows in that, in most normal circumstances when one can see, they are always there and always occur together, but an apparatus could no doubt be constructed involving trick photography or even perhaps holograms, in which, for example, shadows could be absent or made to behave in strange ways. Following Michotte, these would be the stimulus conditions which observers would comment on, without the need for leading questions, through a sequence of changes controlled by the experimenter.

All this was in reference to the question of getting at the way students might understand the primitive relation between a light, an object and the cast shadow. There is, however, another aspect of students' responses to the shadow item; that of the way in which the conception (or misconception) was expressed in a drawing, and this may not be accessible through interrogation or verbal report on a stimulus. It is a matter of the internal logic of the drawing. In this respect at least much of the argument in Part Two is defensible as it stands, within the Piagetian system.

An awareness of the shortcomings of what I had been able to do and the accompanying pondering on method, what might be done, had other results. It produced further feelings of circularity.

Michotte's simple and elegant method was part of his view of his 'subjects' (subjects being people who agreed to act under his instructions and control). On this view the perceptual impressions they reported were determined primarily by the immediate stimulus pattern. In using techniques such as his one would have to move in a world of direct connections between stimulus and response.

This, of course, was opposed to the Piagetian view. When I used Piaget and Inhelder's work on imagery to help understand students' responses I was struck by the bold way in which they had solved the problem of method. Their solution rested upon their definition of an image. If images are part of accommodation, internalised imitations, then you can get at them through gestures and drawings which are closely related external imitations. Problems such as those of introspection which have occupied a succession of researchers into imagery are removed at a stroke - again a similar elegance and simplicity to that which made Michotte's work attractive. But as I used the arguments I had the feeling that the methodological solution might be a little too simple and elegant because, as with Michotte, there must be a great deal left out which may be of crucial importance. Could images be considered as merely imitations, isolated from all that we know of them at first hand and from studies of sensory mode, imagery types and E.E.G. patterns, unconscious functioning and the rest? Piaget and Inhelder did not ignore this problem. They brushed it aside in the introduction to the book. The affective aspects of imagery were "a splendid subject" not yet properly investigated, with which they were not at present concerned.

However, at the time I used the argument it was enough that the basis that had been contrived for method was supported by the enormous volume of Piagetian work over fifty or so years. Later this uneasiness about the method of getting at images led to a reconsideration of how solid was the basis of the general theory as an explanatory notion to illuminate actual cases.

All this threw into relief the fact that 'method' and 'theory' are not two things closely connected but facets of the same thing.

CHAPTER FIVE

Interpretation of Events during the process of inquiry.

At the end of the academic year 1976-7 my duties as tutor at the college ended, and I had the opportunity to be seconded for one year's full-time study.

When considering the choice of activity for this secondment I had decided to spend time on a wider area of interest than I had previously been able to attend to. I applied for a place on the M.A. Curriculum Studies course at the University and was accepted. The present study was suspended until the end of the M.A. course in March, 1979.

During the course I came to regard several notions, which I had held to be more or less self-evident, as open to question. Among these were ideas of what may count as research in education. My dissertation (Bury, 1979) described an attempt to study problem-solving in a skilled manual occupation and to relate this to Piagetian notions of levels of thinking.

This exercise led to a lessening of my confidence in the comprehensiveness of the Piagetian system as an explanation of intellectual development.

My tutor during the M.A. Course, Tutor E, agreed to take up supervision of the present study at the end of the course.

I wrote a brief description of what had happened since the beginning of the study. Tutor E saw the erratic course of events as an area for examination in itself, the process of inquiry becoming the subject of study.

Reconsidering what had happened, it was apparent that the study had gone through three phases, and that separating the phases were critical events which ended the action of the previous phase and determined the direction of the subsequent phase.

Phase 1 was an awareness of a difficulty in my work as a teacher, apparently connected with some disconcerting observations. In Phase 2 various influences led to the classification of the difficulty as one requiring a 'scientific' explanation, with an attempt to predict, quantify and verify on the basis of the classification. In Phase 3 the difficulty was re-classified, and an attempt made at 'qualitative' description and explanation.

The activity of re-examining the course of events and tracing reasons for their occurrence led to a re-interpretation of the nature of the difficulty and of the kind of description and explanation that might be appropriate. The process of re-examination itself was a fourth phase, and Phase 4 is represented by this and the remaining chapters.

During what I have called Phase 1 I believed that there was reason to be concerned about student teachers' work on the topic of Piagetian descriptions of intellectual development. Students often seemed to have little better grasp of essential notions at the end of their work than they had before it commenced.

In an attempt to improve this state of affairs, students were asked to carry out an exercise which gave them the opportunity to experience for themselves the responses of children to Piagetian-type problems. The assumption was that in order to appreciate the significance of Piaget's findings, a student must abandon ideas of the self-evidence of certain principles to do with the workings of the physical world.

As a result of this exercise I suspected that, far from believing that the principles were self-evident, many students did not themselves understand the principles. Informal observations of older students reinforced these suspicions.

Some of the principles apparently misconceived by students were of the kind that most people (including Piaget and those who have built up systems on Binet-type testing) assume are assimilated during childhood through play and everyday interaction rather than primarily through a process of formal instruction. Yet at the same time the students had successfully completed an extended schooling and were generally capable young adults.

If my suspicions were correct it would not be surprising that a substantial number of students found work on Piaget barren and unrewarding, since, in the context of Piagetian experiments, they started from a position apparently similar to that of Piaget's child subjects.

These possibilities were disquieting because, according to received knowledge, they should not occur. I wondered why no one else seemed to have reported similar difficulties among student teachers. There was a need to probe and explain.

My interest, therefore, was primarily in the apparent failure of quite large numbers of students to understand everyday phenomena, and in the consequences that this might have for their work on Piaget, yet during Phase 2 I found myself dealing with the psychometric notion of 'abilities' rather than with what students did when asked to tackle problems concerned with shadows, water-levels and such like. These 'everyday phenomena' had become peripheral and were represented only by my unofficial test, which was justified by the idea that its results might come in useful in a discussion of spatial ability.

To trace the reasons why this came about it is necessary to go back to preliminary discussion of M.Phil. work at the University, described earlier in Chapter 1, P. 11.

After describing my observations I was asked how I might account for students' misconceptions of everyday phenomena, and how I thought a study of them would achieve the breadth of interest normally associated with research degree work. These were the kind of 'open' questions by means of which a practised interviewer hopes to give the interviewee an opportunity to say what he thinks is important about the topic under discussion.

For someone embarking on work which is going to be described as 'research', however, there may be a certain awesomeness about the prospect. There appear to be ways in which research ought to be carried out, and accepted bodies of knowledge or belief which must be taken into account before questions can begin to be framed. The most persistent impression is that research is a scientific enterprise, to be conducted within the concepts and methodology of appropriate disciplines. Recourse to published texts which advise the would-be researcher confirms this impression.*

The questions became the first of the critical events. They implied for me that I ought to be able to account for the student's misconceptions, that M. Phil. work sets out from an hypothesis derived from a theoretical framework of 'broad interest', and that the business to be discussed really ought to be concerned with ways of testing the hypothesis.

Instead of answering, "I don't know" I went away to think about a frame of reference, of suitably broad interest, which would provide an explanation of the observations and thereby indicate a methodology.

Piagetian theory, which provided the context for my observations, did not look promising as a source of hypotheses. According to the theory, adults should have developed logico-mathematical structures in conjunction with physical experience which would enable them to deal with the problems my students had difficulty with, even without the manipulation of concrete objects.

As Bateson (1972) points out, scientific research starts from two beginnings; the observations, which cannot be denied, and the fundamentals, which must be fitted:

For example, Nedelsky (1965) P. 193:
"First, let us lay the ghost of the unprejudiced, open-minded researcher who respectfully listens to nature and records all her gibberish. The tool of the modern researcher, whether in science or education, is increasingly more like an objective (perhaps even a true-false) test. The choice of such a tool shows that the researcher thinks he knows or assumes nearly all there is to know and that his mind is open no more than a crack; the crack is wide enough to admit a yes-or-no answer to his question and little else that is not striking or persistent."

> If you are surveying a piece of land, or mapping the stars, you have two bodies of knowledge, neither of which can be ignored. There are your own empirical measurements and there is Euclidian geometry. If these two cannot be made to fit together then either the data are wrong, or you have argued wrongly from them, or you have made a major discovery leading to a revision of the whole of geometry.

It was highly unlikely that revision of Piagetian theory, if that could be regarded as something resembling a 'fundamental', would be necessary. It was more likely that the data, which were to say the least unsystematically gathered, were wrong in some way, or that the argument from them which was likely to lead to a contradiction within the Piagetian system was misguided.

There were no reports in the available literature to suggest that anyone had made similar observations among college students. Papalia (1972) reviewed the limited amount of literature on Piagetian concepts across the life span. Her own work examined the responses of 96 people, ranging in age from 6 to over 65 years, to problems on the conservation of number, substance, weight and volume. Only three subjects exhibited pass-fail performance patterns which deviated from predictions derived from Piagetian studies, and her main interest, as in the work of others she reviewed, was in decrements in old people's performances hypothesized to be reflections of the neurological decrement inherent in the aging process.

More promising ground was offered by the psychometric tradition, which was not only avowedly scientific but eminently respectable. There were few educational research studies which did not 'control' intelligence as a variable, and many which described patterns of performance as due to the 'contribution' or 'effect' of one or more of the various abilities postulated by factor analysts. Some attempts, such as Bart (1971) and Mycock (1968), had been made to relate factorists' abilities to performances on Piagetian tests.

It was true that the nature of abilities was a matter of concern for leading writers in the field, who warned against reification, but these writers also argued as though a person uses abilities and therefore possesses some real attribute. An example from Vernon (1961) illustrates this:

> Thus one individual may score well on a test <u>through</u> high 'g', another might get the same score <u>by virtue of</u> some group factor, yet another <u>through</u> specific ability .....
>
> (P. 9 my emphases .)

The relative strengths of abilities may thus 'underlie' particular performances, and in a sense 'explain' them.

Once this was accepted a disturbance could be converted into a problem, with its own implied course of action. Variables could be chosen and measurements taken, for the most part with ready-made instruments. The problem became one of prediction and verification.

The possibilities for constructing dimensions along which students can be measured are many. In a study such as the one mine had become, with spatial ability as a major consideration, a plausible case could be made out for taking such things as retinal pigmentation into account (Jahoda, 1971). There were numerous possible 'non-intellective' variables to be considered. However, practicality, how much testing a group of students would tolerate, and how much a tester could handle, indicated a limited number of variables restricted to 'traits of intellect', and this was supported by an examination of published reports of similar studies.

King (1963), for example, examined relationships between children's age, sex, their scores on a test of verbal ability, scores on a test of non-verbal ability, and scores on a test of knowledge of science concepts. Some differences were found between the science scores of boys and girls after primary school age, and the study ended by saying that differences "may not be due so much to differences in verbal and non-verbal ability, but to other non-academic influences, e.g., teaching, interest motivation, self-involvement, etc., <u>with which this study was not concerned</u>." (my emphasis).

Lin and McKeachie (1973) compared the scores of students in an American college on an intelligence test, a measure of study-habits, and a measure of 'achiever personality', with achievement in introductory psychology courses. Their report concluded:

> Our own studies of interaction, however, like those studies of single predictors reported in this paper, do not produce striking increases in our ability to predict student achievement. It may well be that progress in this field of many, many variables will depend on hacking away at the variance one small bit at a time.

This type of study demonstrated that it was possible and desirable to tackle "one small bit", one aspect of a problem, leaving those aspects with which one was "not concerned" to other studies. Indeed, the hypothetico-deductive method demands that inference may only be drawn from refutation; "hacking away" the hypotheses that are found wanting and forming others from what is left.

When my study outline was accepted for registration, I felt reassured that this approach was appropriate.

Phase 2 ended with the second critical event, or events. The interesting responses of students to the first administration of the Everyday Phenomena test induced a return of the hankering for an explanation of the responses themselves, and the difficulties revealed in my attempts to construct a suitable criterion test of 'Cluster 3' achievement, made me begin to have doubts about what the notion of abilities might be said to explain.

The resistance of the psychology course essay system to a measure which could be appropriate for the comparisons I wanted to make suggested that an examination of the system itself was required to illuminate at least part of the problem. This raised questions about the procedure I was following.

If I supposed for a moment that a satisfactory criterion could have been obtained and that after analysis of the results of testing a significant correlation had been found between spatial ability and 'Cluster 3 ability', what would this indicate?

Spatial tests might discriminate between students who would tend to have difficulty in parts of their psychology course, and those who would tend to have less difficulty. This might contribute in a minute way to theories of abilities, but in order to know something about the students' difficulties I would need to know what it is in the spatial tests that brings about this discrimination. The answer, presumably, would be that discrimination is obtained through tasks which require for their completion "the capacity to perceive and hold in the mind the structure and proportions of a form or figure, grasped as a whole". Any further attempt to pursue the question of the connection between this capacity with performance on 'Cluster 3' tasks would probably be lost in circularity or the postulation of some ghost in the machine.

Work in the field of psychometrics is aimed at discovering (or perhaps more properly 'constructing') a structure of human intellectual abilities when the nature of the abilities is not known, perhaps in the same way that Mendeleev constructed his table of elements. The difficulty is that abilities are only discernible in terms of the tests used to detect them. Consequently, work in the field has amounted to a search for tests made up of tasks which do not resemble tasks used in other tests, but the results of which correlate with the results of other tests.

Miles (1957) pointed out the difficulties involved:

> A factor is real, it might be said, if from behaviour at one test prediction is regularly made about behaviour at another test allegedly saturated with the same factor. This, however, opens the door to the postulation of a host of useless factors.

Earlier, Miles argued that the proliferation of useless factors was avoided only by the judgment of the investigators:

> Correlation co-efficients can be worked out between as many different abilities (or 'substrates') as we please; but no figures, whether high or low, can lead us to abandon a substrate which we are sure is helpful or accept one which we are sure is unhelpful. To work out correlation co-efficients is to _operate_ our hypothesis not to _test_ that hypothesis.

Psychometric research is essentially an inductive science, striving towards the identification of 'factors of the mind' which may one day be seen to be embodied in, say, genes and neurones.

What dawned on me after this kind of reflection was the realisation that, by its very nature, psychometric research can not offer a causal explanation of behaviour.

This is not a fault in psychometric research itself. As Ryle (1949) commented:

> ..... not all psychological researches are searches for causal explanation. Many psychologists are occupied, with greater or less profit, in devising methods of mensuration and in making collections of the measurements so achieved. Certainly the hope is that these measurements will one day subserve the establishment of precise functional correlations or causal laws, but their own work is at best only preparatory to this ulterior task.
>
> (p.308)

Psychometric theory is a _descriptive_ theory* and the error lies in treating it _as though_ it can provide causal explanations. When this happens (and I was clearly not alone in falling into

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* Craik (in Sherwood, 1966) distinguished between three types of explanation, causal, descriptive and relational. "A descriptive theory asserts ... that it is vain to seek 'causality' - it is either non-existent or unobservable. But we are aware that certain sequences of events recur regularly, and though they may cease to do so at any moment, the chances are that we shall fare most sucessfully in our environment if we anticipate and respect these regularities; consequently it is pragmatically important to learn their ways; and the very fact that they occur may fascinate, as a theoretical problem, even if we permit outselves no speculation as to any invisible mechanism."

the trap) what Bateson (1972) calls 'dormative hypothesis' may result.

Bateson describes the process of explanation as "the mapping of data onto fundamentals". Data are not events or objects but always selected records or descriptions or memories of events or objects. Fundamentals may be propositions and systems which are truistical, such as the eternal verities of mathematics, or may be propositions which are scientifically or generally and empirically true, such as the conservation laws for mass and energy.

The trouble with inquiry into human behaviour, says Bateson, is that the behavioural sciences commonly use imperfectly defined explanatory notions in the absence of fundamentals.

Quoting Moliere, he tells the story of an examination candidate who, when asked for "the cause and reason" why opium puts people to sleep, replied,"Because there is in it a dormative principle". Bateson goes on:

> The scientist observes change in a complex interactive system (the man falls asleep). The scientist then explains the change by giving a name to a fictitious 'cause' located in one or other component of the interacting system. Either the opium contains a reified dormative principle or the man contains a reified need for sleep, an adormitosis which is 'expressed' in his response to opium .... This is self-reinforcing. High value is set on prediction, which is a poor test of a hypothesis. One can set up research to study the characteristics of a fictional principle - and find answers. The multiplication of dormative hypotheses (hypotheses which put questioning to sleep) is a symptom of an excessive preference for induction. The result is a mass of quasi-theoretical speculation.

Whether or not Bateson's strictures on induction in the behavioural sciences may be fairly applied to psychometric theory, the notion of abilities 'underlying' (in some way explaining) aspects of my students' performances in work on Piaget amounted to the use of a dormative hypothesis.

Its use led me into a procedure which, even if technically successful, could only end in tentative suggestions of relations between unexplained performances. It had also obscured the total interacting system of which the students were a part, at least until it was too late, because of changing circumstances, to do anything about it.

During Phase 3 attention was focussed on the results of the Everyday Phenomena test.

There were several studies reported in the literature which related younger people's 'levels of thinking' to the conceptual levels deemed necessary by the authors for understanding various aspects of the school curriculum, for example Goldman (1964), Hallam (1966), Ingle and Shayer (1971), Shayer (1970:1972), Shayer et al (1976) and Lovell (1973:1974).

In a similar way, students' difficulties with Everyday Phenomena items, and more generally with work on Piaget, might be accounted for by ascertaining their 'levels of thinking' as described by Piaget.

In the event, examination of test responses regarded as errors, and of statements about the test items in discussion groups, showed that the students concerned had genuine difficulties in understanding relations in the situations described by the test items.

This had implications for some areas of the students' subsequent work in schools and for an assessment of the value of including work on Piaget in their college course.

First, most of the students tested were likely to teach children in Primary or Middle schools. In these schools teachers are often required to carry out work aimed at helping children to acquire basic scientific ideas which are assumed to provide a foundation for the more focussed later work in scientific 'disciplines'. Also, more broadly, much of the direction of modern Primary educational practice is provided by a belief in the value for intellectual development of children's active inquiry into their environment, typified by the views of Susan and Nathan Isaacs, and interpreters of Piaget himself. It seems clear that the students concerned would have great difficulty in understanding what their purposes were in this type of endeavour. To arrange the conditions for a progression in, say, sand and water play requires an appreciation of the 'physical' and 'logico-mathematical' experience that is presumed to come out of it.

Second, the content of the test items is closely related to the content of many of the 'experiments' by means of which Piaget has demonstrated his theory. Students who have not grasped the relations involved in the events described in the test items are unlikely to be able to understand the results of exercises conducted with children dealing with similar content. If the students concerned were unable to understand the content of Piagetian experiments, notions which are central to Piagetian theory would be inaccessible to them. For a student teacher to learn off a series of statements about young children's thinking being different from that of older children or adults is of little value. It is well known on the common-sense level that there are differences. It is necessary to grasp the nature of the differences for the theory to have any chance of being useful, or of being seen as relevant.*

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* The following example is of interest. In preparing the items for the Psychology Test I asked third year students to complete a paper which contained questions requiring short written answers. Their responses were to provide material for some of the 'distractors' in the Psychology Test proper. Question 2 ran - "Please write down the names usually given to Piaget's stages of development and the approximate ages at which he suggests they occur." One student wrote, "I cannot remember them, as they soon float to the back of one's mind, being unimportant to everyday living." Further on in the paper, when asked to comment on Piagetian experiments, she wrote, "These experiments were shown to us on a film, and again they have gone in one ear and out of the other. It is difficult to retain this sort of information." This was typical of students' general response to the paper. If one does not understand a sequence of events their point is hard to grasp, they are "difficult to retain", are "unimportant to everyday living" and can be allowed to slip away without much regret.

Leaving aside other difficulties in understanding Piagetian theory and in interpreting it as a guide to educational practice, it would seem that, for students who experience the kind of difficulties described here, time spent on Piaget could be employed to more useful ends.

To this extent my original suspicions had been supported. Also, there was evidence that might justify reference to Piagetian 'levels of thinking'.

Students frequently mentioned in discussion instruction they had received at school or college on the topics dealt with by the test items. This teaching had not, apparently, helped their understanding. It was not that they had forgotten ideas gained in childhood or adolescence, rather that they had never understood.

Using the Piagetian frame of reference, this was because they did not have at their disposal the necessary intellectual structures to deal with the problems posed. Many instances of reasoning exhibited some or all of the characteristics of pre-operational thinking.

But the students' difficulties could not be said to be explained: a theoretical problem remained.

Piagetian constructs provided possible descriptions of the way in which students arrived at their responses, but these descriptions were surprising.

If the students had been children or young adolescents there would have been nothing unexpected about the results. The Geneva School has shown that such responses would be in keeping with a well-defined order of development. The responses would be as they were because the child or young adolescent had <u>not yet</u> developed the necessary intellectual structures to deal with the problems. These structures would appear later, within certain time limits.

Thus the <u>order of development</u> would explain the responses.

But the students did not fit the norms. They were not children or young adolescents but adult women who, at the time of the discussions, had little more than one term left in college (which would be taken up by teaching practice) before taking up posts as qualified teachers. They had passed through an extended schooling with above average success in terms of certificates and awards when compared with the general school population.

Their scores on two established tests often used to predict success in adult education (Murray House Verbal Adult, Cattell Culture-fair Scale 3) were above the general average. At the end of their college course, none of the students in the discussion groups 'failed' or was considered inadequate and many were highly recommended by internal and external examiners for their work in the various academic domains and for their extended periods of work as teachers in schools (Appendix XII).

These achievements presumably imply that the students had serviceable means of thinking available to them in contexts other than those of the Everyday Phenomena topics.

Taking just one activity as an example, successful teaching involves making judgements about a continuous flux of complex interactions, both actual, in the classroom, and anticipated, in planning and preparation. This process of evaluation and re-evaluation demands the relativity in thinking that is characteristic of 'mature' thought.

Thus the students were people who, while successfully following their adult professional lives, apparently functioned on a quite primitive, childlike, level of cognition when dealing with problems in a particular context; and this childlike functioning was not a matter of momentary regression, but appeared to be the only mode available to them in that particular context.

Furthermore, the context in which the students functioned on a 'low level' was the one chosen by Piaget to define his notion of qualitatively different stages of intellectual development.

Piaget uses the term 'horizontal decalage' to acknowledge that discrepancies exist between the ages at which different people arrive at higher levels of cognition in certain contexts, and argues that this is what should be expected because of the gradual nature of the transition between stages. But the question arises of how gradual the process can be allowed to be.

Piaget (1972a) attempted to resolve this question, at least in respect of the transition to formal operations.

He considered problems raised by cross-cultural and sub-cultural studies which did not confirm his own findings on the ages at which the major periods of development occur. Speed of progression through the stages was not the same under all social conditions. Differences between groups were especially marked at the later periods of development. The fourth stage had not the universality of the previous stages.

In one interpretation Piaget suggests that speed of progression may be affected by the quality of the physical and social environment in which a person grows up. In a poor environment development of the first three stages would be slowed down and the fourth stage would perhaps never really take shape.

A second possibility was that diversification of aptitudes with age may account for the fact that formal structures do not appear in all 14 - 15 year olds. Those with aptitudes for logic, physics and mathematics would manage to construct formal operational structures; those without these aptitudes would not.

Both these interpretations imply that the fourth period of development can no longer be regarded as a universal stage.

He regards a third possibility as the most probable. This is that all normal people attain the stage of formal operations, if not between 11 - 15 years then between 15 - 20 years, and this stage is reached in different areas according to aptitudes and professional specialisations.

Piaget thus retains the fourth stage as the characterisation of adult thinking, the ideal to which development has led, although formal operations may only be available to a person within areas for which he has an aptitude and in which he has specialised. Unfortunately Piaget says nothing about how the person will cope with those areas in which he has not specialised and has little in the way of aptitude. The stage is defined by a description of how things ought to be on maximum performance.

Now the fourth stage is crucial for the consistency of Piaget's system, as a brief reference to its central tenets shows.

Piaget (1972b) makes clear the idea which provides the direction of all his work:

> Child psychology certainly constitutes a kind of embryology of the mind, both in describing developmental stages in the individual, and especially in studying the actual mechanism of this development itself. Developmental psychology, moreover, represents an integral part of developmental embryology (which ends not at birth, but on arrival at that state of equilibrium which is the adult state).
>
> (p. 17)
>
> ..... if we remember, together with the biologists, that differentiation of tissues in the embryonic phase governs the whole adult anatomy, we will cease to regard the larval state of the various forms of knowledge as being a situation devoid of theoretical significance .....
>
> (p. 31)
>
> Developmental psychology can be described as the study of the development of mental functions, in as much as this development can provide an explanation, or at least a complete description, of their mechanisms in the finished state.
>
> (p. 32)

Piaget thus offers a genetic explanation. Human capabilities are to be understood in terms of the adaptation of organisms. A description of the stages of mental development will enable the 'adult state' or 'finished state' to be understood. This final state is where cognition can take part in "the universe of our existing scientific thought taken as the norm" (Piaget, 1930), with "physics and its relations with mathematics (as) the highest forms of cognitive development" (Piaget and Inhelder, 1971).

It is this reasoning which, explicitly or implicitly, is usually accepted in studies which incorporate Piaget's work as an explanatory notion. The behaviour of 'Subjects' may be explained by fitting it against Piagetian norms. The stages of development explain how the 'finished state' comes to be as it is, and why individuals do what they do in appropriate circumstances.

When one stands back for a moment to examine the kind of explanation afforded, however, circularity becomes evident.

Like any genetic explanation, Piaget's system is of necessity teleological. Development is directed towards the end state. The starting point of the explanation and its point of reference throughout is the final stage of the process of adaptation. The process itself is determined as a series of successive changes or transformations which are necessary to reach this end.

Thus the process explains the end, and the end explains the process.

The way in to this circle is through the assumption that a complete description of the 'adult state' or 'finished state' is available.

This assumption obscures a difficulty. The 'finished state' of mental development in Piaget's system is an abstraction, the essence of the processes which are conjectured to govern formal scientific-mathematical thinking. But living, 'real' human beings, who have reached the mature, adult stage when judged by the way in which they cope with most aspects of their lives, seldom seem to use this highest level of operation. Wason (in Geber, 1977), for example, has shown that it is doubtful that the Piagetian finished state typifies the thinking of highly accomplished people. In advanced scientific work, if well established practitioners are to be believed, formal operations do not appear to be only, or even the dominant means. As Medawar (1967) comments in discussing hypothetico-deductive processes in scientific thinking, "The critical process in scientific reasoning is not ... wholly logical in character, though it can be made to appear so when we look back upon a completed episode of thought".

Piaget's 'adult state' appears to be a 'looking back' on episodes of thought rather than a complete description of the reality of adult capabilities.

Using an idealised description of the development of the Intellect of Man when attempting to explain the performances of men and women leads to the kind of difficulties encountered in this study. Men and women tend not to measure up to the way they ought to be. Horizontal decalage is an anomaly within the system.

Following Piaget's argument that the 'finished state' is reached in different areas of knowledge according to aptitudes and professional specialisations, it might be said that the students who responded on the pre-operational level to Everyday Phenomena items could achieve higher levels of thinking in, say, teaching, by virtue of their aptitude for and specialisation in whatever intellectual activities teaching demands.

But Piaget's interpretation of decalages in the adult period depends upon aptitude and specialisation as 'mechanisms' of development (transition between earlier stages needed only equilibration). It could well be that an examination of these mechanisms, particularly aptitude, would turn out to be more complicated than the phenomena they were brought in to explain. The mechanisms strongly resemble the 'abilities' rejected earlier as explanatory notions.

The range of students' performances can not be explained by the Piagetian order of development without bringing in these notions from 'outside'. The range cannot be accounted for within the system.

Tutor E had asked, at one point, "Why were you surprised by the students' performances?" This was the critical event which led to the end of Phase 3. The question was worrying; it was surprising in itself. It had seemed obvious that there was a gap between what anyone would expect of the students' performances and what the students actually did, and that the gap cried out for explanation. I had, at different times, shown examples of the students' responses to many people who were experienced in teacher education and who were well versed in theoretical matters to do with intellectual development. Initial reactions, particularly to drawings of shadows and liquid levels, were invariably expressions of incredulity. "My God!" was a frequent comment. The casual question, "Why were you surprised?" demanded that the obvious should be examined.

As the argument set out in the foregoing pages developed, it became clear that this examination of the obvious was crucial. My problem arose because certain expectations were refuted. The problem was shaped by the expectations, which in turn were shaped by theory unconsciously accepted as the natural order of things. The circularity of the Piagetian system determined not only the nature of the explanation to be sought in the difficulty which generated this study, but also the character of much of what there was to be explained. The implications of this are developed in Chapter 6 which follows.

CHAPTER SIX

The Nature of Explanation in Educational Research.

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I had found two systems of explanation commonly used in educational research to be unsatisfactory, and I was forced to consider the question of what kind of explanation would be acceptable - what was I looking for? The answer seemed to be that I was looking for something which could be said to 'cause' the situation which was to me, problematical. The underlying question, more or less unconscious, was "Why?".

Psychometric theory could not point to the 'why' of the matter, and I had dismissed it as 'descriptive' and not properly 'causal'. A genetic explanation, apparently different in character, turned out on closer examination to rely upon 'mechanisms of development' which themselves required explanation.

The following passages consider aspects of explanation, particularly 'scientific' explanation, and lead to the opinion that the cause that I was looking for was within myself.

Causal Explanation.

Everyday thinking is permeated with ideas of causation. Words such as 'teacher', 'student', 'educate' and 'learn' are implicitly causal. Causality is a basic scientific notion. Knowledge of causes enables effects to be accounted for, and may be applied to produce desired effects or to prevent undesired effects. Textbooks on scientific research in education naturally take for granted a search for causes as the business of research. A passage from Burroughs (1971), for example, assumes a researcher eager to assign cause and effect:

> A correlation does not necessarily give information as to causes. A high correlation between weight-lifting ability and intensity of dramatic sensibility

> shows neither that weight-lifting develops greater histrionic skill nor that regular theatre going builds muscles. It merely indicates that there is a relationship. The only occasion when causality might be inferred is when one of the variables is clearly the independent and the other clearly the dependent variable. Otherwise one should be particularly alert to the insidious tendency of correlations to suggest causality and of the ease with which we fall victim to this.
>
> (p.257).

The proposition that Event A is the cause of Event B if events like A are regularly followed, in similar circumstances, by events like B, is an apparently straightforward notion. But, as Hume pointed out, every causal proposition is general since it implies a universal law, and it can be justified only by induction. Following Hume, nothing can be known _a priori_ about the connection of cause and event.

In an event, antecedent and consequent are not directly related, and the consequent can only be explained in terms of a cause distinct from the antecedent. If I place a pin close to a magnet and the pin is drawn to the magnet, the consequent (the pin jumping to the magnet) can not be explained by the antecedent (my placing the pin near to the magnet). I could, for example, _place_ a matchstick there instead. Some hidden mechanism, in this case a force of attraction, is invoked to explain the event. The antecedent is therefore not a cause but a _condition_ for the operation of acause.

If this is so, a search for a causal explanation will describe the conditions in which a postulated (and always unobservable) cause operates.

In the sciences which have generated laws, or propositions which are empirically 'true', causal explanations describe the conditions in which a particular law operates, and this leads to a difficulty in even the hardest of sciences. In any particular event the observable elements can not be regarded as causes, but only as the means through which something else produces the occurrence being investigated. What at first seems to be a cause becomes another event (or group of events arranged into a law) which must itself be referred to another cause - an infinite regress.

The natural sciences have managed to live successfully with this problem, but it becomes acute in the human sciences. A law, of the kind agreed upon in science, is a constant and necessary relation, which although subject to possible refutation, stands up well to testing. But no laws of human action have been formulated which are of the same status as the laws of the natural sciences, and in attempts to find causal explanations of human action there must be recourse to explanatory notions which have neither the universality nor the necessity of laws.

The consequence of this for scientific educational research which sets out to account, causally, for human performances, is that attention is diverted from the persons who performed and their circumstances, so that what becomes important is their relation to something else - the explanatory notion. For the reasons given above, questions in this kind of inquiry will necessarily involve a mystery element, the explanatory notion, and this will be some quality or power which, although unknown, must be apprehended and its 'dimensions' measured in units. The underlying assumption is that the same process of inference which allows us to make fairly precise statements about natural events such as the wind blowing will allow statements of similar precision to be made about the mystery element proposed in human action. Observing the branches of trees and the movement of smoke, etc., enables one to say that there is a wind blowing, of such and such an average force on a pre-determined scale. The conditions (branches shaking, smoke moving, etc.) indicate the operation of a cause (the wind blowing) the intensity of which can be measured (Beaufort Scale force X). By the same token, it is assumed, observing 'subjects' making marks on a test paper enables one to say that an ability is at work 'within' the subject of such and such strength. The conditions (occurrence of 'right' or 'wrong' responses) indicate the operation of a cause (this or that ability) the strength of which can be measured (test score). Eysenck (in Suddaby, 1965), for example, arguing for the use of spatial tests in the selection of students for university science and technology courses, is quite explicit:

> The abilities we are measuring are very largely innate. There is very little that can be done through teaching to make any great difference in them ....
>
> (p. 29-30)
>
> .... selecting them (students) on the basis of verbal ability when what is really required is spatial ability is a very poor device for selecting the right sort of people to become scientists.
>
> (p.30)
>
> .... it might be worth while trading, say, a number of points of ability which are over and above the average against a few points of knowledge which are lacking.
>
> (p.33)

These remarks illustrate the way in which the notion of abilities is <u>used</u>. Eysenck is saying that abilities exist, are required for successful work in science and technology, and can be measured precisely enough for a few points to make a crucial difference to the careers of their possessors.

Some factorists may object that they do not propose causal relations, but it is hard to see what practical consequences follow from the description of valueless relations - description of relations entails constantly living in the future - and in any case, as I argued earlier, and demonstrate below, notions such as those of 'abilities' are almost invariably used in research in a 'Causal' way.

A typical example of the kind of research that I found when searching the literature on abilities is Lewis (1964). His report is introduced by the statement, "This investigation is concerned with an analysis of attainment in elementary science in terms of cognitive factors defined by psychological tests." Tests of attainment in physics, chemistry and biology, together with a battery of verbal, number and spatial tests, were administered to over three hundred pupils from three co-educational grammar schools in Belfast. These measures were then factor-analysed. The questions

to be answered were:
1) is attainment in physics, chemistry and biology linked together by a group factor over and above a general factor? and 2) to what extent does attainment in science, or in its separate branches, depend upon (a) verbal ability, (b) spatial ability, and (c) numerical ability?

Analysis of the results of testing produced a science group factor and verbal, spatial and numerical group factors. Attainment in science was found to be "dependent upon (a) the general factor, and (b) the scientific group factor." In addition attainment in physics "depends to some extent on the spatial factor," while "attainment in biology (for girls) depends to some extent on the verbal factor."

Discussing these results, Lewis comments, "What has been demonstrated conclusively; is that when the teaching of junior-form science is organised on a unified basis, a prominent scientific group factor exists, and can be isolated by factorial techniques, "and" .... a relatively superior, or inferior, attainment in physics could be (at least partially) an effect of the spatial factor. In the same way a noticeably different attainment in biology for girls might be explained by the verbal factor."

Lewis' research takes for granted the objective existence of certain mystery elements which can cause effects to happen, and it proceeds as though they are so powerful in the situation that other influences which might be proposed can be ignored. But the number of variables which might bear on the children's performances on science test papers is enormous. To mention a few, Lewis' subjects came from a variety of homes and had a variety of parents, relatives and friends. They were taught in groups, by a number of teachers each with different experiences of life, in three schools with particular head-teachers and their particular policies, maintained by a particular education authority. To take just these potential influences and their subdivisions into consideration, controlling and varying them systematically as the scientific model demands, would be impossible, as I found in my consideration of variables in the early stages of this study. The researcher following the scientific model has therefore to choose what he will regard as relevant for his purposes and to hope that sampling techniques will hold the rest constant. Allowing sampling to support this heavy responsibility means that any conclusions that are drawn from the research have to be hedged around with qualifications and limitations (although, as Lewis' remarks show, this is not always acknowledged).

What is more important, however, is that the hidden hypotheses in the research are not tested. Lewis set out to examine attainment in science "in terms of cognitive factors defined by psychological tests." He asks, "to what extent does attainment in science depend upon (a) verbal ability, (b) spatial ability, and (c) numerical ability?" The appearance of relationships of some kind can be guaranteed by the use of the tests, and all that is is question is the extent of dependency. The real hypothesis, that abilities exist in causal relation with other abilities, is not stated and can not be tested because the whole procedure circles around the unspoken acceptance that what is hypothetical is fact.

The research is presented on the confident assumption that everyone knows what abilities are and where, in principle, their effects may be found. This confidence is derived from the research tradition. Variables are usually chosen, as in Lewis' case, in the light of previous similar researches. The preliminary search of the literature demanded by the tradition makes it highly likely that explanatory notions will be preserved unchallenged and that there will be continuity of method.

This is unfortunate if only from the point of view of scientific procedure. Magee (1973, p. 24-25) gives an example to illustrate Popper's arguments on the refutation of conjectures. The hypothesis "Water boils at 100 degrees Centigrade" is refuted when tested by heating water in closed vessels. The hypothesis could then be modified, narrowing its empirical content, to "Water boils at 100 degrees Centigrade in open vessels." When tested at high altitudes this second hypothesis is refuted. The hypothesis could be modified again so that its empirical content is narrowed to

"Water boils at 100 degrees Centigrade in open vessels at sea-level atmospheric pressure." Systematic attempts to refute this third statement could then be made. But to proceed through a series of statements with vanishing empirical content misses the most important feature of the situation. When water was found not to boil at 100 degrees Centigrade in closed vessels there was the possibility of discovering a new problem, the question, "Why not?" This is a challenge to produce a hypothesis which explains both why water boils at 100 degrees Centigrade in open vessels and also why it does not in closed vessels. This second formulation would have not less empirical content than the first, but considerably more, and the systematic search for refutations of the second hypothesis would lead to further new problems rather than, as in the first procedure, an attempt to pin down ever more precisely knowledge about the boiling point of water.

By arranging their work so that it inevitably preserves their basic explanatory notions, researchers in education such as Lewis follow the first procedure described by Magee, rarely finding it necessary to ask, "Why not?" Where refuting instances do arise, they absorb them by various means - there was error in the reported observation, the measurement techniques were wrongly applied, the instance was outside the scope of the inquiry because it did not fit the hypothesis, etc. To quote Miles' (1957) footnote again, "Correlation co-efficients can be worked out between as many different abilities (or substrates) as we please; but no figures, whether high or low, can lead us to abandon a substrate which we are sure is helpful or accept one which we are sure is unhelpful."

The advice given by Burroughs on the interpretation of correlation co-efficients (shown on Page 187 of this Chapter) is interesting in this connection. Discussing a high correlation between two scores, he warns, "It (the high correlation) merely indicates that there is a relationship. The only occasion when causality might be inferred is when one of the variables is clearly the independent and the other clearly the dependent variable." To allow causality to be inferred on these terms is a fairly safe bet, since dependency is a causal relation. As the postulation of variables rests upon the researcher's preference in explanatory notions, Burroughs' advice illustrates how hypotheses in the style of research discussed here are operated rather than tested.

Returning to Lewis' study, a science teacher actually working in the schools concerned might, on reading the report, conclude that the research had shown that if you give science, verbal, spatial and numerical tests to a number of children and factor-analyse the results, you produce science, verbal, spatial and numerical factors. The teacher might note that he was asked to see some science scores as the 'effect' of particular factors, and that other science scores were to be 'explained by' other factors. He could be forgiven, nevertheless, for failing to see how the results furthered his teaching action, except that, if he were inclined to sort children into potential scientific sheep and goats, the results might reinforce his inclination.

Since the questions posed in this kind of inquiry are asked in terms of the mystery element, answers, where they are found, are in terms of the mystery element and not in terms of the performances, actions, of the people in the situation which was the stimulus for the inquiry. These answers lead to further questions about some aspect of the mystery element, leaving the situation unexplained. This creates an abstract problem for contemplation, about what to believe concerning the effects of the mystery element, but does not invite action in the actual situation thought to warrant investigation. There now seems to be a further problem to be investigated, and this serves to endorse and reinforce belief in the concreteness of the mystery element. Embedded a little deeper in 'the facts' of scientific research it is a little more removed from scrutiny, its reality a little more taken for granted, as the search for its effects moves on.

Apparent Halt in the Regress of Explanation: Classification and Background Knowledge.

Bridgman (1927) considered a crisis in the state of physics at that time, and suggested the point at which the reaching back for explanations of explanations actually stops in practice:

> Perhaps the climax of our task of interpreting and correlating nature is reached when we are able to find an explanation of phenomena; with the finding

> of the explanation we are inclined to feel that our understanding of the situation is complete. We now have to ask what is the nature of the explanation which we set as the goal of our efforts. The answer is not easy to give, and there may be a difference of opinion about it. We shall get the best answer to this .... by adopting the operational point of view, and examining what we do in giving an explanation. I believe that examination will show that the essence of an explanation consists in reducing a situation to elements with which we are so familiar that we accept them as a matter of course, so that our curiosity rests.
>
> (p.37)

He adds in a footnote, "The ultimate elements of explanation are analogous to the axioms of formal mathematics", and later (p.38), "The physicist .... requires that the familiar elements to which we reduce a situation be such that we can intuitively predict their behaviour".

Bridgman's account of explanation suggests that it is a process of "discovering familiar correlations between the phenomena of which the situation is composed". But there is a prior process. Before familiar correlations can be recognised the situation must be 'seen' to be composed of phenomena - things, entities. It is these entities which are familiar and the relations between them which seem self-evident. Are they 'discovered'?

Bridgman acknowledges this more 'primitive' process in a later section on the concept of identity:

> There can be no question that the concept of identity is a tool perfectly well adapted to deal approximately with nature in the region of our ordinary experience, but we have to ask a more serious question. Does not the apparent demand of our thinking apparatus to be furnished with discrete and identifiable things to think about impose a very essential restriction on any picture of the physical universe which we are able to form? We are continually surprising ourselves in the invention of discrete structure further and further down the scale of things, whose sole raison d'etre is to be found entirely within ourselves ......
>
> (p.91).

Another way of putting Bridgman's description of scientific explanation might be: the regress of explanations of explanations ends when we believe that we can analyse the situation to be explained into component parts. Since we have to know these parts beforehand (intuitively) they are familiar and we feel comfortable.

The process is one of classification based upon intuition and belief, and the skills are taxonomical.

To ask, What gives rise to intuitions and beliefs in science? leads to notions of 'background knowledge'.

Lakatos (1976) examines the nature of knowledge which is held to be 'axiomatic':

> In Euclid's time the word 'axiom' - like 'postulate' - meant a proposition in a critical dialogue (dialectic) put forward to be tested for consequences <u>without</u> being admitted as true by the discussion partner. It is the irony of history that its meaning was turned upside down. The peak of Euclid's authority was reached in the Age of Enlightenment. Clairaut urges his colleagues not to "obscure proofs and disgust readers by stating evident truths: Euclid did so in order to convince 'obstinate sophists'".
> Again, Newton's mechanics and theory of gravitation was put forward as a daring guess, which was ridiculed and called 'occult' by Leibnitz and Berkeley and suspected even by Newton himself. But a few decades later - in the absence of refutations - his axioms came to be taken as indubitably true. Suspicions were forgotten, critics branded 'eccentric' if not 'obscurantist'; some of his most doubtful assumptions came to be regarded as so trivial that textbooks never stated them. The debate - from Kant to Poincare - was no longer about the truth of Newtonian theory but about the nature of its certainty.
>
> (p.49).

Elsewhere Lakatos comments:

> Good textbooks in informal mathematics usually specify their shorthand, i.e. those lemmas, either true or false, which they regard as so trivial as not to be worth mentioning. The standard expression for this is, "We assume familiarity with lemmas of type X". The amount of assumed familiarity decreases as criticism turns background knowledge into knowledge .... One wonders when "the author confesses ignorance about the field X" will replace the authoritarian euphemism "the author assumes familiarity with the field X": surely only when it is recognised that knowledge has no foundations.
>
> (p.45).

Lakatos presents his argument in the form of a discussion between imaginary mathematicians and he characterises 'background knowledge' by making one of the participants comment, wryly, "Background knowledge is where we assume that we know everything but in fact know nothing".

It is from this background that Bridgman's 'familiar elements' arise which make a scientist's curiosity rest. If he can 'see' a situation so that it fits a theory, preferably one about which debate concerns 'the nature of its certainty', then he has explained the situation, until, that is, some disturbance in the background makes restructuring necessary.

Stability.

It would seem that all that a scientific explanation, causal, relational, genetic or otherwise, can offer is a sort of temporary freezing of motion, or equilibrium.

Polanyi (1958) discusses three aspects of this kind of stability, circularity, self-expansion and suppressed nucleation, using the traditions of an African community as illustration. The Azande rely upon a poison oracle. If the oracle answers "Yes" to a question, and then "No" to the same question, belief in the oracle is unshaken - the contradiction is because something, such as the wrong incantation or defective poison has been used in the process of consultation.

Polanyi argues that the stability of beliefs in the Azande tradition and in scientific systems alike is due in the first place to the fact that objections to beliefs can be met one by one:

> The power of a system of implicit beliefs to defeat objections one by one is due to the circularity of such systems. By this I mean that the convincing power possessed by the interpretation of any particular new topic in terms of such a conceptual framework is based on past applications of the same framework to a great number of other topics not now under consideration, while if any of these other topics were questioned now their interpretation in its turn would similarly rely for support on the interpretation of all the others.
>
> (p.288)

The second aspect of stability proposed by Polanyi

> .... arises from an automatic expansion of the circle in which an interpretive system operates. It readily supplies elaborations of the system which will cover almost any conceivable eventuality, however embarrassing this may appear at first sight. Scientific theories which possess this self-expanding capacity are sometimes described as epicyclical ....
> All major interpretive frameworks have an epicyclical structure which supplies a reserve of subsidiary explanations for difficult situations.
>
> (p.291).

The third aspect of stability is the way such systems deny to any rival conception the ground on which it might take root.* Polanyi sums up:

> Any contradiction between a particular scientific notion and the facts of experience will be explained by other scientific notions; there is a ready reserve of possible scientific hypotheses available to explain any conceivable event. Secured by its circularity and defended further by its epicyclic reserves, science may deny, or at least cast aside as of no scientific interest, whole ranges of experience which to the unscientific mind appear both massive and vital.
>
> (p.292).

Polanyi contends that scientific explanation, like all interpretation, depends upon "tacit assent and intellectual passions, the sharing of an idiom and of cultural heritage, affiliation to a like-minded community" and that no intelligence can operate outside what he calls a 'fiduciary framework' (Concise Oxford Dictionary: 'fiduciary' ..... (paper currency) depending for its value on public confidence ....)

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* Lakatos (1976) describes techniques used by mathematicians to preserve theories, such as dismissing counterexamples to a conjecture as pathological cases - monsters - and 'concept stretching' to accommodate counterexamples. One of his characters comments, ".... the power of the theory lies in its capacity to explain its refutations in the course of its growth".

Scientific Explanation and 'The Sciences of Man'.

Taylor (1971) refers to cyclic patterns of explanation and describes empiricist science as an attempt to reach a level of certainty which can only be attained by breaking beyond the circle of our own interpretations - to get beyond subjectivity:

> The attempt is to reconstruct knowledge in such a way that there is no need to make a final appeal to readings or judgements which cannot be checked further. That is why the basic building block of knowledge on this view is the impression, or sense datum, a unit of information which is not the deliverance of a judgement, which has by definition no element of reading or interpretation, which is a brute datum. The highest ambition would be to build our knowledge from such building blocks by judgements which could be anchored in a certainty beyond subjective intuition.

This, says Taylor, is what lies behind the ideal of verification, the detection of relations between 'brute data' by means of logical and mathematical inference, which would lead to inferences which are beyond the challenge of rival interpretation. Taylor is content to leave natural science to its own problems in this respect, but is concerned about the adoption of an empiricist epistemology in 'the sciences of man' (studies in which the actions of men and women are the subject matter). In the sciences of man, he says, the temptation has been overwhelming to launch lines of inquiry that fit the verification paradigm. This has led to the concentration upon features of human action which can supposedly be identified in abstraction from our understanding or not understanding experiential meaning. This is a mistake, Taylor argues, because, "We have to admit that intersubjective social reality has to be partly defined in terms of meaning; that meanings as subjective are not just in causal interaction with a social reality made up of brute data, but that as intersubjective they are constitutive of this reality".

Using examples from political science Taylor maintains that the institutions and practices of the 'bargaining culture' of Western civilisation are taken as starting points from which to understand the politics of all societies, with the result that theories of political development place the 'Atlantic-type polity' at the summit of human political achievement. This is because, in the search for brute data, political scientists give up trying to define further what are the practices and institutions of a bargaining culture and what the clusters of intersubjective meaning are which the practices and institutions require and hence sustain.

Taylor describes how ideas such as 'working' and 'the civilisation of labour' constitute a web of meanings and goes on:

> But of course such a massive fact doesn't escape notice. What happens rather is that it is re-interpreted. And what has generally happened is that the independent productive and negotiating society has been recognised by political science, but not as one structure of intersubjective meaning among others, rather as the inescapable background of social action as such. In this guise it no longer need be an object of study. Rather it retreats to the middle distance, where its general outline takes the role of universal framework, within which (it is hoped) actions and structures will be brute data identifiable, and this for any society at any time.

This leads to non-comprehension of situations which do not fit the grid:

> Mainstream social science .... will not recognise intersubjective meaning, and is forced to look at the central ones of our society as though they were the inescapable background of all political action. Breakdown is thus inexplicable in political terms; it is an outbreak of irrationality which must ultimately be explained by some form of psychological illness.

Taylor rejects the idea of 'brute data' and interpretations which can be scientifically verified in the sciences of man. He argues that interpretation is essential to explanation, and that a study of man's actions is inescapably 'hermeneutical' in that it must clarify meanings which are confused and incomplete, so that there can be agreement and a starting point for communication. Circularity is accepted as inevitable, and the aim of explanation is not certainty but freedom from illusion.

<u>A View of Educational Research</u>.

I think that the naive (and the not so naive) researcher unconsciously understands a search for a cause as taking the form of the question, "What is the truth of this matter?" In spite of the opening ritual of 'choosing a frame of reference' and the relativity that this implies, it seems to require the experience of perplexity to bring about the practical realisation that all that can be hoped for is a momentary coherance. And further, that there are no 'objective' means of deciding which of the ways of thinking about a situation that he is familiar with is nearer to 'truth' than another; and again, that to choose a way because 'it works in practice' merely reinforces the beliefs, and the practices which flow from them, that prevail at the time.

In education, and particularly in the field with which this present study is concerned, notions such as 'the structure of abilities', 'norms', 'stages of development', 'operational structures' and so on, are common. They have emerged from research in education, and, more often, from the generalisations of other disciplines, to form the fabric of thought of those concerned with education, a Popperian World 3 of intellectual objects. They form an inescapable background, the elements of which have become so familiar that "we accept them as a matter of course". The implications of the concepts which make up the background include the methodology by means of which the ideas were formed.

If educational research as generally practised is seen as an essentially scientific enterprise, committed to an ideal of verification and aspiring to scientific method, as discussed in this chapter, a study comes to be conceptualised in terms of the dominant theories of the 'background'. Hypotheses are derived from the theories and are operated rather than tested by the methods implied in them.

This process of reduction amounts to a situation in which the researcher, at the outset of inquiry, applies whatever taxonomical skills are available to him, classifying the process he wishes to study in order to identify a problem which can be solved by the application of a known range of methodological recipes.

Bartlett (1932) complained of this in psychology, without going in to why it might happen, when he commented tartly on

> .... the astonishing way in which many psychologists, even the most deservedly eminent, often appear to decide what are the characteristic marks of the process they set out to study, before ever they begin actually to study it.
>
> (p.311).

The result of this early commitment to a particular kind of explanation is premature closure. Curiosity rests, or is at least arrested.

But a study can not proceed in some way 'outside' the realm of our constructions and interpretations.

Craik (in Sherwood, 1966) states that a phenomenon is unexplained if it strikes us as totally unique - uncorrelated and incomparable with anything else in our experience.

Craik's stark situation is unlikely to occur in educational studies, if at all. Most situations which call for explanation are, like the one from which I started, of a milder kind where there is a discord: what we notice does not harmonise with our expectations.

If this is so, it follows that without our expectations we would not have noticed the phenomenon as difficulty.

A study, therefore, necessarily starts from a position where a direction of explanation is implied or prefigured in the way the discord is experienced.

Taking account of the elements of the 'inescapable background' which give rise to our expectations, however, as starting points in a circle of explanation and not as universal frameworks, allows the discord or difficulty to be examined before a problem is formulated.

It could be that the process would show that the difficulty disappears, or is radically changed in character.

It means that the researcher can not regard himself as a detached observer of the events that puzzle him, since he must consider right at the start what it is that makes him experience an event as disturbing and calling for explanation. This examination reveals that the researcher's problem can only exist within a theory, and that the theory is not tied to actuality except through the fact that he takes the theory for granted and acts as though his problem arises from the natural order of things. He is forced into a re-consideration of the categories habitually used to classify his experience. The fact that the researcher, personally, is led to see things from particular viewpoints, with particular limits to vision, becomes important. He is <u>part of</u> the problem he wishes to understand. He is therefore firmly placed at the centre of the study, his subjective view of how things should be as much a subject of study as the observations he has made.

I have used the idea of an 'inescapable background', referring to it as a 'web of intersubjective meaning' and a 'way of educational life'. By these terms I do not mean to convey just the idea of a consensus of opinions or attitudes, although this is part of it. I refer to a way of going about the business of education which involves speaking of notions like 'high ability children', 'low ability children', 'mixed ability classes', 'formal teaching styles', 'informal teachers', 'the short attention span of infants', 'research has shown', so that we think we know what we mean. In a sense we do, because we live out the meanings. Words and actions sustain each other. It would be difficult to tolerate the discipline of day-to-day educational life, as a teacher for example, if some such taken-for-granted meanings did not provide unspoken purposes and support for action. It is not that contradictions and confusions are not apparent, rather that they must be set aside as local difficulties if the general fabric is to be preserved. A recent newspaper report told of a visitor to a secondary school who was shown a fine sculpture in pride of place in the Head Teacher's room and told, "That was done by one of our least able children." For the inhabitants of this educational world the meanings are what the world is made of.

If Bertie Wooster realised that there was no real need for the turn-ups on his trouser bottoms the whole internally consistent Wodehousian world would be rendered unstable.

There is a hidden morality. It is right to have turn-ups; I ought to present an hypothesis in a proposed research outline; somebody of my age ought to be able to do this; decisions in the classroom ought to be made on the foundations of scientific research.

These 'oughts' are indicators of a circle in which hierarchical structures are supported by practices which are fulfilled in the structures.

CHAPTER SEVEN

The possibility of Inquiry into Action.

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The Possibility of Inquiry into Action.

In Chapter 6 I suggested that a researcher in education may appear to think carefully about which 'frame of reference' will provide the direction of his proposed study, and yet at the same time he may proceed as though his search is for 'truth', or at least for something which will contribute to its discovery. He may appear to say, "I propose to think about the world in one particular way chosen from among many ways, and looked at in this particular way there is a problem," but act as though he had said, "This is the way the world is, and there is a problem."

I also suggested that an inescapable background of shared meanings urges that the researcher should adopt the epistemology of empiricist science and aspire to its methods.

Child (1973, p.378) opens the concluding chapter of his book with comments which bear on this, at least in the field of psychology. He begins:

> The strongest tradition adopted by the majority of workers in the psychology of education is that which employs the methods and assumptions of the sciences.

Child acknowledges that there are difficulties:

> ..... the limitations imposed are such that answers to the kinds of questions of significance to practising teachers are not clear cut.

and that

> ..... some psychologists in education have questioned the suitability of scientific method in its purest form as the appropriate technique at this stage in our hazy knowledge of human behaviour.

Nevertheless, he goes on to argue

> ..... the alternatives of inspired (and uninspired) guesswork, speculation or teaching folk-lore are

> hardly likely to provide us with the foundations from which decisions in the classroom are made possible.

Having disposed of the unscientific, he adds, "Of course there are differences of approach even within the bounds of scientific method" and lists various types of scientific study.

As Child describes it, the situation is clear-cut; a choice between guesswork and speculation on one hand, and, on the other, the application of scientific method to obtain knowledge which is not based upon guesswork and speculation. Choice of the second option, on these terms, is irresistible, although scientific method, at present, has limitations which lead to some dissatisfaction with the results of research among practising teachers who wish to be guided by these results. The limitations on scientific research are imposed "at this stage" by the incompleteness of what has been revealed up to now.

Child's argument illustrates why a researcher may appear to take into account the fact that his inquiry will be informed by a particular frame of reference from among many, and yet proceed as though he were searching for 'the truth'.

Behind the physical science model of research into human action is the idea of a determinate world governed by laws which will gradually be revealed if researchers are patient and skilful enough. This lawful world of human action can be apprehended through science, which, although in its infancy in the field of human action at present, will eventually provide the keys to understanding and control. It is necessary to choose a frame of reference - but from a range which excludes the unscientific, because ways of proceeding which are not 'scientific' (i.e. do not measure, predict and verify) will not lead to ..... the truth? For Child, the world is determinate and its governing laws await discovery. Choosing a frame of reference from which to conduct research in education amounts to deciding upon method within the empiricist paradigm.

In Chapter 6 I described the line of argument which loosened the hold of this powerful, if unarticulated, belief. If knowledge generally has, as Polanyi described it, a fiduciary basis, then perhaps the scientific investigation of educational phenomena is built on fundamentals which rely as much on guesswork and speculation as do those of the 'unscientific'. I argued that expectations define problems and that if a researcher traces the reasons why he held the expectations he finds that research is personal and subjective, and, because problems emerge from the 'Weltanschauung' of the community to which he belongs, intersubjective. It is, then, the 'world view' in which the researcher is immersed that comes into question.

Macmurray (1957) challenges the general conception of the world which I have represented by Child's comments on psychological research in education. Macmurray argues for a radical shift away from the traditional belief, in philosophy, in the primacy of thought, which has led, he says, to "an attitude of misplaced reverence for Nature as the Lawgiver, which echoes an ancient worship; and (invests) the professional scientist with magical powers for the salvation of the world" (p.154).

Macmurray adopts the standpoint of the Agent rather than that of the Thinker of traditional philosophical theory; the 'I do' (the fact that there is action) is the primary certainty. This point of view is practical rather than theoretical and the distinguishable elements in experience are activities, not objects: while for primary awareness (knowledge in action) they are changes. Macmurray classifies all changes as 'acts' or 'events'; either they are 'doings' or they are 'happenings', and what 'happens' is the negative aspect* of what 'is done'.

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* Macmurray's notion of the negative aspect of action is perhaps best illustrated by his description of an experimental situation: "To determine the law which governs the movement of the pendulum, I erect a pendulum, and I set it swinging. Then I begin to take the measurements I need. But during the experiment I do not interfere with its motion. My practical concern is to keep the conditions constant throughout - to prevent interference. When I have made all the measurements I require, I stop the pendulum, and I sit down to study the measurements I have noted. The whole experiment is an action of mine: I <u>do</u> the experiment. But the pattern of movement I observe and the law that I elicit, refer only to what happens <u>within</u> my action. I leave out of account my starting the pendulum when I begin and my stopping it when I have finished. The law of the particular instance refers to what happens between these points; to that aspect of my doing the experiment which I do not <u>do</u>; that is to say, the negative aspect of my action".

To call any apprehended change an 'act' is implicitly to refer it to an agent as its source. To call it an 'event' is implicitly to refer it to a non-agent - for an event there is a cause, for an act there is a reason. The explanation of an event is the discovery of the cause which produced it and the explanation of an act is the discovery of the reason for its performance.

Macmurray defines action as activity informed by knowledge. Action is, in principle, indeterminate because an agent can always change his mind. Since the ends determined in action are also starting points of further action, an agent never knows with full finality 'what he is doing'.

An event is a change which cannot be referred to an agent as its source. The idea of an event, Macmurray argues, is the idea of an action from which the element of knowledge has been excluded. A 'cause' is a source of occurrences which is a non-agent, an existent which is other than an agent.

The conception of 'cause' is therefore inherently self-contradictory - it is the conception of an agent that is not an agent.

This leads to the negative aspect of agency being thought of as existing independently of the positive - the non-existent is thought of as existing - and the difficulties of any theory of causation (such as, presumably, those discussed in Chapter 6 of this study) arise from this contradiction. The conception of cause both includes and excludes the idea of the 'production' of an effect. In consequence, whatever we assign as the cause of an event is something that is not in itself capable of producing an effect, but only, as it were, of transmitting it.

Macmurray points out that when the use of the notion of cause falls within action and so has a practical reference, it is meaningful and indispensable. It refers to a negative activity which falls within the positive activity of an actual agent. A breakdown in a machine used by an agent, for example, leads to a search for the cause of the breakdown, a practical matter of finding what must be altered by the agent in order to restore his capacity to act through the machine.

In the case of purely theoretical construction, Macmurray continues, the idea of an existing non-existent is a source of embarrassment, and in scientific theory the idea of cause is replaced by the idea of natural law. Instead of inquiring for the cause of an event we ask for a law in accordance with which it happens. The notion of natural law rests upon the concept of what Macmurray calls continuance in the 'Other' (that which is not the agent). The concept is of the 'Other' as non-agent in process.

Macmurray describes a law of Nature as a pattern of continuance, and the discovery of such laws is the discovery of such patterns in our experience of the 'Other'. To say of any group of phenomena that it obeys a law is to assert that it contains a pattern of change which recurs without change. To say that Nature in general obeys laws, or that all phenomena occur in accordance with laws, is to assert that Nature is the Continuant, a pattern of change that recurs without change - the non-agent in temporal existence.

Macmurray outlines the consequences of such a view. The development of practical discrimination of the world, through reflection, into scientific understanding of Nature depends upon the isolation of recurrent patterns. This results in conclusions being liable to endless revision; an element of idealisation is always present. In a scientific inquiry phenomena may be isolated in accordance with some principle of relevance, so that the elements excluded are negligible for the inquirer's purposes, but this must produce an ideal case which is never fully actual. Laws established in this way, and predictions derived from them, are based on an ideal isolation from the actual complexity of conditions to which they refer and in which they must be realised. Predictions must therefore always be made with the qualification, expressed or understood, "provided nothing interferes". They depend on an abstraction from the presence of agents with their capacity to determine the future. A world in which there is no action must be postulated, and such a world is itself an ideal isolate, a world in which there are no persons.

This can never be the actual world in which we operate, says Macmurray, for the process of determining patterns of recurrence is itself a personal activity which requires experiment, and an experiment is itself a deliberate personal interference with the processes which are observed. The world in which the 'Thinker' arrives, therefore, is an imaginary world:

> What we call the physical world is, therefore, in all strictness, an imaginary world. Even in conception, it is the world which we know, of which we are part and in which we act imagined as existing without ourselves or any other agents whatsoever in it; a world in which there is no action.
>
> (p.159).

Science keeps within this world of events by barring questions which involve a reference to agency:

> ..... the substitution of the idea of law for the idea of cause in science does not solve the causal dilemma. It excludes it from consideration by avoiding the question which requires a causal answer. If I observe a process of change I can seek to discover a recurrent pattern in it and so to determine a law of continuance. In doing this, however, I refrain from asking another question, 'What set the process going in the first instance?' This is, of course, the question, 'What is the cause of the process?' and it is not a senseless question, unless we are prepared to deny that the process ever had a beginning ....
> The replacement of the notion of 'cause' by that of 'law' ..... defines a different mode of abstraction or isolation within which the question of a cause does not arise.
>
> (p.p. 163-4).

The scientist abstracts from action - his own action in observing and making experiments - and so constitutes an ideal world which is purely continuant. He is justified in saying that the laws of Nature hold of the actual world, but only, Macmurray insists, <u>in so far as it is a continuant</u>.

Macmurray's argument concerning science in general has particular force when it is brought to bear on attempts to explain scientifically what people do. In this case, he says, continuance appears as habitual activity. Habit is the negative aspect of action without which the action could not take place. If a psychologist, as scientist, abstracts from action and considers only those aspects of personal behaviour constituted by habit he can then study the activities of the persons <u>as if</u> they were purely continuant. Experiments can be made in which normal persons will agree to behave in accordance with instructions and not for their own ends and on their own initiative. In this way the psychologist can isolate, under laboratory conditions, those aspects of human behaviour which would normally be habitual responses within deliberate action, and seek to determine psychological laws. The psychologist encounters greater difficulties than the natural scientist. Patterns of behaviour are much more complex; experiments are more difficult to arrange; the number of instances is far less so that reliability of generalisation, even through the use of statistical methods, is greatly diminished. Above all, the probability of interference is very much higher. Nevertheless, the knowledge obtained can be used, as in physics or biology, for deliberate control, in this case of human behaviour. Verification of the laws can be obtained through this control. But in doing this the psychologist creates an ideal continuant world, imagined as existing without agents or action - a denial of his own purposes in 'doing science'.

Macmurray, then, presents a number of propositions which point towards an approach to attempts at understanding situations involving people which is different from that advocated by Child. The deliberate 'doings' of persons are the context for processes that 'happen'. Those aspects of the world which are determinate, in which 'laws' are discoverable, are timeless idealisations taken, so to speak, out of context. The actions of people, on the other hand, take place in time and look forward to a future. This future is indeterminate, because people, as agents, can change their minds - 'man' can be seen in large part as self-determining, choosing between different possible futures. Understanding what people do is necessarily concerned with intentions, reasons, purposes and is not primarily a matter of 'causes', which can only operate in the limited, negative field of things that merely happen.

Shotter (1970; 1975; 1976) has proposed this change of view in psychology:

> Many psychologists argue that (psychology's) goal must be to specify certain scientific laws of behaviour. But the process of arriving at scientific laws involves just the very psychological processes that we are trying to explain by them ..... Scientific laws refer not to actual situations but to abstractions; people deal with both, deriving as far as we can tell, the latter from the former. Just what reasonable grounds are there for hoping that we can turn round the consequences of such a process to give an account of its operation? ...... with living things we cannot idealise them as being independent of their context of existence as we can with non-living things.
>
> (1970)

> The truth about people, about human nature .... is not something that is awaiting discover, ready made, like something under a stone on the beach; it can only be made by people in dialogue, as the product of a social act, in continual interrogation and reply.
>
> (1975; p.135).

Rather than an empirical science of behaviour, Shotter urges, psychology should become a moral science of action, concerned not with discovering the order and structure of things 'outside' ourselves, but with the order and structure of things 'inside' ourselves, in the shared meanings and understandings by which we live our lives. Rather than prediction and control, psychology should seek to understand more clearly what we are and the situation we occupy.

People can not be reduced to mechanisms or organisms, Shotter maintains, although they may contain both. Man lives not directly in nature but in a culture in nature, and his form of living is that of the personal. A Man's culture is not to be characterised in terms of objective properties but in terms of shared beliefs and purposes.

> People, then, must be treated not like organisms dealing directly with nature, but as rather special organic forms which deal with nature from known 'positions' within a culture, in terms of a knowledge of the part their action plays in relation to the part played by other people's actions in maintaining or progressing the culture.
>
> (1976; p.14).

Shotter indicates the kind of inquiry that follows from his view of psychology. Actions must be understood as attempts to realise intentions in a way that conforms to standards or criteria shared by all those within the community of the agent.

> In terms only of observational criteria, people do not differ from organisms and the rest of what there is in nature. But indirectly, people demonstrate that they act in the knowledge of who and what they are, and what they are trying to do, by the way in which they respond to the consequences of their own actions. It is in terms of what it implies for future action (and reaction) that the knowledge informing people's actions is revealed - often, for instance, in the surprise they manifest when the result is not the one they expected. Thus, in our attempts to make sense of people's actions, we must be prepared to theorise about the concepts that people might hold, and to test our theories, not as we would test the logical deductions from a natural scientific theory, but by seeing whether the implications of holding a certain concept are realised in a person's behaviour.
>
> (1976; p.14).

I believe that the arguments above provide an adequate philosophical basis and a hint of possible procedures for the conduct of educational inquiries which would have at least the merit of concentrating attention upon the situation of the people concerned.

Educational issues are primarily about what human beings do 'on purpose' and only secondarily about what merely 'happens'. In trying to understand these issues we should be concerned with the reasons people have for acting as they do. If this is so, purposive explanations may help understanding in ways that the various forms of 'scientific' explanation can not. A search for such explanations would be concerned with the beliefs, intentions and reasons held by the agents concerned, and would relate them to what the agents thought would be the consequences of alternative courses of action open to them. These are the kinds of consideration taken into account in making judgements in everyday life, and indeed are thought to be adequate basis for reasoning in courts of law, where judgements of the utmost practical importance to individuals and communities are made.

In the situation which gave rise to this study, it seemed that students were getting little benefit from their work on Piaget and Intellectual Development. Belief in the need to search for an explanation based in the 'scientific' tradition led to questions of the kind, What is the cause of this effect? What theories of learning/development/behaviour account for this? These questions diverted attention away from the actual situation of the people concerned and focussed it instead on theories.

Following Macmurray and Shotter, inquiry would start instead from a different question, What is the position of students and tutors as agents in this matter? The primary aim of inquiry would be to understand the agents' attempts to realise their intentions within the 'shared meanings' of the lecture-reading-essay-grading system. An indication of some of the areas to be clarified emerged during work on the psychology test (p. 45), for example, the time and effort that a student was willing - and for which she had the opportunity - to spend on particular requirements; the form of the information that she was required to make sense of; the purposes of tutors in presenting the information and in specifying what was required of students.

An assumption would be that the people concerned were not isolated, but part of each other's actions, in what Bateson (1972; 1979) calls 'mental systems':

> The boundaries of the individual, if real at all will be, not spatial boundaries, but something more like the sacks that represent <u>sets</u> in set theoretical diagrams, or the bubbles that come out of the mouths of the characters in com ic strips.
>
> (1979; p.132)

> What about "me"? Suppose I am a blind man and I use a stick. Where do "I" start? Is my mental system bounded at the handle of the stick? ... my skin? .... half way up the stick? These are nonsense questions. The stick is a pathway along which transforms of difference are being transmitted. The way to delineate the system is to draw the limiting line in such a way that you do not cut any of these pathways in ways which leave things inexplicable. If what you are trying to explain is a given piece of

> behaviour, such as the locomotion of the blind man, then, for this purpose, you will need the street, the stick, the man; the street, the stick, the man and so on, round and round.
>
> (1972; p.465)

It seems clear that to set out to be an 'observer' would be an inappropriate standpoint for interpretation. I learned the limitations of the standpoint of 'observer' in a study reported in my M.A. dissertation (Bury, 1979). This study arose from a question put to me about Piagetian 'formal operational structures'. I was asked what was to be understood by this term. The question was troublesome because, although it was fairly easy to summarise Piaget, I felt that I ought to be able to give an ostensive definition, outside a to-ing and fro-ing between Piagetian terms.

It was not easy to point to someone's action and to say that it was a typical manifestation of the operation of formal operational structures. I began to search for examples of human action in the 'real world' of day-to-day living which could, on analysis, be said to depend upon formal operations.

My son is a professional arborist. I had seen him fell large trees in confined spaces so that the mass of timber fell exactly where he intended and predicted that it would. In solving the problem of how to make a tree fall in the desired way, the feller has to prepare the tree, making cuts and gaps in the trunk, changing the tree's total state, until, at an all-or-nothing point, the tree becomes unbalanced and falls, testing the hypotheses the feller has made about the effects of his preparations. This is a special kind of problem solving, because, unlike, say, a sheep-dog, who herds a flock of sheep into a pen by successive approximation, or a carpenter who joins pieces of wood by shaping-testing-adjusting, the feller must make predictions by means of his actions and submit them to a drastic test which permits no adjustment or correction.

It seemed to me that this kind of performance, dealing as it apparently does in judgements and propositions, was worth studying with the idea of formal operational structures in mind.

It soon became clear that the question of how to understand, get at, what was involved was a difficult one.

My son is articulate and takes readily to analytical thought.

He described in detail the sequence of actions taken during felling, enumerated the factors to be taken into account, and ended by saying, "But it's not as simple as that. It depends on the tree."

Close observation of felling confirmed that the wholeness of the sequence of acts defied operational description. In the end I found no other way to get at what a tree feller knows (the knowledge that informs his action) than to fell trees myself, which was a form of introspection.

The idea of the necessity of considering the whole exchange between an individual and whatever else formed part of his action was developed to some extent in the tree felling study. Somehow the inquirer must get himself within the circle if he is to begin to understand relations between the elements of the interaction. The elements can not be considered as entities in themselves. They are given their significance or meaning by their function in the system, rather than by any formal qualities they may have when thought of as being in isolation from one another. The actions of the tree feller, the cuts he makes in the wood, the wedges and cables he uses and the forces he exerts, can all be described separately, objectively and operationally, in terms borrowed from physics and engineering, but their value is derived from the whole action, which is beyond this kind of description.

Similarly, the elements making up a particular piece of teacher-training practice would need to be conceived in their relation to a whole, in Bateson's terms the system delineated so that 'pathways' are not cut in ways which leave things inexplicable. Since the psychology essay system operated simultaneously with other similar systems and students themselves were the essential synchronising or synthesising agents, it would not be inconceivable for such 'mental systems' to include, as negative aspects, quasi-autonomous recursive systems with circular trains of cause and effect and conservative characteristics; so that, for example, students could hold certain beliefs and intentions about what it is to teach and how one becomes a teacher, while at the same time agreeing to become part of a cause-effect recursive system which appears to them to have little bearing on what they believe and intend.

To interpret the intersubjective meanings which were the context for such systems would entail entering into dialogue, as distinct from interrogation, with the agents concerned. Obvious forms of dialogue are conversations with individuals and groups, but, as in the 'dialogue' between the tree-feller and the tree, within the system - the interpreter would need to take part as teacher, and, as far as possible, student.

It seems likely that in such an inquiry the difficulties students found in understanding the content of Piagetian experiments would appear in a somewhat different light. Fitted against a theoretical order of development the difficulties appear in some way pathological; inexplicable in terms of the 'proper' sequence, and significant not for what they might be in themselves but for what they might stand for or portend (although teachers of younger children may be interested in the kind of explanations that adults can offer of 'everyday phenomena'). Seen as part of the dialogue between teacher and taught (rather than between 'subject' and 'objective observer') the difficulties raise a more practical question, What shall we do about these difficulties? Given that the inquiry has led to the belief that it is worth while to require students to understand Piaget's work (which is not necessarily so)* the problem is an educational one, What kind of help do students need in order to grasp the notions involved? This question can not be answered by reference to Piagetian theory but only by actually devising and using some means of helping. The change of stance does not, of course, get rid of theory, which is pre-supposed in the devising of means, but the theorising involved would be based upon what emerged from the transactions between actual people rather than upon unembodied norms.

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* Or that, since the idealised worlds of scientific explanation are an important part of our culture, they should be at least broadly accessible to teachers.

Two incidents during the course of the study are of interest in this respect. In conversation about the responses of students to Item 14 (shadows) of the 'Everyday Phenomena' test, Tutor E asked me to describe the shape of a shadow cast on the ground by a rectangular wooden board suspended horizontally above the ground, with a light shining from a point above and to the side of the board, and what would happen if the board was moved laterally a few feet away from the light. I immediately thought of the beam of light thrown by an overhead projector pointing slightly upwards and shining against a wall, and began, "It would be slightly tapezoid ...." Tutor E pointed out that the shadow would be rectangular, and added that he had asked a number of people the same question with similar results.

In another conversation about Item 9 (bicycle) Tutor E put the question to me: "If you just hold an ordinary bike - without getting on it - so that the pedal is at the bottom, and you push the pedal backwards, what would happen?" I said that the rear wheel would skid round because the weight of the cycle would not provide enough friction between the rear tyre and the road for forward movement of the whole machine. He said that the cycle would move backwards, and that he had asked a number of people all of whom had said that the machine would move forwards. It took some moments for me to agree that the movement would, in fact, be backwards, and I was not absolutely convinced until I had tried out the exercise in practice. I asked the same question of a number of young men who had been, not many years previously, expert in all matters to do with cycles and are now sophisticated mechanics, one or two of them professionals. All said that the cycle would move forwards.

These two instances illustrate how easy it is for adults to continue to use a generalisation for prediction and explanation which is adequate in a particular situation but is inadequate when, although the situation still appears familiar, the conditions are changed. The changed conditions represent not just a few complications in the old problem but a new problem, and it is the disarming impression of familiarity which obscures this transformation.

Thus 'misconceptions of everyday phenomena' may involve drawing conclusions which are fully logical on the basis of one's previous experience of apparently similar situations, and are only illogical when the situation is recognised as new.

Increased understanding of the situation depends upon meeting refutations of one's expectations and the subsequent modification of the expectations - what applies in the case of shadows cast by 'vertical objects', for example, does not apply to those cast by 'flat horizontal objects', and what applies in the case of mounted bicycles does not apply in the case of unmounted bicycles. There is, of course, a further part of understanding, finding out what does apply in the situation now seen as new, and this involves the construction of a new generalisation, that is, looking for regularities and experimenting.

From the standpoint of Piagetian theory this raises the question of what it is that enables the person to see the situation as new and to construct a new generalisation. 'Seeing the situation as new' would presuppose the availability of the necessary logical structures 'within' the person, and would be part of the process of equilibration.

From the educational point of view, however, the question of the level of hypothetical intellectual structures that may or may not be operating is less pressing than the rather obvious proposition that a greater experience of shadows and bicycles is likely to produce more opportunities for the refuting of expectations of what shadows and bicycles do in varied circumstances.

It would seem that adults, when dealing with unfamiliar situations or with new aspects of otherwise familiar situations, may well proceed in much the same way as children do. If this is so, the qualitative differences proposed by Piagetian theory between stages of development may be much more situation-specific than is claimed by the theory. Children have to contend with more new situations than adults.

If Piagetian experiments or tests, as indicators based on performances in a particular set of contexts, suggest that a certain level of intellectual development has been achieved, this may not be a strong reason for expecting that the cognitive structures presumed to characterise this level of development will be brought to bear in dealing with another, novel, set of contexts without considerable help from 'outside'. This puts the emphasis firmly upon teaching, and less on an inexorable progress through stages, and the primary task in teaching is helping the learner to find something in a particular phenomenon which calls for explanation.

The outcome of the inquiry would be an avowedly personal interpretation of a particular situation with no claims to tie it, through objective laws, to other situations which may be different in all sorts of ways. Description and interpretation of action may, however, awaken the same intuitions in others. Those who see their own circumstances as similar will agree (or not) about the interpretation, and in this agreeing lies the 'degree of generalisation' of the outcome.

Brookes (1977) describes the unstable character of situations in education which become the subjects of research, and develops an argument for interpretative inquiry. He sums up the outcome of research; " .... hermeneutical inquiry is offered to the reader for interpreting in terms of the problem faced by that reader."

In this study I have described my experience of a local difficulty in teacher education in the context of attempts to make sense of it. The study has been its own subject. The main points may be summarized as follows:

1) A group of women student teachers were given a paper-and-pencil test based on well-known Piagetian 'experiments'. The test was intended to indicate whether students had the basic general knowledge necessary for a ready understanding of the Piagetian problems. Reactions to the test suggested that some students' grasp of the ideas involved was insecure. Reactions to items dealing with primitive notions such as shadows suggested that some students used 'pre-operative' reasoning in these areas. A study of Piaget's work as part of initial teacher-training may be difficult for these students.

2) The nature of a traditional lecture-reading-essay system may also have made an adequate study of Piaget's work difficult.

3) Use of psychometric tests of abilities led to the opinion that studies based in the psychometric tradition have a circular, self-confirming form and that their methods divert attention from the people involved in the situation being studied to

abstractions. The psychometric system is descriptive and its work is preparatory. Use of its findings as explanatory notions is misleading.

4) Use of Piagetian theory as an explanatory notion led to the opinion that the system is circular: process explains product and product explains process. Exceptions to an order of development are inexplicable within the system.

From the above the following argument developed:

5) The dominant mode of educational research adopts a 'scientific' stance, that is, one which assumes a realm of objective, predetermined order in human action which may be discovered, albeit in glimpses of fragments, through measurement, classification, prediction and verification. Inquiry is valid if the methods used allow an observer to be independent of his own wishes, desires and prejudices and of those of the people he studies (even on the occasions when he studies the wishes and desires of his 'subjects', who together with their wishes and desires, are to be seen as 'objects').

6) Expectations define problems. Expectations arise from internalised explanatory systems, that is, from those systems which have shaped an unquestioned way of educational life. The explanatory systems are derived from previous research and practice in the same tradition.

7) Research is personal since it is a discord in the researcher's experience which constitutes a problem. His wishes, desires and prejudices are the independent variable in the problem he studies.

8) A researcher in the 'scientific' tradition may be unaware that methodological principles hide a metaphysical view, because the background of intersubjective meaning against which he moves demands 'objectivity' as its legitimatising principle. Choice of mode becomes choice of method within a determinist world-view.

9) Human action may not be susceptible to explanation in terms of cause and effect (although behaviour may). There is a valid form of inquiry which interprets purposes and the meanings that situations have for participants in them. This form of inquiry deals with a range of human experience inaccessible to objective quantitative measurement, prediction and verification.

I quoted Wittgenstein in the Introduction to the green pages and pointed to the paradoxical "Catch 22" nature of "finding the road from error".

Bateson (1979) used an electrical circuit as a model to illustrate how, when sequences of cause and effect become circular or more complex than circular, description of the sequences in logical terms becomes self-contradictory. An electrode is connected by a wire to an electromagnet, and an armature extends from the electromagnet to meet the electrode at a point A. Current will pass around the circuit when the armature makes contact with the electrode at A. But the passage of current activates the electromagnet, drawing the armature away from the electrode, breaking the contact and switching off the current. Without the current the elctromagnet becomes inactive, the armature returns to make contact at A, and the cycle continues.

If this cycle is spelled out in a causal sequence, it becomes:

> If contact is made at A, then the magnet is activated.
> If the magnet is activated, then contact at A is broken.
> If contact at A is broken, then the magnet is inactivated.
> If the magnet is inactivated, then contact is made at A.

If the 'if-then' junctures are moved over into the 'if-then' of logic, a contradiction is produced:

> If contact is made, then contact is broken.
> If p, then not p.

Bateson points out that the 'if-then' of causality contains time, but logic is timeless.

Wittgendtein's 'circuit' contains time, and it also contains the possibility of intervention, although "telling" will not help: "*We* must find the road..." Intervention depends upon processes of interpersonal perception similar to those described by Laing et al (1966). In the case of student researcher and supervisor each must interpret what the other offers, and this account of a research project shows, at the points of interpretation, the possibilities for twists, at the time imperceptible, into Laingian knots.

To intervene in the sense suggested by Wittgenstein's comment, the supervisor will interpret to the student what the student offers, not by 'telling', but by some means prompting an adequate depiction of the student's situation. This situation may be full of contradiction, but if the depiction is adequate, it provides a coherence between the actions of the student and the meaning of the situation for him. This dialectic process of transforming contradictory experience into momentary stable structures may be, at times, uncomfortable for the student. From the supervisor it demands empathy and the capacity to step away from the 'dominant background', to hold different paradigms in mind and know the approximate consequences of their use.

It could be that the procedures of application for research degree registration make this difficult. Normally the candidate presents an outline of his proposed study to a university. The outline usually contains a statement of the problem, some form of hypothesis and an indication of the course of action proposed. The embryo study can then be said, by those who have to make judgements about it, to be of this or that type, within this or that discipline. It can be handed over to members of staff who are interested in that particular kind of subject matter and method, for discussion with the candidate and, if accepted, for supervision.

Before a candidate who starts from puzzlement about a situation can write an outline for submission he must find questions to ask about the situation and formalize these questions in a statement of a problem, that is, classify the situation. The difficulty is this; the crucial point in a research study which starts from a genuine perplexity is in gaining insight into the nature of the perplexity in order to know what kind of question to ask and hence what kind of problem to construct. Yet in the unaided writing of the outline, explanation has already crystallized. In classifying the situation that seems to him to warrant study, the candidate commits himself prematurely to a particular kind of inquiry, and this commitment is reinforced when his pre-shaped explanation is received by someone chosen because the explanation is in his field.

In these circumstances there is a danger that what I have called intervention may not take place. The student may merely exercise within the circle that produced his problem. If, as I suggested through Polanyi in the main Introduction, it is important for research to examine structures and practices rather than to confirm them, this outcome is unfortunate.

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APPENDICES

LIST OF APPENDICES

APPENDIX I

Students' Ages on Entry to College, and

Number of G.C.E. Passes.

APPENDIX I

Students' Ages on Entry to College, and Number of G.C.E. Passes.

'O' level passes are at Grade C or above. A small number of C.S.E. passes at Grade 1 are included as G.C.E. 'O' Level passes. Members of discussion groups are shown by an asterisk.

Student Identification Number	Age in years on entry to college.	Number of G.C.E. Subjects passed. 'O' Level	'A' Level
1	19.00	5	1
2	21.25	3	1
3	20.50	6	
*4	18.42	5	3
5	18.42	6	
6	18.33	4	2
7	19.75	7	1
8	18.58	5	
9	18.42	6	3
10	18.42	4	3
11	18.83	3	2
12	18.75	5	
13	19.00	8	
14	19.25	5	
15	18.25	6	
16	19.00	8	3
*17	18.83	5	1
*18	19.67	5	
19	18.17	6	2

Number	Age	'O'	'A'
*20	19.00	7	3
21	19.00	8	2
*22	24.00	4	1
*23	20.75	6	3
24	18.67	4	2
25	19.75	4	1
26	19.50	4	2
27	18.25	5	1
28	18.75	8	3
29	19.42	5	
30	19.83	4	3
*31	19.08	3	1
32	23.33	6	
33	19.08	3	1
34	18.75	3	2
*35	18.67	4	
*36	18.58	6	
*37	20.25	5	
38	18.75	4	1
39	18.58	5	1
*40	19.58	4	1
*41	18.33	3	2
42	18.50	4	1
43	23.00	5	
*44	18.33	4	2
45	22.50	6	
46	18.50	4	
*47	18.25	6	
48	20.50	4	2
*49	18.17	5	
*50	18.92	4	
*51	18.42	7	
52	18.50	4	2
53	19.83	5	
54	18.17	4	1
*55	18.17	5	2

Number	Age	'O'	'A'
56	19.25	5	2
57	18.58	6	
58	18.50	5	1
59	18.25	5	2
60	18.25	3	2
61	18.08	6	2
*62	20.83	4	1
63	18.42	4	1
64	18.75	5	
65	32.08	6	
66	19.50	5	
67	18.17	5	
68	19.00	5	2
*69	18.17	6	
*70	18.08	6	2
*71	18.67	6	3
*72	18.33	5	3
73	18.58	5	
74	19.00	4	1
75	18.50	4	1
76	20.00	3	1
77	22.83	4	1
78	18.17	5	4
*79	18.08	6	3
*80	18.75	3	3
81	20.17	5	
82	18.33	4	1
83	18.17	4	2
84	18.50	5	1
85	18.75	9	3
86	19.00	3	2
87	18.83	7	2
88	19.75	4	2
89	19.08	5	
*90	20.17	6	

Number	Age	'O'	'A'
91	18.42	3	2
92	19.92	5	
*93	18.92	4	3
94	18.58	9	
95	18.67	4	1
96	19.92	5	2
97	20.33	4	
98	18.75	6	3
99	18.58	5	
100	19.25	4	1
*101	19.50	5	
102	18.25	5	1
103	18.17	6	2
104	19.92	5	2
105	18.25	4	1
*106	19.17	4	
107	18.33	5	
108	20.67	6	
109	18.75	5	2
110	18.75	4	1
*111	18.33	5	
112	18.33	5	
113	18.67	4	1
114	19.42	3	1
*115	18.75	4	3

APPENDIX II

<u>The 'Cluster 3' Psychology Test and Answering Sheet.</u>

APPENDIX II

The 'Cluster 3' Psychology Test and Answering Sheet.

COPY

PSYCHOLOGY

LEARNING AND CONCEPT DEVELOPMENT

In this test you are asked to think about the work you have done on Learning and Concept Development. No 'written answers' are needed. Answers are recorded by putting a ring round letters on your separate Answer Sheet.

PLEASE DO NOT WRITE ANYTHING

ON THIS TEST BOOKLET

1. A teacher tells her five-year-old pupils that they are to have a 'red corner' (a display of red objects). Which of the following would be most likely to help the children to put limits on their concepts of 'red'?

   (A) The teacher arranges a collection of objects, ensuring a good, attractive standard of display.

   (B) The children bring the objects and arrange their own display.

   (c) The children bring objects specified by the teacher and arrange their own display.

   (D) The teacher sets up a display and allows children to add suitable objects after class discussion.

---

2. A child enters a classroom noisily. If you wish to end this pattern of behaviour by 'extinction', which of the following courses of action would you choose?

   (A) Send the child out again and make him enter quietly.

   (B) Ignore his entrance.

   (C) Punish him.

   (D) Explain that he is causing a disturbance and ask him not to do it again.

   (E) Refuse to admit him until he enters quietly.

---

3. According to Piaget, thought has its origins in -

   (A) Words

   (B) Socialisation

   (C) Growth

   (D) Habit

   (E) Action

---

4. A child learns that the written words <u>ball</u> and <u>tall</u> refer to two different spoken words. Which item from the list below best describes the process?

   (A) Whole learning

   (B) Trial and error learning

   (C) Semantic differential

   (D) Stimulus discrimination

---

5. You are a Head Teacher. One of your staff comes to school every day looking grubby and unkemp. You would like him to come to school looking smart and clean. Using principles derived from B.F. Skinner's work, what would you do to modify his behaviour? Choose one of the items in the following list which you think

would be an appropriate start to behaviour shaping in these circumstances.

(A) At varying intervals, have him 'on the carpet' until he smartens up.

(B) Give him a pep-talk to get him to have pride in his appearance.

(C) Change his attitude towards his appearance by persuasion.

(D) Give him an early morning free-period to comb his hair, get the mud off his boots, etc. Withdraw this concession gradually.

(E) Wait until he cleans his shoes, or is forced to wear new trousers or have his hair cut, etc.; then say how good he looks.

---

6. Piaget uses the term adaptation to describe the process by which a child maintains dynamic ______________ with its environment. Which of the following would be the most appropriate word to put in the blank in the sentence above?

(A) assimilation

(B) operation

(C) accommodation

(D) equilibrium

(E) internalisation

---

7. If a teacher has been teaching a child some new fact or skill, can the child's learning be directly observed? Which one of the following is the best answer to the above question?

(A) Yes. An experienced teacher can observe the child and check the learning that has taken place.

(B) It would depend on the type of learning- some learning (e.g. learning to balance) is internal.

(C) No. One can only infer from performance that learning has taken place.

(D) It would depend on the teacher and the child - each case is different.

---

8. A teacher asks four children (A, B, C, and D) to think about tying a reef-knot.

Child A pictures in his mind a piece of string tied in a knot.

Child B internally goes through the motions of tying a knot.

Child C says to himself, "Left over right and under ...."

Child D 'feels' himself manipulating a piece of rope.

In Bruner's terms, which mode of mental representation (iconic, enactive or symbolic) was each child using?
For this item write 'I' for iconic or 'E' for enactive or 'S' for symbolic, against each letter on your answer sheet.

---

9. Some children are shown a glass half full of water and a ball of plasticine. They are asked, "If I put the ball of plasticine in the water, will the water level go up, go down, or stay the same?" This is followed by the question "Why?" The following are answers given by the children. Which answer/answers shows/ show understanding of the problem?

(A) It will stay the same because the ball is little.

(B) It will go up because the ball is heavy and makes the water go up.

(C) It will stay the same because the water can get under the ball.

(D) It will go up because the water is lighter.

(E) It will go up because the water can't get into where the ball is.

---

10. Julian, aged eight, is punished on the spot by his teacher for running down a corridor as his class comes into school. In future he walks down the corridor when the teacher is present, but runs when she is not present.

(i) In terms of Learning Theory (Behaviourist Theory), this exemplifies

(A) extinction of learned responses

(B) inhibition of learned responses

(C) generalisation of learned responses

(D) negative transfer of learned responses.

10. (ii) According to the principles of operant behaviour, a more useful procedure for Julian's teacher to adopt would have been to

(A) wait until Julian was in the classroom before administering punishment.

(B) wait until Julian was in the classroom and reward his first bit of 'good' behaviour

(C) reward the children who walked down the corridor

(D) make the whole class practise walking down the corridor.

---

11. A child learns to respond with the same spoken word to the written words <u>Ball</u> and <u>ball</u>
Which item from the list below best describes the process?

(A) trial and error learning

(B) stimulus generalisation

(C) successive approximation

(D) whole learning

12. Which of the following statements about concept learning is most likely to be true?

(A) Concept learning becomes less efficient with increasing age as a child grows from five to fourteen.

(B) Concept learning brings the individual under the control of specific stimuli.

(C) Concept learning enables the individual to put things or events into a class and respond to the class as a whole.

(D) Concept learning is independent of present needs and past experiences.

---

13. From a baby's birth, three basic factors interact to produce new patterns in its behaviour. Which three items from the list below best describe these factors?
You will need to 'ring' <u>three</u> letters on your answer sheet for this question.

(A) love	(E) maturation
(B) learning	(F) thinking
(C) understanding	(G) innate tendencies
(D) excretion	(H) hunger

---

14. A pupil has learned about convection currents by doing practical exercises with heated air in the classroom. Later, he has to learn about patterns of winds over the earth's surface.
The practical work will probably be useful for the later learning because, in Piaget's terms

(A) he will probably have formed an appropriate cognitive scheme.

(B) it is likely that no further accommodation will be needed.

(C) he will have reached the stage of formal operations.

(D) only assimilation will be necessary.

---

15. Some children are shown a glass of water and a heaped table-spoonful of sand. They are asked, "If I put this sand in the water, will the water level go up, go down, or stay the same?" Which answer/answers shows/show understanding of the problem?

(A) It will go up because the sand takes room up.

(B) It will go up because the sand will not dissolve.

(C) It will stay the same because the sand will soak up a lot of the water.

(D) It will go up because the sand is heavier.

(E) It will stay the same because the water is lighter than sand.

16. A boy wished to weigh his dog on a bathroom scale, but each time he put the dog on the scale it jumped off again. The boy thought for a while, weighed himself, then picked up the dog in his arms and weighed himself and the dog together. He then deducted his own weight from the weight of himself-and-dog. Below are four explanations of how the child solved the problem. Which one is most likely to be the explanation given by a Gestalt psychologist?

(A) He took in the whole problem, mentally rearranged it and saw a solution.

(B) He analysed the problem into its component parts and recalled previous solutions to these smaller problems.

(C) He had achieved the stage of development necessary for solving the problem.

(D) He had previously learned a rule for solving this kind of problem.

17.

(A)	Concrete operations	(C)	Pre-operational
(B)	Formal operations	(D)	Sensori-motor

Above are the names usually given to Piaget's stages of intellectual development (<u>not</u> arranged in correct order). Each of the sections below describes the activity of children. Which of Piaget's stages (A, B, C or D above) would each activity exemplify?

(i) A child holds a pebble near his mouth, smiles and says "Bickie" (his version of 'biscuit') and pretends to bite the pebble.

(ii) A girl knows that, because she is shorter than Anne, and Anne is shorter than Jenny, then she must be shorter than Jenny too. She is asked, "<u>Suppose</u> Anne was shorter than you, and Jenny was shorter than Anne. Would Jenny be shorter than you?" She answers, "She can't be, Jenny is the tallest girl in the class."

(iii) A child says, "Mick ma" ('milkman') on hearing the doorbell, any footsteps on the garden path, barking from the dog next door, seeing any van parked in the street or any bottle outside the house.

(iv) A child watches an amount of water poured from a tall narrow glass into a low wide glass. When asked about the amount of water he maintains that there is more water in the low wide glass than there was in the tall narrow glass.

(v) A mother hides a toy under her child's blanket. He reaches under the blanket and finds the toy. She then hides the toy under his pillow while he watches. The child searches, in vain, under the blanket.

(vi) A child is shown a pendulum made from a piece of string and a weight. Different weights are available and the

17. (vi) length of string can be adjusted. He is asked to experiment and find a 'law' which governs the rate of swing. He decides that there are a number of 'things that might make the pendulum swing faster or slower'. He alters one of these 'things', keeping all the others constant while he tests out the pendulum. He repeats this procedure for each of the 'things' in turn.

---

18. Some Behaviourist psychologists propose a 'hierarchy' of types of human learning, ranging from very simple learning to very complex learning. Some of these types of learning are listed below. From the list, choose (i) the simplest type, and (ii) the most complex type of learning. You will need to 'ring' two letters on your answer sheet for this question.

(A) response chains
(B) problem solving
(C) concept learning
(D) classical conditioning
(E) principle learning
(F) operant conditioning

---

19. Helen Keller became deaf and blind after an illness when she was a baby. This extract from her book, "The Story of My Life", tells of an incident when she was about seven years old.

"We walked down the path to the well-house .... someone was drawing water and my teacher placed my hand under the spout. As the cool stream gushed over one hand she spelled into the other the word W-A-T-E-R, first slowly, then rapidly. I stood still, my whole attention fixed on the motion of her fingers. Suddenly I felt a misty consciousness ..... I knew then that W-A-T-E-R meant the wonderful cool something that was flowing over my hand".

The spelling of 'water' on Helen's hand was important on this occasion because it was -

(A) her first concept of water
(B) a symbol or sign
(C) an S-R connection
(D) an image of water

---

20. Billy, who has problems at home, causes disruption in his Junior classroom by attacking his classmates frequently. His teacher intends to use methods based on B.F. Skinner's theories to make Billy's behaviour more acceptable in class. Which of the following would be the most useful statement from which to start planning the teacher's treatment of him?

(A) Billy is an aggressive child with quite severe emotional problems.

(B) Billy's behaviour is often hostile in class.

(C) Billy comes from a disturbed home background.

(D) Billy hits his classmates twelve times a day on average.

---

21. A pupil has acquired a concept of animal which excludes the concept of bird. That is, he considers a bird is not an animal. After instruction he realises that the concept animal includes all living things that are not plants. His concept of animal, therefore, is changed radically. Using Piaget's terms, does the process referred to above exemplify -

(A) equilibrium

(B) accommodation

(C) conservation

(D) assimilation

(E) operation.

---

22. Some children are shown a set of balance scales and two balls of plasticine. The balls are placed on the scales and shown to be equal in weight. One of the balls is removed and flattened slightly. The children are then asked, "If I put this flattened plasticine back on the scales, will they still balance?"
Which answer/answers shows/show understanding of the problem?

(A) The ball will go down because its weight is all together.

(B) They will still balance because when you flattened that piece you didn't leave any sticking to the desk.

(C) They will still balance because you didn't flatten that ball very much.

(D) The flattened piece will go down because now it can press more.

(E) The ball will go down because it's a heavy shape.

---

23. Which of the following statements would best represent Behaviourist principles in education?

(A) The teacher should ensure that learning is made easy for the learner.

(B) The teacher should ensure that the learner uses trial and error methods of learning.

(C) The teacher should ensure that all the efforts of the learner are rewarded.

(D) The teacher should ensure that the learner uses programmed texts or teaching machines.

---

24. Some children are shown two glasses of water and two balls of plasticine. The children agree that there are equal amounts of water in the glasses and that the balls are made of equal amounts of plasticine. One of the balls is placed in a glass of water and the effect on the water level is noted. The other ball is flattened into a disc. The children are asked "If I put this flat plasticine in the other glass, will the water still rise by the same amount?"
Which answer/answers shows/show understanding of the problem?

24. (A) It won't go up as much because the ball has been spread out sideways.

(B) It will go up as much because the disc might stand on its edge, leaning against the side of the glass.

(C) It won't go up as much because the disc is lighter than the ball.

(D) It will go up as much because the disc used to be a ball.

---

25. Which of the following statements about concepts is most likely to be true?

(A) Children are born with concepts which develop and grow according to their experiences.

(B) Concepts, in general, are fully formed by the age of 21 years.

(C) Concepts are formed with little reference to the physical world and operate independently of each other.

(D) The concepts that an individual has are unique to him and act as an integrated system of thought.

---

26. From the list below choose one item which best exemplifies <u>learning sets</u>.

(A) Any set of apparatus which provides concrete models of relationships (e.g. Dienes equipment).

(B) Traffic lights (e.g. 'red' acts as stimulus for the response 'stop').

(C) A child pronouncing the sound 'a' to different sizes of the printed letter.

(D) Persistent, recurring mistakes in maze-running by animals such as rats.

(E) A child picking out the odd one from each of **- ftf oxx

---

27. Classify the following behaviours as 'rote' or 'meaningful' learning. Write 'R' for rote <u>or</u> 'M' for meaningful against the appropriate letters on the answer sheet.

(A) A pupil learning to label the partsof a jet engine on a diagram as a first step in studying the subject.

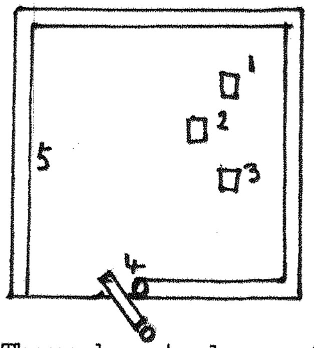
(B) A pupil, who has studied soil science, reading what the constituent elements are in the soil of a particular region.

(C) A child starting to learn grammar by committing to memory definitions such as 'a noun is a naming word'.

(D) Children introduced to multiplication by learning multiplication tables until they know them 'forwards and backwards'.

---

28. The diagram shows a plan view of a board surrounded by a rubber-lined buffer. Targets are placed on the board (1, 2 and 3). Balls can be shot at the targets from a spring-gun at one corner (4), but the targets can only be hit by bouncing the balls off the buffer (5).



Some children play with the apparatus. They are then asked to find a rule for hitting the targets.
Which answer/answers shows/show understanding of the problem?

(A) There has to be a right-angle between the angle of incidence and the angle of reflection.

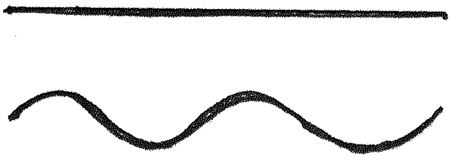
(B) The angle of incidence has to be the same as the angle of outsidence - it has to come off the buffer at the same angle as it went on.

(C) You have to make the ball come off the buffer at a right-angle - you have to point the gun so that you get a right-angle.

(D) When it misses by four inches, you have to hit the buffer four inches back - and the same for other inches.

---

29. A straight rod and a rolled out piece of plasticine are arranged with their end points in alignment as in the diagram.



Some children are asked, "Are the rod and the plasticine the same length or is one longer than the other?"
Which answer/answers shows/show understanding of the problem?

(A) The plasticine is longer because to make the rod like that, all wriggly, you would need a longer rod.

(B) They're the same because the ends are together.

(C) They're the same because the plasticine is curly and it doesn't go any farther.

(D) If you pull the plasticine straight that will make it longer.

PSYCHOLOGY. Learning and Concept Development.

ANSWER SHEET

Please fill in these details - Name ______________________

INSTRUCTIONS: For each question put a ring round the letter you chose as correct in the test booklet.

Question Number		Question Number	
1.	A B C D	17.(i)	A B C D
2.	A B C D E	(ii)	A B C D
3.	A B C D E	(iii)	A B C D
4.	A B C D	(iv)	A B C D
5.	A B C D E	(v)	A B C D
6.	A B C D E	(vi)	A B C D
7.	A B C D	18.	A B C D E F
8.	A	19.	A B C D
	B	20.	A B C D
	C	21.	A B C D E
	D	22.	A B C D E
9.	A B C D E	23.	A B C D
10.(i)	A B C D	24.	A B C D
(ii)	A B C D	25.	A B C D
11.	A B C D	26.	A B C D E
12.	A B C D	27.	A ....
13.	A B C D		B ....
	E F G H		C ....
14.	A B C D		D ....
15.	A B C D E	28.	A B C D
16.	A B C D	29.	A B C D

APPENDIX III

'Cluster 3' Psychology Test: classification of items.

APPENDIX III

'Cluster 3' Psychology Test: classification of items.

Classification of Items into four categories based on Bloom (1956). For each item a description of the testee's task in answering the item is given, followed by the category indicated by the description.

Item No. 1. Given a description of a novel problem situation, choose, from four courses of action, one that is in accord with generally accepted principles within a field of study.
Knowledge of Principles and Generalisations.

Item No. 2. Given a description of a novel problem situation, identify, among four courses of action, one which is in accord with a named principle from the field of study.
Knowledge of Principles and Generalisations.

Item No. 3. Given an incomplete statement, identify, among five terms, one which will make the statement compatible with a named theory within a field of study.
Knowledge of Specific Facts.

Item No. 4. Given a description of novel phenomena, identify, among four terms, one which describes the phenomena appropriately according to criteria generally accepted in the field of study.
Comprehension (Interpretation).

Item No. 5. Given a description of a novel problem situation, choose, from five courses of action, a solution that is in accord with a body of principles which are named but not described.
Application.

Item No. 6. Given an incomplete statement about a proposition within a particular theory, identify, within five terms, one which completes the statement in accordance with the theory.
Knowledge of Terminology.

Item No. 7. Identify, among four propositions concerning a field of study, one which is most in accord with generally accepted principles within the field.
Knowledge of Principles and Generalisations.

Item No. 8. Classify each of four descriptions of novel phenomena as belonging to one of three named categories according to generally accepted criteria in a particular field of study.
Application.

Item No. 9. Given a description of a problem situation and five explanations of the phenomena involved, assess the adequacy of the explanations with reference to relevant laws and principles generally accepted within the field of study.
Evaluation: Judgement in Terms of External Criteria.

Item No. 10 (i). Given a description of novel phenomena, identify, among four terms, one which describes the phenomena appropriately according to a named body of criteria.
Comprehension (Interpretation).

Item No. 10 (ii). Given a description of a novel problem situation and four courses of action proposed as solutions, assess the likely effectiveness of the solutions in accordance with a named body of principles.
Evaluation: Judgement in Terms of External Criteria.

Item No. 11. Given a description of novel phenomena, identify, among four terms, one which describes the phenomena appropriately according to criteria generally accepted in the field of study.
Comprehension (Interpretation).

Item No. 12. Given four statements, identify one which is in accord with generally accepted principles within the field of study.
Knowledge of Principles and Generalisations.

Item No. 13. Identify, within a list of terms taken from a field of study, three items which are essential to a commonly accepted generalisation within the field.
Knowledge of Principles and Generalisations.

Item No. 14. Given a description of a novel problem situation, choose from four propositions one which is most appropriate according to a named theory.
Application.

Item No. 15. As in Item No. 9.
Evaluation: Judgement in Terms of External Criteria.

Item No. 16. Given a description of novel phenomena, choose, from four explanations of the phenomena, one which is most in accord with a body of principles and generalisations which is named but not described.
Application.

Item No. 17.(i). Classify a description of novel phenomena as belonging to one of four categories, according to generally accepted criteria within a particular field of study.
Application.

Item No. 17 (ii). As in Item No. 17 (i).
Application.

Item No. 17 (iii). As in Item No. 17 (i).
Application.

Item No. 17 (iv). Recall a description of phenomena as belonging to one of four categories well-known within a field of study.
Knowledge of Principles and Generalisations.

Item No. 17 (v). As in Item No. 17 (i).
Application.

Item No. 17 (vi). As in Item No. 17 (iv).
Knowledge of Principles and Generalisations.

Item No. 18. Given a list of terms from a field of study which are normally presented in a prescribed order (but are 'scrambled' in this item) recall the prescribed order and identify the first and last in the series.
Knowledge of Specific Facts.

Item No. 19. Given a description of a novel phenomenon, choose, from four descriptions, one which is most appropriate according to generally accepted criteria within a field of study.
Application.

Item No. 20. Given a description of a novel problem situation choose, from four statements of the problem, one which is most in accord with a particular methodology.
Application.

Item No. 21. Given a description of a novel phenomenon, choose, from five terms, one which names the phenomenon appropriately according to a particular theory within the field of study.
Application.

Item No. 22. As in Item No. 9.
Evaluation: Judgements in Terms of External Criteria.

Item No. 23. Identify, among four propositions concerning a field of study, one which is most in accord with a named theory within the field.
Knowledge of Principles and Generalisations.

Item No. 24. As in Item No. 9.
Evaluation: Judgements in Terms of External Criteria.

Item No. 25. Given four statements about a phenomenon, interpret them and choose one which is in accord with generally accepted theories within the field of study.
Comprehension (Interpretation).

Item No. 26. Given five descriptions of novel phenomena, choose one which exemplifies a particular term in accordance with generally accepted criteria within a field of study.
Comprehension (Interpretation.)

Item No. 27. Classify each of four descriptions of novel phenomena as belonging to one of two named categories, according to generally accepted criteria in a field of study.
Application.

Item No. 28. As in Item No. 9.
Evaluation: Judgements in Terms of External Criteria.

Item No. 29. As in Item No. 9.
Evaluation: Judgements in Terms of External Criteria.

APPENDIX IV

'Cluster 3' Psychology Test:

Content Category and (Bloom) Performance Level of Items.

APPENDIX IV

'Cluster 3' Psychology Test:

Content Category and (Bloom) Performance Level of Items.

Numbers shown in the cells are Test Item numbers, e.g. Item No. 2 deals with the notion of extinction of learned responses at the Bloom Knowledge level.

Content \ Performance Level	Knowledge	Comprehension	Application	Evaluation
Learning Theory.				
Generalisation		11		
Discrimination		4		
Reinforcement			5	10(ii)
Successive Approximation	23		5	
Extinction	2			10(ii)
Inhibition: Punishment		10(i)		
Operant Conditioning	7		20	
Basic Factors in Behavioural Change	13			
Hierarchies of 'Types of Learning'	1, 18, 12	26 25	27	
Cognitive Theory.				
Developmental Stages	17(iv) 17(vi) 3		8 17(i) 17(ii) 17(iii) 17(v)	
Insight			16	
Piaget: Adaptation	6		21	
Piaget: Semiotic Function			19	
Piaget: Schema			14	
Piaget: Development of Cognitive Structures				9, 15, 22, 24, 28, 29.

APPENDIX V

The 'Cluster 3' Psychology Test: Distribution of Responses, Number Correct and Item Facilities.

APPENDIX V

The 'Cluster 3' Psychology Test: Distribution of Responses, Number Correct and Item Facilities.

N. = 93
N.R. = No response.

The preferred responses are underlined.

Item No.	Option	Times Chosen	Number Correct	f%
1	A	3	79	84.9
	B	9		
	C	2		
	<u>D</u>	79		
2	A	53	7	7.5
	<u>B</u>	7		
	C	2		
	D	14		
	E	17		
3	A	10	62	66.7
	B	3		
	C	17		
	D	1		
	<u>E</u>	62		
4	A	24	35	37.6
	B	14		
	C	20		
	<u>D</u>	35		
5	A	6	41	44.1
	B	8		
	C	23		
	D	15		
	<u>E</u>	41		
6	A	4	59	63.4
	B	3		
	C	18		
	<u>D</u>	59		
	E	9		

Item No.	Option	Times Chosen	Number Correct	f%
7	A	12	55	59.1
	B	14		
	C	55		
	D	12		
8			6	6.5
9	A	2	25	26.9
	B	63		
	C	2		
	D	27		
	E	73		
10(i)	A	2	29	31.2
	B	29		
	C	6		
	D	55		
	N.R.	1		
10(ii)	A	3	46	49.5
	B	35		
	C	46		
	D	8		
	N.R.	1		
11	A	6	40	43.0
	B	40		
	C	18		
	D	29		
12	A	1	79	85.0
	B	10		
	C	79		
	D	3		
13	A	16	35	37.6
	B	68		
	C	25		
	D	3		
	E	77		
	F	18		
	G	60		
	H	10		
14	A	46	46	49.5
	B	2		
	C	29		
	D	15		
	N.R.	1		

Item No.	Option.	Times Chosen	Number Correct	f%
15	A	68	21	22.6
	B	43		
	C	13		
	D	26		
	E	8		
16	A	62	62	66.7
	B	17		
	C	8		
	D	5		
	N.R.	1		
17(i)	A	4	36	38.7
	B	0		
	C	36		
	D	53		
17(ii)	A	49	49	52.7
	B	18		
	C	25		
	D	1		
17(iii)	A	4	61	65.6
	B	1		
	C	61		
	D	27		
17(iv)	A	20	65	69.9
	B	7		
	C	65		
	D	1		
17(v)	A	4	54	58.1
	B	3		
	C	31		
	D	54		
	N.R.	1		
18	A	49	15	16.1
	B	58		
	C	22		
	D	28		
	E	16		
	F	10		
19	A	31	21	22.6
	B	21		
	C	36		
	D	5		

Item No.	Option	Times Chosen	Number Correct	f%
20	A	47	13	14.0
	B	16		
	C	17		
	D	13		
21	A	1	63	67.8
	B	63		
	C	6		
	D	22		
	E	1		
22	A	2	81	87.1
	B	88		
	C	7		
	D	2		
	E	2		
23	A	4	4	4.3
	B	38		
	C	55		
	D	6		
24	A	1	83	89.3
	B	7		
	C	2		
	D	89		
25	A	23	67	72.0
	B	3		
	C	0		
	D	71		
26	A	23	17	18.3
	B	13		
	C	23		
	D	16		
	E	17		
	N.R.	1		
27			31	33.3
28	A	34	28	30.1
	B	32		
	C	29		
	D	18		
	N.R.	1		
29	A	77	10	10.8
	B	2		
	C	1		
	D	83		

APPENDIX VI

The 'Cluster 3' Psychology Test: Details of Item Analysis.

APPENDIX VI

The 'Cluster 3' Psychology Test: Details of Item Analysis.

Scores were ranked and two groups formed ('high ability' and 'low ability'.) made up of the 29 highest scores and the 29 lowest scores respectively (29 being the nearest convenient number to 27% of N.).

N.H. = number of correct responses to a particular item in the 'high ability' group.

N.L. = number of correct responses to a particular item in the 'low ability' group.

k = number of items in test (35).

n = number of scores in approx. 27% group (29).

$\frac{NH - NL}{n}$ = item discrimination index.

Analysis Data.

1	2	3	4	5	6	7
Item No.	NH	NL	NH - NL	NH + NL	$(NH + NL)^2$	$\frac{(NH - NL)}{n}$
1	27	22	5	49	2401	.19
2	5	0	5	5	25	.19
3	26	11	15	37	1369	.56
4	16	6	10	22	484	.37
5	16	11	5	27	729	.19
6	25	9	16	34	1156	.59
7	23	12	11	35	1225	.41
8	2	0	2	2	4	.08
9	13	5	8	18	324	.30
10i	12	4	8	16	256	.30
10ii	16	9	7	25	625	.26
11	20	7	13	27	729	.48
12	24	17	7	41	1681	.26
13	14	8	6	22	484	.22
14	16	8	8	24	576	.30
15	8	6	2	14	196	.07
16	26	11	15	37	1369	.56
17i	14	11	3	25	625	.11
17ii	22	7	15	29	841	.56

1	2	3	4	5	6	7
Item No.	NH	NL	NH - NL	NH + NL	$(NH + NL)^2$	$\frac{(NH - NL)}{n}$
17iii	18	16	2	34	1156	.07
17iv	22	16	6	38	1444	.22
17v	20	12	8	32	1024	.30
17vi	22	11	11	33	1089	.41
18	7	5	2	12	144	.07
19	12	3	9	15	225	.33
20	6	0	6	6	36	.22
21	25	10	15	35	1225	.56
22	25	16	9	41	1681	.33
23	0	0	0	0	0	0
24	27	21	6	48	2304	.22
25	25	13	12	38	1444	.44
26	9	3	6	12	144	.22
27	12	5	7	17	289	.26
28	12	4	8	16	256	.30
29	3	2	1	5	25	.04
			269 (NH-NL)	871 (NH+NL)	27585 $(NH+NL)^2$	

Substitution of the sums of columns 4, 5 and 6, k=35, and n=29 in the formula

$$r = \frac{k}{(k-1)} \left\{ 1 - \frac{2n \sum (NH + NL) - \sum (NH + NL)^2}{0.667 \left[\sum (NH - NL) \right]^2} \right\}$$

gives a reliability co-efficient of r=0.62.

APPENDIX VII

Individual Scores on M.H.V., C.C.F., S.T.3 and C3P Tests.

APPENDIX VII

Individual Scores on M.H.V., C.C.F., S.T.3 and C3P Tests.

Members of discussion groups are shown by an asterisk.

Student Identification Number	M.H.V.	S.T.3	C.C.F.			C3P
			A	B	Comb.	
1	60	90	29	32	61	18
2	52	59	25	26	51	20
3	59	70				
*4	62	58	24	28	52	12
5	60	90	34	38	72	19
6	79	86	34	39	73	16
7	82	67	32	33	65	18
8	85	91	33	34	67	
9	79	92	25	28	53	22
10	64	56	24	31	55	20
11	48	61	30	30	60	
12	43	60	19	29	48	14
13	52	72	25	37	62	18
14	48	59				
15	69	54				
16	66	77	33	33	66	21
*17	54	56	23	30	53	9
*18	57	64	27	29	56	15
19	63	74	28	35	63	17
*20	64	64	24	32	56	17
21	50	90	28	33	61	11
*22	70	55	31	28	59	19
*23	52	84	28	33	61	8
24	57	94	30	33	63	17
25	51	44	19	26	45	13
26	42	50				
27	56	95	30	29	59	21
28	70	78	24	29	53	19
29	60	94	27	33	60	15
30	56	52	22	29	51	16
*31	33	59	20	25	45	11
32	70	87	30	30	60	16
33	65	89	23	26	49	15

Student Identification Number	M.H.V.	S.T.3	C.C.F.			C3P
			A	B	Comb.	
34	64	79	24	23	47	16
*35	37	49	20	19	39	11
*36	48	39	27	22	49	14
*37	45	40	30	29	59	14
38	34	37				
39	62	79	27	31	58	17
*40	79	87	31	31	62	17
*41	72	91	32	35	67	18
42	49	83	27	30	57	17
43	85	65	30	32	62	
*44	56	61	20	30	50	23
45	89	99	28	33	61	24
46	33	59	22	26	48	12
*47	72	66	26	30	56	9
48	59	83	32	30	62	
*49	38	59	18	25	43	7
*50	50	66	24	28	52	10
*51	50	64	27	33	60	14
52	65					
53	54	81	22	26	48	
54	78					
*55	58	64	23	30	53	15
56	72	87	30	33	63	21
57	87	84	26	31	57	
58	69	97	35	36	71	20
59	48	62	25	24	49	15
60	61	65	25	31	56	10
61	65	89	27	35	62	26
*62	41	43	22	28	50	10
63	54	81	27	32	59	18
64	47	59	24	28	52	
65	46	65	29	32	61	15
66	52	61	29	29	58	22
67	46	88	30	31	61	20
68	53	82	30	34	64	17
*69	43	79	28	30	58	16
*70	61	73	27	32	59	16
*71	54	51	30	31	61	19
*72	58	78	27	33	60	16
73	49	86	24	29	53	
74	41	55	24	28	52	18
75	56	59	26	29	55	14
76	47	74	28	29	57	15
77	51	42	20	31	51	
78	80	96	31	32	63	16
*79	41	82	26	28	54	11
*80	33	46	19	24	43	11
81	83	78	35	37	72	20
82	51	40	28	32	60	13
83	84	82				

Student Identification Number	M.H.V.	S.T.3	C.C.F. A	C.C.F. B	C.C.F. Comb.	C3P
84	66	81	30	30	60	14
85	52	96	31	30	61	17
86	57	75	22	30	52	15
87	58	77	29	35	64	19
88	44	64	22	22	44	17
89	39	71	20	24	44	18
*90	36	47	22	27	49	19
91	50	80				
92	41	82	30	26	56	17
*93	44	64	22	26	48	22
94	52	89	31	31	62	14
95	77	70	25	29	54	8
96	62	70	31	34	65	24
97	56	88	34	34	68	17
98	53	66	29	32	61	16
99	72	82	38	36	74	
100	42	60	28	32	60	14
*101	43	52	21	29	50	12
102	60	89	30	37	67	18
103	64	89	28	35	63	17
104	68	48	26	29	55	19
105	42					
*106	33	39	21	26	47	9
107	57	86	25	36	61	12
108	48					
109	57	46	32	26	58	18
110	49	60	24	30	54	
*111	49	60	24	30	54	8
112	61	81	31	37	68	16
113	45	65	31	34	65	17
114	48	79	33	24	57	17
*115	50	49	25	28	53	17

APPENDIX VIII

Distribution of Scores on M.H.V.

C.C.F., S.T.3 and C3P Tests.

APPENDIX VIII

Distribution of Scores on M.H.V., C.C.F., S.T.3 and C3P Tests.

The Murray House Verbal Reasoning (Adult) 1 Test.

Raw Score Frequencies, Mean and Standard Deviation.

Raw Score	Frequency.
31 - 33	4
34 - 36	1
37 - 39	3
40 - 42	5
43 - 45	7
46 - 48	6
49 - 51	8
52 - 54	11
55 - 57	10
58 - 60	7
61 - 63	7
64 - 66	8
67 - 69	2
70 - 72	6
73 - 75	0
76 - 78	1
79 - 81	4
82 - 84	2
85 - 87	0
88 - 90	1
N	93
Mean	55.9
S.D.	12.5

The N.F.E.R. Spatial Test 3.

Raw Score Frequencies, Mean and Standard Deviation.

Raw Score	Frequency.
38 - 40	4
41 - 43	1
44 - 46	3
47 - 49	4
50 - 52	3
53 - 55	2
56 - 58	3
59 - 61	10
62 - 64	7
65 - 67	7
68 - 70	2
71 - 73	3
74 - 76	3
77 - 79	9
80 - 82	6
83 - 85	2
86 - 88	7
89 - 91	9
92 - 94	3
95 - 97	4
98 - 100	1
N	93
Mean	70.7
S.D.	16.2

The Cattell Culture-fair Intelligence Test, Scale 3, Forms A and B Combined.

Raw Score Fequencies, Mean and Standard Deviation.

Raw Score. (Comb. A & B)	Frequency.
38 - 40	1
41 - 43	2
44 - 46	4
47 - 49	9
50 - 52	9
53 - 55	11
56 - 58	12
59 - 61	22
62 - 64	11
65 - 67	6
68 - 70	2
71 - 73	4
N	93
Mean	57.1
S.D.	7.2

The 'Cluster 3' Psychology Test.

Score Frequencies, Mean and Standard Deviation.

Score	Frequency
7 - 9	7
10 - 12	12
13 - 15	18
16 - 18	34
19 - 21	15
22 - 24	6
25 - 27	1
N	93
Mean	15.7
S.D.	4.5

APPENDIX IX

The 'Everyday Phenomena' Test:

Copy of Test

Please fill in this section in BLOCK CAPITALS

Date ________________

Surname ________________________

Forename/s _____________________

Age ______ years ______ months

Education Group ________________

Main Subject ___________________

- -

Everyday Phenomena

This short paper is part of a project which aims to understand some of the problems which you are likely to encounter when you take a course in educational psychology during your 3 year initial teacher education course.

The investigator has no part in your assessment and your working of the paper will in no way affect your college grading in an adverse way. The personal details asked for above are needed only to make possible an analysis of the results (and for this they are essential)

You will find most of the questions which follow easy to answer, perhaps even slightly entertaining. There may be one or two items which require a little harder thought.

The method of answering on Pages 2-7 is simple. All that is required is for you to put crosses in 'boxes' in the answer column on the right hand side of each page.

On Page 8 numbers are put in the boxes instead of crosses.

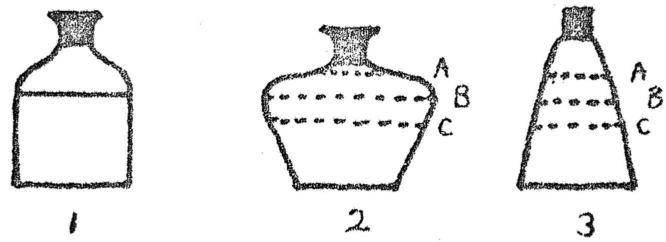
Pages 9 and 10 are different because on these pages you are asked to do some very simple drawing.

If you are not sure of an answer, try to work it out by means of 'common sense' rather than make a haphazard guess.

APPENDIX IX

Reduced from foolscap.

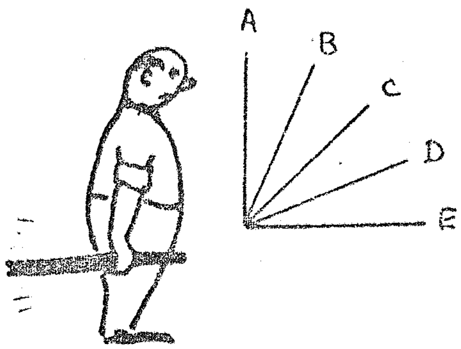
Answer Column

① 

These are scale drawings of bottles in which a certain brand of perfume is sold. Each bottle is round. Which of the dotted lines (A, B or C) on Bottles 2 and 3 show where the perfume should come up to in order to have the same amount as Bottle 1? Put a cross in the appropriate boxes in the answer column.

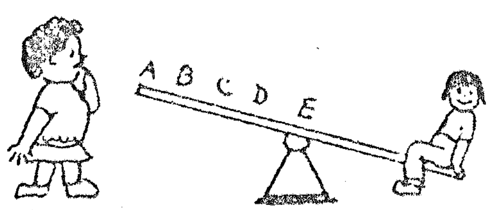
① Bottle No 2: A ☐ B ☐ C ☐

Bottle No 3: A ☐ B ☐ C ☐

② 

Fred wants to water the far end of his garden, but the hose-pipe is pulled as far as it will go. How should he hold the hose-pipe to make the water go farthest (A, B, C, D or E)? Put a cross in the appropriate box in the answer column.

② A ☐ B ☐ C ☐ D ☐ E ☐ None of them ☐

③ 

Jill is twice as heavy as her brother Jack. Where should Jill sit on the see-saw (A, B, C, D, or E) to balance Jack?

Put a cross in the appropriate box.

③ A ☐ B ☐ C ☐ D ☐ E ☐ None of them ☐

Answer Column

4)

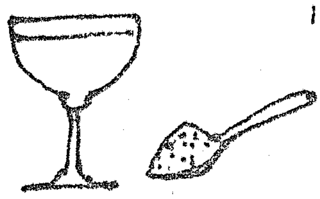
i) An olive is put into a drink. Is the level of liquid then higher, lower or the same? Choose one of the following and put a cross in the appropriate box

A. It depends on the size of the olive

B. The same

C. Higher

D. Lower



ii) A spoonful of sugar is added to a drink. Is the level of liquid then higher, lower or the same?

A. It depends on how much sugar.

B. It depends on whether the sugar dissolves or not.

C. Higher

D. Lower

E. The same.

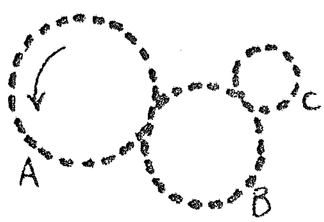
Choose one and put a cross in the box.

Answer column 4)

i) A B C D

ii) A B C D E

5)



The drawing shows three cog-wheels, A, B and C. Cogwheel A turns in the direction shown by the arrow.

i) Which wheel/wheels turns/turn in the same direction as A?

ii) Which wheel (A, B or C) turns fastest?

Put a cross in the appropriate box in the answer column for i) and ii).

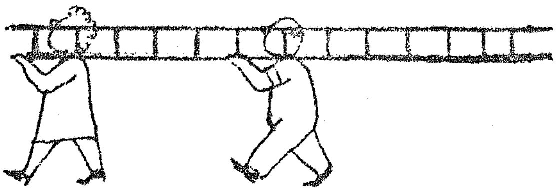
Answer column 5)

i) B C Neither

ii) A B C

	Answer Column.

⑥



Fred and his wife are the same height. They are carrying a ladder so that Fred can mend a window. Which of the following is most likely to be true? Put a cross in the box.

A. Fred's wife is carrying a heavier load than Fred is carrying.

B. Fred is carrying a heavier load than his wife is carrying.

C. They both carry about the same load.

D. It depends on their relative strengths.

⑥

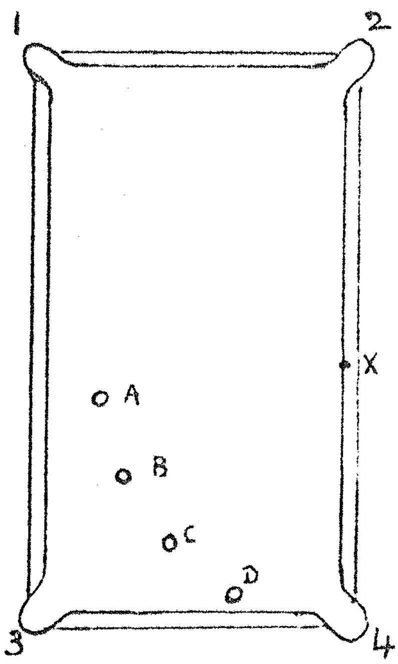
A ☐

B ☐

C ☐

D ☐

⑦



This is a plan of a billiard table with four pockets, numbered 1, 2, 3 and 4.
If each of the balls (A, B, C and D) is hit with the right amount of force, exactly in the centre of the ball, and bounces off the cushion at X, which ball is most likely to go into Pocket 1?

⑦

A ☐

B ☐

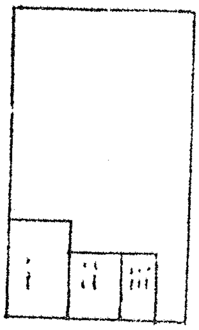
C ☐

D ☐

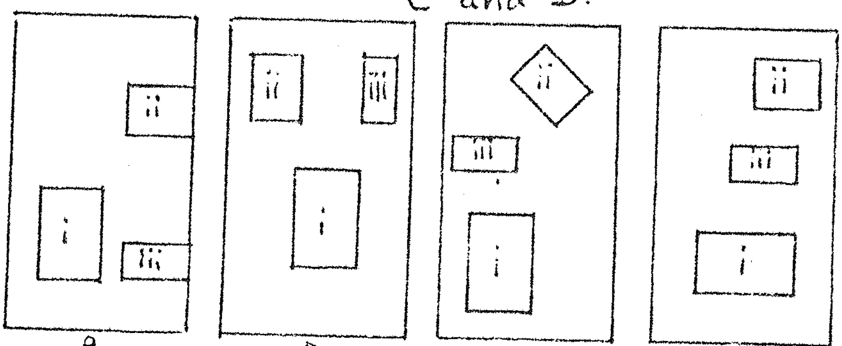
Put a cross in the appropriate box

Answer Column

(8)



This is a plan of Fred's garden as his wife wants it to be. Rectangle i is the garden shed, Rectangle ii is the greenhouse and Rectangle iii is Fred's wife's flower bed. All the rest of the garden is to be taken up by lawn. Fred doesn't like mowing lawns. He proposes other arrangements shown in Drawings A, B, C and D.



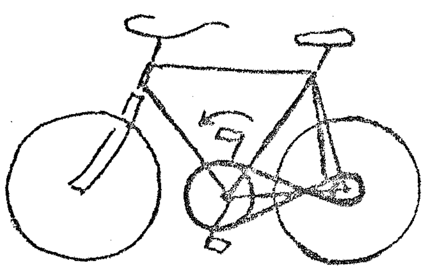
A B C D

Which, if any, of these arrangements would give him less grass to cut? Put a cross in the appropriate box/boxes in the answer column.

(8)

A ☐
B ☐
C ☐
D ☐
None of them ☐

(9)



This drawing shows a bicycle which has a belt instead of a chain. The belt is twisted into a figure-of-eight. If you pushed the pedal in the direction shown by the arrow, which way would the bicycle go?

Choose one of the following and put a cross in the box.

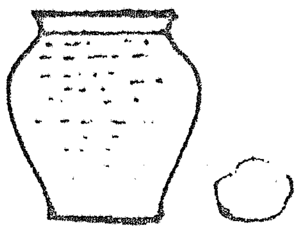
A. Forward
B Backward
C. Not enough information given.
D. It depends on the amount of pressure

(9)

A ☐
B ☐
C ☐
D ☐

	Answer Column.

(10)



Fred's wife put a ball of plasticine in a flower vase to hold a pin-holder for flower arrangement. She found that the water over-flowed. Fred said, "Why don't you squash the plasticine flat, then the water level won't rise as much?"

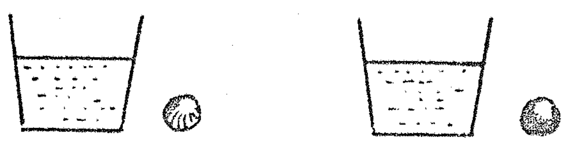
Was Fred's idea useful? Which of the following do you think is correct? Put a cross in the appropriate box.

A. It depends on how much she squashed it.
B It wouldn't make any difference
C. The water level would rise more
D. The water level would rise less.

(10)

A ☐
B ☐
C ☐
D ☐

(11)



The drawing shows two beakers with water in them, and two balls. Ball No.1 is made of plasticine and Ball No.2 is made of lead. The balls are exactly the same size, but the ball of lead is much heavier than the plasticine ball. Beaker No.1 is exactly the same size as Beaker No.2. and both beakers have exactly equal amounts of water in them.

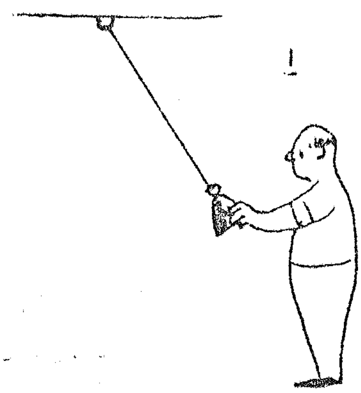
If the plasticine ball is placed in Beaker 1 and the ball of lead is placed in Beaker 2, which of the following would be correct?

A. The water level in Beaker 1 would be higher than the water level in Beaker 2.
B. The water level in Beaker 2 would be higher than the water level in Beaker 1.
C. The water level in both beakers would be lower by the same amount.
D. The water level in both beakers would be higher by the same amount.

(11)

A ☐
B ☐
C ☐
D ☐

	Answer Column

(12) 

Drawing 1 shows Fred about to swing a pendulum made from a piece of string and a weight.

Fred wants to make the pendulum swing faster. Which of the following would affect the rate of swing (number of swings per minute) of the pendulum, making it faster?

A. Replacing the weight by a heavier one.

B. Replacing the weight by a lighter one

C. Giving the pendulum a harder push.

D. Giving the pendulum a gentler push

E. Shortening the string.

F. Lengthening the string.

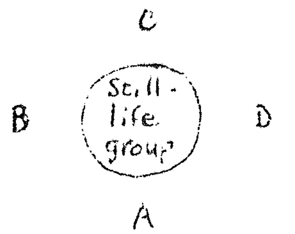
G. None of them.

Put as many crosses as you think are needed in the boxes in the answer column.

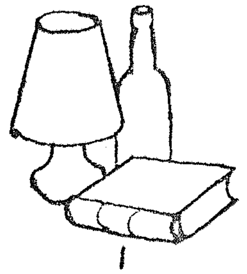
(12)

A	
B	
C	
D	
E	
F	
G	

(13)

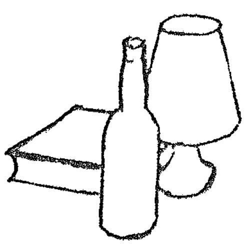


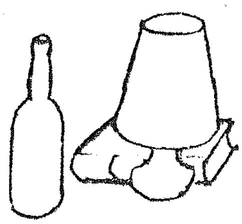
The above plan shows the positions of four art students (A, B, C and D) who are painting a 'still-life' group of objects placed on a table in the centre.


1

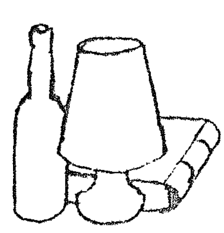
Drawing 1 is the view of the still-life group painted by Painter A.

From the views shown below, choose the views that each of the other three painters would have, then put the numbers of the drawings in the appropriate spaces in the Answer Column.


2


3


4


5

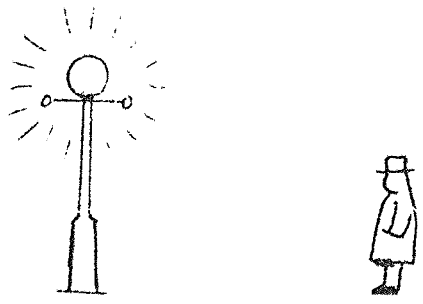
Answer Column

(13)

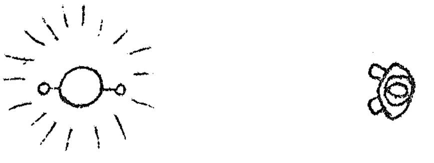
A	1
B	
C	
D	

(14)

i)

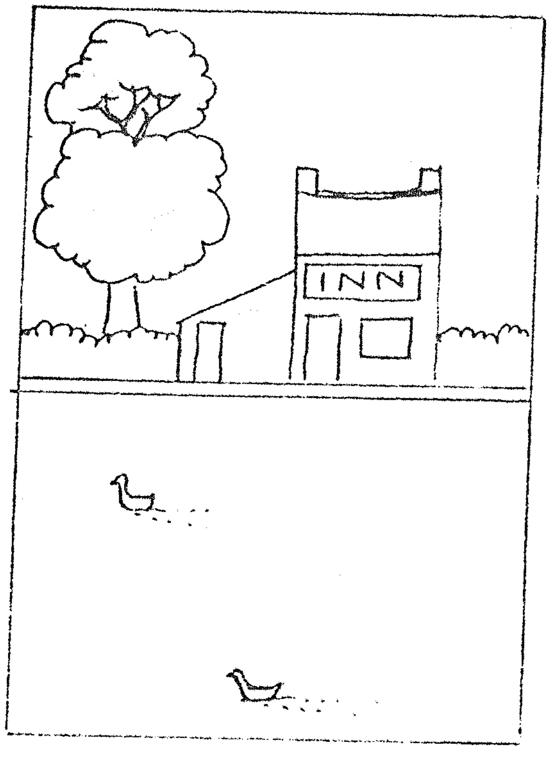


ii)



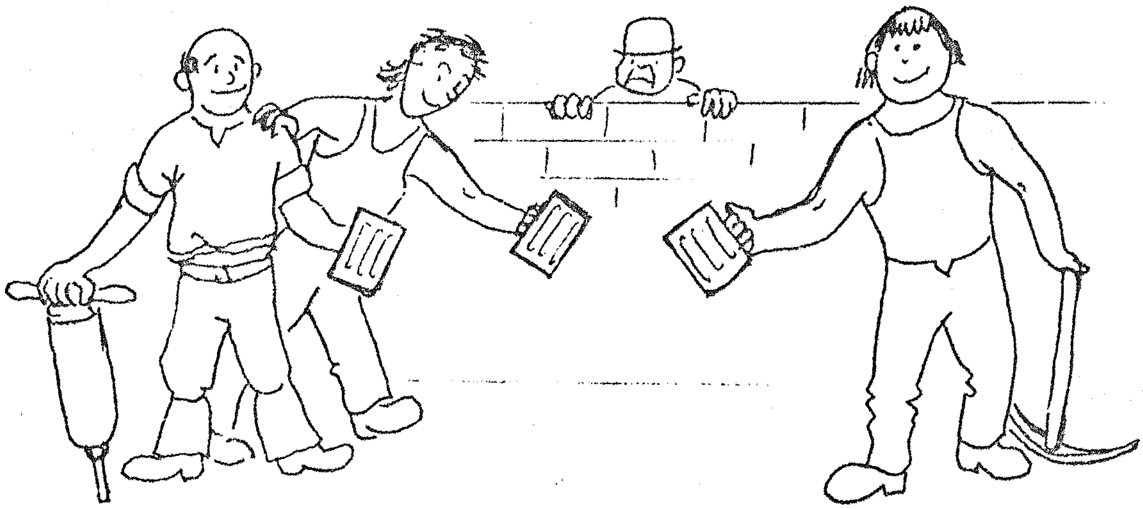
Drawing (i) above shows a side-view of Fred waiting for his wife by a lighted street-lamp.
Drawing (ii) is a plan-view of the scene.
Indicate, by drawing on the two views, where Fred's shadow would be

(15)



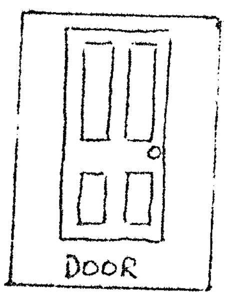
The drawing shows a building and other objects standing by a stretch of calm water.
Complete the picture by drawing in the reflections in the water.

(16)



Draw lines across each of the pint glasses to show the level of half a pint of beer.

(17)



In each of the spaces below make a drawing of the object named there. Make the drawings as large as possible as shown in the drawing of the door on the left. Concentrate on the outline of the shape rather than a lot of detail.

MILK BOTTLE (Pint)	GARDEN SPADE	CUP and SAUCER

APPENDIX X

The 'Everyday Phenomena' Test: Distribution of Responses, 1974.

APPENDIX X

<u>The 'Everyday Phenomena' Test: Distribution of Responses, 1974.</u>

<u>1974 Administration. N.115.</u>

In the tables below, for most multiple-choice items, the number of students choosing each option is shown. For Items Nos. 12, 13, 14 and 16, the number of responses accepted as correct and the number judged incorrect are shown.

N.R. (no response) indicates the number of students leaving the item unanswered.

Preferred responses are underlined.

<u>1(i)</u>	
A	1
B	22
<u>C</u>	92
N.R.	-

<u>1(ii)</u>	
<u>A</u>	100
B	15
C	-
N.R.	-

<u>2</u>	
A	2
B	-
<u>C</u>	42
D	51
E	18
None	1
N.R.	1

<u>3</u>	
A	-
B	1
<u>C</u>	85
D	21
E	3
None	4
N.R.	1

<u>4(i)</u>	
A	8
B	9
<u>C</u>	97
D	1
N.R.	-

<u>4(ii)</u>	
A	1
B	29
<u>C</u>	34
D	-
E	49
N.R.	2

<u>5(i)</u>	
B	7
<u>C</u>	102
Neither	5
N.R.	1

<u>5(ii)</u>	
A	14
B	5
<u>C</u>	93
N.R.	3

<u>6</u>	
A	6
<u>B</u>	70
C	23
D	16
N.R.	-

7	A	11	8	A	1	9	A	20
	B	21		B	1		B	64
	C	57		C	1		C	26
	D	26		D	-		D	3
	N.R.	-		None	109		N.R.	2
				BCD	1			
				ABCD	1			
				N.R.	1			

10	A	10	11	A	1	12	E	15
	B	95		B	28		Others	98
	C	2		C	-		N.R.	2
	D	7		D	85			
	N.R.	1		N.R.	1			

13	Correct	66	14	Correct	66	16	Correct	88
	Others	46		Others	45		Others	22
	N.R.	3		N.R.	4		N.R.	5

APPENDIX XI

The 'Everyday Phenomena' Test: Distribution of Responses, 1976.

APPENDIX XI

The 'Everyday Phenomena' Test: Distribution of Responses, 1976.

1976 Administration. N.86.

In the tables below, for most multiple-choice items, the number of students choosing each option is shown. For Items Nos. 12, 13, 14 and 16, the number of responses accepted as correct and the number judged incorrect are shown.

N.R. (no response) indicates the number of students leaving the item unanswered.

The numbers in brackets show the responses from the 1974 administration of those students who completed the test on both occasions.

Preferred responses are underlined.

1(i)

	1974	1976
A	(-)	1
B	(19)	22
C	(67)	63
N.R.	(-)	-

1(ii)

	1974	1976
A	(77)	79
B	(9)	6
C	(-)	1
N.R.	(-)	-

2

	1974	1976
A	(-)	-
B	(-)	-
C	(30)	31
D	(40)	38
E	(14)	16
None	(1)	1
N.R.	(1)	-

3

	1974	1976
A	(-)	1
B	(1)	1
C	(59)	67
D	(19)	10
E	(3)	2
None	(3)	5
N.R.	(1)	-

4(i)

	1974	1976
A	(8)	2
B	(8)	4
C	(69)	80
D	(1)	-
N.R.	(-)	-

4(ii)

	1974	1976
A	(-)	-
B	(21)	18
C	(24)	39
D	(-)	1
E	(40)	27
N.R.	(1)	1

5(i)	1974	1976
B	(6)	3
C	(76)	81
Neither	(3)	2
N.R.	(1)	-

5(ii)	1974	1976
A	(10)	6
B	(5)	5
C	(69)	73
N.R.	(2)	2

6	1974	1976
A	(6)	6
B	(50)	48
C	(16)	24
D	(14)	8
N.R.	(-)	-

7	1974	1976
A	(7)	6
B	(14)	18
C	(43)	41
D	(22)	21
N.R.	(-)	-

8	1974	1976
A	(-)	1
B	(1)	-
C	(1)	1
D	(-)	-
None	(84)	83
BCD	(-)	1
N.R.	(-)	-

9	1974	1976
A	(16)	21
B	(48)	48
C	(19)	13
D	(2)	1
N.R.	(1)	3

10	1974	1976
A	(9)	3
B	(69)	76
C	(1)	1
D	(6)	5
N.R.	(1)	1

11	1974	1976
A	(1)	2
B	(21)	13
C	(-)	-
D	(64)	69
N.R.	(-)	2

12	1974	1976
E	(12)	25
Others	(74)	61
N.R.	(-)	-

13	1974	1976
Correct	(46)	55
Others	(38)	29
N.R.	(2)	2

14	1974	1976
Correct	(49)	55
Others	(33)	26
N.R.	(4)	5

16	1974	1976
Correct	(62)	72
Others	(19)	14
N.R.	(5)	-

APPENDIX XII

Final College Grades of Discussion-group Members.

APPENDIX XII

Final College Grades of Discussion-group Members.

Student Identification Number	Main Subject	Combined Subjects	Educational Studies	School Practice
4	C+	C+	C	C
17	B	B-	C	B
18	C+	C+	C	B
20	C+	C+	B	C
22	B-	B+	B	B
23	B	B+	B	B
31	B	B	B	C
35	C	C+	B	B
36	C	B-	C	C
37	C	C+	C	B
40	C+	B+	B	B
41	C+	B-	B	B
44	B-	B-	B	C
47	C	C+	C	C
49	C+	B-	C	C
50	D	C+	C	C
51	C+	C+	C	C
55	C+	B-	B	B
62	C-	B-	C	D+
69	C-	C+	C	C
70	C+	B+	B	C
71	B	B+	B	B
72	B	B-	B	C
79	C	C+	C	B
80	B-	B-	B	B
90	B+	C+	B	B
93	C	B-	B	B
101	C	C+	B	B
106	C-	C+	C	C
111	C	C	C+	C
115	C+	B-	C	B

APPENDIX XIII

The 'Everyday Phenomena' Test: transcripts of discussions of the test items by students in groups.

APPENDIX XIII

The 'Everyday Phenomena' Test: transcripts of discussions of the test items by students in groups.

'R.B.' indicates the writer speaking; an asterisk indicates a student speaking.

GROUP ONE (8 Students)

Item No. 12.

R.B. When you looked at this one did you find that any of the items - er - any of the answers which you could eliminate right away?
(Pause)

* G

R.B. Yes G. So that reduces it to .... six answers doesn't it? Was there anything that looked obviously a good possibility?

* C

R.B. But was it difficult going down to some sort of a selection?

* Mmmmmmm, Mmmmmmmm (Murmurs of assent).

R.B. Can you remember any of your thinking .... what sort of ... er .... did you go back in your mind to physics lessons at school?

* Mmmmmmm. Yes.

R.B. Did you?

* My dad hanging wallpaper.

R.B. Yes?

* Mmmmmm, plumblines.

* I was thinking about the experiment we did on this.

R.B. At School?

* .... and what we did.

R.B. What sort of things did you use in making your choice?

* I got more and more confused .... in the end it was just pot luck really.

* Just sheer elimination .... until in the end you get to the stage where you don't know what to put.

R.B. Can you remember any of the reasons why you eliminated some of them?

* Mmmm, D, giving the pendulum a gentle push - well that would make it go slower so that's out, yes? Right? It's not going to go very fast is it? For very long, right?

* Harking back in my mind was this business of physics, you know, now was it if you put a heavier weight on the .... the way you took the pendulum back, or was it the string ... you know. I found that with a lot of them especially, you know, the ones with the level of the water ....

* What I imagined was that if you shortened the string and gave it a hard push it's bound to go faster.

* I think I reduced it to A and E.

* I couldn't remember whether you shorten the string or put on one of the weights.

R.B. But you actually tried to think of the consequences of er ... doing it, imagining?.....

* Mmmmmm. Yes.

Item No. 14.

R.B. Is it fairly clear .... was it easy to follow, you know the instructions (instructions read aloud). No problems about what is a plan-view .... or side-view?

* (Laughter) .... well we don't know whether we're right or wrong.

R.B. We're not particularly interested in right or wrong answers .... you may have perfectly plausible reasons for doing something that somebody else says is wrong. There may be perfectly good reasons for saying 'I do it this way' even if somebody else says 'that's the wrong answer'. When it came to making a mark on the paper, the moment of decision, what sort of things did you have in mind?

* A guess, I think.

* The thing with these is, a lot of people, you read it through and think, it's bound to be that, and then you think sort of what type of test it is, and think well maybe it's not that after all, maybe it's some deep psychological meaning that influences what you put down and you tend not to put down what you .... well I did anyhow ..... what I sometimes really thought the answer was.

* It was too easy - can't be that ....

R.B. Did this (Item 14) come into that category?

* No, here I put down what I thought it was. But there again it could be quite a few things. The light is falling all around, it's not like a spotlight. And I've put my shadows more like a spotlight.

R.B. Did you actually think of a spotlight .... on the stage or something like that?

* I was trying to think of standing by a lamp - what would happen.

R.B. Did you find yourself having difficulty in sorting out the two views?

(Silence)

Did you find yourself using words when you did this .... were you trying to put a principle into words? You know, when there's a light here and an object here, such-and-such will happen.

* No, not with that one.

* I do main Art .....

R.B. Could you put a principle into words do you think? Is there a principle there that could be put into words or is it purely something to do with being able to draw? A description of what happens when shadows are cast like that?

(Long pause).

* I just came to the conclusion I wasn't very observant. I've never noticed which way shadows have fallen.

R.B. Did you have to spend a fair amount of time on this ... thinking?

* Yes.

* I found this one of the most difficult ones.

* I went on the basis that if the light was in front of me the shadow went behind me, because you are stopping the light ... you know.

* I didn't have any theories to work on.

* I seem to remember doing, goodness knows what, something at school, to do with a light and an object ....

* I felt I ought to know the answer .....

* Yes, and there ought to be some sort of theory that you could put into practice and get the answer right ....

Item No. 16.

R.B. What did you think of Number 16?

* Thirsty

(Laughter)

* I remember thinking .... Piaget ....

* I was more wary of this one ..... I was frightened of getting it wrong because I know that children of such and such an age should know what they're doing .....

R.B. What were you concentrating on, the amount or the level?

* The amount.

* The level.

* The level.

* That little chap with his face over the wall .....

* No, it wasn't till I'd actually done it that I started thinking about what the amount should be.

* You try and tilt the glass upwards as you look at it and see where your line is going to level out to.

Item No. 1.

R.B. What sort of things did you do with this one?

* The B line on both of them is the same as the first one so that couldn't be right. The second bottle was bigger so it should be lower down, and the third bottle was smaller so it should be higher up.

* I think I did it the same way as ....

Item No. 2.

* I was standing with a hose-pipe.

R.B. You were harking back to actually watering gardens, were you?

* Mmmmmm. The height the water reached, and .... how far it would go ....

R.B. How did you go about eliminating ....?

* A can go out ..... I though it was between C, D and E. C would make it about the right height .....

* ...... said to .... about putting E, but somebody said that was wrong because it was C. But if you put your finger over the end of the hose ....

R.B. What made you choose E in the first place?

* Just seemed to me that if you stuck it out in front it should go farther.

R.B. Less force to waste?

* Mm, if you chose C it would have to go up, but if you pointed it directly it would just have to go straight.

* Doesn't it depend on how much water is coming out of the hose pipe in the first place?

* But surely if you just put it on the ground .... were you measuring from where the water touches the ground or how far it goes, if you do from ...... going up it .... goes up and then lands and that would be farther, wouldn't it? (Means distance along the curve - not between two points)

Item No. 4.

* There's something vaguely reminiscent of physics lessons in that as well.
(Discussion of physics lessons)

R.B. Have you used a balance beam in college?

* No ......

R.B. But you remember doing that in school?
How about remembering see-sawing?

* I remember see-sawing last summer .... that's what I related this to. I was always one of the heavier ones and I always had to sit nearer the middle bit ......

R.B. Did that help in choosing how near to the centre ....

* ..... as she was twice as heavy as her brother she'd be in the middle.

* That's what put me off - as soon as I saw it was 'twice' I thought, 'Oh, it's got maths in it, that's me out for a start'.

Item No. 4.

* Oh, this one with the sugar ....
(Discussion of other tests)

* A body in water displaces its own weight ..... I remembered that but got confused when we got to the sugar.

* ...... if you put in half a ton of sugar it's bound to go up, isn't it .... unless it dissolves .... Oh dear.

* If it dissolves it must dissolve in something, mustn't it? Therefore there must be more of something than there was before ....

* I put 'The same'.

* I didn't put anything.

Item No. 5.

* I remember playing with things like clocks - but again I couldn't remember which one went which way. I was trying to remember what it did used to do. I expect it was ...... a child's ...... plastic cogwheels ...... tried to sit and think, if I turned that one which way did that one go. I played for hours with it but I couldn't visualise it sufficiently well to actually see it.

R.B. What did you do, when you were tackling this, did you use your finger to trace round the outside ......?

* I put down the first thing that came into my head because I haven't the faintest idea, simple as that really.

R.B. Try to imagine movement is difficult isn't it, especially when one thing's acting on another .....
(Discussion of whether test was timed or not)

Item No. 6.

* Oh dear, yes ....

R.B. Could you eliminate any of these pretty easily?

* D

* Now I see a different answer to this one. The person behind is always the worse off - I mean is better off than the person in front, because they can't see how much the person behind is carrying, can they?

.... the person behind might only have his finger tip on it as far as you know.

...... like on a tandem - yes.

R.B. Are all the answers pretty plausible - er - probable?

* I'd say C you could get rid of because to carry the same load you'd have to be further along down to the bottom of the ladder .... yes.

* A

R.B. What sort of things did you think about - I don't suppose you've carried many ladders in your time?

* One thing that I thought about was that if Fred's there he's sort of supporting the end bit that his wife's carrying but he's got nobody supporting that bit (other end) so that would tend to drop down a bit.

* Oh, I've just noticed, Fred is actually dead in the middle of the ladder. Therefore it should belance on his shoulder. So in that case Fred's carrying a heavier load than his wife.

* Not necessarily.

* Not necessarily if his wife is carrying all the first bit.

* Well, if it balances it might just be leaning on her shoulder.

* How do you know that? How do you know she's not carrying a heavier load than him - he might just have his hand on it?

* But he's dead in the middle.

* Yes, but she might be just as strong as him, so she might pull heavier so she'll be carrying more than him.

* ...... equal weight on each side so that he's carrying virtually all the weight of the ladder.

* No, I don't agree.

* Yes, if his wife wasn't there, he'd still balance the ladder on his shoulder.

*	It would drop down at the front ......

*	.... if you count the stiles on the ladder ....

*	I don't think it makes any difference to it.

*	If you put a pencil on the middle of your finger it balances, doesn't it?

*	It depends on how much they were carrying, doesn't it?

*	No. (Demonstration of pencil balanced on one finger with another finger near end).

*	I think they both carry about the same weight.

*	One, two, three, four .... (counting steps of ladder).

*	Well, I've got that Fred's carrying a heavier load but I couldn't tell you why I got that in the first place because I definitely didn't think of what I just said.

Item No. 7.

*	..... I was trying to remember what I'd seen on television, I was trying to work out what I'd seen, but I couldn't .... the principle that any ball that bounces off the side bounces off at a right-angle. So therefore you drew a right-angle from where you .... make a right-angle with x.

*	I'd got some idea that it had to bounce off at the same angle that it bounced on .....
(General laughter)

R.B.	Did you remember that from some work at school?

*	I think it goes back to some time in physics.

R.B.	Were you able to eliminate some of these pretty easily?
(Discussion of shots made by skilled billiards players)

*	Really, any of them could have gone in.

R.B.	It (the test time item) says, 'If each of the balls is hit with the right amount of force ....' (etc.). I believe that in order to put spin on a ball you have to hit it at the side ....

*	Yes, but we're not to know that, are we?

Item No. 8.

*	I immediately thought of the psychology we did - what was it - conservation of space or something where the children knew

all the funny answers .... it's sort of the same.

Item No. 9.

R.B. Motor-bikes used to have belts at one time - well, some did anyway.

* Twisted into a figure-of-eight?

R.B. No.

(Laughter)

* It's like that cogwheel, you can't really remember.

* A chain's not a figure-of-eight is it?

R.B. On an ordinary bike?

* Yes.

R.B. No, you can't very well twist a chain.

* When I looked at this I thought .... you know, inside a Hoover ..... the band is a figure-of-eight ....

* I tried to work it out ..... if the band was going like that ...... oh, I don't know what I thought now, but I remember thinking that if you turned the pedal forward, which presumably you could do with that, if you forced the pedal forward then what would happen to the band? It would snap.

* I thought it would be a pretty useless bike if it didn't go forward anyway.

R.B. Well, the arrow does suggest that the pedal can be pushed forward ....

* It makes you think that it's going to go backwards.

R.B. Why should it do that?

* What?

R.B. Go backwards.

* Because the chain is on a twist and it probably won't do what it normally does.

R.B. But you actually traced it round with your finger, didn't you?

* Yes.

* It's one of those things you just can't visualise in your mind.

R.B. Is it the fact that you are trying to imagine movement?

* Mmmmmmmm Mmmmmmmmm

*	Once you've worked out one stage, you've forgotten one stage.

*	It was the same with the cogs .... got so far round ...... but then I got confused and I couldn't remember what the first one was doing, in relation to the second one, when I came to the third one.

R.B.	Which was the confusion point on this one?

*	It was the twist .....

R.B.	In spite of your finger going round?

*	Yes. If it had been a three-D picture I might have been able to ...... but because I couldn't actually go round it properly ....

*	Actually, I think I stuck to the cog thing ...... the band thing ......

R.B.	You put cogs there?

*	Mmmmmmmmm

*	Because we'd done the cogs.

R.B.	You saw it as being related to the cogs?

*	Yes

R.B.	Did A, B, C, and D seem equally plausible - er - likely? Were there any that you could get rid of right away?

*	D

<u>Item No. 10</u>.

R.B.	You all know what a pinholder for flower arrangement is?

*	Yes.

*	Depends on the size of the plasticine. Is that what it's supposed to be in relative size to the jar?

R.B.	Well, it's the change in shape that's in qustion really. It says, (item 'stem' read out).

*	I didn't think about that.

*	I thought again, in physics, the man displacing the water .... (comments on the term 'mass')

R.B.	So you would be able to get rid of one of these?

*	B

*	C and D

*	Yes, but that was the point of the question, D, would it

make any difference .... because I was thinking it was B or D ....

* But surely if you put anything in the water it would rise ...

* I took that to mean it had risen before .... if you squash it, it would rise less than if you put it in as a ball.

* But they're still the same ..... Oh I dunno.

* .... the plasticine hasn't got any smaller, it's still got the same amount, mass orwhatever it is ..... just because it's been squashed ....

* You see, I immediately thought it would be B, then I thought perhaps it wasn't.

* .... it's the surface area ....

* The only way you can find out is to do it to prove it ..... we've all got different ideas so the only way you can prove anything like that is to try it ...... it's difficult to see it in your mind ...... I sat there and sat there and sat there .... but then I thought that the water would have gone into the plasticine ...... like paper ..... what's the word it ....

R.B. Absorbs?

* Yes - the only way you could really do it is to try it. Some people can do it in their minds but I can't, I have to do it. I haven't got that sort of mind.........

Item No. 11.

* This one, I immediately thought, 'Ah, he's trying the cup of lead is equal weight to a cup of sugar type ....

* Again I tried to remember the theory about mass displacing the water, and then I couldn't decide whether the mass was the weight or the size or what ...... was the mass the weight or was it the size of the ball?

R.B. You remembered the formula, the words, but one of the words 'mass', you were having trouble with it?

* Yes.

* If it had been 'which ball would sink to the bottom quickest?) that would have been the weight, therefore it couldn't be

anything to do with the weight, and it would be something to do with the size ....

R.B. Which of these, then could you get rid of pretty easily?

* A

* C

* So it must be D

* You've still got B left.

* No, it's not likely to be B.

Item No. 13.

* I tried to think it out logically, where you would be standing.

* I drew mine.

R.B. What sort of things did you - try to imagine yourselves standing in these positions? Or did you work out a verbal formula - 'the bottle's in front of the book .....'

* When I found that I couldn't visualise it I did it from one of the objects, the bottle.

R.B. You used the bottle as a sort of reference point?

* Yes.

R.B. Did this remind you of any of those Piagetian experiments?

* The ones with water ......

* I kept thinking that I should be able to do it ..... somebody of my age ought to be able to do this ..... we had it drummed into us so often in Child Development that children of this age can do this and this ....

* So funny you've just been thinking about that Piaget .... we didn't give it a thought ..... no, not during these tests at all.

* I just thought there are certain things I just ought to know ......

* I related ...... (Item No. 1.) .... to the children, thinking they could do it and I couldn't.

General Comments.

R.B. Which of these (items) gave you most to think about?

* The plasticing ones, and the sugar ....

* The sugar ....

* .... displacement of water.

R.B. Were they worse than the shadows?

* I thought the shadows were the most difficult, but I knew that there was some sort of answer I ought to be able to get.

* That shadow .... you had nothing concrete to work on. At least with the others you could eliminate things.

* You get four clues, don't you, but there's absolutely nothing with the shadows one.

GROUP TWO (8 Students)

Item No. 12

* I tried to put myself in Fred's place.

R.B. Do you mean you imagined yourself holding a weight?

* Yes

* I was trying to remember a theory we did in maths.

R.B. In college?

* Yes. I tried to recall what happened and reason it out from there.

R.B. Were you remembering the actual feeling, the swing of the thing, or watching it go backwards and forwards?

* First of all the result. I tried to recall the result. Then I went through each one of the possibilities .... tried to imagine how the .... it felt ....

R.B. When you say you tried to rememberthe result, do you mean a sort of rule in words?

* Yes, it was almost like remembering a formula.

R.B. But it wouldn't come - it had gone?

* No, it was there, but I wasn't certain.

R.B. Did most of you go through an elimination process, getting rid of unlikely ones?

* Yes.

R.B. Which one went first?

* A gentle push.

R.B. Why?

*	If you only push it gently it won't go fast. Then I thought it wouldn't be A because if you put a heavier weight on, it would slow down. If you think of a swing, if you push someone on a swing, someone light, it's easy to push and it goes further, but with a heavier person it doesn't go so far.
R.B.	So A and D went out.
*	And lengthening the string. If you put a lighter weight on, it will go faster, so therefore G was out.
R.B.	What were the hot favourites then?
*	B and C.
*	I put E as well.
R.B.	Was this general, trying to <u>imagine</u> what would happen?
*	Yes .. Yes .... Mmmmmmmmmmm.
*	Well, shortening the string and lengthening the string is a matter of opposites really, so if you decide to put one the other must be out.

<u>Item No. 13</u>.

R.B.	Anything about the illustrations?
*	One of them didn't fit in with my mental picture.
R.B.	Was it No. 3?
*	I think so. The bottle's quite a long way .... Drawing No. 1 may be deceptive, you can't see whether theres a gap in between the book and the bottle.
*	No, but you can see the bottom of the bottle, can't you?
*	That's true.
R.B.	Did you use ...... reference point ....
*	Yes.
R.B.	How hard was this one?
*	I puzzled over it for ages ....
*	I'd change my answer ......

<u>Item No. 14</u>.

R.B.	What did you think of this one?
	(Loud giggles)
R.B.	Did you find any difficulty in relating the two views?

* (Murmurs signifying no difficulty)

* I remember doing these things at school and being told that I was an utter idiot because I didn't know where the shadows came. I just couldn't visualise - I just couldn't work it out any way. I can look at this and I know I've done it wrong, but I don't know why I've done it wrong and I haven't got a clue about how to put it right.
(Plan view no shadow)

R.B. Anyone else feel like that, one of the things could be right and the other wrong?

* Yes .... Yes.

R.B. What makes you feel that they're wrong, then?

* There's something about it I think is wrong, I'm sure is wrong.

R.B. The first one's O.K.?

* I think so.

R.B. And the second one is wrong?

* Well, it's just that I didn't know where to put them, so it's likely to be wrong.

R.B. Could you go in imagination to the point where you are just going to put your pencil to the paper, you know, if you were doing it now, what would be going through your mind?

* I'd say that the light's there, the man's there, the shadows going to be behind.

R.B. So it would be a verbal formula, so to speak?

* Yes.

* And I sort of drew lines from the top of the lamp-post by the head, down to the ground, then back to where he stands and said "That's the length of it", I'm not sure that's right but that's what I thought anyway.

R.B. And how about the other one? (Plan view)

* I wasn't sure on this one whether to draw shapes .... I wasn't sure what shape he would be.

R.B. So on the first one you actually drew a line and that determined where the shadow would be?

* Yes.

R.B. But on the second one it was a different thing altogether ... there was no help from drawing lines?

* Mmmmmmm Yes.

* What I tend to do is if I can't work it out one way, if I can't reason it out verbally, I sort of look at it again from a different level and try to think of it, what does physically happen. What has happened when you were standing by a lamp-post and your shadow has been cast, or what happens when you're in the sunlight and your shadow's been cast, which side does it occur, is it bigger than you are or is it smaller ...

R.B. And did you actually do that?

* I remember thinking about it - trying to picture in my mind what has actually happened - I came up against this barrier again .... I knew it was wrong but I didn't know where it was wrong and I didn't know how to put it right ...... there's some special way of doing it ..... I've been told over and over again, and I don't remember.

R.B. Did anybody else try to go back to experience ....

* I thought about football .... we used to play football in the evening .....

R.B. Did you think about reading lamps - you know, in your rooms?

R.B. Do you have reading lamps in your rooms?

* Yes.

R.B. You didn't use that ..... as a reference point?

* .... when I was a child we used to stand, and we were always fascinated by shadows and we were always chasing our own shadows and I thought of that.

* It depends where the position of the sun is ....
Mmmmmmmmm Mmmmmmmmmm

* ...... you know, in relation to the figure, and that's what I found difficult.

R.B. How many people found your difficulty, that it was all right on the first one, you had ways of dealing with it, but not on the second one where it was a plan view? Four out of seven ....

Item No. 16.

R.B. Did you concentrate on the quantity or the level?

* Level .... Mmmmmm

*	I reckon that was the easiest of the lot - I've been a barmaid.

Item No. 1.

R.B.	Did you assume that the bases were all the same?

*	Yes .... Mmmmmmmm.

Item No. 2.

(Jumbled conversation)

R.B.	You remembered using a hose-pipe?

*	Yes.

R.B.	Do you know of any rule that might apply?

*	No.

R.B.	Could you eliminate any of the answers fairly easily?

*	A (Laughter)

*	B

R.B.	But the other three are worth considering?

*	Yes.

*	No, E, it's either C or D really.

*	Course, it does depend on the force of the water.

*	Does it?

*	Yes.

R.B.	You mean, in addition to these ....

*	Mmmmmmmm

Item No. 3.

*	There's a rule to this, isn't there, the distance from the fulcrum or something ....

*	The work at school was confusing in these questions. We had to remember so many different factors that affected something.

Item No. 4(i)

*	It won't go lower.

(Jumbled conversation)

*	It depends on the size of the olive too.

Item No. 4(ii)

*	I guessed this.
R.B.	Well, how did you go about guessing, was it again a matter of getting rid of improbable ones?
*	Thinking about the sugar and whether it dissolves or not.
*	Yes........ Yes.......
R.B.	So the steps were - decide whether it dissolves or not, and if it does, do one thing, and if it doesn't, do another?
*	Yes.... Mmmmmm.
*	.... experience as against reason. Reason says that when it goes in it's displacing something, but if it's being dissolved it must be adding to the liquid ...... it must be a fraction higher, you know, it's not really perceptible.

Item No. 5(i).

*	I was trying to think of a watch ... you know, what you find in a watch with the back off, wheels going round. For some reason I thought that if one goes round one way the other must go round the opposite way, so the other one, the tiny one, will go the same way as B.
R.B.	Did anyone trace round the drawing with a finger?
*	Yes ..... Mmmmmmm.
R.B.	Did it help?
*	Yes ....

Item No. 5(ii).

No comment judged to be significant.

Item No. 6.

R.B.	Is there anybody who has never carried a ladder or something similar?
	(One person had not)
	General conversation.
*	Obviously ..... can't both be carrying the same load.
	(Laughter)
*	I threw that one out ..... because the weight of the ladder ...

and whether you are stronger or not just depends on how easily, it makes a difference on how easily you do it .....

R.B. So you threw that one out, did you?

* Yes.

R.B. Sorry, I missed that (interjection by student)

* I put that they both carry about the same load.

R.B. What sort of argument did you have to ......

* I can't really remember ...... I didn't like the question ... because ..... er .... I didn't think there was enough information. Because I think it depends on their height .... I mean if Fred is ....

R.B. It says they are the same height ......

* Yes.

* Fred is half way along the ladder so there's half of the ladder over his shoulder, and he is balancing on the .... (Interruption - person coming into the room)
..... I took it that he was half way along the ladder so you've got half of it in front of him with his wife holding it, and half behind, er ..... now you could be more definite, er ..... certain about the answer if you knew the length of the ladder and what position on the left and where his wife was ...

* Yes, but it tells you.

* She's holding the end of the ladder there .....

* Yes, precisely, it's just an approximation; it could be ...

* ...... but then you've got to sit and measure it, haven't you.

* .... Well, er .....

* .... to make sure that whoever's drawn it is accurate.

* That's what you assume.

* ..... not enough information given.

* I thought there was enough information to answer the question, but then .....

<u>Item No. 7</u>.

* I've watched billiards on television.

R.B. Pot Black?

* Yes, I tried to think of that.

* I was trying to visualise the angle it would come off ....

R.B. From the bumper?

* Yes.

R.B. Through doing that were you able to get rid of any of the possibilities?

* Yes.

R.B. Which one first?

* D.

R.B. What made that one come first?

* I was visualising some somebody holding a cue ... if he was holding it there, it wouldn't .... go over there.

R.B. If you were pressed, could you say why?

* It just seems reasonable, I don't really know why.

R.B. If you get rid of D, what's the next one to go?

* A

R.B. Why's that?

(Unintelligible)

R.B. So that's got rid of the two extremes .... How did you decide between the other two?

* You just had to weigh up the angle ......

* Mmmmmmm ... or try to.

R.B. When you say "weigh up ..."?

* I mean, you know ......

R.B. See which looked better?

* Yes.

* Well, I tried to see it on an actual table.

R.B. Does this remind you of any of those principles you learned at school that you were talking about earlier?

(Pause)

R.B. It doesn't ring any bells?

* It does somewhere.

R.B. So you had to rely almost entirely on trying to imagine how the ball would behave?

* Yes ...... Mmmmmm

Item No. 8.

No comment judged to be significant.

Item No. 9.

*	I traced that with my finger.
R.B.	Did it help?
*	Yes it did.
*	I haven't even a vague idea about bicycle chains or anything like that. I just couldn't figure it out.
R.B.	Where did it start being difficult? You said you ran your finger round it, didn't you ....
*	No, I don't tend to do that. I look at it and try and measure it.
R.B.	When you were looking at the larger of the two wheels with the belt round it, I imagine it was fairly easy to see that turning that way, wasn't it?
*	Mmmmmm
R.B.	Where did it start to get difficult?
*	Well, it wasn't .... I mean if you ..... could just put A, saying it was going forward ..... because to me the arrow is pointing that way, it's almost biassed.
R.B.	Oh, you mean that's acting as a cue to make you say "Yes, it's going forward"?
	(Unintelligible)
R.B.	It's necessary to mention it, isn't it, otherwise .....
*	But surely, if it pointed backwards, you'd go backwards.
*	Yes, but surely, if that's going round that way .... you'd go forward ...... no .... twisted .... the push comes...
*	That's where you've got the push, and the wheel will go round the way the push goes, and that wheel will be going backwards.
	(Unintelligible comments)
*	Then the pull bit will go round under .....
*	.... pushing at the top which will start the wheel in motion backwards, and then the pull ...... underneath which continues ...... in other words, it's going backwards.
*	Yes.
*	Well, I don't know, I've just looked at it again, it would break, I mean it's silly.

*	I thought of it going forward, but I wrote backwards. Looking at it now, I'd say forwards.
R.B.	What would make it go forwards, did you say?
*	Because of the arrow and this little thing.
*	Yes, it's a figure of eight.
*	If it was a chain it would go all round one way, and that's twisted isn't it, so it starts off that way and pushes round <u>that</u> way.
*	Do you agree with what I said - it's a push as it goes round, and a pull underneath .....
*	Yes.
R.B.	Did you say that the belt would snap?
*	I thought so. I put that ....
*	I don't know - that would make that one turn backwards, and it couldn't turn .... so ......
R.B.	So one wheel would be going one way and the other would be going the other way, and therefore the belt would snap?
*	Yes.
R.B.	Did anybody consider D to be worth thinking about?
*	No.

<u>Item No. 10</u>.

R.B.	Did any of these answers seem to be completely useless?
*	Yes, "It depends on how much he squashed it". (Laughter)
R.B.	What sort of considerations did you have in mind in getting rid of the others?
*	Piaget. (General hubbub)
*	I just thought of the Eureka thing .....
R.B.	Back to school?
*	Yes.

<u>Item No. 11</u>.

R.B.	..... a lot of words in this, weren't there?
*	Yes, Mmmmmmmmm.

R.B. Which could be thrown out?

* A

* C

R.B. So that leaves B and D as worthy of consideration.

* No, I don't think B was worth considering. I worked out the answer and then looked down the answers, A? B? C? D?. I just decided that was the one.

On completing the paper, discussion returned to several of the items.

Item No. 9.

* Why does it go backwards? I've written it but I don't know why.

R.B. (Attempt to demonstrate the path of a point on the belt as it travels round the two wheels)

* But then, if you're pushing that way, going like that, you're going forwards this way but your back wheel's going backwards.

R.B. But it's only your leg that goes forward, isn't it, the machine itself wouldn't go forward.
(Unintelligible)

* This seems stupid to me, you pedal it one way and it goes the other.

Item No. 14.

R.B. (Attempting to explain) .... the principle is that if you have a light source and an object near the light source, the shadow will be on the side away from the light source: and the principle would apply wherever you were looking at it from - you know, wherever your view of the thing was, the same principle would apply. And because these (diagrams) are identical events, so to speak, you know it's still the same fellow standing there and it's still the same light shining there, and the shadow would be the same length .... it's the same shadow ....

* It would still be the same? It wouldn't come out like that? (Further expressions of doubt, not intelligible on tape)

GROUP THREE (3 Students)

Item No. 12.

R.B. Could you eliminate any of these?

* D. G. B.

R.B. What did you have in mind when you were thinking, "I'll throw that one out, or that one ....?

* You have a sort of visual picture; you imagine yourself swinging the pendulum ....

* .... you watch the results.

R.B. There is a principle, isn't there, that you could put into words ..?

R.B. Do you remember doing anything like this at school?

* Yes I don't remember the questions but I should know what the answer was. I remember reading problems like it in books, something to do with Piaget's stages of thinking.

Item No. 14.

R.B. Did you have any problems in reconciling the two views?

* No.

R.B. How did you set about this?

* It was just a guesss, I think.

* It was very hard to visualise where the shadow would be.

R.B. When .... you were going to make a mark on the paper, can you remember why ....?

* I think you mentally take a line from the light to the man.

R.B. That's because of something you know, isn't it. Is it possible to put that into words?

* I think it's imagining, actually.

R.B. So if you were coming to this now, you would think about standing near a lamp and imagine what would happen?

* Yes.

Item No. 16.

* I can remember doing this in school.

R.B. Did you go for the quantity or the level?

* .... the line you should use and the angle it should be.

Item No. 1.

R.B. Did you look at the bases of the bottles?

* Mmmmmmm

* No.

* I did.

R.B. Which could you eliminate on Bottle 2?

* A.

Item No. 2.

R.B. Which could you eliminate?

* A, straight away.

* I just considered each in turn.

* I'd say E was a possibility, but not B, it's not much difference from A to B really.

* No, I wouldn't say there was any possibility of E.

Item No. 3.

* I went back to childhood .....

* I related it to science - we used to try to get rules to balance ......

R.B. So you were thinking of a general principle?

* Yes.

R.B. Is it one you could put into words?

* No.

Item 4(i).

* You really had to think about this.

R.B. Which could you eliminate?

* A. D. B.

Item No. 4 (ii).

R.B. Could you eliminate any of these easily?

* D. A.

R.B. B deserves consideration?

* It's difficult.

* At first sight you'd consider it.

Item No. 5.

No comments judged to be significant.

Item No. 6.

R.B. Which could be got rid of?

* D.

R.B. Which were worth considering?

* C. B.

R.B. What decided the issue?

* The amount of ladder and the fact that she's carrying the first half so ...... there was pressure on the back.

Item No. 7.

* I've played a lot of pool.
(Conversation about pool)

R.B. Which of these were improbable?

* A.

* When you play pool you can hit them from all angles.

R.B. But it says "exactly in the centre of the ball with the right amount of force ...."

* It depends on where the actual ball you're hitting is being hit from.

R.B. Do you know any principle - theory - which would explain what would happen?

* I was under the impression it should make a right angle with the line the ball travels to X.

R.B. So between C and X and 1 there would be a right angle?

* Yes, that's what I worked on when I did that.

Item No. 8.

No comments judged to be significant.

Item No. 9.

* I couldn't answer it. I got half way and couldn't get back.

* I think what put me off, I can't ride a bicycle, I don't know anything about them.

R.B. Did you try tracing your finger round it?

* Yes.

R.B. It didn't help?

* No. I think I decided that would be pulling against that and the belt would break. If you pushed the pedal forward that would go back and it wouldn't work at all .....
That would go forward ('Gear wheel') that would go backwards (Rear road wheel) therefore it wouldn't work at all.

* It would depend on the amount of pressure. The bike would stay still and the belt would eventually snap or something.

<u>Items 10, 11 and 13</u>.

No comments judged to be significant.

GROUP FOUR (6 Students)

<u>Item No. 12</u>.

* We'd been doing something in maths like this just the week before we did this.

R.B. You had actually swung pendulums?

* Yes, we'd fixed it up to one of the windows. It was to do with things we could do in school.

R.B. How did you go about this question ..... which of the answers is clearly out?

* C. G.

R.B. Most of the others deserved a bit more consideration?

* Yes.

R.B. Did one stand out as being highly likely?
(Long pause)
Discussion of imaging.

<u>Item No. 13</u>.

R.B. What sort of strategies did you use on this one?

* I thought about being in place ... thinking of an artist's impression.

* I tried to look at them as though I was standing (in each of the places).

*	I took a plan view (stood in one place and 'bent over' the objects)

Item No. 14.

*	Difficult .....
R.B.	Is that general?
*	Yes. Yes.
*	You don't really think about where a shadow is when you're standing under a light.
R.B.	Did anyone have problems with the two views?
*	No. No.
R.B.	If you were doing it now, what would be .....
*	I'd put myself in the situation .... standing under a light.
R.B.	In his place?
*	Yes.
*	I just couldn't visualise this one at all.
*	I just can't remember where it shoudd go,
R.B.	Did anything that you did at school or college come into mind here?
*	Something we'd done about reflection of light, but I couldn't remember the actual ......
*	We had some prisms ....
R.B.	Do you think it would be possible to put the principle into words .....
*	Yes, I think so.
R.B.	Can you do it?
*	No.

Item No. 16.

R.B.	Did you go for the amount or the level?
*	The level.
*	When I worked in a bar I measured half a pint in a glass for pint shandies.

Item No. 1.

*	On thinking back I wasn't so sure.
R.B.	What sort of doubts?

*	With the sides being wider would it really go higher or would it be the same if it was that bit lower?

Item No. 2.

No comment.

Item No. 3.

No comment.

Item No. 4(i).

*	I thought of the theory of the weight of something going into the container and the amount of water being displaced being the same as the weight of the object that was placed into it.

Item No. 4(ii).

R.B.	Which of these deserved a bit more consideration?

*	I thought about A and B.

*	Whether it dissolves or not the sugar is still there, isn't it?

Item No. 5.

No comment.

Item No. 6.

R.B.	How did you go about deciding between A, B and C?

*	Well, Fred was really the balancing point.

Item No. 7.

*	There's a principle.

*	I tried to imagine what would happen.

R.B.	What was the principle?

*	Angles of reflection - it had to be the same angle going on as going off.

Item No. 8.

No Comment.

Item No. 9.

After discussion of difficulty of predicting movement:

R.B. When does tracing your finger round cease to help?

* When it comes back the other way.

Item Nos. 10 and 11.

No comment.

GROUP FIVE (6 Students)

This group did not wish their discussion to be tape-recorded. The students agreed to my taking written notes. This procedure was awkward, since I had to ask for time to make a note on many occasions, thus producing lags in the conversation.

Item No. 12.

Two members commented immediately that they had done no physics at school.

Five said that they had imaged swinging pendulums.

Five said that they "ought to remember the answer".

"I only put one answer, but there may be more - I don't know what happens if the weight is changed".

"The obvious answer is E. But a harder push would give a faster rate of swing initially, although this would slow down, so you should keep pushing every now and then."

Item No. 14.

"I thought of the sun and how it made shadows longer as I moved about".

"I thought about standing in the sun to decide where to put the marks".

"Fred takes up space and blocks the light rays and creates a mass of darkness in front of him" (In front of him?) "Er .. yes".

(Asked to explain the idea of plan and elevation) Various contributions e.g. "looking down from above", "looking directly from the side".

Five members agreed that the two views (in diagrams i and ii) represented the same objects seen at the same time.

There was no response to questions about the light in the room and where the shadow would be if I held my hand up.

Item No. 16.

"I had to think which way the glass was tilting."

"It would have been easier to decide where the marks should go if the difference between the amount of tilt had been greater"

(After top-of-wall cue was pointed out)

"I never thought about the top of the wall being level".

Item No. 1.

"I imagined the straight bottle placed over the top of the others"

"I looked at the amount of white paper inside the lines and thought about how much there was".

Item No. 2.

"If you point the hose pipe straight up it comes down next to you, so the one furthest away from that must be the one that goes furthest, so I chose 'hose-pipe level'."

"I imagined myself looking at the place where the water had to go, and chose the middle one."

"I picked D because it was nearest to E - I thought that there must be a catch in it so I didn't put E".

"It depends on the pressure of the water".

Item No. 3.

"I kept thinking about the word 'fulcrum'."

"I thought about see-sawing when I was at school. One of us sat at one end and two of us would work our way up from the middle till we balanced."

Item No. 4(i)

"I put C but A could be right."

"Do olives float?"

Item No. 4(ii)

"If it dissolves, how can you see a difference?"

Item No. 5.

"Circular lines are difficult to see."

Item No. 6.

"He is balancing the ladder so he's not taking so much weight: If you balance something you're carrying, it's easier to carry. His wife's taking the weight."

Item No. 7.

"It depends on where you stand. You can hit X from anywhere."
"I drew lines and chose the one that looked right."
"I've played pool, but I don't understand the geometry."

Item No. 8.

No comments noted.

Item No. 9.

"I think the belt would snap."
"You need more information".
"I don't think the bike would move at all. Surely the wheels would go in a different direction and prevent movement either way."
"If you pedal forwards this gives a slight forward momentum to the bike, but it wants to go backwards - you would fall off."

Item No. 10.

"I'm not sure whether the surface area would make a difference."
"All I could think of was a story the teacher told at school - 'when a body is immersed in water the telephone rings'."

Item No. 11.

"These words, mass, weight, are confusing - weight was used when I was at school, not mass."
"The more you think, the more possibilities there are. I have doubts about my answer now."
"You get bored reading this one half way through."

Item No. 13.

No comment noted.

APPENDIX XIV

Diagram of Re-direction of Study.

APPENDIX XIV

Notes on Diagram.

Note 1

Comparison of scores on M.H.V. and C.C.F. tests, average number of 'O' and 'A' level passes, average age; using figures given by Lomax (1969) as criterion.

Note 2

Each item asks subjects to identify a principle which explains cause and effect in everyday situations. The principle may be known by the subject.

a) so that it can be put into words or diagrams and recognised as being at work in different contexts.

b) intuitively so that, although it can not be put into words or diagrams, its effects can be predicted in different situations.

c) vaguely, so that its effects may be recognised in familiar contexts but not in unfamiliar ones.

d) As a verbal response-chain without the necessary underlying concepts capable of generalisation to different contexts.

or

e) the subject may have no grasp of the principle.

'Type 1' Errors. Responses which indicate a genuine misconception of the event in the 'real world' which the test item describes. These responses would indicate levels (c), (d) and (e) above.

'Type 2' Errors. Responses which indicate that some aspect of the item itself has led to misunderstanding. Subjects giving Type 2 responses may or may not understand the event in the 'real world' described by the item.

Note 3.

Information on the nature of errors will come from approximately thirty subjects, interviewed in small groups. Subjects chosen so most kinds of response on the second administration of the test are represented.

<u>Note 4</u>.

Riegel's (1973) notion of 'dialectic operations' provides possible theoretical framework.

<u>Note 5</u>.

E.g. idiosyncratic ways of interpreting text and diagrams, unnoticed ambiguities, etc.