A STUDY OF STUDENT LEARNING THROUGH LECTURES BASED ON INFORMATION PROCESSING THEORY

BY

WALTER YU-JEN SU

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY OF CHEMISTRY DEPARTMENT, FACULTY OF SCIENCE. UNIVERSITY OF GLASGOW.

1991

Acknowledgements

It is my great privilege to express my deepest gratitude to my supervisor - Professor A H Johnstone, from whom I received unfailing encouragement and inspiration throughout the period of my study. His academic enlightenment, judicious supervision and invigorating guidance made this research a most enjoyable and rewarding experience.

I am very grateful to the Class Head of the First-year Ordinary Chemistry course - Dr R A Hill and all the staff members involved in this course for their kindness in allowing me to sit in their lectures. Special thanks to my troops - all the seventy-five students in my sample; without their generous assistance and enduring cooperation, this study would not have been possible.

I really appreciate the warm support and friendship of my colleagues in the Centre for Science Education, University of Glasgow. Special thanks are due to Dr R A Hadden for his helpful suggestions on the observation of lecturers. My grateful thanks are due to Dr P R P MacGuire, who gave me a great deal of support and offered a great deal of help in handling students' evaluation data.

I would like to extend my sincere thanks for the financial support from the Ministry of Education, Taipei, Taiwan.

Last but not in the least, I am greatly indebted to my wife and my family, who have shown extraordinary patience and continuous support during the long years of my demanding study.

Abstract

This study provides an account of a naturalistic research into students' learning through lectures. It documents aspects of students' rating of courses and lecturers, the researcher's participant observation and students' note-taking behaviours during normal lectures in a naturally occurring classroom. Students' opinion about the course and the lecturers involved was collected by using a specially designed questionnaire. Access to students' learning was obtained by using audio-tapes of lectures and students' lecture notes. Analysis of lecture notes and interview data provided insights into the nature of, and factors influencing students' note-taking. It also called into question the value of some conventional wisdom about lecturing.

This project described three phases of an extended research study planned to investigate how the effects of lecturers' styles interacted with students' cognitive processing of the corresponding lecture information and thus their note-taking behaviours.

The first phase of this study involved an exploratory examination of both lecturing and note-taking at the same time under natural conditions for the purpose of revealing some promising factors for further investigation. It was uncovered that note-taking from lectures under certain conditions was in fact dependent on the lecturing styles.

In the second phase of this study, a more complete framework, based on Information Processing Theory, was advanced to investigate both lecturing behaviours and the note-taking behaviours and performance of particular type of learners with different working memory capacity, learning styles and motivational types under various lecturing conditions.

The third phase of this study was mainly concerned with testing hypotheses to check the reliability of research findings from the previous phases of this present study and in addition, note-taking behaviours of students in general was also investigated.

Based upon Information Processing Theory, this study tried to integrate the research into lecturing and the research into note-taking into a unified framework. Such an attempt has provided a key to a fuller understanding of how lecturing processes (the cognitively oriented stimulus variables) influence students' learning processes (the cognitively orienting response variables) during the lectures. Such study has both theoretical orientations and practical implications for improving lecture effectiveness and students' learning (and note-taking) through lectures.

The findings from this research suggest that the approach adopted in this investigation holds promise for improving our understanding of how lecturing could be presented efficiently to maximise the transmission of information, and eventually for improving the lecturing effectiveness by making it more adaptive to the needs, interests and learning styles of students and for improving learning by developing in students the strategies for effective note-taking from lectures.

One considerable justification and contribution of this present study is that the research into students' cognitive processes during lectures has pursued purely descriptive studies in naturally occurring classroom settings. Such study could ensure that hypotheses and questions posed are relevant and sensible to the subsequent correlational and experimental research. Constructs and variables used in this research have ecological validity and the research designs have taken account of naturally occurring phenomena and other aspects of university lectures.

CONTENTS PAGE.

CHAPTER ONE AN EXPLORATORY STUDY OF LECTURING AND NOTE-TAKING UNDER NATURAL CONDITIONS

CHAPTER TWO THE RESULTS OF THE EXPLORATORY STUDY

CHAPTER FOUR THE PLANNING AND ADMINISTRATION OF THE SECOND PHASE STUDY

CHAPTER FIVE THE INFLUENCE OF LECTURING VARIABLES ON STUDENTS' NOTE-TAKING BEHAVIOURS

CHAPTER SIX THE PLANNING AND ADMINISTRATION OF THE THIRD PHASE OF THE STUDY

CHAPTER ONE

An Exploratory Study of Lecturing and Note-taking under Natural Conditions

1.1 Emergence of the Research Problem

One afternoon in 1988, the researcher was invited to attend a tutorial group in which eleven students took part. When the tutor asked the students how the Daniel cell $Zn \mid Zn^{2+} \parallel Cu^{2+} \mid Cu$ works, an interesting dialogue began as following : (The letters **T** denotes tutor and S_1, S_2, ... stand for student one, student two and etc.)

T In the solution how does a current pass through it ?

S_1 You've got to use a salt bridge to complete the circuit.

T Right! And then what is a salt bridge ?

S_2 It's a gel with AgAl and Kcl in it.

T AgAl ? What's that ?

S_1 I think it's Agar. (He was bending to check his notes.)

S_3 Oh dear! Isn't it a gas and Kcl ? 'coz that's what I took down in my notes.

T What a mess! O.K. Actually it is agar and I just don't know why you've got different notes. Well, now tell me how the salt bridge completes the circuit. Uh, how does the salt bridge work ?

(Two minutes in silence. All of the students looked up in their notes trying to get the answer.)

S_4 The salt bridge separates two half reactions and produces a current.

S_5 Yeah! The current of electrons passes through the salt bridge and thus is able to connect the circuit.

T So, the electrons go through the salt bridge ?

S_5 Yes!

S_1 I don't think so. Salt bridge only conducts electricity without allowing mixing of two solutions. SO_4^- carries charge to complete the circuit.

S_3 Aye. The sulphate ion goes into the salt bridge and the metal ion in too, and what goes in there comes out here.

T You are saying both of them go into the salt bridge. The sulphate ion in one side and the metal ion in the other side. Is that right ?

S_4 My notes indicated only SO_3^{2-} flow along salt bridge.

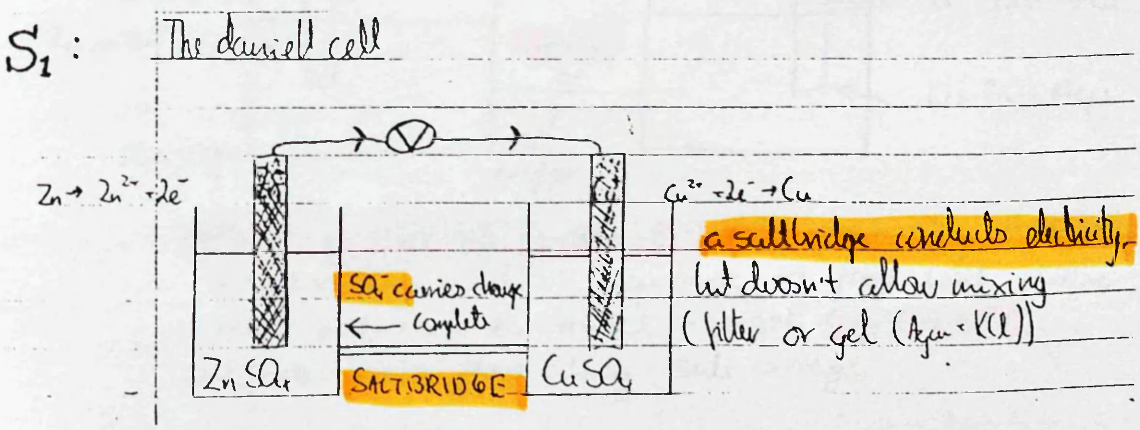
.

.

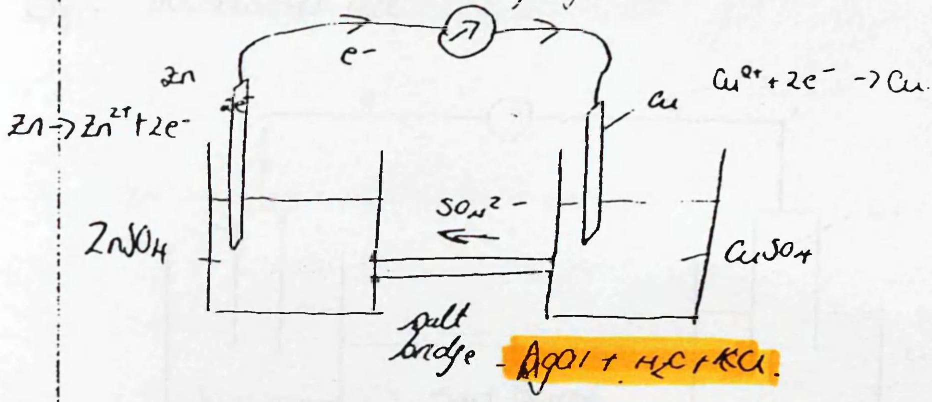
(The dialogue was going on.)

It was really an amazing experience, because all the eleven students attended the same lecture in the morning and all their arguments were based upon their personal notes which they took down during the lecture. The researcher was so impressed that he borrowed and xeroxed the lecture notes of that particular topic from all the eleven students (Appendix 1). The exact copies taken from the notes of some students who participated in the above dialogue were shown below :

S_1 :

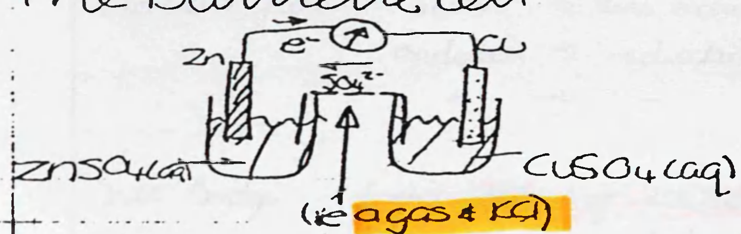


S_2 : The Daniell Cell : (trying to separate both rxs)



Electricity can be carried by anything that will carry charge.

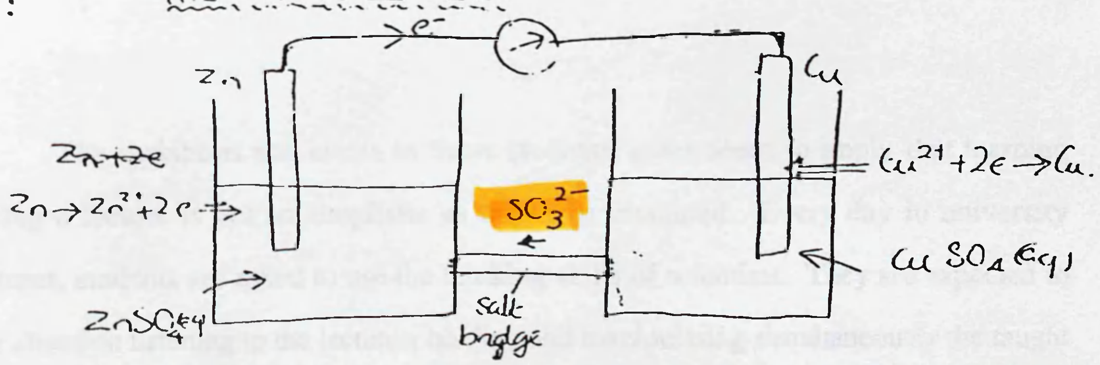
S_3 : The Daniell cell



$Zn \rightarrow Zn^{2+} + 2e^-$
$Cu^{2+} + 2e \rightarrow Cu$

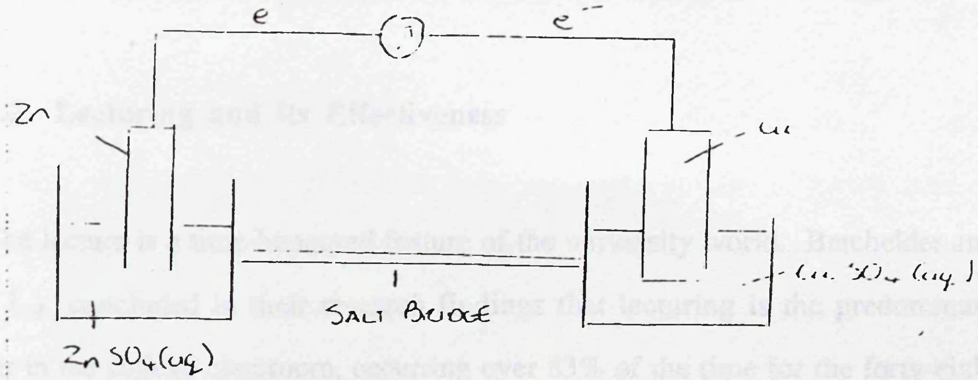
Electricity, charge and Energy.

S_4 : THE DANIELL CELL



separating the half reactions and producing a current
(salt bridge - allows current to flow but doesn't allow solutions to mix). - a gel (AgAl + KCl).
sulphate ions flow along salt bridge.

S_5 : The Daniell Cell



$Zn \to Zn^{2+} + 2e^-$ $\qquad$ $Cu^{2+} + 2e^- \to Cu$.

Electrons flow as active → less active metal
oxidation → reduction
\+ → −

Salt Bridge - device allowing electrons to flow eg. filter paper soaked in salt or agar gel with H_2O and KCl. Solutions do not mix.

The variations and errors in those students' notes seem to imply that learning during a lecture is not so simplistic as might be imagined. Every day in university lectures, students are asked to use the thinking skills of scientists. They are expected to pay attention listening to the lecturer, holding and manipulating simultaneously the taught material, and then taking down whatever they think is relevant and important information that has been conveyed by the lecturer. How reasonable is it to make such demands ?

This exploratory study was thus conducted to examine both lecturing and note-taking at the same time, addressing what is going on in the naturally occurring settings and where the perceptions of the students are given prominence. The purpose was to reveal some promising factors for further investigation.

1.2 Lecturing and its Effectiveness

The lecture is a time-honoured feature of the university world. Batchelder and Keane (1) concluded in their research findings that lecturing is the predominant behaviour in the college classroom, occurring over 83% of the time for the forty-eight subjects in their study and teachers in science lecture 92% of the time.

At first sight lecturing as a method of teaching, is essentially a solo performance by a figure in authority engaging in extended one-way verbal communication with a group of students, with the intention that the latter can learn more about a substantive topic (Dunkin, 2). Such a general statement implies that the task of lecturing is more than the delivery of slabs of facts or loose chipping of ideas, it has several purposes such as giving information, generating understanding and stimulating interest.

The quality of university lecturing has been discussed (for example, Bligh et al., 3) but seldom explored in depth empirically. What are the differences between more effective and less effective lecturing? Are lectures for the benefit of students? These two questions have stimulated research on lecturing, which has involved the explorations of "lecturing effectiveness" by students' academic achievement and student evaluations of the lecturing, with subsequent analysis of naturally occurring lectures.

1.2.1 Students' Evaluation of Teaching Effectiveness

Remmers (4) initiated the first systematic research into students' evaluation of teaching effectiveness and his efforts provided the foundation for many of the successive important methodological advances in student evaluation research.

Since there are neither clearly defined nor universally agreed criteria of effective teaching, there continues to be considerable debate about the validity of student ratings. But the way higher education is organised and operated strongly indicates that students are pretty much the only ones who observe and are in a position to judge the teachers' effectiveness (Remmers, 5).

The term "students' evaluations of teacher performance" was introduced in the ERIC (Educational Resources Information Centre) system for the first time in 1976, but the study of students' evaluation has been one of the most frequently emphasised areas in Northern American educational research over the past fifteen years (Marsh, 6).

After summarising a body of empirical findings in this area of research, Marsh (7) described in one monograph that students' evaluations were found to be multidimensional, reliable and stable, reasonably valid against a variety of indicators of effective teaching, relatively unaffected by potential biases, and seem to be useful for students, teachers, and administrators.

Since the main purpose of seeking students' opinion of lecture courses in this study was to provide "diagnostic feedback to the lecturers about the effectiveness of their teaching" (Marsh, 8), students' perceptions of a lecturer's performance should be presented as a factual summary report for the lecturer concerned and also be able to highlight specific aspects of any given lecture presentation.

From a review of the published literature, the questionnaire based on a five-point scale is a suitable instrument because it is inexpensive, easily administered and easily scorable. It allows data to be collected from a large number on students, and objective results can be obtained soon after statistical analysis.

Marsh (9) conducted the factor analysis of both student ratings and staff self evaluation of their own teaching, and nine distinct components of teaching effectiveness were demonstrated. By utilising these components, ***SEEQ (Students' Evaluation of Educational Quality***) was designed as "an instrument and programme for collecting students' evaluations of college / university teaching". The nine components are :

1. Learning	Valuable learning experience, was intellectually stimulating, challenging.
2. Enthusiasm	Lecturer displayed enthusiasm, energy, humour, and ability to hold interest.
3. Organisation	Organisation / clarity of explanations, objectives, course materials, and lectures.
4. Group Interaction	Students encouraged to discuss, participate, share ideas and ask questions.
5. Individual Rapport	Lecturer accessible, friendly, and showing interest in students.
6. Breadth	Presentation of broad background, concepts, and alternative approaches / methods.
7. Examinations	Student perceptions of value and fairness of exams / graded materials.
8. Assignments	Value of assignments in aiding appreciation and understanding of course.
9. Workload / Difficulty	Relative course workload, difficulty, pace and outside hours required.

Because three components - breadth, examinations and assignments were judged less relevant for evaluating short lecture courses, they were not taken into consideration in this present study.

Similarly, from the results of factor analysis, Ormerod and Moore (10) identified six factors listed as follows :

Factor 1	friendly, cheerful enthusiasm.
Factor 2	student motivation.
Factor 3	empathy between student and lecturer.
Factor 4	balance in content of teaching.
Factor 5	lecturer's attention to students' work.
Factor 6	lecturer's confidence / competence.

According to these factors, they developed a questionnaire of twenty-six items - the ***Student - Lecturer Interaction Questionnaires (SLINT).***

Based upon these studies and a literature survey of good practice in universities in the U.K. and overseas, several common factors were finally identified and included in this study : enthusiasm, preparation and organisation of course materials, rapport with students, and pace. Ideally, each separate factor should have several statements to allow for checking the internal consistency (Johnstone and MacGuire, 11).

In spite of the generally supportive research findings, student ratings should be used cautiously, and there should be other forms of systematic input about teaching effectiveness. Abrami et al. (12) advocated research in settings more like those occurring naturally in educational contexts, and they suggested such research would lead to better understanding of lecturing if the systematic observation of lecturers' behaviours are included in the study.

1.2.2 Systematic Observation of Lecturers' Behaviours

Most of the commentators on the research on lecturing have more or less criticised the wholesale adoption of experimental designs to the exclusion of field studies (For examples, see Kulik & Kulik 13, and Cooper 14). Dunkin (2) concluded in his review that the control which might have been gained over extraneous variables in the experiments seems to have been won partly at the expense of the credibility of the findings, but also at the expense of knowledge and understanding of the nature of lecturing as it occurs in actual teaching contexts in higher education.

Although students' evaluation of teaching effectiveness has been used to uncover the strengths and weakness in a lecturer's teaching performances, few attempts have been made to determine which teacher behaviours actually yield high student ratings. To understand the process of lecturing, the actual nature and rates of occurrence of those lecturing activities under natural conditions should be illuminated from observing classroom behaviours of lecturers.

An extensive account of the methods and problems of measuring classroom behaviors by systematic observation is given by Medley and Mitzel (15), and a more recent and influential work in this field is devised by Flanders and Simon (16). With regard to the interaction studies in science education, numerous attempts have been made to develop the appropriate teacher-observation schedules for science lessons in the secondary school (Power, 17).

Eggleston et al. (18) produced a very widely used instrument, i.e., the *Science Teacher Observation Schedule (STOS)*, and some of the interesting differences and similarities between teaching styles have been revealed by using this instrument. In this observation schedule, the judgements about the nature of science and what science teachers might do that relates to it are adopted, and so result in such categories as : teachers ask questions of fact; teachers ask questions calling for hypotheses; pupils refer to sources of information, etc.

While most of these analysis systems have made meaningful observations possible in the elementary and secondary school level, it is not so convenient to apply them to the observation studies at the tertiary level since teacher lecturing is the most frequent classroom behaviour in university or college courses, and student behaviour is not observed as part of the interaction.

From the students' evaluation of teaching effectiveness, it seems to be true that different lecturers are perceived to be more or less effective due to their varying techniques and characteristics. It then could be reasonable to suggest there are different characteristics within lecturing behaviours that can be observed and measured.

Cranton (19) utilised a category observation system which was developed by Shulman (20) and based on Flanders Interaction Analysis (Flanders, 21). In the system, an instructor's class is video-taped with a digital clock providing a time reference on the tapes. The fifteen categories of behaviours are : data lecturing, data A.V., data illustration, data linking, management, structuring, silence, questions, discussion, clarifying, crediting, criticizing, demand, monitoring and affect.

Tomic (22) collected his data on teaching behaviours by using the "Five Minute Interactions Instrument" (FMI). The FMI instrument was largely based upon instruments devised by the Stanford Research Institute (Stallings et al., 23) and the coding on this instrument was teacher-oriented. Student behaviour was coded only when the student was interacting directly with the the teacher, so it is of practical consideration for this study. Within the content area, there are five categories : instruction, questions, response, feedback and non-academic interactions.

From these observation systems, some of the common categories which are concentrated only on lecturing behaviours were selected to form the basis for observing the various techniques and characteristics of different lecturers. Among them are the following categories : personality (e.g. enthusiastic, amicable, humorous or pleasing), presentation style (clarity, expressiveness, logical structure, and stimulating interest), basic communication skills (voices, speech rate, and blackboard writing), use of appropriate audio-visual aids and student participation.

1.3 A Review of Relevant Research into Note-taking

Note-taking during lectures is such a common practice in university learning environment that it has largely been ignored by science education researchers as a phenomenon of study. Taking lecture notes seems to be highly appealing to both lecturers and students alike simply because of the intuitive belief held by them that note-taking promotes learning.

Di Vesta and Gray (24) postulated that the facilitative effect of note-taking is likely to derive from one or both of those two functions : the encoding function and the external storage function. The former function addresses the learner's active processing of information by activating attentional mechanisms, and coding and transforming the received input into his personally meaningful form. The latter function emphasises the product of note-taking - the lecture notes, that can serve as an external repository of information which allows later revision and review.

1.3.1 Correlational Studies of Note-taking

Some research has been conducted to provide empirical evidence to the aforementioned postulates. For instance, several studies have examined the relationship between note-taking and test performance (See Hartley and Davies, 25).

As early as 1925, Crawford (26) first tried to conduct experimental studies in college note-taking. His findings indicated that the number of lecture points correctly recorded in students' notes displayed a significantly positive correlation with their performance on a number of different evaluations of learning made throughout the course (Crawford, 27).

Howe (28) examined the relationship between note-taking and delayed free recall performance, and he found that textual information had a 34% chance of being recalled if it was taken down in the students' notes, but only a 5% chance of being recalled if it was not noted.

Similar results were obtained by Aiken, Thomas, and Shennum (29) , who showed that the chance of noted information being recalled (47%) was four times that of neglected unnoted information (12%). In a latter study, Locke (30) also detected that material from a single lecture which was not written on the board but was recorded in students' notes significantly correlated with subsequent course grades.

Based upon all these data, it seems reasonable to conclude that taking notes will not guarantee successful recall but that failure to do so will almost decrease the chance to recall information following a delay and with no opportunity to review.

However, there were a few contradictory research findings (Kiewra, 31) which suggested that note-taking may inhibit rather than facilitate learning. The overt response of writing may interfere with the receiving of new information, and as a result the student may be cognitively passive because he is engaging only as a receiver-transmitter of the message (Weener, 32).

Several investigators have found that note-taking had a significantly adverse effect upon performance. By quoting the findings of an experiment conducted by P.J. Freyberg, McLeish (33) indicated that those subjects who didn't take notes performed better than groups of students who took either detailed or outline notes.

Peters (34) demonstrated as well in his research that subjects who took no notes made significantly more correct responses than subjects who took notes in a recall test conducted immediately after the presentation. He thus suggested taking notes during a rapid presentation would interfere with listening, but at slower speed note-taking may enhance listening by arousal of students' concentration.

Thomas et al. (35) pointed out that note-taking between segments of a lecture is superior to note-taking during a lecture. In other words, the listening and the writing functions interfere with each other, so they had to be separated to improve learning during a lecture.

Considered as a whole, the combined evidence from the correlational studies which involved note-taking and no-notes conditions does not provide support for any straightforward conclusion about the direct effect of note-taking on learning (Howe and Godfrey, 36). As indicated above, in some conditions note-taking has been found to aid learning, but in others to hinder it.

1.3.2 Recent Development in Note-taking Research

Since this line of investigation has yielded such a mixed picture, research has recently advanced beyond this argument and has examined the quantity and quality of notes associated with the performances of learners (Kiewra and Benton, 37).

Research evidence by Aiken et al. (29) found a positive relationship between the content of lecture notes and test performance, that is to say, the quantity has to do with performance.

Howe (38) reported a significant positive correlation between "efficiency" of note-taking and subsequent recall. Howe's "efficiency index" is defined as the total number of words in a set of notes, divided by the total number of main ideas or critical points contained in those notes. Thus ideally, efficient notes will be conceived as capturing the key ideas in as few words as possible.

From another point of view, quality of notes was defined by Fisher and Harris (39) as the number of ideas from the lecture included in the notes. But they noticed that the correlations of efficiency rating with performance ranged from .15 to -.39, therefore they concluded that note efficiency may actually be inversely related to academic performance and note-taking should thus be extensive rather than terse.

Alternatively, Locke (30) defined "completeness" as the percentage of total thought units in the lectures which have been taken down in each student's notes. A thought unit may be the name of a person, place or concept; the definition of a concept, or some other pertinent facts such as a date and etc. After analysing the notes taken by college students actually enrolled in courses, he detected a significant positive correlation between completeness of lecture notes and course grades.

Since the empirical relations between the quantitative and qualitative aspects of students' lecture notes and the comprehension and retention of lecture information in science lessons are not well known, it is extremely important to explore this area. The actual format and content of students' notes should be examined thoroughly enough to understand the underlying factors which cause such variations as seen before.

To be more specific, this present study tried to answer the following questions:

(1) What are "effective notes"?

(2) Are those notes which contain possible answers to exam questions "effective notes"?

(3) Are there any relationships between the note-taking and class exam and degree exam performances?

Besides, because little research exists on the type of information that students take down in their notes (Einstein et al., 40), it was decided to examine how new lecture information was being represented in students' notes.

Most researches have shown note-taking during a single lecture is related to subsequent course evaluations and so perhaps indicating the consistency of note-taking behaviours from lecture to lecture. Oddly enough, few studies have investigated note-taking behaviour over an extended period (Kiewra, 41). Thus the verification of the consistency of note-taking behaviour over a long period was incorporated into this present study also.

1.4 Looking at Lecturers through the Eyes of Students

It has long been recognised in our Chemistry Department that student opinions could provide a valuable component of teaching effectiveness, and one of the staff members was appointed to be in charge of designing a questionnaire to explore the students' perceptions of a lecturer's performance and to highlight specific aspects of any given lecture presentation. The questionnaire - "Student Evaluation of Teaching", was developed on a 5 - point rating scale and accepted as a suitable means of sampling student opinions by the staff members (Appendix 2).

This questionnaire addressed a number of factors, such as enthusiasm, preparation and organisation of course materials, rapport with students, and pace. There are fourteen statements altogether on the response sheet, the statements about the course content (statement 1 to statement 6) were kept separate from the statements about the lecturer characteristics (statement 7 to statement 14).

From October 1988 to May 1989, a study of students' evaluation of lecture courses was carried out in the Department of Chemistry, University of Glasgow. Most of the students enrolled in the First Year Ordinary Chemistry course were asked to evaluate the lectures and the lecturers from time to time by filling in their ratings on this specially prepared form.

According to the departmental timetable, it was arranged that any given lecturer was supplied with an adequate number (250 - 500) of blank response sheets, at least one week before the particular lecture course was completed. The lecturer selected any convenient time available - usually during the final lecture - to get the sheets filled in, and returned the completed sheets for processing.

The data was then processed using Masterfile - a simple database program running on a BBC Micro. For each lecture course, two confidential summary reports were produced - a complete report for the lecturer who had given the course, including all the gratuitous written-in comments; and an abbreviated report for the course organiser. This routine data processing was a regular activity from October 1988 till May 1989, when a second stage of the processing was conducted to look for the overall patterns of the lecturers.

1.5 Participant Observation of Lectures

Since most of the staff members agreed that their lecture courses could be investigated, it opened the possibility for setting up detailed observation of the lecturer in action. If the results of such in-depth studies of certain courses can be tied in to the students' evaluation of lecturing effectiveness, then the prospects for the research will be enhanced.

This investigation was restricted to lectures of 50 minutes duration in the First Year Ordinary Chemistry course from November 1988 to May 1989. Lectures were given to about 250 students in the Main Lecture Theatre with a capacity for 400. The course consisted of 97 lectures, divided into twelve different blocks presented by eleven different lecturers (One of the lecturers was in charge of two different blocks of lectures).

In general, the lecture was largely an un-interrupted discourse from a lecturer with hardly any discussions between students or interactions between the lecturer and students, and no student activity other than listening and taking notes. So the lectures were conventional in style in that they were content-based, lecturer-controlled and lecturer-dominated. All the lecturers were requested to provide for the students detailed behavioural objectives of their own particular lecture series.

At least two or three lectures were randomly selected from each lecturer for systematic observation. After acquiring prior permission from the lecturer, the researcher went into the lecture theatre about five minutes before the lecture started to set up the tape-recorder which was hidden somewhere around the lectern. Only the lecturers knew that a tape-recording was being taken, but the students didn't. So their lectures were audio-recorded in as natural a setting as possible, no attempt being made to control or affect the behaviours of either lecturers or students.

All the recordings were subsequently transcribed and analysed by using the " Observation Schedule of Lecturing" (Appendix 3). The general characteristics of the lecturer, such as enthusiasm about the subject, sense of humour, ability to hold interest, audibility of lecturer and quality of blackboard work were observed by means of the above observation schedule. In the mean time, the nature, preparation and organisation and the clarity of explanation were closely examined.

There are nine categories of behaviour in this observation schedule, and the descriptions of the categories are illustrated in TABLE 1-1. Each lecturing behaviour was noted every time it occurred, including repeated or re-stated ones.

For each lecture observed, a copy of the details of the blackboard writing and any materials presented on the OHP's or slides were carefully taken down. Any distributed handouts, data sheets, outlines and behavioural objectives were also collected for investigation.

1.6 Investigation of Students' Lecture Notes

The study was intended to be conducted under conditions occurring as naturally as possible. In the beginning, fifteen students attending a series of lectures (Chemical Kinetics) were randomly selected from the class. They didn't know any study or investigation was taking place until after the lecture. By that time they had completed

TABLE 1-1. Descriptions of Categories in Observation Schedule of Lecturing

Categories	Lecturer's overt behaviours
Personality	Smiling or laughing, telling jokes, humorous talk or behaviours making students laugh, approachable for students to ask questions.
Information - giving	Giving facts, ideas about subject content.
Blackboard writing	Legibility, organisation (headings) and size.
Cues for note-taking	Verbal or non-verbal signposts.
Illustrations	Illustrating data with personal anecdotes, real case presentations or applications.
Audio-Visual use	Presenting materials with the aid of transparencies, slides or films. Demonstrations with models, graphs, charts or experiments.
Structuring	Setting objectives, reviewing or summarising subject content.
Waiting	Pause or short periods of silence.
Student participation	Lecturer asking questions or responding to students' questions, student interrupting or complaining.

their notes. So the first sets of notes were taken and collected in an ordinary manner and there were no prior instructions concerning taking notes.

Shortly after the lecture session in that morning, when students were waiting for the afternoon lab to begin, the investigator entered the lab and asked the students to cooperate in the study. The purpose of this investigation was described briefly and the promise of keeping their data as confidential was also assured. Since no student showed reluctance to cooperate in the investigation, they were immediately requested to lend their notes on that morning lecture to the investigator.

An exact copy was taken from each set of notes by xeroxing, and because prior arrangements had been made, all the notes were returned to participants on the same day. This proved to be helpful and won the trust of the subjects, so that all of them were willing to take part in the second stage of study.

For the purpose of investigating the consistency of students' note-taking behaviours across different lecture series, the subjects' notes afterwards were collected either immediately after the lecture or one certain day of the same week, on which the subjects had lab work or a tutorial session. At least two sets of lecture notes from each student for every lecturer were collected, xeroxed and examined from time to time without prior signalling.

The content of the lecture notes is summarised as follows:

A. Chemical Kinetics	(1) Rate laws and reaction order.
	(2) Arrhenius' equation and catalyst.
B. Phase Equilibria	(1) Vapour pressure and Raoult's Law.
	(2) Osmotic pressure and Vant Hoff factor.

C. Organic Chemistry II	(1) Acetal and semi-acetal.
	(2) Carboxylic acid and its derivatives.
D. Inorganic Chemistry I	(1) Nitrogen group and Halogen group.
	(2) Noble gas.
E. Macromolecules	(1) Physical properties of polymers.
	(2) Synthetic polymers.
F. Solid State Chemistry	(1) Diffraction and Unit cell.
	(2) Crystal structures.
G. Food Chemistry	(1) Carbohydrate
	(2) Proteins.
H. Environmental Chemistry	(1) Nitrogen cycle and greenhouse effect.
	(2) Adsorption and Dissolution.
I. Inorganic Chemistry II	(1) Ligands and complexes.
	(2) Complex stability.
J. Nuclear Chemistry	(1) Radioactivity.
	(2) Nuclear reactions.
K. Electrochemistry	(1) Electrochemical cells.
	(2) Corrosion of metals and applications.
L. Organic Chemistry III	(1) Amine and amides.
	(2) Carboxylic acid amide.

CHAPTER TWO

The Results of The Exploratory Study

2.1 The Results of Students' Evaluation of Lectures

In this section, the method used for data analysis and the results of students' evaluation of lectures in the exploratory study will be presented and discussed in detail.

2.1.1 Methods of Data Analysis

For each separate lecture course, the actual and percentage frequency of the student responses, for each rating on the " 1 ... 5 " scale, was calculated for all fourteen statements appearing on the sheet. TABLE 2-1 shows a typical summary data table for a single lecture course. Based upon the 3013 completed response sheets which were obtained from students during this lecture period, the composite totals were computed for the whole course (TABLE 2-2).

Since the rating scale is not a numeric scale, but an ordinal scale of categories, it is more appropriate and more valid to use non-parametric tests of significance (See Cohen and Holliday, 42), such as the Chi-square (χ^2) test and the Spearman rank order correlation coefficient (r_0), to make comparisons between the lecture courses.

If one hypothesises that no measurable difference exists in the overall lecturing behaviours between those twelve lecturers involved, then it should be expected that students would rate each lecturer in much the same way for each statement. Any small variations between the student ratings would be negligible, and within the random fluctuations expected by chance (MacGuire, 43). For any given item on the student

TABLE 2-1. Typical raw data for a single lecture course

DATE - 17-02-89 COURSE - E N - 284

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	41	69	129	33	10	282
ITEM 2	15	34	104	94	37	284
ITEM 3	13	33	49	98	90	283
ITEM 4	48	55	130	23	5	261
ITEM 5	68	95	60	31	19	273
ITEM 6	63	56	101	40	16	276
ITEM 7	7	14	153	59	48	281
ITEM 8	15	50	121	69	26	281
ITEM 9	21	69	109	65	15	279
ITEM10	54	85	78	47	17	281
ITEM11	17	50	113	74	26	280
ITEM12	12	26	143	69	14	264
ITEM13	39	52	101	62	19	273
ITEM14	21	52	124	68	15	280

DATE - 17-02-89 COURSE - E N - 284

(Percentage values)

	1	2	3	4	5	TOTAL
ITEM 1	14	24	45	12	4	99
ITEM 2	5	12	37	33	13	100
ITEM 3	5	12	17	34	32	100
ITEM 4	17	19	46	8	2	99
ITEM 5	24	33	21	11	7	96
ITEM 6	22	20	36	14	6	98
ITEM 7	2	5	54	21	17	99
ITEM 8	5	18	43	24	9	99
ITEM 9	7	24	38	23	5	97
ITEM10	19	30	27	17	6	99
ITEM11	6	18	40	26	9	99
ITEM12	4	9	50	24	5	92
ITEM13	14	18	36	22	7	97
ITEM14	7	18	44	24	5	98

TABLE 2-2. Data totals for the whole course

DATE - 14-06-89 COURSE - All N - 3013

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	397	555	1146	703	193	2994
ITEM 2	345	426	711	976	548	3006
ITEM 3	320	516	848	722	595	3001
ITEM 4	244	375	1272	679	318	2888
ITEM 5	607	572	689	631	473	2972
ITEM 6	870	695	859	327	222	2973
ITEM 7	165	256	1932	320	299	2972
ITEM 8	306	691	1110	532	349	2998
ITEM 9	256	368	780	882	705	2991
ITEM10	537	570	691	739	462	2999
ITEM11	408	430	739	897	523	2997
ITEM12	135	228	1214	746	506	2829
ITEM13	419	370	721	778	644	2932
ITEM14	311	380	847	921	527	2986

DATE - 14-06-89 COURSE - All N - 3013

(Percentage values)

	1	2	3	4	5	TOTAL
ITEM 1	13	18	38	23	6	98
ITEM 2	11	14	24	32	18	99
ITEM 3	10	17	28	24	20	99
ITEM 4	8	12	42	22	11	95
ITEM 5	20	19	23	21	15	98
ITEM 6	29	23	28	11	7	98
ITEM 7	5	8	64	11	10	98
ITEM 8	10	23	37	17	11	98
ITEM 9	8	12	26	29	23	98
ITEM10	18	19	23	24	15	99
ITEM11	13	14	24	30	17	98
ITEM12	4	7	40	25	17	93
ITEM13	14	12	24	26	21	97
ITEM14	10	13	28	30	17	98

response sheet, one might expect the relative frequencies for the five ratings to be in the same proportion as the relative frequencies for the total of all the lecture course.

To illustrate the calculation of the expected frequencies, one can take the actual frequencies for item 1 (for the 2994 students given in TABLE 2-2) to calculate the expected frequencies for item 1 (for the 282 students given in TABLE 2-1). The expected frequencies will be (282 / 2994) times the actual frequencies given in TABLE 2-2 (i.e. '37', '52', '108', '66' and '18' respectively). TABLE 2-3 shows the results of calculating the expected frequencies for all 14 items and the actual frequencies (viz., the observed frequencies).

TABLE 2 - 3. A Typical set of Observed and Expected Values

DATE = 17-02-89 COURSE = E N = 284

(Observed values)

	1	2	3	4	5	TOTAL
ITEM 1	41	69	129	33	10	282
ITEM 2	15	34	104	94	37	284
ITEM 3	13	33	49	98	90	283
ITEM 4	48	55	130	23	5	261
ITEM 5	68	95	60	31	19	273
ITEM 6	63	56	101	40	16	276
ITEM 7	7	14	153	59	48	281
ITEM 8	15	50	121	69	26	281
ITEM 9	21	69	109	65	15	279
ITEM 10	54	85	78	47	17	281
ITEM 11	17	50	113	74	26	280
ITEM 12	12	26	143	69	14	264
ITEM 13	39	52	101	62	19	273
ITEM 14	21	52	124	68	15	280

DATE = 17-02-89 COURSE = E N = 284

(Expected values)

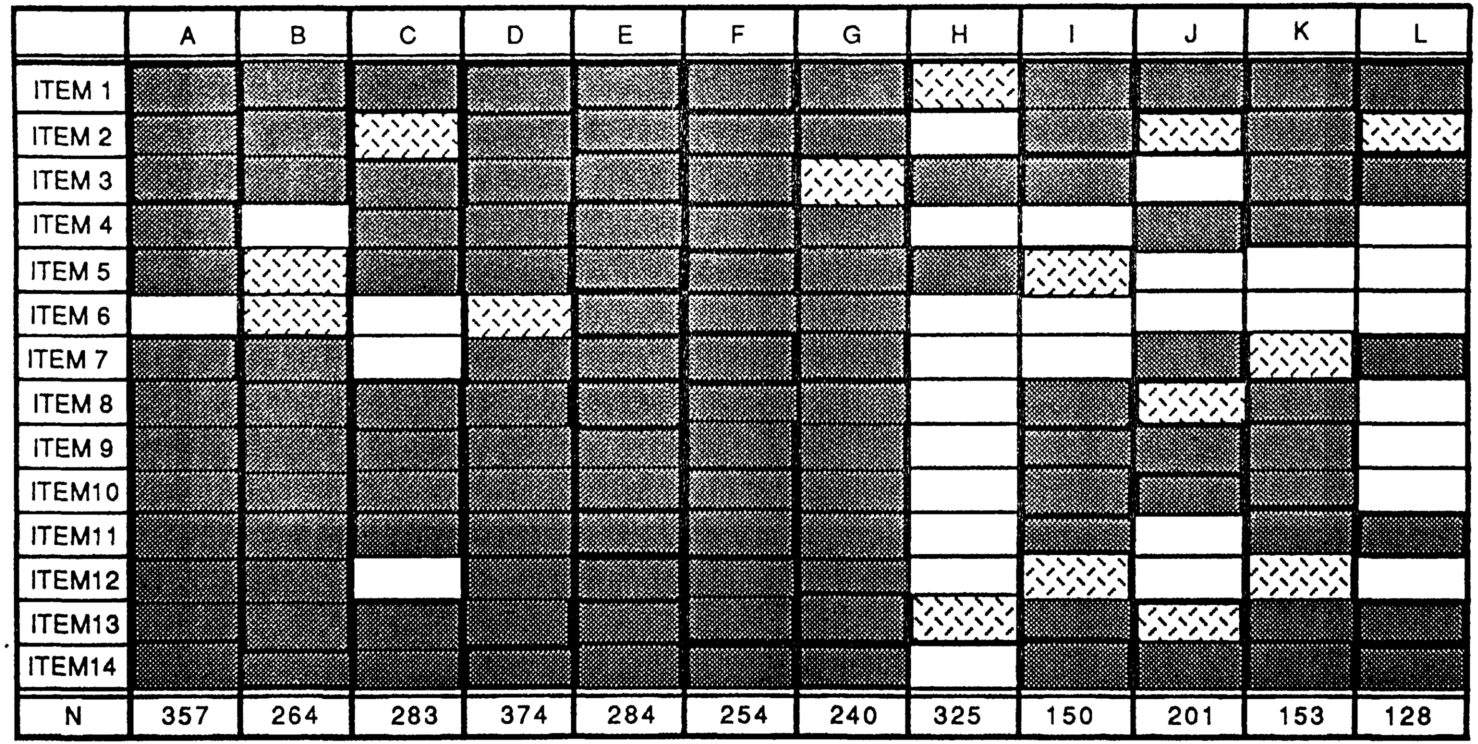
	1	2	3	4	5	TOTAL
ITEM 1	37	52	108	66	18	282
ITEM 2	33	40	67	92	52	284
ITEM 3	30	49	80	68	56	283
ITEM 4	22	34	115	61	29	261
ITEM 5	56	53	63	58	43	273
ITEM 6	81	65	80	30	21	276
ITEM 7	16	24	183	30	28	281
ITEM 8	29	65	104	50	33	281
ITEM 9	24	34	73	82	66	279
ITEM 10	50	53	65	69	43	281
ITEM 11	38	40	69	84	49	280
ITEM 12	13	21	113	70	47	264
ITEM 13	39	34	67	72	60	273
ITEM 14	29	36	79	86	49	280

The levels of significance of all fourteen items for the twelve separate lecture series, A, B, C, ..., and L are shown in TABLE 2-4. The shadings in it highlight the lecture courses which were significantly different from what would be expected if all the lecturers were evaluated by the students to be equally effective.

TABLE 2-4 : Significance levels of the 14 items for separate 12 lecturers

(→ significant at 0.01 level, and → significant at 0.05 level

A,B,C ... etc. are different lecturers; and N represents the number of total response)



2.1.2 An Account of Lecturing Styles Identified

From Table 2-4 it can be seen that eight or more out of the fourteen items were significant for the following lecture courses: A, B, D, E, F, G, H, I and L. For the purpose of understanding whether these lecture courses were significantly good or significantly bad, the "measurement of agreement" was estimated by ignoring any "3" ratings, and only calculating the value of { ('4' + '5') minus ('1' + '2') } for each item on the percentage summary tables (such as Table 2-1). The overall "measurement of agreement" with the given fourteen items is shown in TABLE 2-5.

The students were asked to fill in the given 14 items according to the criterion that, a rating of '5' indicated strong agreement, and a rating of '1' indicated strong disagreement, unless it said otherwise. So now it is obvious whenever a lecture course has a high negative rating (i.e., strong disagreement) for almost every item, it is significantly bad; while a lecture course has a high positive rating (i.e., strong agreement) for almost every item, then it is significantly good.

If the "measurement of agreement" is shown instead as bar chart, then each lecture course has its own "profile" and the same conclusion can thus be more easily seen. Figure 2-1 shows three contrasting profiles for different lecture courses. For item 8, a negative rating is actually better than a positive rating because of the wording of the statement, and for item 7, the optimum rating would be '3' or 'about right'. Similarly, all the performance profiles of twelve lecturers are shown in Fig. 2-2, Fig. 2-3 and Fig. 2-4 (See Appendix 4, Page 327 for detail).

A visual inspection of these profiles easily and clearly separates them into three groups, viz., three different lecturing styles :

Group I : Lecturers B, D, I and K.

TABLE 2-5 : The overall 'measure of agreement' { i.e. (4 + 5) - (1 + 2) } with the given items

	A	B	C	D	E	F	G	H	I	J	K	L
ITEM 1	-48	+36	-12	+35	-22	-34	-54	+22	+54	-2	+15	-24
ITEM 2	-53	+69	+37	+76	+29	-34	-63	+26	+84	+54	+41	-26
ITEM 3	-34	+70	+41	-1	+49	-7	-14	+61	+80	+42	-26	+14
ITEM 4	+35	+24	+36	+15	-26	-30	-24	+22	+39	+13	+5	-3
ITEM 5	-24	-1	+67	+11	-39	-54	-73	+51	+43	+38	-17	-50
ITEM 6	-28	-46	-31	-45	-22	-24	-16	-30	-54	-51	-25	-34
ITEM 7	+3	-7	+1	+2	+31	+18	+36	+5	-6	-12	0	-10
ITEM 8	+52	-43	0	-46	+10	+38	+44	-17	-60	-11	+2	+25
ITEM 9	-45	+93	+18	+85	-3	-5	+57	+33	+84	+65	+42	+3
ITEM10	-77	+84	-24	+67	-26	-47	-56	+20	+81	+27	+10	-43
ITEM11	-66	+77	+15	+74	+11	-40	-41	+15	+84	+56	+28	-30
ITEM12	-11	+65	+19	+79	+16	-2	-20	+32	+60	+39	+41	+14
ITEM13	-61	+84	-4	+83	-3	-21	-21	+32	+67	+44	+40	-7
ITEM14	-64	+87	+10	+91	+4	-27	-31	+29	+90	+54	+44	-16
N	357	264	283	374	284	254	240	325	150	201	128	153

** A,B,C ... etc. are lecturers; and N is the number of total response

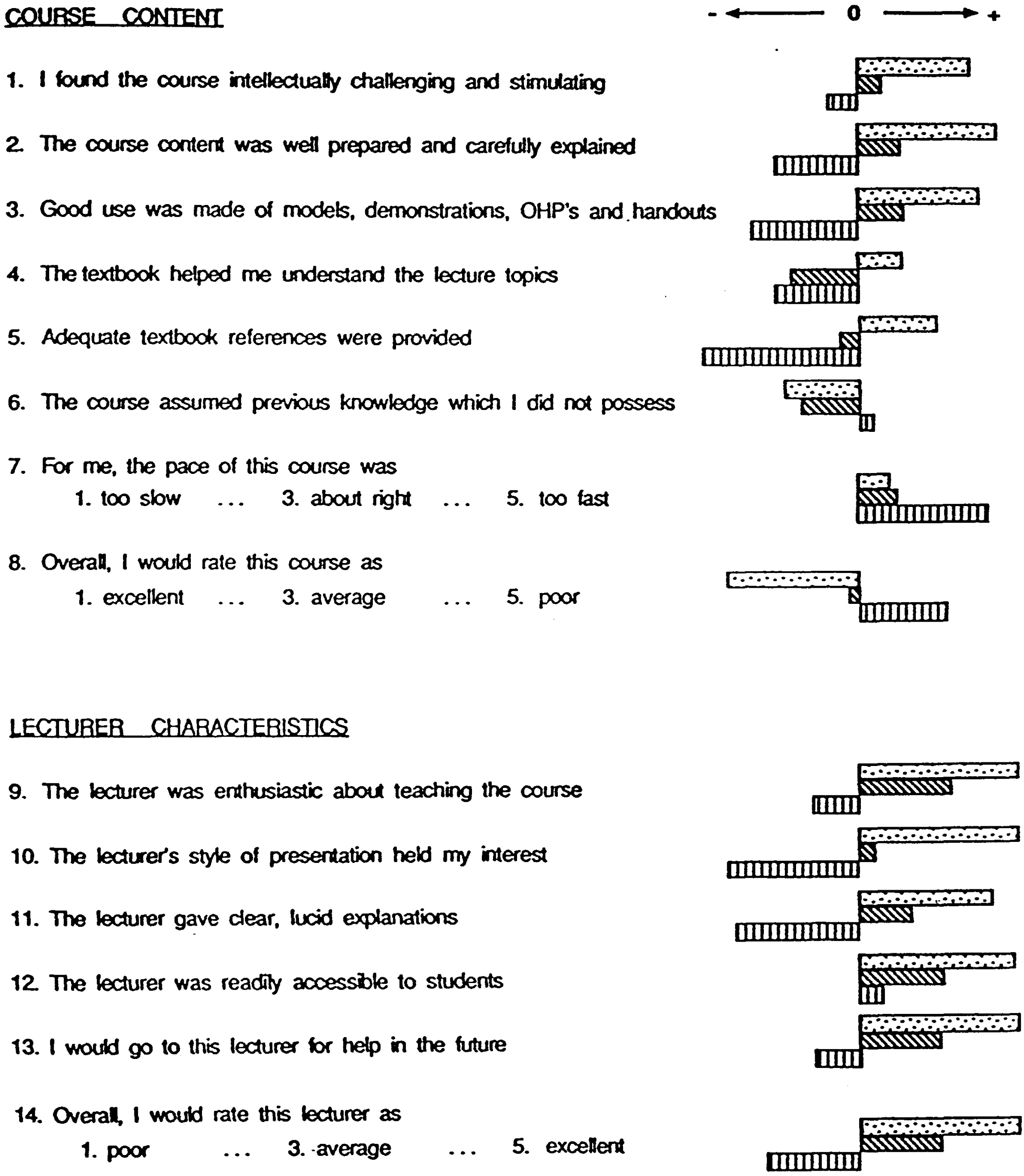


Figure 2 - 1. Three Contrasting 'Profiles' of Lecturers

([dotted] = I, [hatched] = J, and [vertical lines] = A)

Group II : Lecturers C, H, J and L.

Group III : Lecturers A, E, F, and G.

The lecturers in Group I were rated by the students as "good" or "effective", while in contrast, the lecturers in Group III were rated as "poor" or "ineffective".

How did students distinguish the "effective lecturers" from the "ineffective lecturers" ? What did the lecturers do to make such differences ? From the statements in the questionnaire and students' ratings, the common characteristics of effective lecturers seem to be : good communication skills, careful preparation and logical organisation, clear and lucid explanation, enthusiastic about teaching, and interesting style of presentation.

2.1.3 Reliability and Validity of Students' Evaluation

As far as possible, all the student response sheets received were processed to get the results. Generally speaking, very few of response sheets were spoiled or blank, but occasionally certain dubious response sheets, on which students had circled, for example, the same response for all 14 items, were deleted at the processing stage. Eventually a total of 3013 student response sheets was processed, with twelve lecturers involved.

From the information presented in TABLE 2-5 (Page 27), the different blocks of lecture courses can be arranged in a rank order by using the "measures of agreement" for each item, going from positive values through zero to negative values. The rank orders are in turn used to calculate the Spearman rank order correlation coefficient, r_0, and the degree of inter-correlation between each item in the response sheet can thus be estimated. The results are shown in TABLE 2-6, where significant results are shown by shading.

TABLE 2-6. Inter-correlations between each of the 14 items .

(→ significant at the 0.01 level, and → significant at the 0.05 level)

	ITEM 1	ITEM 2	ITEM 3	ITEM 4	ITEM 5	ITEM 6	ITEM 7	ITEM 8	ITEM 9	ITEM10	ITEM11	ITEM12	ITEM13	ITEM14
ITEM 1		+0.86	+0.60	+0.53	+0.57	-0.92	-0.66	-0.97	+0.77	+0.99	+0.96	+0.94	+0.95	+0.97
ITEM 2			+0.29	+0.43	+0.50	-0.83	-0.51	-0.87	+0.62	+0.83	+0.93	+0.91	+0.83	+0.86
ITEM 3				+0.41	+0.37	-0.46	-0.25	-0.51	+0.48	+0.60	+0.48	+0.43	+0.52	+0.48
ITEM 4					+0.80	-0.67	-0.57	-0.46	+0.34	+0.46	+0.47	+0.40	+0.34	+0.40
ITEM 5						-0.60	-0.41	-0.50	+0.26	+0.52	+0.49	+0.50	+0.40	+0.49
ITEM 6							+0.85	+0.90	-0.73	-0.90	-0.92	-0.85	-0.85	-0.89
ITEM 7								+0.65	-0.56	-0.64	-0.68	-0.53	-0.61	-0.64
ITEM 8									-0.86	-0.97	-0.97	-0.95	-0.96	-0.99
ITEM 9										+0.83	+0.81	+0.83	+0.86	+0.83
ITEM10											+0.96	+0.96	+0.98	+0.97
ITEM11												+0.96	+0.96	+0.97
ITEM12													+0.96	+0.97
ITEM13														+0.97
ITEM14														

A glance at this table clearly illustrates that the block of six statements which refer to Lecturer Characteristics (i.e., the statements 9, 10, 11, 12, 13 and 14) are all strongly related to each other, and to both statements 1 and 2. There are strong negative correlations between the above statements and statement 8, referring to the overall rating for the course. This negative correlation is due to the reverse polarity in statement, where a rating of '1' means "excellent" and a rating of '5' means "poor".

The highest single correlations are between statement 2 (" The course material was well prepared and carefully explained") and statement 11 (" The lecturer gave clear, lucid explanations"). There are also very high correlations between both of these statements and statement 9 (" The lecturer was enthusiastic about teaching the course"), statement 10 (" The lecturer's style of presentation held my interest ") and statement 13 (" I would go to this lecturer for help in the future").

Reliability refers to the repeatability of an experimental result or the consistency of a measuring instrument, while validity refers to whether an observation or procedure is sound or genuine (Elmes et al., 44). Marsh (8) also pointed out :

" The reliability of student ratings is commonly determined from the results of item analysis (i.e., correlations among responses to different items designed to measure the same component of effective teaching) and from studies of inter-rater agreement (i.e., agreement among ratings by different students in the same class) ".

Four lecture courses were randomly selected and arranged so that student ratings were carried out by both the morning session group and the afternoon session group. (Same lecture course to a large class has to be divided into two teaching groups, taught by the same lecturer.) This provided a useful consistency check on the data. For example, TABLE 2-7 shows the results of one data consistency check which was carried out on the data for the Lecturer A. The remarkable consistency of students' evaluation of lecturing in this study has been verified by such a repeated data consistency check (See Appendix 5, Page 330 for more examples).

TABLE 2 - 7. An Example of Consistency Data Check

DATE = 18 - 10 - 88 COURSE = A / A N = 252

(Morning group)

	1	2	3	4	5	TOTAL
ITEM 1	2	11	47	33	5	98
ITEM 2	2	7	16	46	29	100
ITEM 3	2	9	28	43	18	100
ITEM 4	3	8	34	34	16	95
ITEM 5	3	6	15	35	41	100
ITEM 6	38	25	18	8	9	98
ITEM 7	4	6	78	7	4	99
ITEM 8	15	31	39	12	1	98
ITEM 9	4	4	20	49	23	100
ITEM 10	2	8	23	41	24	98
ITEM 11	3	8	14	40	34	99
ITEM 12	3	5	34	33	19	94
ITEM 13	4	5	19	40	31	99
ITEM 14	1	1	19	47	31	99

DATE = 18 - 10 - 88 COURSE = A / A N = 165

(Afternoon group)

	1	2	3	4	5	TOTAL
ITEM 1	1	15	44	35	4	99
ITEM 2	2	6	30	38	24	100
ITEM 3	2	17	29	31	21	100
ITEM 4	2	10	37	37	10	96
ITEM 5	3	5	19	47	25	99
ITEM 6	38	27	15	12	7	99
ITEM 7	5	7	78	5	5	100
ITEM 8	12	24	53	9	1	99
ITEM 9	2	7	33	42	16	100
ITEM 10	6	12	29	38	15	100
ITEM 11	2	7	27	40	24	100
ITEM 12	1	6	34	42	13	96
ITEM 13	1	5	29	41	24	100
ITEM 14	1	3	30	44	22	100

What is even more, the observed correlations between, for example, statement 2 and statement 11 are highly consistent across different lecture courses in the Chemistry Department, and they lie remarkably within the range of .90 to 1.00 (MacGuire, 43).

With regard to the validity of students' evaluation, Marsh has argued as well :

" Student ratings, which constitute one measure of teaching effectiveness, are difficult to validate because there is no single criterion of effective teaching.... The most widely accepted criterion of effective teaching is student learning, but other criteria include changes in student behaviours, instructor self evaluation, (and) the evaluation of peers and / or administrators who actually attend class sessions."

Based upon the well developed SEEQ document (Marsh, 9) and student ratings forms obtained from other sources (Appendix 6, Page 332), with minor modifications and additions, all the statements appearing on the STUDENT EVALUATION OF TEACHING could have content validity. Besides, the input from suggestions of staff and responses of students added on to the validity.

2.1.4 Written-in Comments from Student Ratings

Statement 6 on the student response sheet was : " The course assumed knowledge which I did not possess 1 2 3 4 5 ". To check on the nature and extent of this assumed knowledge, a blank space was left at the bottom of response sheet for students to complete as necessary. But during the data processing, it was found that a lot of students were using this space to make occasional comments about the lecture course or the lecturer.

Since these gratuitous comments were un-invited and found very helpful in highlighting some particular features of the course or some characteristics of the lecturers, all written-in comments were recorded verbatim in a file. In general, it was interesting to find that the overall ratings awarded to a lecturer were clearly related to the number of students who felt the need to write comments, and so the lowest rating ones (A, E, F and G) received the greatest number of written-in comments.

A total of 307 different statements of written-in comments was collected from the twelve lecturers involved in this lecture course (Appendix 7, Page336), and after analysis they can be classified into one of these following categories :

Lecturer characteristics

1. Attitude: showing interest in or enthusiasm about lecture.
2. Stimulation: challenging, boring, or stimulating interest to learning.
3. Personality: warmth, understanding, amiable, approachable, or humorous.
4. Board writing: clear, lucid, easy to take notes.
5. Voice: loud enough to be heard, clear and fluent speech.
6. Pace: speech rate, waiting time or material amount in a lecture.
7. Improvement: specific suggestions.
8. Lecturer overall: good, poor, effective or ineffective.
9. Others: noncodable responses.

Lecture course

10. Content: understanding, useful or sufficient.
11. Materials: handouts, references or A.V aids.
12. Structure: objectives, lecture organisation, or clarity of explaining.
13. Previous knowledge: assumed too much or waste of time on unnecessary points.
14. Overall course: enjoyment, challenging, good, or boring.

15. Others: statements not codable.

TABLE 2-8 shows the frequency distribution of students' written comments classified by the above fifteen categories. The following results have been observed :

1. Nearly three quarters of all comments were negative (235 out of 307, i.e., 76.6%). Three of every four comments was about a characteristic of the lecturer, whereas only one of every four was about a characteristic of the course.
2. Of the 221 comments about the lecturers, nearly one third were about the lecturer's audibility of voice or blackboard writing quality. The second most commonly stated characteristic was lecturing pace, followed by three characteristics reflecting the lecturer's personality and relationship with students (i.e., enthusiasm, approachableness and sense of humour).
3. About one third of the student comments about the course related to student learning of the subject content. Students complained that too much assumed prior knowledge was put into the thermodynamics and macromolecules blocks of lectures, and they also expressed strong negative comments on too many chemical equations in inorganic chemistry I block and enormous mathematical equations in chemical kinetics and environmental chemistry.
4. Nearly one quarter of the comments were concerning the use of audio-visual aids in lectures. Most of students favoured its use but they pointed out the time left for recording the presented materials was far too short.
5. The lecturer's ability to communicate clearly in class was also frequently mentioned in the written-in comments.

TABLE 2 - 8. Frequency (f) Distribution of Student Written-in Comments by 15 Categories

Category	*Written-in comments*										
	positive			positive+negative			negative			total	
	f			f			f			f	%
	1	2	3	1	2	3	1	2	3		
Lecturer characteristics											
1. Attitude	2	0	0	1	2	0	3	5	13	26	8
2. Stimulation	2	0	0	1	1	0	2	3	8	17	6
3. Personality	3	1	0	0	1	1	2	4	12	24	8
4. Board writing	2	2	1	1	0	2	4	7	27	46	15
5. Voice	3	2	2	0	1	1	2	5	14	30	10
6. Pace	1	1	0	1	0	1	4	7	16	31	10
7. Improvement	0	0	0	2	2	4	2	3	8	21	7
8. Lecture overall	3	2	1	0	1	1	1	3	7	19	6
9. Others	0	1	1	0	0	0	1	1	3	7	2
Total	16	9	5	6	8	10	21	38	108	221	72
Lecture Course											
10. Content	0	0	0	1	0	0	5	7	13	26	8
11. Materials	1	1	0	0	1	1	2	2	11	19	6
12. Structure	1	1	0	1	0	1	0	2	3	9	3
13. Previous knowledge	0	0	0	0	1	1	2	3	7	14	5
14. Overall course	1	1	0	1	1	1	1	1	8	15	5
15. Others	0	0	0	0	1	1	0	0	1	3	1
Total	3	3	0	3	4	5	10	15	43	86	28

Taken from different blocks of this lecture course, the following selection of students' written-in comments highlighted some of the most frequently stated characteristics which called for special attention :

" The lecturer is too quietly spoken and speaks to the blackboard."

" It would be better if the OHP's were photocopied and given out. We have thus time to listen and not write blindly."

" The course was boring and did not hold my interest."

" The course was potentially very interesting, but too much was crammed into too short a space."

" It would be extremely helpful if a summary sheet of the reactions/mechanisms was provided at the end of the course."

" Lectures were far too fast. By the time you wrote down what was on the board, the lecturer was explaining something 6 lines ahead but not writing down his explanations, so you missed it. This happened all the time."

" Giving lectures in the form of a handout is totally useless!"

" It would be better if the lecturer wrote bigger and not so squashed up."

" Lecturer is sometimes hard to hear due to mumbling. Lecturer should not use blue chalk in diagrams - it is not an easy colour to see!!"

" Not enough time was given to copy down OHP or slides, which made it impossible to listen at the same time."

" I found the standard of this lecturing was quite shocking. Not enough was written on the board and too much was just spoken."

Considered as a whole, most of the students' written-in comments generally pin-pointed the specific lecturing behaviours which had caused them problems in following the taught material, such as illegible writing, overcrowded OHP slides, messy blackboard work and inaudible speech. The students seemed to know what went wrong and suggested what should be done to improve matters.

2.2 An Account of Findings from Participant Observation

The number of occurrences of each behaviour category in a particular lecture was determined for the individual lecturer by using Observation Schedule of Lecturing (Appendix 3, Page 326). Every lecturer had two lectures investigated, and so he had two data sheets, each one being a frequency distribution of nine categories. The data were coded continuously after each five seconds, and the corresponding proportion of time lecturers were involved in each of the teaching behaviours respectively was also recorded.

Since this exploratory study was aimed at understanding which lecturing behaviours lead to different student ratings, the observation data were again clustered into three groups: Group I for effective lecturers, Group II for average lecturers, and Group III for ineffective lecturers. TABLE 2-9 presents the frequency distribution of lecturing behaviours for three different groups of lecturers.

As can be seen from the results in this table, of all the coded frequency counts, 71% to 80% pertain to the information-giving and blackboard writing categories. In most cases, the lecturer used the blackboard or material aids during presentation or explanation of subject matter (31% to 37%). The lecturers seldom gave students opportunity to ask questions (student participation was the least observed behaviour), the percentage of interactions that allowed students to express their personal ideas, feelings, or opinions related to chemistry subject was negligible. In general, the lecturers involved were more concerned with factual content while they were lecturing. Not surprisingly, information-giving by talking and writing on the blackboard are the most frequently occurring

TABLE 2 - 9. Mean Frequency and Percentage of Lecturing Behaviours of Three Different Groups of Lecturers

Category	Mean Frequency and Percentage of occurrence		
	Group I (Effective)	Group II (Average)	Group III (Ineffective)
Personality	18 (3.0)	15 (2.5)	8 (1.3)
Information - giving	240 (40.0)	246 (41.0)	258 (43.0)
Blackboard writing	185 (30.8)	215 (35.8)	221 (36.8)
Cues for note-taking	24 (4.0)	22 (3.7)	13 (2.2)
Illustrations	23 (3.8)	18 (3.0)	12 (2.0)
Audio-Visual use	19 (3.2)	23 (3.8)	36 (6.0)
Structuring	14 (2.3)	11 (1.8)	4 (0.7)
Waiting or Pauses	65 (10.8)	56 (9.3)	41 (6.8)
Student participation	12 (2.0)	9 (1.5)	5 (0.8)
Total Frequency and Percentage	600 (100)	600 (100)	600 (100)

*** The Figures in the parenthesis are percentages of occurrence.

behaviours in the lectures, and the frequency percentages are 41.3 % and 34 % respectively.

Because lecturing (or talking) and blackboard writing were used for such a large percentage of the time, the differences in other behaviours seemed to be more important in understanding why students rated the lecturers differently. Further comparisons between the afore-mentioned behaviours and the other more frequently occurring behaviours were made in order to discover any differences in the behaviour patterns for three different groups of lecturers.

Between Group I and Group III lecturers, it became obvious that the key differences seemed to be located in the following categories : personality, cues, waiting or pause, structuring, illustrations and lecturer-student interactions.

As can be seen, for Group III lecturers, teacher-initiated questions to ask for students' responses or responses to students' ideas were extremely rare. While in contrast, a total of 12 out of 26 times of student participation category frequency counts was noted among the Group I lecturers. It was also found that actually even those 5 frequency counts were the students' interruptions or complaints due to the inaudible speech or illegible writing.

Category 5 (structuring) was a major area which differentiated Group I lecturers from Group III ones. The lecturers who spent a higher proportion of time in structuring behaviours, such as explanation of course objectives, reviewing, summarising, and arranging blackboard work by heading or subheading tended to be rated higher by students.

Concerning the personality category, the Group I lecturers seemed to have more of the following behaviours: telling jokes, smiling or laughing during lectures, having sense of humour, and being approachable to students. On the contrary, such behaviours seldom occurred among the Group III lecturers.

Concerning the waiting time, Group I lecturers not only paused more frequently but also for longer intervals for students to record the necessary information when the materials were presented by using audio-visual aids. Another point worthy of notice is that Group III lecturers seemed to use fewer illustrations and instructional cues than Group I lecturers. Could it have been that students were feeling less interested and not aware of which were the essential points to take down in their notes?

2.3 A Comparison Between Students' Ratings and Participant Observation Data

The results from students' evaluation of lecturing indicated Group I lecturers were rated as "effective lecturers" because they might have good communication skills so that their presentation style were more interesting. They were perceived to be enthusiastic about teaching, besides, they tended to give clear and lucid explanations by using illustrations and logical organisation.

The additional findings from students' written-in comments largely pointed out the specific difficulties or problems encountered in a particular lecturer's course. Most of the comments were negative and centered around Group III lecturers. The communication skills were the most frequently stated comments, followed by lecturing pace and personality characteristics.

From another point of view, the analysis of participant observation data showed that Group I and Group III lecturers differed in certain lecturing behaviours quantitatively and qualitatively. The frequency counts in personality, illustrations, cues, structuring, waiting time and student participation were apparently different.

Combined all together, those three different sets of findings have in common the following factors : (i) personality characteristics, (ii) communication skills, (iii) style of lecture presentation and (iv) lecturing pace.

It is interesting to find that students paid great attention to the lecturers' basic communication skills, especially the audibility of voice and the quality of writing, probably due to their perceived necessity to take essential notes. But it is quite natural for them to reflect such complaints, because the students visually or aurally receive lecture information and this in turn depends heavily upon the visibility and clarity of the signals.

It was also demonstrated in students' comments that they were so influenced by the lecturers that three quarters of those written-in comments in fact focused on their personality characteristics, which included enthusiasm about teaching, interesting presentation style and clear explanation. Indeed in most of the lectures of Group I lecturers, more laughter and a happy atmosphere were observed; on the contrary, doodling, restlessness or talking among students were relatively frequently observed in the lectures of Group III ones.

As MacGuire admitted in his conclusions about students' rating of lectures (43): *" I cannot claim to have proved that students' perceptions of a lecturer's performance are accurate, because the term 'accurate' is itself debatable."* But at least, the students were in general able to detect the basic problems in seeing the blackboard writing and hearing the spoken words. And when the lecturers were in a rush or didn't wait long enough so that students were left behind or got lost, their perceptions were more or less judged to be correct from the participant observation findings of the researcher.

2.4 The Results from Analysing Students' Notes

2.4.1 The Results of Quantitative Analysis

The total number of lecture notes collected from fifteen students were 360 sets, and by using the "Analysis Schedule of Student Notes" (Appendix 8, Page347), they were examined in terms of four indices for the content of notes:

(a) The total number of words : the total number of words, symbols, abbreviations, and illustrations pertaining to the information presented by the lecturer.

(b) The total number of information units : the total number of information units contained in a student's notes. The information unit is defined by using Anderson's (45) propositional definition of an information unit as equalling the smallest unit of knowledge that can stand as a separate assertion.

(c) The completeness percentage : the total number of information units taken down in a student's notes, divided by the total number of all possible information units conveyed in the lecture, multiplied by one hundred.

(d) The efficiency index : the number of information units, divided by the total number of writings (i.e., words, abbreviations, symbols, and illustrations) found in the notes (Howe, 46).

TABLE 2-10 shows the total number of words recorded by fifteen students across twelve different blocks of lectures. Overall, subjects copied down an average of 538 words with a range from 214 to 1154 words. Relatively speaking, note-taking was

TABLE 2 - 10. Total Number of Words Recorded by 15 Students in Different Lecture Blocks

Lecturer / Student	LecturerA 1	LecturerA 2	LecturerB 1	LecturerB 2	LecturerC 1	LecturerC 2	LecturerD 1	LecturerD 2	LecturerE 1	LecturerE 2	LecturerF 1	LecturerF 2	LecturerG 1	LecturerG 2	LecturerH 1	LecturerH 2	LecturerI 1	LecturerI 2	LecturerJ 1	LecturerJ 2	LecturerK 1	LecturerK 2	LecturerL 1	LecturerL 2
	(5347	4988	5120	5435	4995	5123	2957	3520	4893	5094	4176	4820	5849	5632	5394	5150	5986	3716	4501	4861	3704	4469	4685	5039)
S 1	866	674	534	542	---	775	454	469	403	711	814	1020	279	296	389	349	285	529	253	301	496	547	615	302
S 2	853	----	528	492	725	712	482	479	448	574	798	947	251	214	304	412	326	503	300	343	524	502	503	335
S 3	1008	709	545	518	801	789	499	494	410	622	683	966	308	318	242	328	385	490	234	385	563	598	641	334
S 4	1067	767	606	577	824	814	566	518	604	----	840	1072	316	460	460	595	420	594	317	424	609	643	636	382
S 5	998	681	613	----	817	807	515	502	544	602	892	999	323	369	473	399	399	864	603	496	574	667	657	409
S 6	1102	794	572	598	797	829	520	567	564	698	942	1077	----	347	412	525	384	668	374	507	633	614	661	527
S 7	1046	733	588	563	841	791	615	514	515	634	796	1112	369	439	318	379	396	574	352	451	607	689	653	347
S 8	1023	702	----	537	806	770	491	451	504	643	816	1004	298	316	339	380	360	603	326	369	581	592	636	314
S 9	1072	698	547	602	794	843	525	459	556	694	795	1154	334	476	470	453	429	625	608	413	685	701	651	341
S 10	986	661	518	505	723	689	498	449	380	496	735	928	268	291	299	358	260	464	217	324	527	486	609	325
S 11	998	655	531	524	786	782	548	494	516	627	825	----	302	324	395	368	362	588	241	380	568	602	628	320
S 12	1134	726	562	615	868	---	546	526	555	740	960	1120	312	385	438	528	367	610	311	466	702	674	570	381
S 13	993	665	533	544	752	776	545	490	433	563	677	870	304	298	300	386	364	517	339	377	562	608	612	323
S 14	1003	673	509	573	---	727	502	462	602	959	761	959	267	264	267	----	357	576	----	363	547	591	---	---
S 15	----	708	544	471	779	744	523	498	622	906	---	906	280	309	528	555	378	602	266	298	508	573	526	346
Mean	1011	703	552	547	793	775	522	491	495	631	809	1010	301	340	376	430	365	587	339	393	579	606	614	357
S. D.	21	11	9	12	12	12	10	8	17	17	22	23	8	19	23	23	12	25	33	17	15	16	13	15

*** The figures in the parenthesis are the total number of words spoken in that particular lecture.

rather complete when compared with the lecturers' blackboard writings. The students apparently used very few words to elaborate upon those critical points, or in other words, they seemed to copy down blindly what was put on the board.

In Lecturer A and Lecturer F, the total number of words taken down by students were noticeably higher than others (obviously also due to the enormous blackboard works from the lecturers). On the contrary, the students recorded relatively fewer words in Lecturer G and Lecturer J (both lecturers correspondingly didn't put very much on the blackboard).

All the results of quantitative analysis of students' lecture notes are shown in TABLE 2-11. During the fifty minute lecture, students recorded an average of 65 information units or 50.5% of the 131 information units presented. In other words, students missed almost half of all the information that had been conveyed by lecturers concerned. At least for lecturer G and lecturer L in this present study, it is suggested if the lecturers consider it important for students to take down some information, it is insufficient to discuss this knowledge without the enough support of blackboard signals.

With respect to the efficiency of note-taking, the average efficiency index (number of information units divided by the total number of words recorded) was 0.132 which indicates that there were, on the average, only eight words recorded in notes for each information unit contained in notes. On the average, students wrote down only 4 to 15 words per minute during the fifty minute lecture. This indicated that students recorded incomplete notes, and most of them almost completely neglected the verbal signals from lecturers.

2.4.1.1 An Account of Note-taking Types Identified

TABLE 2 - 11. Quantitative Results of Students' Lecture Notes

		LecturerA	LecturerB	LecturerC	LecturerD	LecturerE	LecturerF	LecturerG	LecturerH	LecturerI	LecturerJ	LecturerK	LecturerL	Mean
1st Lecture	Total Spoken Words	4988	5120	4998	2957	4893	4176	5488	5394	5986	4501	3704	4685	4741
	Total No. of I.U.	136	105	163	115	157	173	172	105	108	74	144	139	133
	Total Board Words	998	531	786	548	517	825	302	395	362	243	568	628	559
	Total Board I.U.	94	58	110	83	52	105	41	61	53	35	62	40	66
	Mean Completeness	74%	61%	72%	76%	38%	64%	26%	62%	58%	55%	48%	32%	45%
	Mean Efficiency Index	.101	.120	.145	.162	.112	.134	.165	.174	.160	.168	.125	.075	.128
2nd Lecture	Total Spoken Words	5347	5435	5123	3520	5094	4820	5632	5150	3716	4861	4469	5039	4851
	Total No. of I.U.	127	98	134	109	125	154	164	116	128	97	119	173	129
	Total Board Words	655	526	782	494	627	1014	324	366	587	382	602	320	557
	Total Board I.U.	74	62	87	71	61	75	53	63	63	54	57	47	64
	Mean Completeness	62%	72%	69%	69%	52%	51%	35%	59%	58%	63%	52%	34%	56%
	Mean Efficiency Index	.124	.131	.120	.158	.107	.082	.179	.183	.118	.157	.105	.166	.136

*** I.U. = Information Units; Mean Completeness = Average I.U. recorded by students divided by the total I.U. presented (verbally and on board)

The analysis from the above tables allows us to identify four types of note-taking displayed by the students. Among those four types, three actually have much to do with the approximate copying of blackboard writing and the printed materials on the transparency (See Appendix 9, Page 348, examples of different types of notes).

In the first type, BS - (Blackboard Signal Minus), the students have been listening to the lecturer, taking down the materials on the board, then sometimes they are distracted so when they return to the message some time later, they might either miss out some points or have no idea at all of what has been said and written.

In the second type, BSO (Blackboard Signal Only), the students only pay attention to what appears on the board or transparency, the words are taken down verbatim without further processing. This type of note-taking results in an exact copy of the blackboard writing from the lecturer. The percentage of the students using this note-taking type was very high.

In the third type, BO + (Blackboard Signal Plus), in addition to the materials written on the board or transparency, the words from the lecturers are selected or translated into certain meaningful forms, and get into working memory, but are not processed much further. The student listens to the lecturer, in the sense of decoding the uttered speech into words, but probably cannot make sense of what they were about.

The fourth type, EL (Elaboration), here the term of "elaboration" means any strategies that a student uses to construct meanings for the new notions, such as adding extra examples, or interpreting in his own words. It is by elaboration that students are able to build up a meaning for any written statement, in other words, the students have paraphrased and constructed their own notes and summaries, some of the students even have utilised the technique of networking. The students in this type hear or see the words and check out what they are, and then try to make sense of them. This involves a deeper processing where the acts of linking, explaining and evaluating are carried out.

2.4.1.2 Note-taking and Exam Performance

TABLE 2-12 summarises the effects of students' note-taking types on academic performance. In most cases, note completeness (judged by total number of words and of information units) showed a noticeably better exam performances, with the increasing order : BS- (Board Signal Minus), BSO (Board Signal Only) and BS+ (Board Signal Plus). The only one student belonging to EL (Elaboration) had an impressively good performance. These findings were consistent with those of Howe (47) and Kiewra (48), i.e., the quantity of note-taking was correlated with achievement in a subsequent exam.

TABLE 2-12. Mean performance scores for the four different note-taking groups on class exams and final degree exam.

Exam / N.T Type	1st class exam	2nd class exam	Degree exam
BS- (4)	29.3	32.0	2 failed, 2 passed
BSO (4)	43.0	49.7	1exempted,3 passed
BS+ (6)	56.8	65.5	3exempted,3 passed
EL (1)	75.0	79.0	exempted

*** (1) N.T. Type --- Note-taking type.
(2) Exemption --- In this University, students who perform well in the two class exams are excused from the final degree exam.

2.4.2 The Results of Qualitative Analysis

Since both a qualitative as well as quantitative analysis of the notes taken by students is particularly important for advancing an understanding of note-taking behaviour, this section has focused on such analysis to uncover the actual format and content of students' notes.

2.4.2.1 Characteristics of Students' Notes

As detected in the previous section, the results from quantitative analysis showed that most students copied down only what was written on the board. This was further confirmed by analysing the format and content of students' notes. To take for example; Lecturer B and Lecturer D wrote the relevant subject materials in capital letters all the way through, and it was found that six out of fifteen students also recorded board signals in exactly the same CAPITAL format. Sometimes the lecturers stressed certain specific points which were just asides and they clearly asked students not to take them down, but it was found frequently that most students still took them down.

Comparisons were made between the notes taken by BS- group, BSO group and BS+ group to detect what was written down and what was neglected. It seemed that there is a list of priorities of what students choose to record, or even omit. Although it might vary from person to person and from lecturer to lecturer, the following list is of practical use to understand the general pattern of note-taking differences between different students :

most often recorded Equations, diagrams

↓ Reasons for steps between mathematical equations when doing calculations

Meaning of new technical terms or symbols

Overall sequence of logical arguments

Examples of applications or new discoveries

least recorded Demonstrations

It was interesting to identify those information units that BS- group students failed to write down. Firstly, the blackboard signals which lecturers wrote before the lecture started were more likely to be neglected. Secondly, when there was a series of similar illustrative examples presented, those students tended to select only part of them. Thirdly, the materials written on a side board to elaborate a specific point being developed on the central board were also likely to be ignored. And finally most materials which the lecturers suggested to omit or required not to copy down generally didn't appear in their notes.

2.4.2.2 The Commonest Methods of Elaboration

Anderson and Reder (49) have proposed the differences in the number and types of elaboration stored in memory will result in the differences in memory encoding. Research evidence has shown elaboration is particularly effective when it is directed toward understanding the potential relevance of the information presented (Stein and Bransford, 50). The students' lecture notes were analysed to understand the commonest methods of elaboration that they used when taking notes.

There were altogether twenty ways of elaboration, which can be further clustered into eight categories :

I. Abbreviations (1) General shorthand: e.g., 4 for "for" and U for "you", etc.

	(2) Technical terms: rxn for "reaction", eqn for "equation", etc.
	(3) Symbols: 1°, 2° and 3° for "primary, secondary and tertiary" separately.
	(4) Self generation: V for "very", c for "with".
II. Emphasising marks	(1) Symbols: ? for "I don't understand". * or star to highlight importance. circle or < > to pinpoint information.
	(2) Underlings: using single line or double lines to stress importance.
	(3) Capitalising or special font: "ENTROPY" or *"molecularity and reaction order"*.
	(4) Signalling words: "Important!" or "Exam related".
	(5) Signalling colors: Using different colors to high-light important parts.
III. Logical structuring	(1) Quantifiers: using enumerators and symbols which ordered subordinate with superordinate information.
	(2) Logical connectives: so, therefore, etc.
	(3) Symbols: $\therefore$, $\Longrightarrow$,etc.
IV. Summarising	
V. Paraphrasing	(1) Shorter sentence with the same meaning.
	(2) Interpretation in one's own words.
VI. Supplements	(1) Adding on lecturer's comments.
	(2) References from textbook.
VII. Mnemonics	
VIII. Rearrangement	(1) Rearranging important formulae and putting

them in separate sheets.

(2) Rewriting the notes.

In general, few students seemed to elaborate on the lecture material. Each of them might sometimes use some sort of elaboration, but in fact the only "EL type" student was found to use paraphrasing, summarising and logical structuring more frequently. Three out of six "BS+ type" students tended to use more abbreviations, emphasising marks, supplements and rearrangements. "BSO type" and "BS- type" students sometimes used emphasising marks, abbreviations, or supplements but were seldom found to paraphrase or summarise the lecture materials.

It was also noticed that students tended to omit most of the definite article "the", which they might think were redundant and could be neglected.

2.4.2.3 The Inaccuracies in Students' Notes

The results from thorough examination of students' lecture notes identified a few inaccuracies which will be described more in detail. At first the quantitative determination of the frequency of inaccuracies in the students' notes is tabulated in TABLE 2-13. On average each student had 5.5 inaccuracies in two sets of lecture notes, or 2.8 inaccuracies in each set of lecture note.

It has been found that students made relatively more mistakes in the lecture blocks of Lecturer A, Lecturer C, Lecturer F, Lecturer H and Lecturer K. The reasons why students had such high frequency of inaccuracies in those lectures were further studied. Lecture A, Lecture C and Lecture F had considerably high proportions of mathematical expressions, and most students made mistakes in copying the figures, especially in

TABLE 2-13. The Frequency of Inaccuracy in Students' Notes Across Different Lectures.

	Student \ Lecture	LectureA	LectureB	LectureC	LectureD	LectureE	LectureF	LectureG	LectureH	LectureI	LectureJ	LectureK	LectureL
		(108	35	113	74	69	111	58	127	17	61	137	57
		(7.2	2.3	7.5	4.9	4.6	7.4	3.9	8.5	1.1	4.1	9.1	3.8
BS-	S 1	9	3	14	4	6	4	1	9	0	2	5	3
	S 10	9	3	11	6	3	8	2	14	1	14	13	5
	S 14	12	3	10	7	8	12	7	15	3	9	14	8
	S 15	16	4	17	9	10	6	9	14	0	2	17	6
	Mean	11.5	3.3	13	6.5	6.8	7.5	4.8	13	1	6.8	12.3	5.5
BSO	S 3	12	4	9	8	3	19	12	15	2	3	7	7
	S 8	9	3	11	6	9	14	8	13	0	6	10	6
	S 11	15	4	7	11	7	10	5	12	5	12	21	4
	S 13	8	5	12	5	10	17	3	8	4	4	12	9
	Mean	11	4	9.8	7.5	7.3	15	7	12	2.8	6.3	12.5	6.5
BS+	S 4	3	0	4	4	2	4	2	3	0	1	6	1
	S 5	3	1	2	4	2	3	3	8	0	2	3	2
	S 6	2	1	3	1	2	1	0	6	1	2	0	2
	S 7	1	0	1	3	3	6	1	2	1	2	19	0
	S 9	4	2	6	3	2	4	2	7	0	1	4	3
	S 12	3	2	4	1	1	2	3	3	0	1	6	1
	Mean	2.7	1	3.3	2.7	2	3.3	1.8	4.8	0.3	1.5	6.3	1.5
EL	S 2	1	0	2	1	1	1	0	2	0	0	0	0
	Mean	1	0	2	1	1	1	0	2	0	0	0	0

*** The first row figures in the parenthesis are the total frequency of inaccuracy in that lecture and the second row figures are the mean frequency of inaccuracy in that lecture.

Lecture C due to the size of blackboard writing.

Lecturer F put most of the materials on transparencies, but because too many words were crammed into a single sheet, students could not see very clearly and so more inaccuracies occurred. In Lecture H and Lecture K, there were occasions where the lecturers dictated and students were requested to take down the stated paragraph. It could be that students were just unable to cope with this so that a lot of errors were made.

It was also found that students had fewer inaccuracies in Group I lecturers' blocks than that in Group III lecturers' blocks. On average, EL type and BS+ type students made fewer errors than BSO type and BS- type students.

Qualitatively, the closer inspection of the sorts of inaccuracies that occurred in students' notes was even more convincing. There are several kinds of inaccuracies found in students' notes:

(1) Misspelling or wrong writing of chemical compounds or terminology, such as $\underline{Na}SO_4$, Ryberg equation, isotopic for "isotropic", etc.

(2) Figures or characters were wrongly taken down.

(3) Bond valency, charge, electron dots or the direction of curly arrows were very commonly detected as inaccuracies.

(4) Wrong logical conclusions were drawn after several facts or statements were presented.

(5) Others which are not codable.

It was found that students were more likely to have inaccuracies when they were recording the following information : diagrams, numerical figures, chemical equations and any corrections or latter additions that the lecturer made. Sometimes the inaccuracies in fact were just the exact copy of the same mistakes made by the lecturers themselves or due to the illegible writing.

2.4.3 The Consistency of Students' Note-taking Behaviours

In this present study, students' lecture notes taken down over a period of three terms (about eight months) were examined quantitatively in terms of the total number of words and total number of information units to assess the long term behaviour of note-taking across a series of different lecture courses. Since later on it was found the quantitative assessment was naively direct and might not be accurate enough, the qualitative assessment of content was also taken into consideration.

The data was analysed, simplified and presented in TABLE 2-14 by categorising each set of students' notes into one of the four different note-taking types identified in **Section 2-4-1-1**, viz., BSO, BS-, BS+ and EL. An inspection of this table showed that the note-taking style which a student utilised in a particular block of lectures, in most cases, remained basically the same as that in other blocks. This pattern seemed to suggest that students' note-taking behaviour was consistent across the different lecture series over the eight month period.

It was interesting to find that most students tended to take notes verbatim in Lecture A and Lecture F, and in fact it was observed that both lecturers relied heavily upon either writing on the blackboard or transparencies and required students to record them. On the contrary, most students recorded much less in Lecture G where the particular lecturer rambled around and didn't write enough tidy materials on the blackboard. But in general, the note-taking behaviour was quite consistent over the extended period.

TABLE 2 - 14. Students' Note-taking Behaviours Across Different Lecture Series.

Student	Type	Lecture A	Lecture B	Lecture C	Lecture D	Lecture E	Lecture F	Lecture G	Lecture H	Lecture I	Lecture J	Lecture K	Lecture L
S 1	BS-	BSO	BS-	BSO	BS-	BSO	BSO	BS-	BS-	BS-	BS-	BS-	BS-
S 2	EL	BS-	EL	BS-	BS-	BSO	EL	BS-	EL	EL	EL	EL	BS-
S 3	BSO	BSO	BS-	BS+	BS-	BSO	BS-	BS-	BSO	BSO	BSO	BSO	BSO
S 4	BS+	BS+	BS+	BS+	BS+	BS+	BS+	BSO	BS+	BS+	BSO	BS+	BS+
S 5	BS+	BS+	BS+	BS+	BSO	BSO	BS+	BSO	BSO	BS+	BS+	BS+	BS+
S 6	BS+	BSO	BS+	BS+	BS+	BS+	BS+	BSO	BS+	BS+	BS+	BS+	BS+
S 7	BS+	BS+	BS+	BS+	BS+	BSO	BS+	BS+	BS-	BSO	BS+	BS+	BS+
S 8	BSO	BSO	BSO	BSO	BS-	BSO	BSO	BSO	BS-	BSO	BS-	BSO	BSO
S 9	BS+	BS+	BS+	BS+	BSO	BS+	BS+	BSO	BS+	BS+	BS+	BS+	BS+
S 10	BS-	BSO	BS-	BS-	BS-	BS-	BS-	BS-	BS-	BS-	BS-	BS-	BSO
S 11	BSO	BSO	BS-	BSO	BSO	BSO	BSO	BS-	BSO	BSO	BS-	BSO	BSO
S 12	BS+	BS+	BS+	BS+	BSO	BS+	BS+	BSO	BS+	BS+	BSO	BS+	BSO
S 13	BSO	BSO	BSO	BSO	BSO	BSO	BS-	BS-	BS-	BSO	BSO	BSO	BSO
S 14	BS-	BS-	BS-	BS-	BS-	BSO	BS-	BS-	BS-	BSO	BS-	BS-	BS-
S 15	BS-	BSO	BS-	BS-	BSO	BSO	BS-	BS-	BS+	BS+	BS-	BS-	BS-

*** BS- represents Blackboard Signal Minus, BSO represents Blackboard Signal Only.
BS+ represents Blackboard Signal Plus, and EL represents Elaboration.

2.4.4 Sex Differences and Note-taking Behaviour

One of the purposes of this present study was to explore the effect of such individual difference as sex on the note-taking behaviour and performance. The comparisons of note-taking completeness and exam performance between females and males was described in TABLE 2-15. As shown clearly in this table, in general females were more complete notetakers than males in respect of both the average of total number of words recorded (673 vs. 459) and the average of total number of information units (76 vs. 58) respectively. But regarding the exam performances, females didn't score higher than males either in two class exams or final degree exam. The first result was consistent with most of studies in note-taking research, viz., women take more notes than men (Fisher and Harris, 51). As for the second finding, it conflicted with their result but supported Kiewra's (41).

TABLE 2-15. Comparison of various performances between sex differences

Performance / Sex	Mean of Total words	Mean of Total I.U.	Exam performance 1st class exam	2nd class exam	degree exam
Female (7)	673	76	37.58	44.14	{ 2 E, 1 F, 4 P
Male (8)	459	58	49.88	55.00	{ 3 E, 1 F, 4 P

*** I.U. — Information Units E — Exempted

F — Failed P — Passed

And the figures in the parentheses are the number of students

2.5 Effects of Lecturing Styles on Students' Note-taking Types

Both the quantitative and qualitative analyses of the students' notes demonstrated that the majority of students mainly recorded blackboard information only, even the BS+ (Blackboard Signal Plus) type students were just trying to add on some limited verbal signals from the lecturers without deeper processing of the taught materials.

On some occasions where the lecturers didn't write a great deal on the board and their lecturing styles were rated highly, the students tended more likely to record more verbal lecture information (eg., in Lecture B and Lecture I). But in contrast, on other occasions where the blackboard writing was not used enough or the lecturers dictated too much, students seemed to have difficulty in taking more complete notes (eg., in Lecture G and Lecture K).

But it seems odd that most students had quite consistent note-taking behaviours across the whole lecture course. Could it be that in the physical sciences (like chemistry) where the information concerns mainly accuracy, there is little room for elaboration (i.e., amplification or interpretation) and so verbatim copying prevails. Or could it be some other factors underlying such an apparently simple mechanism still remain hidden and unexplored?

2.6 Summary of the Results

The main purpose of this exploratory study was to investigate both the lecturers' teaching behaviours and students' note-taking behaviours in naturally occurring settings, such that the differences between the more effective lecturers and less effective lecturers and their effects upon students' note-taking could be uncovered.

Results from both students' ratings and the researcher's participant observation showed that:

(1) There are three kinds of lecturers, or lecturing styles identified in this lecture course : Group I as the "more effective lecturers", Group II as the "average lecturers" and Group III as the "less effective lecturers".

(2) The lecturers were rated higher as "effective", who communicate well by speaking clearly, loud enough and coherently; by writing big enough, legibly and in an orderly fashion.

(3) Students paid great attention to a lecturer's enthusiasm and personality characteristics. Their ratings had great to do with those factors.

(4) The waiting time seemed to play a very important role in students' note-taking performances, especially when the lecture materials were presented in slides or transparencies.

(5) Considered as a whole, the students seemed to be satisfied with the majority of the lecturers in the Chemistry Department.

In respect of the effects of lecturing styles upon students' note-taking performances, the overall findings can be summarised as follows :

(1) Quantitatively, on average students recorded about 90% of the blackboard information in terms of both total number of words and total number of information units. But students only recorded less than 50% of the total amount of information conveyed in a lecture.

(2) Particularly in Lecture E, Lecture G and Lecture L, the lecturers should be reminded to put more information which they think is important on the board so that most students wouldn't miss it.

(3) It was apparently probable that terse note-taking is disfunctional, the students

who took more complete notes benefited more in exam performance.

(4) Efficiency index used in this present study was perhaps not a logical index of note-taking effectiveness since most notes were almost exact copies of blackboard work that the differences in efficiency indices were negligible.

(5) The inaccuracies in students' notes were identified and the occasions on which students were most likely to make mistakes were when : copying diagrams, numerical figures, equations, items on the OHP's or slides and any later corrections or additions.

(6) Not all the lecture signals were recorded by students. Items which tended to be neglected were roughly in the following order : demonstrations, examples of applications or new discoveries, overall sequence of logical arguments, meaning of new technical terms or symbols, reasons for steps between equations, and diagrams.

(7) Four note-taking styles were used by the students involved in this study, but in most cases lecture information was almost recorded without any enrichment by later processing.

(8) The note-taking behaviours of most students demonstrated a high consistency across the majority of lectures over an extended period of eight months.

(9) Female students took more complete notes than their male classmates, but they didn't have higher academic performance either in two class exams or in the final degree exam.

In summary, note-taking behaviour has been falsely described by many researchers as an encoding function in which the lecture material has been digested or elaborated and notes are assumed to be the processed product. But thorough analysis of subjects' lecture notes in this exploratory study revealed little evidence for a deeper processing of the nominal stimulus. As Kiewra et al. suggested (52) the processes of note-taking should be divided into the distinct processes of note-copying and note-encoding. Such variations in note-taking behaviours could only be confirmed through the qualitative analysis of students' notes.

2.7 Implications for the Second Phase of This Study

Although some aspects of the findings were consistent with a limited version of the quantitative study, the qualitative analysis allowed us to acquire deeper understanding in the effects of lecturers upon students' note-taking behaviours and academic performance. If research in note-taking is to be of any practical utility and theoretical validity, the quantity and quality of lecture notes associated with different learners and various lecturers under naturally occurring conditions must be examined to explore the characteristics of these learners and lecturers and how the information is transmitted and processed.

Further research is needed to determine what effective note-taking students use to help them structure the lecture material better and identify the central concepts. "This may be attributed to differences in situational, organismic, or criterion variables associated with particular lectures. In other words, such variables as lecturer's rate, presentation styles and content; the students' personality characteristics and ability; and test mode expectancies are just a few variables which may have an important influence on note-taking and subsequent performance" (See Kiewra, 53 for a complete review). The results from this present study also suggested that note-taking from lecture under certain conditions was in fact dependent upon the lecturing styles.

To sum up, in the second phase of this study, a more complete framework for lecturing and note-taking research was designed to investigate the note-taking behaviours and performances of a particular type of learners with different learning capacities in various lectures. The research design for the second phase study is shown in the following diagram:

For particular types of learners
- Working Memory Space (X = 4, 5, 6, 7 etc.)
- Cognitive Style (Field Dependence / Field Independence)
- Motivational Characteristics

In certain lecturing conditions
- Lecturer Personality (enthusiasm, sense of humour, rapport)
- Basic Communication Skills (audibility and legibility)
- Presentation Style (clarity, structuring, pace and cues.)

With specific note-taking types
- Note Copying (BS- and BSO)
- Note Encoding (BS+ and EL)

To different academic performance

Fig. 2 - 5 The Research Scheme for the Second Phase Study.

CHAPTER THREE

A Cognitively Oriented Framework of Lecturing and Note-taking

3.1 An Outline of the Approach Adopted in Further Investigation

From the exploratory study it was found that, on average a lecturer delivered about 5000 spoken words in a session of fifty minutes (TABLE 2-10, Page 44), but students recorded less than one fifth of these. What was the underlying mechanism that determined how the selection would be made? What was going on in a student's mind to separate the recorded portion from that which he omitted? A more detailed review of literature was conducted to see how these note-taking effects were explained theoretically.

According to Pepper and Mayer (54) the specific theories which have been developed to explain the effects of note-taking can broadly be classified as either quantitative or qualitative theories. Quantitative theories propose that note-taking mainly affects how much information is recalled, but qualitative theories instead argue that note-taking increases recall by affecting the nature of processing.

Einstein et al. (40) carried out two experiments to examine the encoding function of note-taking and processing differences among students in lecture situations. They concluded that both quantitative theory and qualitative theory are necessary for interpreting the entire pattern of their experimental results. The qualitative theory appears useful for explaining which ideas will be attended to, and recorded in the notes, but the restricted version of the quantitative theory may explain why the propositions noted are well recalled later.

After a thorough review of the literature on note-taking, Kiewra (37) was critical in that most researchers in this area have been largely preoccupied with dividing note-taking into its process and product functions, and with comparing the relative advantages of each, so that we still hardly understand the cognitively oriented characteristics of effective note-takers. He suggested the information-processing ability is related to note-taking outcomes, and so the information-processing ability is a more useful research variable to be addressed.

This line of research interest has also been advocated elsewhere, for example, Mayer (55) summarised in his book that researchers have generally found cognitively oriented variables, such as prior knowledge, memory capacity limitations, employment of memory strategies, and metacognition have distinguished experts and novices operating in the particular academic areas.

But unfortunately, in most of the cognitively oriented research on note-taking, the nature of cognitive processes apparently associated with note-taking has not been considered. Little has been done to find how the cognitively oriented stimuli influence the perceptions, the attentional mechanisms, the active processing in students' memory systems, and thus their processed products.

Hartley and Davies (25) argued that most studies in note-taking utilise only one situation - so that any variability in note-taking due to differences between lecture topics, lecturers and other factors has been ignored. It is not only neglect but a serious methodological defect if the effects of the lecturing situation upon note-taking are not explored simultaneously. The cognitively oriented stimuli are perhaps the most pertinent set of variables, and the research could not be complete without consideration of such an important set of variables.

In summary, to understand the note-taking behaviours of students adequately, it is necessary to focus upon both the cognitively oriented stimuli from the lecturers and the cognitively oriented responses of the learners. Therefore the complete research must take into account both of those two set of variables, and investigate how the lecturer - the information initiator influences the learners - the information receivers. Only when the nature of the cognitive processes associated with note-taking during the lecture has been fully covered, is it a valid theory to describe the whole picture.

Having conducted a case study of the review of the literature of note-taking, Ladas (56) tried to utilise an information-processing model of memory to describe research findings concerned with note-taking during lectures. She emphasised that the information processing variables are strong ones which should be consciously controlled or incorporated as research variables.

Since the aim of her model was to organise what is known about note-taking within the framework of the human information-processing, she has combined some conclusions from "pure" research on human memory and some of the results of applied research on note-taking. Firstly, the effects of lecturing behaviours upon note-taking are in fact not sufficiently dealt with in her model. And secondly, the model she has advanced is far too complicated and must be narrowed down to permit the research to be focussed.

A simpler schema was thus set out as a vehicle for examining the processes of teaching and learning during lectures. It was derived from studies of human information processing (Lindsay and Norman, 57) and the working memory space model (Johnstone and El-Banna, 58). The schema is shown in Fig. 3-1 and it has been adopted as the framework of this research. It might be less complete than Ladas' model, but it is a useful working model to raise hypotheses and thus is of practical use.

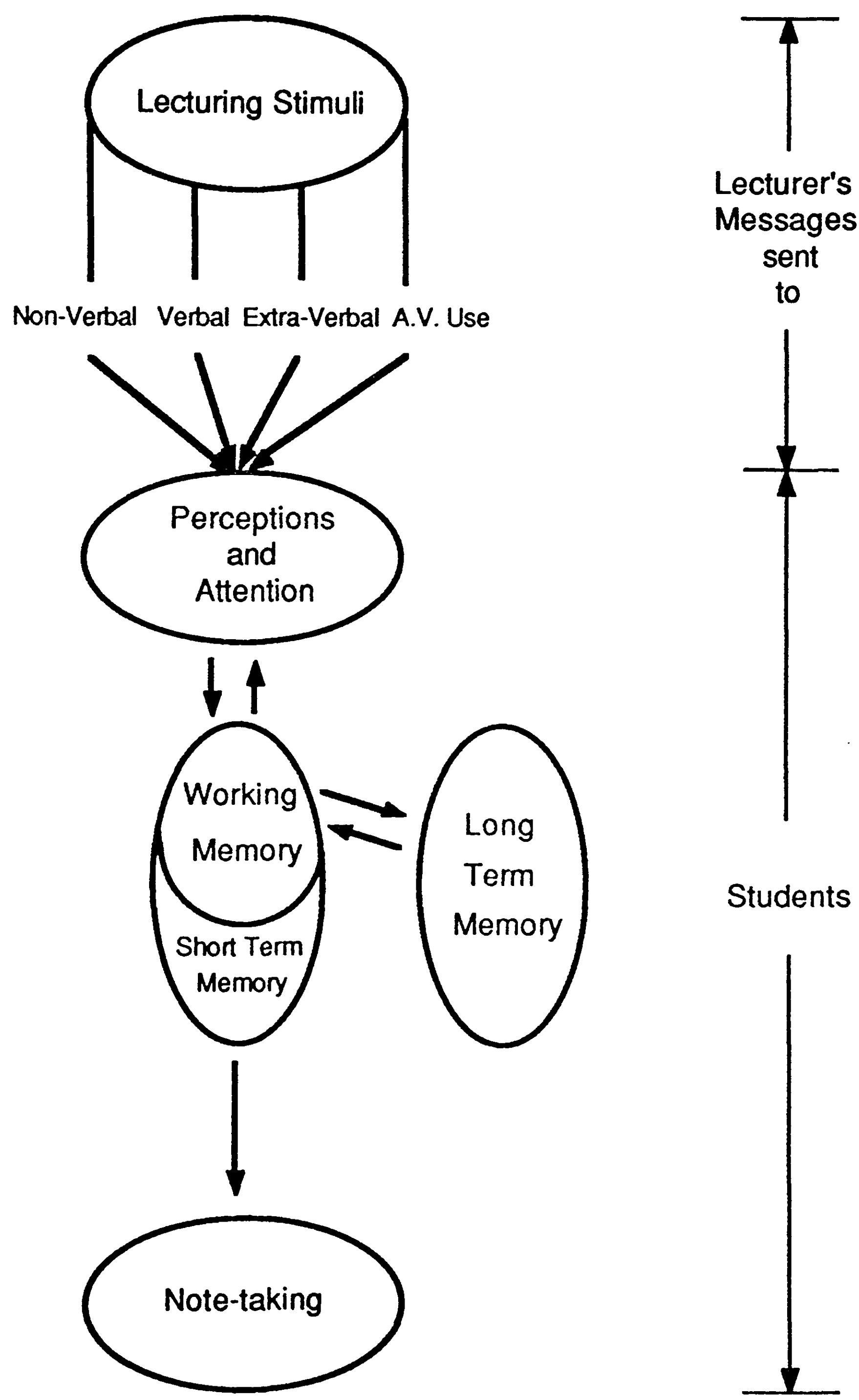


Fig 3 - 1. The Information-Processing Model of Lecturing and Note-taking

A lecturer sends forth messages verbally, non-verbally, extra-verbally and sometimes by using audio-visual aids. But the messages which the lecturer transmits are not only concerned with information, but also his non-verbal and extra-verbal cues may convey meaning and attitudes that highlight, qualify or distort the essential messages (Brown, 59).

The messages are received, sifted in an active process of perception which involves using previous knowledge to interpret the sensory information. Pattern recognition is an important feature of perception (Reed, 60), eg., a student learns to recognise certain specific functional groups in a chemical formula in terms of patterns. Context also helps the learner to recognise patterns (Roth and Frisby, 61) for instance, Fr tends more easily to be recognised as the symbol of the element "francium" in the context of chemistry, while it may tend to be recognised as the monetary unit of "Franc" when it appears in the economics.

Since the human information processing system is selective, the messages sent forth by the lecturers may or may not be attended to. By attention students select the sensory input which they want to focus on. But attention is considerably affected by the difficulty of the task, the distractions in the environment, the motivation of the individuals and also the lecturer's style (Sanford, 62). Throughout a one-hour lecture, attention fluctuates in such a way that after twenty minutes there is a marked decline in attention followed by a peak just before the lecture ends (Johnstone and Percival, 63).

After filtering, the sensory information is passed on and stored temporarily in the working memory, where the new input is scrutinised, shaped, interpreted, and linked to the encoded information retrieved from long-term memory. More recently, researchers consider that working memory is limited by the processing capacity, we can hold a few separate items of information in our working memory at any one time (Miller, 64), so working memory is very easily overloaded (Scardamalia, 65). The processed information can be either transferred to long-term memory, or put on paper, or can be forgotten after about thirty seconds if it is not rehearsed (Atkinson and Shiffrin, 66).

The long-term memory will most readily receive lecture messages which are related to the network of concepts and facts already stored there, and it will also store new information that may be only loosely associated with existing facts and ideas. The information stored in the long-term memory is eventually a highly personal representation and knowledge of the reality (Greene, 67). Long-term memories can be more specifically classified as episodic, semantic and procedural (Anderson, 68; Tulving, 69). Episodic memory refers to memory for episodes and personal experiences; semantic memory has to do with all the general knowledge a person has about the world; and procedural memory contains procedures for the actions which we know how to perform.

So the processes of learning from the lectures can be described using this framework, and what the quantitative and the qualitative theories of note-taking have tried to explain can be interpreted in the context of human information processing. So far as the encoding function is concerned, the students can prevent their attention wandering during a lecture by actively concentrating on what is being conveyed, and by taking notes. Since recall of information from lectures is not notably efficient (Bassey, 70), the loss from long-term memory can be reduced drastically if students take down and study their notes. The facilitative effect of external storage function of taking notes could also be easily explained by using this model. However, the rate of processing may be important in overloading because during a fast lecture the student has little time for interaction in any constructive way with long-term memory. This matter will be considered later on (See Section **3.2.3.**, Page 74 for more detail).

3.2 Cognitively-Oriented Stimulus Variables Involved in Lecturing

Based upon this model, the approach was to study how note-taking varies as the result of different instructional demands are put on into the information-processing system of a student. How do various lecturing events influence note-taking behaviour? What conditions stimulate and what conditions inhibit note-taking? These questions point out some of the factors that could be used as variables to study how the lecturing events influence note-taking behaviour. That is , the lecturing behaviours are viewed as the cognitive-oriented stimuli and the student attitude and learning behaviours as cognitively-oriented responses.

According to Yorke (71), there are a number of factors that are likely to influence the extent to which listening to a lecture is effective, among them being :

(a) previous experience of the subject matter

(b) interest in the subject matter

(c) reaction to the speaker

(d) the ability to recognise key points

(e) the ability to recognise other cues, such as emotive terms

(f) the degree of "match" between the teachers' speed of delivery and the the student's speed of thinking

(g) the amount of energy (i.e., the effort) expected by the student.

Weener (32) proposed that the role which note-taking plays in the storage and retrieval of information is probably dependent on the characteristics of the instructional settings, such as teaching styles, modes of verbal interaction, instructional materials or the active stimulation in an instructional setting.

Hartley and Davies (25) concluded in their critical review of note-taking that any variables such as lecture topics, lecturers , lecture structure, lecturer's cues, lecture handouts, and the clarity of the lecture are clearly important determinants of note-taking practices.

Anderson (72) indicated control of attention is the first stage of the process required to assure learning, and by attention the potential stimuli presented by the lecturer become the actual stimuli for the student. The control of the students' learning behaviours in lectures may be carried out by various cues and prompting techniques such as underlining, differential stress and pauses.

Howe and Singer (73) observed that the way of presenting information was very strongly influencing what the students were doing in lectures, so they emphasised the influence of different forms of instruction and methods of presentation upon performance of note-taking.

Kiewra (31) listed a few teaching variables which are documented for increasing the probability that students will note critical information. For instance, lecturing at slower rates, providing cues for when notes should be recorded, and writing on the board are variables that can affect and facilitate note-taking behaviours by reducing the processing strain among students who are taking notes.

Similar variables were suggested by Carrier and Titus (74) in their study. They pointed out that the lecturer may be as important a variable as the notetaker, therefore emphasising important points, writing on the board, using simple cues, and organising lecture structure are crucial factors for effective note-taking.

After advancing a model to describe research findings concerned with note taking from lectures, Ladas (56) proposed the idea of orienting stimuli, and she pointed out both general and specific behaviours of the lecturer which may influence students' note-taking behaviours. Lecturer enthusiasm, giving instructional cues, slowing down at important points, and the rate of presentation were suggested as research variables.

The analysis of student questionnaires showed many written-in responses which had not been asked for. These were critical but almost always constructive. They tended to focus on such things as the illegible writing, the inaudible speech, overcrowded OHP or slides and messy blackboard work.

Considered as a whole, from the literature and the findings in the exploratory study, several variables which are closely concerned with lecture-information processing or note-taking, were selected as the cognitively-oriented stimuli variables. They were studied further and used as the research variables. They were (i) use of humour and asides, (ii) focussing, (iii) pause or wait-time, (iv) giving instructional cues, (v) lecturing pace, (vi) voice-audibility and (vii) the quality of blackboard writing.

3.2.1 Use of Humour and Asides

Based upon various findings from empirical research, Bligh (75) suggested that there is a need for rests, or variations in activity, to be included within lectures in order to maximise the likelihood of students' learning from lectures.

Erdle, Murray and Rushton (76) explored the relationship between personality and teaching effectiveness. They found that the effective instructor exhibited the general types of teaching behaviours such as speaking expressively, using humour and relating subject matter to student interests.

There has been a claim that using humour in teaching has beneficial effects. To mention a few examples, Browning (77) argued that material spiked with humour can make lessons easier to grasp. Gilliland and Mauritsen (78) suggested humour could stimulate interest in or cause attention to be paid to educational messages.

Cranton and Hillgartner (79) stressed that the ability to encourage learning and to create interest in the course content is a priority of most instructors and that students must be motivated before other goals can be achieved. They have found that, if the instructors use personal anecdotes or real case presentation to illustrate data, it is helpful in creating a classroom atmosphere that encourages learning.

It has been argued and demonstrated that students attend more readily to their studies if the subject matter presented to them is seen to be useful and relevant, than if it appears to be "remote" (Johnstone et al, 80).

According to the study of teaching methods in tertiary education, Percival (81) detected the fluctuation of students' attention during a lecture session of fifty minutes. And the marked decline in attention after about twenty minutes calls for positive interventions of lecturers by using whatever instructional strategies, among them are included the use of humour and asides.

It is reasonable to expect that use of humour and anecdotes, stressing the applications and uses of lecture materials, will potentially bring about an arousal of students' interest in the lecture. This cognitive stimulus seems to have the function of holding students' interest and reversing the decline in attention by arousal of attention and thus may in turn influence their performance in note-taking.

3.2.2 Focussing

Based upon recent meta-analytic studies, Tamir (82) discussed the relationship between teaching strategies and student achievement. He commented that "focussing" has a high probability of substantially improving learning and achievement. "Focussing" is composed of three teaching behaviours, viz., (i) providing students with instructional objectives; (ii) reinforcing objectives at different points during lectures; and (iii) use of various organisers of instruction.

Wise and Okey (83) studied the relative effects of various teaching strategies on students' achievement, and they reported that some instructional strategies, like providing students with objectives and use of various organisers of instruction, might be more effective in improving learning and achievement.

Clark et al. (84) found in their study that an optimal teaching role consisted of high structuring behaviours, such as reviewing the main ideas and facts to be covered in a lesson; stating objectives at the beginning of a lesson; outlining lesson content; and summarising major points as the lesson progressed.

Brown (85) also found the category system such as framework of the lecture (headings, subheadings, topics or subtopics), framing words (a switch in topic), keys and summaries, did improve the students' listening and note-taking during lectures.

Similarly, Korman (86) indicated that the recognition of structure highlights the stress given to verbal understanding in lectures (and in science and technology particularly, to the understanding of symbols), and it could be fairly anxiety-provoking, leading to a lower performance than the student is capable of.

Having conducted research into the effect of instructional organisation on both teaching effectiveness and effective learning, Ford (87) emphasised the importance of organising instruction in order to produce the necessary encoding of information.

To sum up, research findings agree quite well that, if the lecturer specifies the key structuring elements of his lecture by using lists, classification hierarchies (eg. 1, 1.1, 1.2; 2, 2.1, ... etc), or headings, subheadings, the students could more easily perceive the structure of lecture and this might help in their note-taking. Likewise, at the end of lectures, if several minutes is used to summarise the overall message of the lecture and highlight those things which students would do well to remember, it could be extremely valuable to students.

But current research is almost silent in trying to help us understand to what extent and how this variable affects different students' note-taking behaviours, and that needs to be explored in detail.

3.2.3 Pause or Wait-time

As indicated in the above research schema, the rate of processing may be important in overloading. Indeed during a fast lecture the student has little time for interaction in any constructive way with his long-term memory. Once after an instructional stimulus has been attended to and selected into the short-term memory, the working memory starts processing by holding the input, and manipulating it in a meaningful context, but if the students are not given sufficient time before the next piece of information arrives, then the information processing could stop at that point. So time is really an important factor that determines the quantity, and even quality of note-taking if a student wants to process the lectures deeply and thoroughly in his / her own meaningful way.

Rowe (88) first noticed that speech is interspersed with pauses which range from very short time intervals separating individual words to longer intervals which occur after a speaker has completed a segment of speech and pauses to ponder what to say next. She also found when teachers allowed intervals of three to five seconds instead of the more usual one second, students' responses were longer and they seemed to process information more deeply (ibid.).

Rowe defined (89) two types of wait-time : wait-time I, the length of time a teacher pauses after asking a question; and wait-time II, the time a teacher waits after a comment is made or another question is asked. Alternatively, Lake defined (90) the wait-time in terms of the period of silence that precedes teacher talk, so teacher wait-time is the length of the pause preceding teacher talk.

Tobin (91) detected that there was a significant relationship between teacher wait-time and science achievement for students in grades 5, 6, and 7. This study also showed that extended teacher wait-time was beneficial for students operating at a concrete stage of cognitive development and for those at a formal stage.

A synthesis of research outcomes from studies which addressed the wait-time as a variable has demonstrated an impressive set of results which is consistent with postulated benefits of additional pausing time between speeches, therefore Tobin and Capie (92) strongly advocated that teacher wait-time is a promising variable to be used in cognitive processing research contexts.

In a science lecture, the demands on the students to orally interpret data, symbols and make logical judgements are extremely high, therefore greater cognitive activity is called for. As usual, in lecture conditions the rate of flow of information is out of the students' control, but if the lecturers could adjust the rate of presentation by appropriate pauses that separate bursts of speech, it will greatly help to prevent students from overloading their working memories and allow them more opportunity for processing information.

But Anderson (93) reported in a study which involved sixty-two students, randomly assigned to two treatment groups, that physics content was perceived to be less difficult in extended wait-time classes. What surprised him was the seemingly inconsistent finding - an increased apathy towards physics for students in the increased wait-time classes.

Riley (94) suggested that the optimal wait-time to be used may be dependent on the cognitive level of lecture information and the cognitive level of the outcomes to be achieved.

In conclusion, wait-time is required for the students to copy down the information and think about it, so that, up to a point, pauses between different information units conveyed should permit better learning. But if the pauses are stretched too long, then the students' attention might wander to other things, increase boredom and processing would eventually cease.

So wait-time as a research variable in this study is defined operationally and studied to see how the duration of pause and the way that pause is used influence note-taking. Since in the common practice of lecturing in the university, the lecturer almost has primary control over the length of the silent pause, the proportion of student talk or verbal interaction between the lecturer and students are generally rare. Due to these facts, the wait-time is therefore defined as "the length of the silent pause that separates a lecturer's bursts of speech".

3.2.4 Giving Instructional Cues

All the intentional indications from lecturers which help structuring and facilitating the processing of the subject-matter may be reckoned as the "instructional cues". The use of nonverbal presentation or explanation of subject-matter with aid of materials (e.g., writing on blackboard or by using signs) and the use of verbal signposts are both indicators of the importance of note-taking.

Ladas (95) pointed out that providing the cues for what to record is a very specific cognitively orienting stimulus from the lecturer, and it is highly related to students' note-taking performance.

It was demonstrated in the research of Hartley and Fuller (96), that items written or drawn on the blackboard have a high probability of being recorded. Similar finding was detected too in Locke's (30) study of lecture note-taking among college students.

Maddox and Hoole (97) noticed the importance of using cues such as, "It is important to stress that ...", and non-verbal cues such as walking away from or returning to the lectern.

Moore (98) found that cues given by the instructor during the presentation significantly improved students' test scores and probably the student ratings of the instructor.

The use of more obvious cues or cues more closely related to the lecture material results in remarkably facilitative effects in learning from lectures. Certain kind of students who are strongly context-dependent and relying heavily on external frames of reference, may be assisted in their analysis or synthesis of a stimulus complex by the lecturer's using prompts or cues (Noble and Frank, 99).

Davies and Klausmeier (100) summarised the current research on concept attainment which predominantly dealt with the use of cues, and then found that cues facilitated the performance of both field-independent and field-dependent learners.

In instructional settings the control of students' orientation behaviours can be carried out by using various cues, and it has been found to be a crucial ingredient for successful note-taking. Generally students in the act of taking notes from lectures lack the time necessary to make extensive elaboration due to motor processing limitations. So the lecturer has to assume responsibility for the compatibility of instructional cues, and takes into account providing specific cues for note-taking as an important variable in lecturing.

In terms of the model of Johnstone and Wham (101), giving instructional cues, whether they are verbal or non-verbal, is a sort of signalling system. The "noise" or digressions in a lecture could be separated from "signal" by the use of various cues. How do the students respond to a lecturer's instructional cues? Are there any differences among different students in detecting those cues? Does the use of cues improve students' note-taking performances? Those are questions to be answered in this study.

3.2.5 Lecturing Pace

Although Aiken et al. (29) argued that a high rate of lecture presentation can interfere with encoding, and so produce deleterious main effects on the recall of lecture material and note-taking performance, they used a speeded speech rate which was 240 words a minute; compared with the speech rate of lecturers which normally ranged from

100 to 180 words per minute (Johnson, 102).

The results from the exploratory study showed that the speech rates of the lecturers involved in this present research were between 75 and 120 words per minute; moderate when compared with the speech rates in the above research. It seems that there should be a certain variable which is more appropriate to be addressed and it will be discussed later on.

According to Cook and Mayer (103), after reviewing the literature they suggested that note-taking hinders effective encoding when the presentation rate is fast and the informational density is high.

Roshal (104) concluded in his study, when the rate of presentation is rapid and cues are not given, note-taking will be ineffective.

Anderson and co-workers (105) recommended that the rate of introducing new ideas need to be spaced in order to make it easy for students to construct meaning from what they hear.

White (106) pointed out that research on understanding indicates that the pace of coverage of science content is too rapid in many countries. He thus suggested rapid delivery of information inhibits processing, so that only a small proportions of sentences will be stored as meaningful propositions. Students are more likely to contemplate the meaning of each sentence and its relation to others when they are under conditions of slower delivery.

It appears that what matters is not the speech rate but the combination of information and pausing time, in other words, it is the variations in the pace of lecturing that will affect the note-taking behaviours. It is more suitable to take into consideration all those factors such as speech rate, information and pausing time together, and integrate them into a unified cognitively orienting variable as "lecturing pace".

In order to study the effect of lecturing pace on note-taking, the "lecturing pace index" is operationally defined in this investigation as "the total information units sent forth by the lecturer in a period of five minutes". The information unit was defined previously by using Anderson's (45) proposition as equalling the smallest unit of knowledge that can stand as a separate assertion. The higher the index, the more rapid the lecturing pace, and vice versa.

3.2.6 Voice-Audibility and the Quality of Blackboard Writing

Students learn from lectures by listening, observing and reading from the blackboard. Few studies of note-taking have been conducted to explore these as variables or to measure the extent to which the lecturers should attend to them.

A sample questionnaire from a College Physics Department asked students to rate very basic communication skills such as : audibility of lecturer, quality of blackboard presentation (Appendix 10 , Page 352). It became very clear that the students certainly take these basic communication skills very seriously.

The following excerpts from the "written-in comments" highlighted that a lot of students suffered considerably from things like illegible writing, messy blackboard work and inaudible speech (See Appendix 7 , Page 336 for full details).

" Very hard to hear the lecturer, he is mumbling."

" There was a problem - this lecturer doesn't talk loud enough."

" Perhaps Dr. G should write just a little bigger on the board."

" Writing was rather small and therefore rather difficult to read."

" It would be better if the lecturer wrote bigger and not so squashed up."

" Writing could be a lot bigger and clearer."

" The lecturer's writing was too small - especially on overhead projector."

" I couldn't read the lecturer's writing."

" The lecturer's voice was too quiet, sometimes blurred and unclear."

" Lecturer's writing on the board becomes illegible because lecturer writes on top of notes which are already there."

" The lecturer didn't write any titles on the board - just fragmented information and seemed a bit disjointed."

In terms of basic research on human information processing, such an important variable should not be neglected if we want to see the whole picture of how the cognitively orienting stimuli affect students' note-taking behaviours. It is only through students' auditory and visual skills, can their sensory motor systems orient their attention to the instructional stimuli and encode the stimuli. If the potential stimuli presented by the lecturer cause any noticeable problems, they couldn't become the actual stimuli for the student.

As a summary, the model on which this study is based treats the lecturer's behaviours as the cognitively oriented stimuli variables, and these variables are used to explore their influence on students' note-taking behaviours. The research findings suggested that they are useful variables, but little has been done so that we understand the mechanics of information processing - how different students process lecture information under different lecturing conditions.

3.3 Cognitively Oriented Response Variables Involved in Note-taking

Individual differences are evolving as significant dimensions in the study of note-taking, because firstly the previous research findings only provided uncertain results which sometimes were even contradictory, and secondly more and more recent research into note-taking has found cognitively oriented variables such as prior knowledge, capacity limitations, employment of memory strategies have produced among students markedly different performances in some academic areas (Bennink, 107).

Weener (32) implied note-taking involves the storage and retrieval of information and it is probably dependent on the individual difference characteristics. Certain variables such as size of short-term memory and resistance of memory to interpolated material, social desirability and authoritarianism were assumed to influence the effects of note-taking.

Hartley and Davies (25) commented that individual differences have long been neglected and because of this, they strongly advocated that future researchers should address such factors as sex differences, memorising ability and personality characteristics.

DiVesta (108) recommended that the information processing demands of the student must be examined in terms of learner traits and states. One of learner states that he referred to is the expectation a student holds about how mastery of "to-be-remembered" content will be assessed. These expectations may serve as a filter for judging what content is important and what can be ignored.

So far as the cognitively orienting responses of students are concerned in an information-processing model, Ladas (56) suggested several variables like short-term memory, the trait or state of the learner must be considered too, because they presumably affect each part of the components in her model.

A lot of research on field-independent and field-dependent people has accumulated to show that it is a promising cognitive variable to uncover the underlying processes of why and how students of different cognitive styles who attend the same lectures might have considerable differences in their notes (Frank, 109).

The following cognitively-orienting response factors were finally sorted out from researchers's lists of recommendations as research variables in this study : gender differences, information-processing ability (working memory capacity), motivational styles, and cognitive style (Field-Independent / Field-Dependent).

3.3.1 Gender Differences

Hartley and Davies (25) noticed that sex difference is an area between individuals which has been neglected in the correlational studies. In the few studies which report the differences in note-taking between men and women students, it is usual to find that women students tend to take more notes than men but that they don't score higher on subsequent tests (Hartley and Trueman, 110).

An investigation taken by Maddox and Hoole (97), detected a significant difference in the quantity of notes recorded between men and women. Women participants tended to write more copiously than the men, but men were more inclined to take down fewer words and use abbreviations to elaborate the lecture information.

Because sex differences in verbal learning have been shown generally to favour women students, could it be that women students benefit more from the comprehension of speech occurring in lectures ?

To date, since this issue still remains largely unexplored and verbal learning is so closely connected with note-taking, it should be mandatory for the researcher to check the effects of gender differences in note-taking performance.

3.3.2 Information-Processing Ability (Working Memory Capacity)

Baddeley and Hitch (111) defined working memory as a multipurpose central processing system possessing a limited capacity. Such a system is a work space in which information can be held, stored, manipulated and used to search and access long term memory. And a breakdown in performance on cognitive tasks will occur as the concurrent storage / processing demands of the task exceed the capacity limitations of working memory system (Barber, 112).

Hunt, Lunneberg & Lewis (113) have provided evidence to show that high verbal ability is related to facility in encoding and manipulating stimulus input in working memory.

Berliner (114) found the correlation between a short term memory test and criterion test scores for the note taking group was as high as .72. Since this correlation is so strong he suggested that notetaking may not be beneficial for students who have very limited short-term memories.

Einstein, Morris & Smith (40) examined the encoding function of note-taking and processing differences between successful and less successful students in 10-

min videotaped lecture situations. They found that note-taking appears to encourage students to engage in qualitatively different types of processing, and the recall differences between successful and less successful students were due to factors occurring at encoding and to factors involved more with what ideas were included in the notes than with note-taking style.

They thus suggested that one of the factors which determine the processing differences is that successful students may be more capable of handling the heavy information processing demands of simultaneously listening to, organising, and taking notes on a lecture. In other words, it is the working memory that helps successful students structure the lecture better and identify the central concepts.

Benton and his colleagues (115) have also noticed from the results of several studies that those who are competent in language, relative to those who are less competent, hold more information in short-term memory and simultaneously manipulate that information more effectively and more rapidly.

According to the research findings from Berliner (116) and DiVesta & Gray (117), it was also shown that learners with greater working memory capacity profited from note-taking, whereas students with less working memory capacity were hindered by note-taking.

Based upon all these findings, it is plausible to hypothesise that the differences in processing ability, i.e., working memory capacity are related to differences in note-taking, so the students' notes must be examined to understand how working memory capacity affects students' information processing during lectures.

3.3.3 Motivational Styles

One of the determinants of note-taking performance is motivation : it is of extreme importance but oddly enough has been neglected for a long time. Claxton (118) stressed the motivational stance that students adopt in a lesson will influence strongly what and how they learn. Given a particular motivational stance is set in a student, his attention is directed towards certain kinds of events and away from others.

3.3.3.1 Motivation and Information-Processing

Murray (119) conceived in his theory of needs, that besides the physiologically based needs of water, food, warmth and absence of pain, there is a set of psychogenic needs as well, including needs for achievement, blame avoidance and affiliation.

Maslow (120) postulated his famous hierarchy of needs, ascending by the order : physical needs, love, belonging, esteem and self-actualisation. In addition to being ranked in a hierarchy, needs are related to time. Physical needs tend to be more related to short-term goals than are the highest, mental desires to know, to understand and to appreciate.

White (106) argued that the issue of long-term and short-term goals is relevant to the learning of science. The students who go into lectures with a short-term goal of passing class or degree exams, often involve recall of propositions and intellectual skills. Scientific laws and potentially meaningful facts are learned as strings or as propositions unrelated to experience.

On the contrary, the students who have a stronger sense of achievement, or who want to learn more about science, may attend the lectures with a long-term goal of a deeper understanding and appreciation of science. They may approach it involving advanced learning strategies of reflection and inter-linking of knowledge.

That is to say, we need to think about students' motivations for learning. Two students may attend the same lecture but end up with pursuing quite different goals. A student who aims for passing exams is likely to engage in very different thought processes and note-taking behaviours compared with a student who wants to learn something new about the subject matter or to take pride in superior attainment.

As Ames et al. (121) pointed out, students' motivations for learning from lectures have important consequences for what they are attending to, how they are processing information, and how they are reacting to the lecturers.

So when listening to a lecture, it is largely a selective choice determined by a student's motivation, that makes the differences. S(he) may reflect on it by holding the information and thinking about it, or he / she may merely let the input slide out of memory or even try to pass it through memory by verbatim copying.

3.3.3.2 Towards a Typology of Motivation

Claxton advanced the idea of "motivational stance" and he actually classified seven stances which are qualitative descriptions of different motivational types. To put it in a simple way : a stance can be seen as a sort of motivational type held in the students. His categorisation of seven stances are : swot stance, thinker stance, boffin stance, socialite stance, dreamer stance, rebel stance and sinker stance (Claxton, 122).

He argued that the stance determines the quality and the quantity of what is learnt.

The stances can direct students' attention. Besides, a specific motivational stance may comprise its own cluster of learning strategies, such as : to seek for deeper intellectual understanding, to aim for sense of achievement, or to explore the personal significance of what is going on.

With the intention of providing the teachers with a vehicle for understanding students and their learning difficulties, Claxton's stances were not a categorisation of empirical data, so the generalisability and practical utility of his stances may be in fact questioned.

Alternatively, from teachers' descriptions, Jackson, Silberman & Wolfson (123) formed a student typology and the types described by teachers' affective reactions to students were : attachment, indifference, concern and rejection.

Subsequently, Power (124) analysed from his naturalistic study that there are four independent ways, representing different student motivational styles which are categorised as : success, rejection - dependency, person - orientation, and social - alienation.

Based upon the framework of students' types and Power's empirical analysis, Good and Power (125) defined a five-fold typology of students' motivations : success students, social students, dependent students, alienated students and phantom students. They assumed that most students can be classified as belonging to one type and that clusters of students so classified are sufficiently homogeneous on characteristics which have been used as a basis for classification to act as a base for taking an appropriate learning strategy.

Adar (126) proposed the existence of four motivational traits that are attributable to students' needs to "achieve", to "satisfy their curiosity", to "discharge a duty" and to "affiliate with people". She introduced the notion of "motivational pattern" and implied that learners differ with respect to their preference for and responsiveness to different instructional features.

She was able to identify empirically four major motivational patterns in her student sample, and accordingly she divided students into four types : the achievers, the curious, the conscientious and the sociable.

Hofstein and Kempa (127) followed this line of research and found that students of different motivational patterns have their preferred modes of learning, too. In other words, the motivational pattern of a certain group of students has different preference for the nature and orientation of learning activities, such as obtaining information and skills, learning of laws and principles, involvement in learning tasks which demand judgement and evaluation, and problem - solving.

Further to probing empirically into Adar's categorisation, Kempa and Martin Diaz (128) conducted an extensive study in which they reported the development and empirical validation of an instrument for determining students' specific motivational patterns. They have found that a high proportion of the total student population could be fairly clearly assigned to one of the four motivational patterns.

They also argued that since the classification of students in terms of those four motivational patterns is convenient and meaningful only for the purpose of raising research hypothesis, there is no *a priori* reason why the patterns should be fully independent of one another. And it would be expected that a considerable proportion of the students exhibit "mixed" or "overlapping" motivational patterns.

In spite of these potential difficulties, the findings obtained from this study do provide broad empirical support for the four motivational patterns originally postulated and described by Adar.

Martin Diaz (129) developed "The Questionnaire on Students' Motivational Styles" to categorise a student to a particular motivational pattern on the basis of the highest score he / she has obtained in this questionnaire. Since the five-point scale used in her study is an ordinal scale of categories, not a numeric scale, the whole idea of calculating the sum and the average is nonsensical. Eventually a response grid was alternatively developed in this study and served as an instrument for categorising the motivational patterns of the student sample (Appendix 11. , Page 354).

Orbach (130) held the view that students of different motivational orientations respond differently to various instructional procedures. In his conclusions, he implied that those educational approaches which are suitable for "curious" and "sociable" students might not be so for "conscientious" students, and vice versa.

Hofstein and Kempa (131) suggested that students with the "conscientious" type or "achievers" type of motivational patterns would exhibit a strong preference for "formal" modes of teaching in which input from teachers is highly emphasised, note-taking is used as a means of obtaining an accurate record of information and textbooks, and handouts are used as a major source for obtaining information.

This present study explored how the motivational styles of students influence their selection of lecture input, and their effects on students' note-taking behaviours.

3.3.4 The Cognitive Style - (Field - Independent / Field - Dependent)

There are available a number of research reports that have explored the effects of cognitive styles upon students' learning behaviour and performance, and the most extensively researched cognitive style is the field independent / field dependent (FID / FD) (Witkin and Goodenough, 132).

"Field independence" may be defined in terms of an individual's ability to "break up an organised field or configuration and abstract relevant features from an embedding context" (133). While field dependent people are relatively influenced by the contextual and structural configuration in which the information occurs, in contrast, the field independent people are characterised by an analytic approach to a situation which enables them to overcome an embedding context when transcending the salient features.

Witkin et al. (134) indicated that field-independent people were more effective than field-dependent people when they were learning science-like content in physically isolated, low structure situations.

Shymansky and Yore (135) suggested that field-independent university students were more able to handle a low-structure inquiry strategy when dealing with chemistry and physics topics than field-dependent students.

Strawitz (136) found that a structured teaching method produced significantly larger growth in controlling variables for field-independent students than did a free inquiry approach.

Lourdusamy (137) examined the effects of different cognitive styles on students' learning under different modes of instruction and field-dependent students were found to gain relatively less from discovery learning situations than field-independent students, compared with the expository teaching mode.

Annis (138) investigated the effect of cognitive style on study technique effectiveness by having field-independent and field-dependent students read only or take notes on logically organised or scrambled reading passages. The field-independent students were better than field-dependent students at recalling information of high structural importance, regardless of whether the passage was organised or not.

Frank (139) studied the effect of field-independence / field-dependence and study technique on learning from a lecture. The field-independent students were found to have performed better than field-dependent students under the students' notes condition. It is evident from his results that under the typical lectures in which the teacher lectures and the students take notes, field-independent students may be more favoured than field-dependent students.

Robinson and Bennink (140) studied the influence of field-independence on a memory task under varying degrees of information load. Field-independent students demonstrated more efficient recall statistically significantly under the high information load condition.

Frank (141) found that field-dependent students' test performances could be enhanced by providing the students with instructional support in the form of detailed or skeletal lecture notes.

Recently, Kiewra and Frank (142) reported that field-dependent students benefit more from the external storage, as opposed to the encoding function of note-taking.

Kiewra and his colleagues (143) have focussed on note-taking strategies, and have not detected any differences between field-dependent and field-independent learners concerning either number of words or idea units recorded in their notes, although field-dependent learners tend to favour structured note-taking techniques over non-structured note-taking techniques.

Accordingly, one of the main purposes of this present study was to uncover specific differences in information processing between field-independent and field-dependent students in learning, as Frank (139) has pointed out that such research *"will be of great use, because such knowledge would help lecturers to develop lecturing strategies that capitalise on the characteristics of the different styles of students".*

To sum up, by adopting an Information-Processing model, the processes of lecturing and learning were combined in a unified framework and were going to be studied more in depth in terms of a lecturer's cognitively oriented stimulus variables and the students' cognitively oriented response variables. The direction of further research has advanced beyond an examination of the process and product functions of note-taking toward a clarification of the learners' cognitions and related characteristics.

CHAPTER FOUR

The Planning and Administration of the Second Phase Study

4.1 Research Purposes and Hypotheses

The second phase of the study was aimed first to explore the effects of lecturing pace, wait-time, information density, lecturer's use of humour and asides, focussing, giving instructional cues, the quality of blackboard writing and the audibility of voice on the students' processes of note-taking.

This present study attempted to test the following hypotheses :

Hypothesis 1 : The students' working memory space could be overloaded if students are subjected to either of the following conditions :

A. a rapid lecturing pace,

B. short period of wait-time,

C. the high information density and

D. less focussing

and then the tendency of students' note-taking will tend to be verbatim.

According to the proposed model, students' motivational styles will presumably influence their arousal level of attention, and thus the effectiveness of orienting responses. Therefore, it was raised that,

Hypothesis 2 : The conscientious and the achiever students will tend to have more complete note-taking than the curious and the sociable students.

Hypothesis 3 : The conscientious and the achiever students will have better performance in class exams and final degree exam than the curious and the sociable students.

Since the individual differences in the ability to disembed the important information from the irrelevant material play a crucial role in the lecture settings, the following hypotheses were also tested :

Hypothesis 4 : The field-independent subjects will take more complete notes than the field-dependent ones.

Hypothesis 5 : The field-independent students will perform better than the field-dependent students in class exams and degree exam.

Working memory space has proved to be a good predictor of learning from lecture, it was suggested that the processes involved in recording sufficient lecture notes have to do with the special ability of manipulating propositional information in a student's working memory space. So the following hypotheses were tested as well in this present study :

Hypothesis 6 : The students with higher working memory space will be more complete in note-taking than the students with lower working memory space.

Hypothesis 7 : The students with higher working memory space will have better performance in class exams and the final degree exam than the students with lower working memory space.

4.2 Students' Evaluation of Lecturing

4.2.1 Modification of Rating Scale

From the data analysis in the exploratory study, some of the statements were not so appropriate that modifications were made and several new statements were added to increase the validity of this instrument. For instance, Statements **4** and **5** in the original response sheet were changed since there was no set textbook in many courses (Appendix 2, Page 325). Statement 3 was also revised because this single item covered no less than four separate aspects of the teaching method and so students might find it confusing to rate that particular item. In addition, since a lot of students started writing their own comments in the response sheet, a much greater space was thus provided for student comments.

The new version came out in three parts (See Appendix 12, Page 355). Part A is composed of statements about the relative difficulty, workload, pace and overall rating of the course and of the lecturer. Partr B consists of statements about Course Content and Lecturer Characteristics. In Part C, students are now invited to write their comments on the course, or to the teaching. A whole page of space was now provided.

In the autumn of 1989, it was decided to convert the instrument into a **mark-sense** format which could be processed entirely by computer, thus increasing the accuracy of scoring and expediting the return of results to the lecturers. By March 1990, the special response sheets had been designed and printed in two colors (Appendix 13, Page 357), and a suitable "marking" program had been written and tested (Johnstone and MacGuire, 11).

4.2.2 Student Rating of Courses and Lecturers

From October 1989 to May 1990, students' ratings of courses and lecturers were carried out by means of the newly revised version of the rating scale. Lecturers used these sheets at a convenient time - usually during the final lecture or in the afternoon lab, and returned the completed sheets for processing. It was noted that, in general, there were very few spoiled sheets and the response rates of the questionnaire were pretty high, ranging from 75 % to 93 %.

Since it had been checked constantly and finally verified by MacGuire (11), that the overall rating by a random sample of students more than 30 is almost the same as the overall rating by the whole class, it was thus decided to carry out the evaluation by using random samples instead of the whole class. The evaluation was continued throughout the whole session for every block of lectures and for every lecturer by random samples of all the students attending the First-year Ordinary Chemistry course. A total of 1,397 student response sheets were finally collected with 15 lecturers involved.

4.3 Participant Observation of Lecturing

During the same period all the fifteen lecturers for this course were also studied by observing their lecturing behaviours which have to do with the mental load in the students' working memory space. The course consisted of 96 lectures, divided into 16 blocks given by 15 different lecturers. Lectures were given to about 250 students in a theatre with a capacity for 400 and each lecture duration was 50 minutes; and same lecture course to this large class has to be divided into two teaching groups taught by the same lecturer, one in the morning and another in the afternoon.

Two lectures were randomly chosen from each lecturer and studied by using the *Observation Schedule of Lecturing Behaviours*, which had been revised to code all the frequencies of lecturing signals which were only concerned with the afore-mentioned cognitively orienting variables.

Besides, the whole lecture was also tape-recorded and transcribed so that the information units and information-density could be measured; and it was also used for the cross check on the variables observed.

4.4 Investigation of Students' Note-taking Behaviours

4.4.1 Student Sample

The subjects were 28 First-year science students who were studying the introductory chemistry course in the Chemistry Department, University of Glasgow. The students' working memory capacity, motivational attitudes and cognitive styles were measured and then their note-taking behaviour and academic performances were traced from the beginning of the first term till the end of the third term.

4.4.2 Test Materials

Five tests were administered during this phase period of research: the Hidden Figure Test (HFT, Appendix 14, Page 358), the Motivational Style Test (MST, Appendix 11, Page 354), the Figural Intersection Test (FIT, Appendix 15, Page 368), the Digit Span Test (DST, Appendix 16, Page 380) and an immediate recall test on lecture content (Appendix 17, Page 382).

4.4.2.1 The Hidden Figure Test (HFT)

Based originally upon Witkin's work (134), El-Banna (144) designed this test to classify the subjects into field-dependent learners and field-independent learners. In this test six simple geometric and non-geometric shapes are embedded in complex figures (one simple shape in each complex figure) and subjects are requested to identify and outline these shapes. There are altogether 18 complex figures, with two additional complex figures to serve as examples.

The HFT scoring key is located in El-Banna's work (144). One mark is credited to each correct answer, and the total marks each subject obtains are used further to classify that particular subject into a specific cognitive style.

The test / retest reliability coefficient of this test is 0.6 (El-Banna, 144). The split-half reliability coefficient for HFT is 0.72, and Cronbach α coefficient is 0.71 (Cronbach, 145) respectively. So, the FD / FID test is very reliable judged by these above measures.

In connection with the validity, HFT used in this study is based upon the Group Embedded Figures Test, which has been regarded as the criterion measure of field-dependence and field-independence since Witkin et al. (134) developed it in 1971. In addition, the test also has face validity.

4.4.2.2 The Motivational Style Test (MST)

In order to explore students' motivational patterns and traits, the Questionnaire on Students' Motivational Patterns was developed and validated by Martin Diaz (129). There are sixty items in this Likert type questionnaire, which is composed of four dimensions of students' motivational patterns. Each item represents a statement expressing some argument concerning a motivational characteristic and called for a response on a five-point "applicability to me" scale (ranging from 'very true of me' to 'absolutely inapplicable to me') (129). Each dimension has fifteen items respectively and all the sixty items were randomly ordered in this questionnaire.

According to Kempa and Martin Diaz (128), the modified motivational scales from the "Questionnaire on Students' Motivational Patterns" have significantly improved reliabilities. The relevant reliability data is as follows: the "Achiever student scale" --- 0.81, the "Curious student scale" --- 0.79, the "Conscientious student scale" --- 0.79, and the "Sociable student scale" --- 0.68 respectively.

In her study Martin Diaz assigned a student to a particular motivational category, on the basis of his / her highest score on the " Questionnaire on Students' Motivational Patterns". But according to Cohen and Holliday (42), the five-point scale actually is an ordinal scale of categories, not a numeric scale, and thus the whole idea of calculating the sum and the average is nonsensical.

To avoid such an inappropriate way of analysing students' response results, an alternative design was made by using the "selection grid" (Al-Naeme, 146), as shown in Figure 4-1. The student is asked to select optionally up to five descriptions which he/she thinks most closely fit his/her own feelings about learning. In this grid there are sixteen statements which are made up of four categories from the above questionnaire, with four items in each category. By checking the response clusters it is easier to classify a student into a specific motivational pattern.

4.4.2.3 The Figural Intersection Test (FIT)

Devised and used by Pascual-Leone (147), it is a test frequently applied to determine subjects' working memory capacity.

The Figural Intersection Test has many complex designs and each has from two to nine simple geometric shapes overlapping and the subjects are asked to find the

UNIVERSITY OF GLASGOW

CENTRE FOR SCIENCE EDUCATION

NAME____________________

Instructions : (1) Please read carefully ALL the statements in the following grid.

(2) Select up to FIVE descriptions which you think MOST CLOSELY fit your own feelings about studying.

(3) Fill the numbers you have selected into the bracket on the right : (   )

1 I enjoy studying with my friends and discussing our problems together.	2 It is very important to me to be in the top few of the class.	3 When exam times come round I cut out other activities to concentrate on study.	4 I hate being held back by the teacher having to deal with slow students.
5 The support of my friends is very important to me during exam times.	6 My social and recreational interests are very important to me.	7 I am keen to learn about the latest discoveries and inventions rather than sticking to set materials.	8 I am normally so busy enjoying life that I tend to put off my study till the last minute.
9 In class I enjoy hearing about the applications to everyday life whether they are examined or not.	10 Class discussions are boring if you have to listen to a lot of obviously wrong answers from others.	11 Practicals with very rigid instructions bore me. I prefer to follow my own ideas such as in a project.	12 I like practical work when the instructions are clear and you know just where you are and what is expected.
13 I enjoy the challenge of competing with others for top marks.	14 I may not do brilliantly but I feel a duty to do as well as I can.	15 Exams seldom give me a chance to explore the questions properly and show that I can think for myself.	16 I prefer not to offer suggestions in class discussions unless I am sure I am right.

Figure 4-1. The Selection Grid for Categorising Students' Motivational Styles

common intersecting area of a number of simple shapes which overlap to form a complex design. The test is exemplified on the first page of the test booklet and some examples have been provided to practise with.

The subject is required to look at the shapes on the right hand side in which the separate figures are displayed; then he must shade in the common area on the left hand side where the same shapes have overlapped. Moreover, El-Banna (144) has incorporated one more geometric and irrelevant shape in some of the overlap figures in the Witkin test in order to 'confuse' the subject.

The test was finally designed to contain 31 figures distributed over six sets as follows :

Number of shapes :	*3*	*4*	*5*	*6*	*7*	*8*
Number of items :	*5*	*6*	*5*	*5*	*5*	*5*

The scoring key of FIT can be found in Appendix 18 (See Page 383). For each set, a student's percentage of correct responses was worked out. The student's X-value was then determined as the highest item class in which he scored more than 75% (Johnson, 148).

4.4.2.4 The Digit Span Test (DST)

To measure the working memory space of student sample, the Digit Span Test was administered in two ways:

(i) The Digit Forward Test (DFT) --- It is used only for settling the subjects, the results are in fact ignored. The subjects are read a set of digits and then requested to write the digits down in exactly the same order.

(ii) The Digit Backward Test (DBT) --- By reading a set of digits to the subjects and asking them to write the digits down in reverse order, this way allows the determination of students' working memory capacity. By steadily increasing the number of digits, an upper processing limit can be determined.

The design, instructions and administration procedures can be found in Appendix 16, Page 380 .

4.4.2.5 The Immediate Recall Test on Lecture Content

The results from the exploratory study showed that most students took notes verbatim. An immediate recall test on a certain lecture content was thus developed to probe to what extent the lecture material has been processed or understood by students during the lecture.

A short test was designed such as to contain questions ranging from <u>interpreting</u> the technical terms to <u>applying</u> the taught theory to a new situation. The test is shown in Appendix 17 (Page 382).

4.4.3 The Procedure

4.4.3.1 The Selection of Student Sample

In October 1989 when the first term started, all the first-year science students attending Ordinary Chemistry course (total 516), were given two tests: the Hidden Figure Test (HFT) and the Motivational Style Test (MST). The purpose of these tests was to select those students who have distinct typology of motivational attitudes and different cognitive styles.

The results from the Motivational Style Test were shown in the following:

Motivational Styles	*Choice Patterns*		*Number of Students*
The Achiever students (8)	4A, 1S	---	2
(A)	4A, 1Cu	---	3
	4A, 1Con	---	2
	3A, 1S	---	1
The Conscientious students (51)	4Con, 1A	---	10
(Con)	4Con, 1Cu	---	12
	4Con, 1S	---	20
	3Con, 1A	---	2
	3Con, 1Cu	---	2
	3Con, 1S	---	3
	3Con	---	2
The Curious students (18)	4Cu, 1Con	---	2
(Cu)	4Cu, 1A	---	2
	4Cu, 1S	---	3
	3Cu, 1A	---	7
	3Cu, 1S	---	4
The Sociable Students (16)	4S, 1Con	---	3
(S)	4S, 1A	---	1
	4S, 1Cu	---	3
	3S, 1Cu	---	3
	3S, 1Con	---	3
	3S, 1A	---	3

In order to avoid the "position effect" (i.e. the order of items appearing in sequence) on the selection grid, four sets of the randomly ordered statements were used to produce four different selection grids. After analysis, no significant differences were detected among those four selection grids when the proportion of distinct motivational patterns in the tested population was taken into account.

From all the 516 students, only 93 (18 %) chose all four responses in the one specific category or three responses in one category and one in another category, so they were able to be classified into a distinct motivational style. But if all the students who have chosen three responses in one category, one in the second category and one in the third category; or those who have chosen three in one category and two in the second category are taken into account, then nearly 74% of all students can be classified into a certain motivational style.

We admit that the test is still in its infancy and it might be soft or weak, in order to cut down the uncertainty, we wouldn't consider the **3-2**, or **2-1** cases (i.e., the subjects who selected three items in one category and two items in another category, or two in one category and one in another category). Since this is the best instrument we have got in the present, it is useful as a method to categorise the students into a particular motivational style and more refinements have been undertaken to improve this instrument. It is also recognised that people will not fall entirely into one particular category but there may be some overlapping in their motivational characteristics.

Since the proportion of the Achiever, the Curious and the Sociable students was very low, all those students who had selected four items belonging to those particular styles (viz. 4A, 4Cu and 4S as listed in the above) were targeted as the sample. In addition, from the 51 Conscientious students 12 were randomly selected into the whole sample. So, there were altogether 28 students being chosen as the subjects.

4.4.3.2 Determination of Cognitive Style

The distribution of the HFT total scores for all the 507 students (nine students didn't complete the test) is shown in Fig. 4 - 2. The distribution of the HFT total scores was then used to divide all the students into three categories according to the attainment of students in the FD / FI measurement.

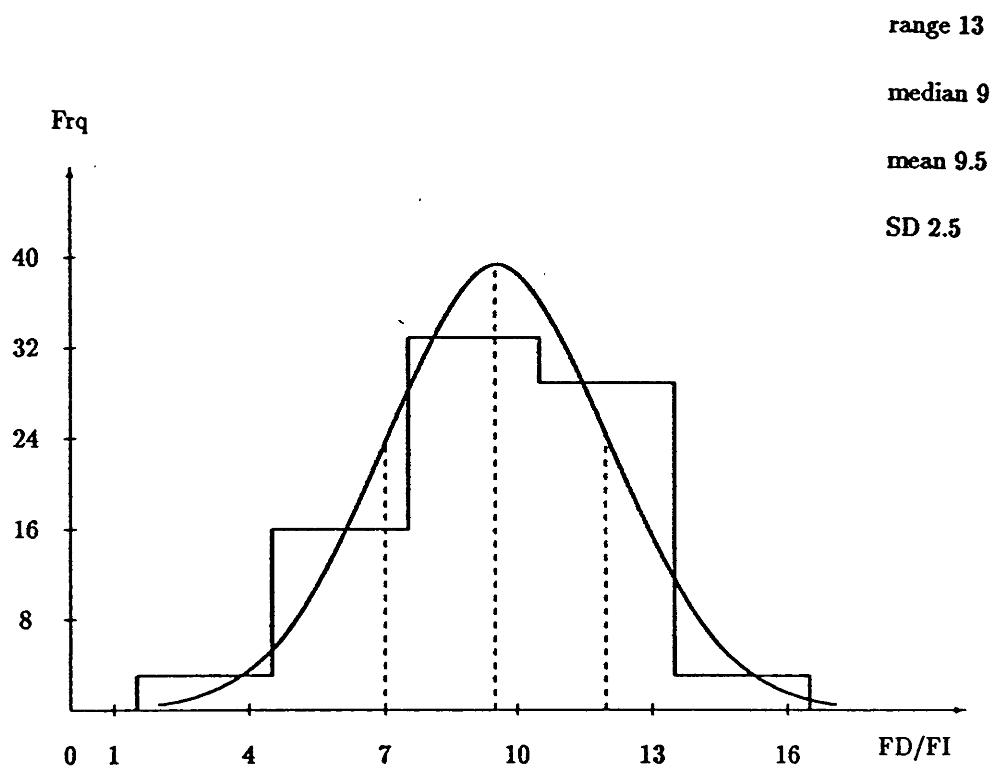


Figure 4-2. The Distribution of HFT Total Scores for All the Students

The criterion by which Case (149) and Scardamalia (65) used to divide the categories is as follows:

(1) Field-independent subject : A student who scores at least one standard deviation above the mean score.

(2) Field-dependent subject : A student who scores one standard deviation

below the mean score.

(3) Field-neutral subject : A student whose score falls in between, viz., $M-\sigma < X < M+\sigma$, where M is the mean score; σ, the standard deviation; and X, the student score.

Table 4 - 1 shows the classification of the whole student sample.

TABLE 4-1. Classifying the Cognitive Style of Total Students

Cognitive Style	Number of Students
Field-Dependent	125
Field-Neutral	274
Field-Independent	108
Total	507

As regards to the 28 selected students, 7 are Field-dependent, 11 are Field-neutral and 10 are Field-independent respectively.

4.4.3.3 Measurement of Working Memory Capacity

Those 28 students were again given the two standardised tests: DST (Digits Span Test) and FIT (Figural Intersection Test). Both tests were carried out in small groups (about 5 to 8 students in a group) at the start of the first term.

After the subjects had been "warmed up" by taking the Digit Forward Test, they were then asked to repeat a steadily increasing arbitrary sequence of digits in reverse order in the Digit Backward Test. In order to obtain a DBT score that could be regarded as a valid measure of working memory capacity, subjects had to be tested under rigorously controlled circumstances.

The performance of each student in DBT and FIT was compared and it was found 19 students obtained the same score in the two tests, 3 obtained 1 more score in FIT, and 6 obtained 1 more score in DBT. (It seemed DBT requires more effort than FIT.) Most students got the same score in DBT and FIT; but when the student got different scores, the score in DBT was used to determine his / her working memory capacity. The reason is that it has been argued by Pascual-Leone (147) :

> *" It could be what was being measured in FIT was both working memory capacity and field-dependence / field-independence style, therefore it is more reliable in the DBT. "*

The sample of students was subdivided into different groups according to their working memory space, cognitive style and motivational style as shown in TABLE 4 - 2.

4.4.3.4 Collecting Students' Lecture Notes

After the sample had been selected, they were contacted and requested by the researcher on an individual basis to cooperate in this study. All of them seemed to be interested and promised to provide their lecture notes for investigation.

From the second week in the first term, the lecture notes of the subjects were collected from time to time without prior warning, sometimes in the afternoon after the students attended the morning lecture and sometimes the next day. But the likelihood that

TABLE 4-2. Classifying the 28 Students into Different Groups

Working Memory Capacity	Cognitive Style	Student	Motivational Style			
			A	Con	Cu	S
LOW (X=4 X=5)	FD (4)	S 1		v		
		S 2		v		
		S 3		v		
		S 4		v		
	FN (4)	S 5	v			
		S 6				v
		S 7			v	
		S 8		v		
	FI (2)	S 9		v		
		S 10				v
MIDDLE (X=6)	FD (2)	S 11				v
		S 12	v			
	FN (6)	S 13	v			
		S 14			v	
		S 15				v
		S 16		v		
		S 17	v			
		S 18		v		
	FI (4)	S 19	v			
		S 20		v		
		S 21		v		
		S 22				v
HIGH (X=7)	FD (1)	S 23		v		
	FN (1)	S 24			v	
	FI (4)	S 25	v			
		S 26			v	
		S 27			v	
		S 28		v		

*** Cognitive Styles : FD = Field Dependent FN = Field Neutral
FI = Field Independent

Motivational Styles : A = Achiever Con = Conscientious
Cu = Curious S = Sociable

some students could annotate or modify their records after lecture was also checked and taken into consideration since how students use their lecture notes was a very important investigation in this second phase of the study.

An exact copy of what appeared on the blackboard was obtained by the researcher by attending the lecture and checked with the lecturer. The blackboard signals were numbered and used to check those which each student recorded. In the same way, this procedure was also used for both verbal signals and materials presented on slides or transparencies.

At least three sets of lecture notes from each lecturer were borrowed from all the subjects and xeroxed for inspection. The content of these lecture notes is summarised as follows :

Lecturer A (Atoms and Molecules)

1. The hydrogen atom spectrum and atomic energy levels.
2. Atomic orbitals and the electron quantum numbers.
3. Electronic configuration of atoms and periodic table.

Lecturer B (Atoms and Molecules)

1. Bonding and 8-electron rule.
2. Bond orders for first row diatomic molecules.
3. VSEPR rules and the shapes of simple molecules.

Lecturer C (Organic Chemistry I)

1. Structural isomerism and drawing possible isomers.
2. Chirality, optical isomers, enantiomers and racemates.
3. The structure and reactions of alkenes.

Lecturer D (Chemical Energetics)

1. Hess's law and determination of bond energy.
2. The entropy and the Second Law of Thermodynamics.

3. Gibbs free energy and the equilibrium constant.

Lecturer E (Kinetics and Mechanism of Chemical Reactions)

1. The rate law and reaction rate.
2. Activation energy and graphical determination.
3. Reaction mechanism and the rate determining step.

Lecturer F (Equilibria)

1. Phase diagram of water.
2. Raoult's Law and the colligative property.
3. Calculation of pH, K_a, pK_a and the degree of dissociation.

Lecturer G (Chemistry of the Halogen and Nitrogen group elements)

1. The properties of metals and non-metals.
2. Chemistry of halogen and the acid strength of oxyacids.
3. Disproportionation, catenation and isoelectronic structure.

Lecturer H (Organic Chemistry II)

1. Conjugation, resonance and delocalisation of electrons.
2. Aldehydes and ketones.
3. Acid chlorides, anhydrides, esters and amides.

Lecturer I (Macromolecules)

1. Determination of molecular weight of polymer.
2. Amorphous, crystalline, isotropic, and anisotropic.
3. Addition polymers and their common commercial applications.

Lecturer J (Solid State Chemistry)

1. Unit cells and measurement of their dimensions.
2. Calculation of lattice energy.
3. Coordination number and radius ratio.

Lecturer K (Environmental Chemistry)

1. Adsorption and desorption.
2. The importance of pH and buffering capacity in natural systems.
3. The mechanism controlling the mobility.

Lecturer L (Food Chemistry)

1. The structures and properties of carbohydrates.
2. The chemistry of amino acids and proteins.
3. The chemistry of fats and their role as food components.

Lecturer M (Transition Metals and their Biological Significance)

1. Ligand denticity and the isomers of complexes.
2. The stability of a complex.
3. The function of ligands in biological situations.

Lecturer N (Organic Chemistry III)

1. Acid hydrolysis and alkaline hydrolysis of esters.
2. Imines, oximes and 2,4-dinitrophenyl-hydrazones.
3. The chemistry of amides.

Lecturer O (Electrochemistry)

1. Electrical energy and electrical potential.
2. The electrochemical cells.
3. The corrosion of metals and its prevention.

Lecturer P (Radiochemistry)

1. The modes of radioactive disintegration.
2. Calculation of nuclear binding energy and activities or half-lives.
3. The geological age determination.

4.4.3.5 Clinical Interview with Students

Little research has been available on what students actually do with their notes once they have taken them. In order to examine the usefulness of the product of note-taking and to make that product more viable, the diary - interview method (Zimmerman and Wieder, 150) was utilised in our research from November 1989.

Prior arrangements were made such that at least two interviews with each subject were taken during the whole session. Each interview lasted about 30 minutes in which the researcher enquired of the particular student such things as :

(1) Any specific problems found in that subject's lecture notes to check whether any note-encoding had been used when taking notes.

(2) Any individual difficulties in following lectures due to lecturing conditions in a specific lecturer's course.

(3) What they have done to the recorded notes.

(4) How they make use of the notes (e.g., preparing for class exams).

4.5 The Immediate Recall Test on Lecture Content

On 12th of March 1990, a total of 135 students attended the afternoon lecture on the topic "The shapes and structures of metal complexes". A blank answer sheet was handed out to every student before they went into the lecture theatre and all the students were informed that there was going to be a short quiz on this particular lecture content.

Ten minutes before the lecture was finished, the test questions were projected on the screen by using the transparency. Students were tested to examine to what extent they had processed and understood the material taught during that lecture.

4.6 Students' Note-taking Behaviours in General

Since there were only 28 subjects in this present study, there seemed to be a need to understand what the general students in this course feel about note-taking. In other words, to round off this study it was decided to administer a survey questionnaire to the whole class (See Appendix 19, Page 387). This questionnaire consists of five questions with several sample optional choices to induce students to express their views.

In this survey, students were asked about the purpose of note-taking during lectures, their opinions about having complete handouts, how they select the essential lecture information to take down, how they use the lecture notes and for what purpose, and any features of lectures that they would like to see changed to enable them to take satisfactory notes.

On the first and second weeks of the third term, the questionnaire sheets were distributed to each student when they went into the lab. Students were then requested to write their responses to those five questions and the researcher immediately collected the completed questionnaire sheets before the laboratory started.

CHAPTER FIVE

The Influence of Lecturing Variables on Students' Note-taking Behaviours

5.1 Students' Ratings of Course and Lecturers

Because the evaluation instrument had been modified, a statistical procedure similar to that used in session 1988 - 1989 was carried throughout the whole session 1989 - 1990. The results below showed that the changes were effective since students were not put off by the increased number of statements, the simplified wording caused fewer problems, and the regrouping of statements made the pattern of student responses more easily understood.

5.1.1 Data Analysis and Results

For each separate lecturer, the actual and percentage frequency of the student responses, for each rating on the Likert scale, was calculated for all twenty-two statements appearing on the sheet. For example, a typical summary data table such as Lecturer **1** is shown in TABLE 5-1.

As stated in Chapter Two, for the ordinal scale of categories, it is more appropriate and more valid to use the Chi-square (χ^2) test and the Spearman rank order correlation coefficient (r_o), to make comparisons between the lecturers.

The procedure for testing the statistical significance of all twenty-two items for the fifteen separate lecturers was :

(1) Computing the <u>composite totals</u> for <u>the whole course</u> by using the 1397

TABLE 5 - 1. A Typical Summary Data Table for Lecturer 1

DATE = October 1989 COURSE = A / 1 N = 150

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	0	15	106	27	2	150
ITEM 2	0	16	106	26	1	149
ITEM 3	5	47	91	6	1	150
ITEM 4	9	69	65	6	0	149
ITEM 5	0	15	56	61	18	150
ITEM 6	10	78	42	16	3	149
ITEM 7	1	8	44	84	12	149
ITEM 8	10	62	56	19	3	150
ITEM 9	23	91	32	4	0	150
ITEM 10	15	76	48	9	2	150
ITEM 11	17	65	56	9	1	148
ITEM 12	19	62	55	14	0	150
ITEM 13	22	71	42	15	0	150
ITEM 14	11	46	53	32	8	150
ITEM 15	13	62	45	27	3	150
ITEM 16	9	13	10	61	57	150
ITEM 17	5	29	89	25	2	150
ITEM 18	28	69	37	11	5	150
ITEM 19	21	65	58	6	0	150
ITEM 20	31	97	20	1	0	149
ITEM 21	36	90	20	2	1	149
ITEM 22	1	10	32	67	38	148

(Percentage values)

	1	2	3	4	5	TOTAL	% BIAS
ITEM 1	0	10	71	18	1	100	+42
ITEM 2	0	11	71	17	1	100	+42
ITEM 3	3	31	61	4	1	100	+22
ITEM 4	6	46	43	4	0	99	+48
ITEM 5	0	10	37	41	12	100	-43
ITEM 6	7	52	28	11	2	100	+46
ITEM 7	1	5	29	56	8	99	-58
ITEM 8	7	41	37	13	2	100	+33
ITEM 9	15	61	21	3	0	100	+71
ITEM 10	10	51	32	6	1	100	+54
ITEM 11	11	43	37	6	1	98	+47
ITEM 12	13	41	37	10	0	100	+44
ITEM 13	15	47	28	10	0	100	+52
ITEM 14	7	31	35	21	5	99	+12
ITEM 15	9	41	30	18	2	100	+30
ITEM 16	6	9	7	41	38	100	-64
ITEM 17	3	19	59	17	1	99	+4
ITEM 18	19	46	25	7	3	100	+55
ITEM 19	14	44	39	4	0	100	+54
ITEM 20	21	65	13	1	0	100	+85
ITEM 21	24	60	13	1	1	99	+82
ITEM 22	1	7	21	45	25	98	-62

complete response sheets which were obtained from students during the whole lecture period.

TABLE 5-2 shows the results of computation.

(2) Calculating the expected frequencies for all twenty-two items by using the actual frequencies (such as those in TABLE 5-2). For instance, we can use the actual frequencies for Item 1 (for the 1391 students given in TABLE 5-2) to calculate the expected frequencies for Item 1 (for the 150 students in TABLE 5-1). The expected frequencies will be (150 / 1391) times the actual frequencies given in TABLE 5-2 (i.e., ' 4 ', ' 24 ', ' 92 ', ' 27 ' and ' 3 ' respectively). TABLE 5-3 shows the results of calculating the expected frequencies for all **22** items. (The observed frequencies are, of course, the same as the actual frequencies shown in TABLE 5-1.)

(3) Calculating the value of Chi-square for each item in TABLE 5-3 by using the following formula

$$\chi^2 = \Sigma\{(O - E)^2 / E\}$$

where O = the observed value

and E = the expected value

TABLE 5-4 shows the levels of significance of all **22** items for the **15** separate Lecturers **1, 2, 3,** ... and **15**. In this table, the shadings are used to highlight those lecturers who were significantly different from what would be expected if all of the lecturers were of the same quality. Lecturers **6, 11** and **15** are unusual in that they received a non-significant rating for almost every item; in contrast, it can be seen clearly that eleven or more of the items were significant for the Lecturers **1, 2, 3, 4, 5, 7, 8, 9, 10, 12, 13** and **14**.

To understand whether these lecturers were rated by the students as significantly good or significantly bad, one can estimate the "percentage bias", viz., "measure of agreement" (See Page 26.), for each item, by ignoring any ' 3 ' ratings, and calculating

TABLE 5 - 2. The Composite Totals for the Whole Course

*** For Items *1*, *2* and *3*, the bias percentage is { '3' - ('1' + '2' + '4' + '5') }.

DATE = 1989 - 90 COURSE = A N = 1397

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	36	225	855	245	30	1391
ITEM 2	22	135	976	234	24	1391
ITEM 3	69	294	879	129	24	1395
ITEM 4	77	474	594	200	47	1392
ITEM 5	72	220	463	454	185	1394
ITEM 6	149	759	278	151	35	1372
ITEM 7	35	156	439	612	123	1365
ITEM 8	46	366	647	257	55	1371
ITEM 9	161	680	366	127	30	1364
ITEM 10	110	552	486	159	52	1359
ITEM 11	70	280	678	202	86	1316
ITEM 12	191	569	345	208	51	1359
ITEM 13	268	577	322	151	34	1352
ITEM 14	148	382	395	308	138	1371
ITEM 15	147	565	386	210	60	1368
ITEM 16	111	170	264	548	265	1358
ITEM 17	59	311	622	262	105	1359
ITEM 18	165	584	410	136	60	1355
ITEM 19	234	566	463	56	34	1353
ITEM 20	210	697	359	71	18	1355
ITEM 21	241	712	333	61	12	1359
ITEM 22	67	133	358	480	322	1360

(Percentage values)

	1	2	3	4	5	TOTAL	% BIAS
ITEM 1	3	16	61	18	2	100	+22
ITEM 2	1	10	70	17	2	100	+40
ITEM 3	5	21	63	9	2	100	+26
ITEM 4	6	34	43	14	3	100	+23
ITEM 5	5	16	33	33	13	100	-25
ITEM 6	11	54	20	11	2	98	+52
ITEM 7	3	11	31	44	9	98	-39
ITEM 8	3	26	46	18	4	97	+7
ITEM 9	11	49	26	9	2	97	+49
ITEM 10	8	39	35	11	4	97	+32
ITEM 11	5	20	48	14	6	93	+5
ITEM 12	14	41	24	14	4	97	+37
ITEM 13	19	41	23	11	2	96	+47
ITEM 14	11	27	28	22	10	98	+6
ITEM 15	11	40	28	15	4	98	+32
ITEM 16	8	12	19	39	19	97	-38
ITEM 17	4	22	44	19	8	97	-1
ITEM 18	12	42	29	10	4	97	+40
ITEM 19	17	40	33	4	2	96	+51
ITEM 20	15	50	26	5	1	97	+59
ITEM 21	17	51	24	4	1	97	+63
ITEM 22	5	9	26	34	23	97	-43

TABLE 5 - 3. The Observed Frequencies and the Expected Frequencies for All 22 Items

DATE = October 1989 COURSE A / 1 N = 150

(Observed values)

	1	2	3	4	5	TOTAL
ITEM 1		15	106	29		150
ITEM 2		16	106	27		149
ITEM 3	5	47	91	7		150
ITEM 4	9	69	65	6	0	149
ITEM 5	0	15	56	61	18	150
ITEM 6	10	78	42	19		149
ITEM 7		9	44	84	12	149
ITEM 8	10	62	56	19	3	150
ITEM 9	23	91	32	4		150
ITEM 10	15	76	48	9	2	150
ITEM 11	17	65	56	9	1	148
ITEM 12	19	62	55	14	0	150
ITEM 13	22	71	42	15		150
ITEM 14	11	46	53	32	8	150
ITEM 15	13	62	45	27	3	150
ITEM 16	9	13	10	61	57	150
ITEM 17	5	29	89	25	2	150
ITEM 18	28	69	37	11	5	150
ITEM 19	21	65	58	6		150
ITEM 20	31	97	20	1		149
ITEM 21	36	90	20	3		149
ITEM 22	1	10	32	67	38	148

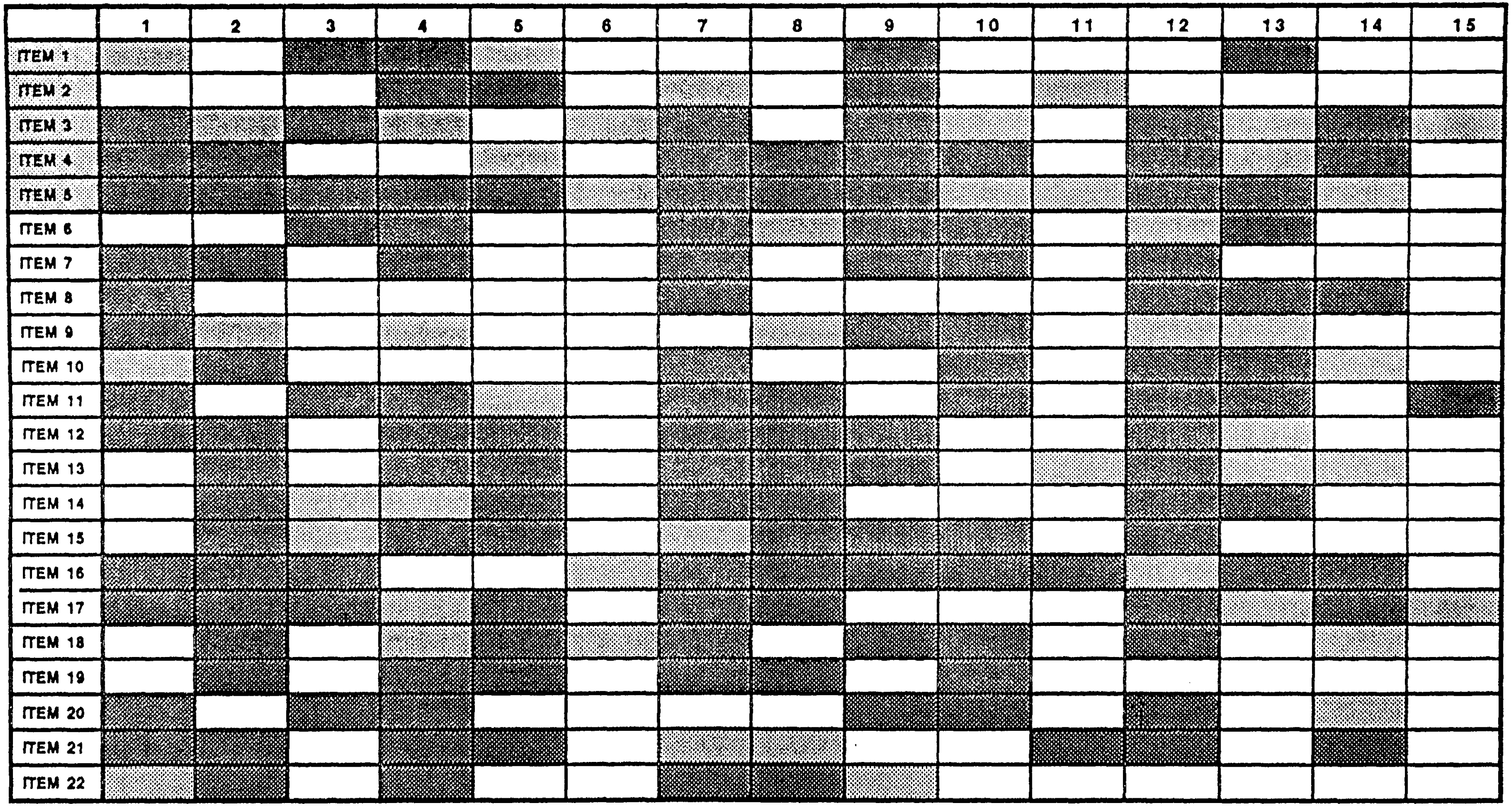
For d.f. = 4 and p = 0.01, $\Sigma(\chi)^2 > 13.277$

(Expected values)

	1	2	3	4	5	TOTAL	$\Sigma(\chi)^2$
ITEM 1		28	92	30		150	8.20
ITEM 2		16	105	28		149	0.05
ITEM 3	7	32	94	17		150	13.58
ITEM 4	8	51	64	21	5	149	22.19
ITEM 5	7	24	50	49	20	150	14.24
ITEM 6	16	83	30	20		149	7.30
ITEM 7		21	48	67	13	149	11.58
ITEM 8	5	40	71	28	6	150	24.66
ITEM 9	18	75	40	17		150	16.34
ITEM 10	12	61	54	17	6	150	11.54
ITEM 11	8	31	76	23	10	148	69.31
ITEM 12	21	63	38	22	6	150	16.72
ITEM 13	30	64	36	20		150	5.15
ITEM 14	16	42	43	34	15	150	7.65
ITEM 15	16	62	42	23	7	150	3.76
ITEM 16	12	19	29	61	29	150	42.12
ITEM 17	6	34	69	29	12	150	15.59
ITEM 18	18	65	45	15	7	150	8.87
ITEM 19	26	63	51	10		150	4.84
ITEM 20	23	77	39	10		149	25.33
ITEM 21	26	78	37	8		149	16.61
ITEM 22	7	15	39	52	35	148	12.64

For d.f. = 4 and p = 0.05, $\Sigma(\chi)^2 > 9.488$

TABLE 5 - 4. The Levels of Significance of All 22 Items for 15 Separate Lecturers



(→ significant at the 0.01 level, and → significant at the 0.05 level) the value of { (' 1 ' + ' 2 ') – (' 4 ' + ' 5 ') }*. This was carried out through all the fifteen percentage summary tables (such as TABLE 5-1), and the results are shown in TABLE 5-5.

* except items *5, 7, 16* and *22*, where the polarity is reversed.

5.1.2 The Identification of Effective and Ineffective Lecturers

By inspection of this table it becomes clear that, Lecturers **1, 2, 3, 8** and **12** are significantly "good" or "effective", since they have a high positive rating (i.e. strong agreement) for almost every item. But in contrast, Lecturers **4, 5, 7, 9** and **10** are significantly "bad" or "ineffective" because they have a high negative rating (i.e. strong disagreement) for almost every item.

The same conclusion can be drawn from Figure 5-1, where the "profiles" of the lecturer are shown as bar charts. For Items **5, 7, 16** and **22**, because of the wording of the statements, a negative rating is in fact better than a positive rating, and the Items **1, 2** and **3**, the optimum rating would be ' 3 ' or ' almost right '.

There are a clear distinction between lecturer profiles. For example, Lecturers **4, 6** and **12** exhibit very different profiles as seen in the above figure. From the lecturer profiles, we can build up a picture of the "effective lecturer" as seen by the students. Comparing the lecturer profiles between the effective lecturers and the ineffective lecturers, one can see the striking differences falling in the following factors : (1) communication skills, (2) organisation and preparation of the lecture, (3) clarity of explanation, (4) enthusiasm about teaching and (5) the interesting style of presentation.

5.1.3 Reliability and Validity of Students' Rating of Lecturers

TABLE 5 - 5. The Results of Percentage Bias for Each of 15 Lecturers

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ITEM 1	+42	+36	+12	+10	+18	+26	+10	+26	+4	+12	+18	+54	+24	+34	+24
ITEM 2	+42	+44	+29	+36	+22	+36	+34	+48	+40	+28	+30	+68	+46	+68	+68
ITEM 3	+22	+54	+18	-12	+26	+50	-22	+42	-28	+12	+36	+88	+36	+48	+66
ITEM 4	+48	+66	+23	-2	+4	+46	-19	+50	-24	-5	+15	+82	+14	-24	+89
ITEM 5	-43	-93	-18	+25	+2	-59	+19	-68	+13	-13	-12	-82	-16	+4	-30
ITEM 6	+46	+61	+84	+6	+38	+67	+32	+76	+6	+42	+58	+84	+73	+50	+45
ITEM 7	-58	-62	-44	-4	-28	-48	-13	-60	+9	-16	-41	-86	-38	-34	-60
ITEM 8	+33	+20	-11	+14	+4	+5	-17	+19	+19	-1	+13	+44	-15	-49	+16
ITEM 9	+71	+72	+66	+24	+41	+72	+34	+69	-3	+19	+44	+84	+45	+37	+62
ITEM 10	+54	+65	+38	+21	+23	+48	+6	+43	+15	+15	+36	+76	+12	-8	+38
ITEM 11	+47	+9	+20	+23	+25	+8	-28	-22	0	-20	+6	-21	-31	-6	+32
ITEM 12	+44	+96	+39	-9	+7	+68	0	+81	-2	+25	+38	+95	+26	+14	+30
ITEM 13	+52	+99	+56	+12	+7	+50	-18	+93	+68	+54	+47	+96	+34	+13	+47
ITEM 14	+12	+90	-11	-31	-35	+17	-55	+59	+1	-6	+6	+89	-16	-25	+14
ITEM 15	+30	+82	+54	-9	+6	+66	+16	+67	-18	+3	+25	+96	+23	+20	+41
ITEM 16	-64	-80	-76	-26	-44	-66	-2	-77	+44	+6	-2	-77	-17	-39	-65
ITEM 17	+4	+56	-4	-26	-30	-5	-40	+30	-1	+1	+1	+63	-18	-35	0
ITEM 18	+55	+67	+61	+19	+36	+29	+39	+53	-6	-7	+45	+81	+41	+29	+43
ITEM 19	+54	+92	+42	+14	+31	+75	+11	+90	+58	+41	+63	+71	+44	+39	+60
ITEM 20	+85	+78	+79	+39	+52	+75	+54	+71	+9	+37	+46	+95	+54	+44	+69
ITEM 21	+82	+97	+61	+31	+28	+61	+51	+83	+71	+61	+64	+95	+59	+27	+69
ITEM 22	-62	-82	-36	-11	-36	-54	-4	-70	-27	-28	-45	-65	-39	-27	-52
N sample	150	108	128	55	108	40	96	103	77	121	109	60	118	47	80

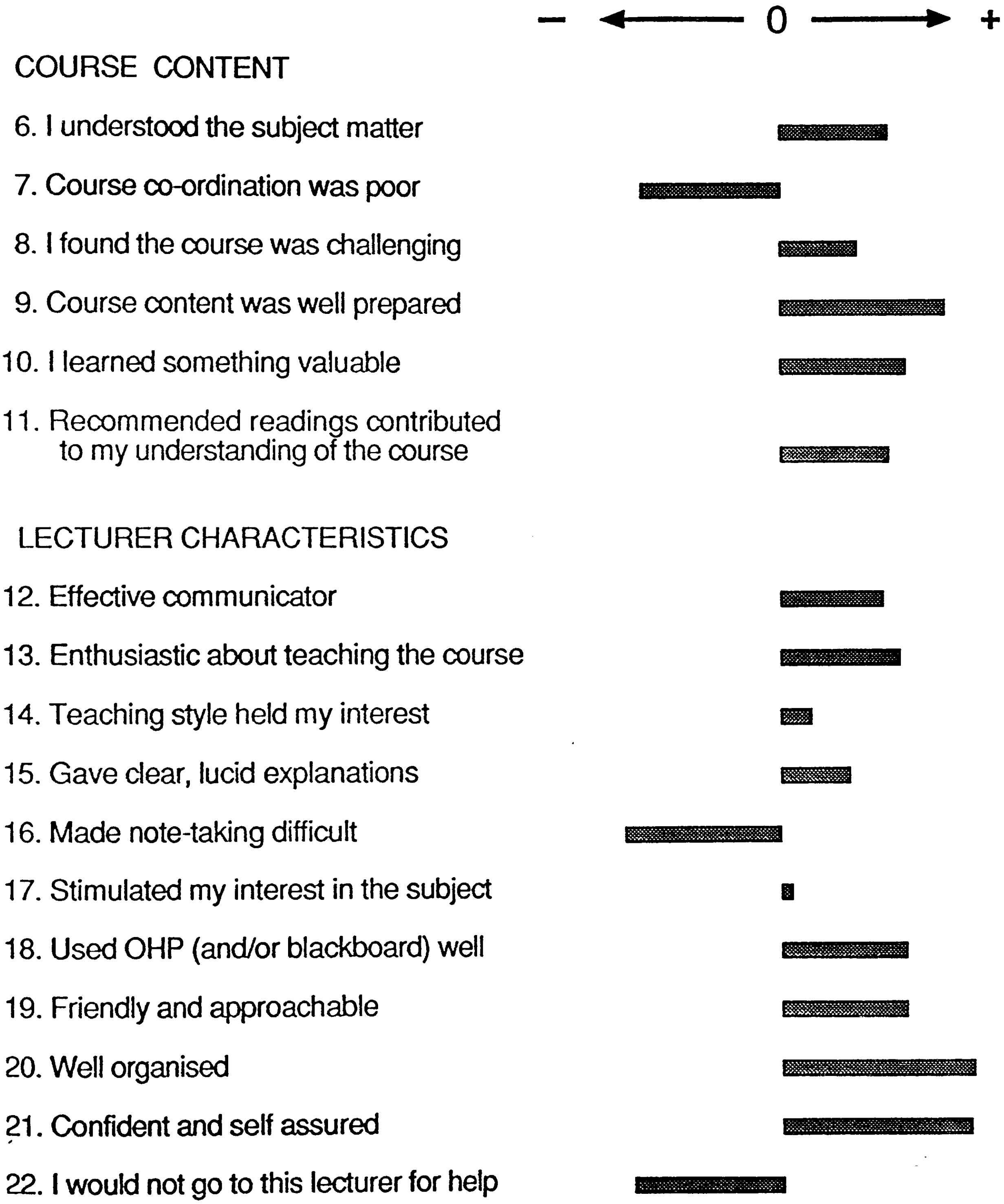


Figure 5 - 1. The Profiles of a Typical Course and Lecturer

The information given in TABLE 5-5 can be used in another way. For each item, the "measure of agreement" (i.e. the percentage bias), going from positive values through zero to negative values, can be used to place the lecturers in a rank order. Several items measuring the same dimension would predict the same rank order. In fact this turns out to be so, therefore those dimensions are all self-consistent. The results of rank orders based upon the "percentage bias" values are listed in TABLE 5-6.

The Spearman rank order correlation coefficient r_0 is calculated by using the rank orders given in TABLE 5-6, and from the value of this coefficient one can estimate the degree of inter-correlation between each item in the response sheet. TABLE 5-7 shows the inter-correlations between each of the 22 items for the whole course. A visual inspection of the figures in this table, it is clear that the inter-correlation between the statements within any factor dimension were extremely high (typically greater than 0.7), indicating that this new version of instrument was operating reliably.

Marlin (151) has warned that

" Although there are many studies on student evaluations, there are extremely few studies relating to student perceptions of the process. If students have no faith in the system and put little thought and effort into their evaluations, then the results will be useless."

From frequent contact with students and staff, the rating instrument seemed to have content validity, because most of them agreed that the statements appearing on the response sheet related to relevant and important matters which were worthy of an opinion. In addition, the modifications and additions have apparently improved this new version of the response sheet because the simplified wording caused fewer problems than that used last year, and the regrouping of statements made the pattern of student responses more easily understood.

TABLE 5 - 6. The Results of Rank Order

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ITEM 1	2	3	11.5	13.5	9.5	5.5	13.5	5.5	15	11.5	9.5	1	7.5	4	7.5
ITEM 2	7	6	13	9.5	15	9.5	11	4	8	14	12	2	5	2	2
ITEM 3	10	3	11	13	9	4	14	6	15	12	7.5	1	7.5	5	2
ITEM 4	4	2	7	11	10	5	13	3	14.5	12	8	1	9	14.5	6
ITEM 5	11	15	9	1	5	12	2	13	3	7	6	14	8	4	10
ITEM 6	9	6	1.5	14.5	12	5	13	3	14.5	11	7	1.5	4	8	10
ITEM 7	11	14	9	2	5	10	3	12.5	1	4	8	15	7	6	12.5
ITEM 8	2	3	12	7	10	9	14	4.5	4.5	11	8	1	13	15	6
ITEM 9	4	2.5	6	13	10	2.5	12	5	15	14	9	1	8	11	7
ITEM 10	3	2	6.5	10	9	4	14	5	11.5	11.5	8	1	13	15	6.5
ITEM 11	1	6	5	4	3	7	14	13	9	11	8	12	15	10	2
ITEM 12	5	1	6	15	12	4	13	3	14	10	7	2	9	11	8
ITEM 13	7	1	5	13	14	8	15	3	4	6	9.5	2	11	12	9.5
ITEM 14	6	1	10	13	14	4	15	3	8	9	7	2	11	12	5
ITEM 15	7	2	5	14	12	4	11	3	15	13	8	1	9	10	6
ITEM 16	9	15	12	6	8	11	3.5	13.5	1	2	3.5	13.5	5	7	10
ITEM 17	4	2	9	12	13	10	15	3	8	5.5	5.5	1	11	14	7
ITEM 18	4	2	3	13	10	11.5	9	5	14	15	6	1	8	11.5	7
ITEM 19	8	1	10	14	13	3	15	2	7	11	5	4	9	12	6
ITEM 20	2	4	3	13	10	5	8.5	6	15	14	11	1	8.5	12	7
ITEM 21	4	1	9	13	14	9	12	3	5	9	7	2	11	15	6
ITEM 22	12	15	6.5	2	6.5	11	1	14	3.5	5	9	13	8	3.5	10

TABLE 5 - 7. *The Inter-Correlations Between Each of the 22 Items for the Whole Course*

$$r_o = 1 - \Sigma\{6d^2 / N(N^2 - 1)\}$$

For N = 15 and p = 0.05, $|r_o| > 0.44$

For N = 15 and p = 0.01, $|r_o| > 0.62$

	ITEM 1	ITEM 2	ITEM 3	ITEM 4	ITEM 5	ITEM 6	ITEM 7	ITEM 8	ITEM 9	ITEM 10	ITEM 11	ITEM 12	ITEM 13	ITEM 14	ITEM 15	ITEM 16	ITEM 17	ITEM 18	ITEM 19	ITEM 20	ITEM 21	ITEM 22
ITEM 1		+0.63	+0.82	+0.76	-0.77	+0.61	-0.99	+0.42	+0.81	+0.63	+0.28	+0.50	+0.60	+0.66	+0.76	-0.69	+0.52	+0.65	+0.58	+0.69	+0.46	-0.87
ITEM 2			+0.64	+0.35	-0.40	+0.38	-0.52	+0.35	+0.41	+0.22	-0.18	+0.35	+0.35	+0.48	+0.46	-0.24	+0.31	+0.34	+0.43	+0.31	+0.38	-0.40
ITEM 3				+0.68	-0.73	-0.63	-0.84	+0.34	+0.76	+0.57	+0.03	+0.72	+0.32	+0.67	+0.79	-0.70	+0.43	+0.53	+0.66	+0.55	+0.38	-0.73
ITEM 4					-1.00	+0.69	-0.93	+0.67	+0.94	+0.94	+0.18	+0.92	+0.83	+0.82	+0.91	-0.81	+0.75	+0.88	+0.76	+0.86	+0.74	-0.86
ITEM 5						-0.75	+0.93	-0.56	-0.93	-0.84	-0.05	-0.96	-0.73	-0.88	-0.91	+0.81	-0.77	-0.71	-0.88	-0.80	-0.75	+0.95
ITEM 6							-0.75	+0.12	+0.78	+0.55	-0.24	+0.85	+0.72	+0.55	+0.84	-0.64	+0.46	+0.70	+0.59	+0.71	+0.40	-0.66
ITEM 7								-0.54	-0.93	-0.80	-0.13	-0.96	-0.58	-0.85	-0.95	+0.86	-0.71	-0.73	-0.76	-0.84	-0.68	+0.92
ITEM 8									+0.49	+0.79	+0.32	+0.51	+0.67	+0.70	+0.43	-0.44	+0.81	+0.46	+0.65	+0.42	+0.84	-0.66
ITEM 9										+0.86	+0.14	+0.92	+0.51	+0.74	+0.95	-0.59	+0.57	+0.80	+0.71	+0.93	+0.59	-0.85
ITEM 10											+0.39	+0.75	+0.66	+0.83	+0.80	-0.79	+0.77	+0.71	+0.74	+0.79	+0.77	-0.86
ITEM 11												+0.01	-0.10	+0.07	-0.01	-0.23	+0.27	+0.09	+0.02	+0.16	+0.04	-0.12
ITEM 12													+0.71	+0.86	+0.95	-0.80	+0.76	+0.78	+0.83	+0.82	+0.73	-0.93
ITEM 13														+0.83	+0.59	-0.50	+0.87	+0.48	+0.77	+0.44	+0.89	-0.66
ITEM 14															+0.78	-0.69	+0.88	+0.55	+0.95	+0.57	+0.90	-0.86
ITEM 15																-0.88	+0.62	+0.83	+0.76	+0.88	+0.64	-0.85
ITEM 16																	-0.46	-0.64	-0.58	-0.81	-0.48	+0.77
ITEM 17																		+0.59	+0.78	+0.48	+0.93	-0.79
ITEM 18																			+0.52	+0.86	+0.68	-0.71
ITEM 19																				+0.49	+0.83	-0.87
ITEM 20																					+0.53	-0.60
ITEM 21																						-0.86
ITEM 22																						

(→ significant at the 0.01 level, and → significant at the 0.05 level)

The following excerpts taken from the written-in comments also confirmed the students' views on the validity of their ratings :

"Why is it that lecturers always make an attempt to improve the course when they hand these response sheets out ? "

"I appreciate your interest in our opinion. It is not easy for us. I enjoy Chemistry even although it can often be impossible. "

"TOO BAD FOR ANY COMMENTS !" (No response circled on sheet)

5.1.4 Written-in Comments from Students' Response Sheets

In **Part C** of the response sheet, a whole page of space was provided and students were invited to write down their comments on the course or the teaching if they felt unable to express their opinions through the fixed responses only.

509 different written-in comments were collected from the fifteen lecturers involved in this lecture course. Again, it was interesting to find that the overall ratings awarded to a lecturer were clearly related to the number of students who felt the need to write comments, for example, the lowest rating ones (Lecturers **4, 5, 7, 9** and **10**) received the greatest number of comments.

In almost most cases the comments were positively helpful even when critical because they highlighted some particular feature of the course or some characteristics of the lecturers. All the written-in comments were further analysed by using the categories found in Section **2.1.4** (Page 33). TABLE 5-8 shows the frequency distribution of student comments classified by the fifteen categories. Detailed comparisons between "effective lecturers" and "ineffective lecturers" were also made to understand what factors

TABLE 5 - 8. Frequency (f) Distribution of Student Written-in Comments

Category	Written-in comments										
	positive			positive+negative			negative			total	
	f			f			f			f	%
	L I	L II	L III	L I	L II	L III	L I	L II	L III		
Lecturer characteristics											
1. Attitude	3	1	1	1	0	1	4	8	27	46	9
2. Stimulation	64	0	0	2	0	0	0	0	0	66	13
3. Personality	26	1	1	1	2	1	0	1	2	35	7
4. Board writing	1	1	1	1	2	4	4	9	48	71	14
5. Voice	1	0	0	1	3	4	3	7	42	61	12
6. Pace	0	0	0	0	0	1	1	6	33	41	8
7. Improvement	0	0	0	1	0	2	5	7	21	36	7
8. Lecture overall	1	0	0	1	0	2	2	5	14	25	5
9. Others	0	0	0	0	1	0	1	1	2	5	1
Total	96	3	3	8	8	15	20	44	189	386	76
Lecture Course											
10. Content	0	0	0	0	0	1	1	4	15	21	4
11. Materials	0	0	0	0	1	0	0	2	12	15	3
12. Structure	0	0	0	0	2	5	1	8	9	25	5
13. Previous knowledge	0	0	0	1	0	1	1	5	8	16	3
14. Overall course	4	2	1	1	0	0	2	7	19	36	7
15. Others	1	0	0	1	0	1	2	3	2	10	2
Total	5	2	1	3	3	8	7	29	65	123	24

*** L I = Effective Lecturers, L II = Average Lecturers and L III = Ineffective Lecturers.

influence the different ratings of students.

The following results were obtained from this analysis :

(1) In general, most of the written-in comments were negative (433 out of 509, 85 %) in the sense that students directly pointed out the problems which had caused them difficulty in following the lecturers. Students seemed to pay more attention to the lecturer characteristics than to the lecture course itself. Students, on the whole, commented less on the Group I lecturers (i.e. the effective lecturers) than the Group III lecturers (i.e. the ineffective lecturers).

(2) For the Group I lecturers - the more effective ones, more positive comments were awarded to them, but in contrast the Group III lecturers - the less effective ones, obtained more negative comments.

(3) As seen from this table, the Group I lecturers were rated higher because :

[I] they have good style of presentation which stimulated students' interest (13 %).

[II] they were perceived to be more enthusiastic about teaching (9 %).

[III] they have better interactions with students (7 %).

Some excerpts taken from students' comments pointed out their strengths as the effective lecturers :

"Absolutely terrific course and terrific lecturer. He made Inorganic chemistry <u>very interesting</u> & also lots of experimental and <u>interesting asides</u>."

"This course was well presented and well explained. The lecturer made the subject easy to follow, and very interesting."

"Interesting lecturer !"

"Good teaching style - summarised each lecture at the end."

"Nothing, --- good, clear lectures, enjoyable !"

"Dr. X was very concise and his style of teaching was excellent."

"I enjoyed the original jokes, indeed good lecturer, the end of an era."

"Very interesting course and good demonstrations."

"Give us more 3 - D slides, really a wonderful lecturer. The model building lab was most helpful."

"Use of 3 D projections was very interesting and Lab great !"

"Although he didn't give us a full set of notes, note-taking was not very difficult because he was an effective communicator once I discovered his style of lecturing."

"Good lecturer --- keen and interesting ! "

"This lecturer was very good, he was friendly and helpful."

Students showed a very high appreciation of their lucid explanation, together with their giving relevant practical examples and illustrations. They also commented on the interesting way they presented the lectures and on the enthusiasm they showed for the subject. Many students mentioned that they related well to students and had a sense of humour.

(4) For the Group III lecturers, a great number of negative comments given to them showed that they were rated lower because :

[I] they have problems in communication skills, such as the audibility of voice, the quality of blackboard writing (26 %).

[II] their lecturing pace was perceived to be so rapid that students felt left behind.

[III] their teaching styles were perceived to be less interesting (some of them dull or even boring !) and not to give clear and lucid explanations.

[IV] they were perceived to be less enthusiastic.

The great number of actual responses taken from the written-in comments highlighted the following aspects of students' perception of an ineffective lecturer :

Blackboard Writing

"She could write a little neater."

"Better blackboard writing ! "

"Board writing was hard to read."

"His writing was far too small and illegible."

"Not enough on board. Fainting writing on board."

"A lot of odd scrappy bits of unlabelled molecules drawn all over, VERY CONFUSING !"

"Write more on the board, it helps note-taking. Don't you know ?"

"If the lecturer could write larger and clearer on the blackboard so that the writing is readable, enabling notes to be taken."

Voice Audibility

"He could talk louder."

"I think if she wore a microphone so that we could hear her. And I have difficulty in understanding her accent."

"The lecturer could speak louder."

"Lecturer doesn't speak loud enough."

"He spoke too quietly, I could not hear him."

"The lecturer tended to talk towards the blackboard, making it difficult to hear what he was saying."

"Lecturer tended to lecture into bench at the end of sentence and his voice tailed off."

Lecturing Pace

"Not so much difficult as too rushed. Slow down a little!"

"Start course at a more reasonable pace to break us in!"

"To speed up a little bit. Far too slow."

"Move at slower pace.'

"Too little time given for the OHP."

"He rushed through the course as if he was running for a bus."

"He should make clear and lucid explanations instead of rushing through the materials."

Style of Presentation

"Extremely boring! It was a struggle to even stay awake in his lectures."

"I found it incredibly boring. Don't stimulate interest to study subject."

"Very boring to sit through his lectures."

"More vigour and interest."

"The lecturer was very boring, and I found it difficult keeping my eyes open."

"His style of talking is no good for lectures, says"right" far too often,i.e.,205 times in 50 minutes."

"He didn't hold my interest."

"I found the lecturer less interesting than previous ones, his lecturing style did not hold my interest."

Attitude

"She was as enthusiastic as a wet blanket."

"The lecturer could be much more enthusiastic and less mechanical about his lectures."

"The lecturer should show more interest in his teaching."

"Should try to be a little bit more enthusiastic."

"Lecturer is pretentious and unapproachable. very vague, impossible to understand."

(5) Comparing the different nature of the above written comments awarded to Group I and Group III lecturers, one can reach the following conclusion : the basic communication skills and the ability to handle the pace of lecturing are the necessary conditions for being rated as an "effective lecturer" by students, but not sufficient conditions. Those lecturers who cause difficulty in students' cognitive perceptions tend more likely to be rated lower, i.e., the ineffective lecturers. Those lecturers who are better at the above abilities and skills will be rated higher or "effective lecturers" only when they also have the power to arouse interest in the subject, the expertise to present the material in a clear and lucid way and the capacity for interaction with students.

5.2 An Account of Findings from Participant Observation

Having identified the main distinctions in lecturing behaviours between the " more effective lecturers" and the " less effective lecturers" from previous observation data (See **Section 2.2**, Page 38 for detail), this present study was to observe those cognitively orienting stimulus factors among different lecturers. Those factors were labelled as : (i) the audibility of voice and the quality of blackboard writing, (ii) focussing, (iii) wait-time, (iv) lecturing pace, (v) the use of humour and asides and (vi) giving instructional cues.

Observations were made of 15 lecturers, with two lectures randomly selected from each lecturer and so a total of 30 sets of observer's ratings were obtained. The researcher judged and coded the presence of all the specific lecturing behaviours representative of each factor, which had been identified from the literature and served as indicators of that particular lecturing performance on the observation instrument.

Behaviour descriptions or specific examples for each item of lecturing behaviour are shown as follows in TABLE 5-9.

The observation was aimed to find whether those cognitively orienting stimulus factors are useful indicators of effective lecturing. For the purpose of coding the frequency of focussing behaviours and giving instructional cues, an exact copy was taken from the blackboard writing, materials presented on slides or transparencies for every lecture observed and any distributed printed material, handouts or course objective sheets were collected and used for analysis (See Appendix 20 , Page 389 for example.)

Regarding the determination of the use of humour and asides and the lecturing pace (viz. the number of information units in every five minutes), all the audio-recorded tapes of observed lectures were transcribed and coded by the occurrence and the length of period of those behaviours (Some of the transcripts can be referred to on Page 400 , Appendix 21). Each event that was intended to be humorous was coded : (1) telling jokes, (2) funny stories, (3) humorous comments and (4) asides that were related to history, the latest development and any applications. After the transcriptions had been corrected, coding forms were provided to make an analysis of each specific event.

With respect of the audibility of voice and the quality of blackboard writing, no quantitative indices were used. When observing the lectures, the researcher sat either on the left-hand side or on the right-hand side of the last row of seats in turn and asked the students sitting nearby if they had any difficulty in hearing or seeing. But interestingly, the responses from students' written-in comments incidentally turned out to be very useful in confirming the observer's ratings. It was also found that some of the more effective lecturers usually started their lectures by checking whether the students at the back row or side rows could hear them or see the board writing clearly, but this kind of behaviour hardly occurred among the less effective lecturers.

TABLE 5-9. Classification of Categories in the Observation Schedule of Lecturing

Categories	Lecturer's overt behaviours
Use of Humour and Asides	1. Telling jokes. 2. Funny stories. 3. Humorous comments. 4. Illustrating data with personal anecdotes. 5. Real case presentations or applications.
Voice-audibility	Loudness and intonation.
Blackboard writing	Legibility, organisation (headings) and size.
Giving instructional cues	1. Verbal signposts. 2. Non-verbal cues. 3. Blackboard writing.
Focussing	1. Setting instructional objectives. 2. Summarising. 3. Outlining or overviewing. 4. Heading and subheading (or numbering). 5. Use of organisers etc.
Wait-time	Pause or short periods of silence.
Lecturing pace	Informational units.

TABLE 5-10 shows the results from the participant observation data, which compares the performance in those cognitively orienting stimulus factors between Group I lecturers and Group III lecturers. From this table one can easily see that the major differences between those two groups of lecturers lie in the voice-audibility and the quality of blackboard writing, focussing and use of humour and asides. These factors are now discussed further in detail :

(1) <u>Voice-audibility and the quality of blackboard writing</u>

As a rule, Group I lecturers speak loud enough to get their message across to the students by checking whether the remote students are able to hear them clearly. They were observed to lecture more expressively, i.e., their voices were more energetic, vivid and had more inflections. They usually used the labelling systems such as headings and subheadings, numbering or underlining to write structurally on the blackboard. They mainly used the central board for developing their theme and if they had to use the side boards, they tended to ask the students sitting at the far side if they could see the writing clearly.

On the contrary, Group III lecturers were observed not to speak loud enough and that from time to time some students shouted to remind them. One other problem with two of Group III lecturers was that they spoke towards the board when they were writing long paragraphs of materials on it and this made it almost impossible for students to hear them. They lectured in a less expressive way, in other words, their voices were more monotonous and dull. They tended to put a lot of things on the board (and two of them spent about three fifths of lecture duration in writing on the board) and then just repeated these paragraphs out loud without much explanation.

In general, they did not write large enough or clearly enough and they nearly

TABLE 5 - 10. The Results of Participant Observation

Cognitively-Orienting Factors	Mean Values of Measurement		
	Group I Lecturers	Group II Lecturers	Group III Lecturers
Quality of Blackboard writing	More headings Large enough Fewer complaints	Fairly well	Less structured Two, not clear More complaints
Voice Audibility	Loud enough More expressive	Middle	Not clearly heard Less expressive
Wait-time	3.5 Sec	3.7 Sec	4.2 Sec
Focussing	9.8	5.4	3.7
Giving Instructional – Cues < Board writing	43	57	64
Giving Instructional – Cues < Verbal and Nonverbal	19	11	7
Use of Humour and Asides	6.3	3.3	1.7
Mean of the Total Lecturing Pace Index	13.2	12.8	15.9

** 1. No quantitative measure was taken for the audibility of voice and the quality of blackboard writing, the method of rating was described in the text.

2. The lecturing pace index is the number of information units in every five minutes.

used all the space of the board, regardless of whether students could see them from the back or from the sides.

(2) <u>Focussing</u>

Since all the lecturers were required to provide students with the behavioural objectives for their separate block of lectures, no differences were found among lecturers in this respect. But Group I lecturers almost always started their first lecture by informing students of the main purpose of his course and telling them <u>how</u> and <u>what</u> to do to understand their lecture materials. They were found to use various ways to structure and highlight their lectures : some of them used the lecture outlines or "spider's web" diagrams to summarise the lecture while some closed their lectures by a summary and others reinforced the course objectives during lectures.

In contrast, Group III lecturers seldom spent time in those behaviours. Two of them even didn't give students the course objectives until the <u>last</u> lecture.

<u>(3) Use of Humour and Asides</u>

One of the most striking differences between the "effective lecturers" and the "ineffective lecturers" lies in this factor. According to the observer's ratings, Group I lecturers consciously attempted to be vocally expressive, to smile, to have a relaxed body position, to gesture, to move about the lectern, to maintain eye contact, and to use humour and asides more frequently. The findings from the above table indicated an average of <u>6.3</u> uses of humour and asides per 50-minute lecture duration. Most of the humour was in the form of brief comments or stories, and some of them jokes. Most humour was also judged spontaneous and related to the educational message. Most of the asides used were the recent development of relevant subject materials, personal anecdotes or the history of science.

In contrast, the observed ratings of using humour and asides for Group III lecturers were relatively low, with an average of 1.7 only. It was found that most lecturers in this group were concerned only with giving information by lecturing, so they tended to write a great deal on the board or crammed a lot of things into a single lecture such that there was no more space available for any asides. They were observed to be more formal with students and less amicable. One of them even got angry with students when one student pointed out one error written on the board and from that moment this lecturer was intolerant and harsh to students. Later it was found that many students commented on her lacking a sense of humour.

To sum up, there was a noticeable difference in the atmosphere of the lectures between the Group I and Group III lecturers. The effective lecturers used humour and asides more frequently so that the classroom seemed to be in a more joyful atmosphere and from time to time an outburst of laughter could be heard during the lectures.

4. Wait-time

There did not seem to be any significant differences in the wait-time between lecturers. On the average, there were 53 pauses in a lecture duration and the length of pause ranged from one second to ninety-seven seconds. Group I lecturers tended to pause more often when they were talking but Group III lecturers were observed to pause longer when they were writing on the board. It was later found that wait-time itself as a factor might work both ways, for example, wait-time allows students to think but if the pauses are filled with "er's" and "um's" or "right's", they may be annoying behaviours to students.

And one of the Group III lecturers did pause very often by ending the sentence with the distracting use of "Right!", which turned out to be inappropriate pause because some of the students started to count the number of "Rights" he said in a single lecture.

5. Information Units

The average number of total information units spoken and written were 129 for Group I lecturers, 132 for Group II lecturers and 142 for Group III lecturers respectively. There were few noticeable differences in the total number of information units conveyed in those three lectures observed. The Group I lecturers tended to put more main points on the board and then spent more time in explanations, but in contrast, the Group III lecturers seemed to have put more complete sentences on the board and paused for students to take notes without spending much time in explanations.

6. Giving Instructional Cues

The results showed that the frequencies of giving instructional cues were not very different among the lecturers. But if the specific behaviour of writing on the board was excluded, the frequencies of giving verbal and non-verbal cues were found to be very different between the Group I and the Group III lecturers. Group I lecturers tended to use verbal and non-verbal cues more frequently than Group III lecturers. The commonest non-verbal cues were knocking on the board or the lectern to call for attention, using pointers to highlight the important points and stressing by raising voice or using gestures. As regards the verbal cues, here are some examples recorded from analysing the lecture transcripts :

"Notice!"

"Note it down!"

"Beware!"

"You'd better put it down!"

"It is extremely important that ..."

"It is absolutely an essential that you have to ..."

"It is really a MUST that you memorise ..."

"So you don't have to bother to write them down..."

"Listen to me and don't just devote yourselves in writing ..."

"Shall I remind you ..."

"One needs to be especially careful ..."

"It might be better if you note it down."

7. <u>Lecturing Pace</u>

In this present study, the pace of a lecture was measured by the "lecturing pace index" (viz. the average of total number of information units in every five minutes). For Group I lecturers, the lecturing pace index ranged from 9.6 to 13.6 and had an average of 13.2. For Group II lecturers, the lecturing pace index ranged from 11.4 to 14.4, with an average of 12.8. For Group III lecturers, the lecturing pace index had an average of 15.9 with the range from 13.0 to 18.9. The results didn't indicate much difference between lecturers in the lecturing pace index. But it was noticed that Group III lecturers on average spent about three fifths of the time in writing on the board, and another two fifths in explanations. If this was taken into consideration, Group III lecturers tended to go faster than both Group I and Group III lecturers.

Another major difference between Group I lecturers and Group III lecturers fell in the area of appropriate use of audio-visual aids, especially in using slides and transparencies. In general, Group I lecturers tended to use transparencies or slides only when they were presenting materials which were either too complex to draw (such as diagrams, tables or figures) or they had been given as handouts to students. And if they wanted students to take down something, most times they asked students to listen to them first and then gave students time to record. In contrast, Group III lecturers used audio-visual aids very often and two of them presented most of their materials on transparencies. It was found that too much material was crammed into a single slide or transparency and that the lecturer wanted students to copy down the content. This caused great difficulty.

5.3 Synthesis of Findings from Students' Evaluation and the Participant Observation Data

1. Student ratings on response sheets

From students' ratings of the courses and lecturers, it is obvious that for most students, the essential criterion for an effective lecturer is the basic communication skills such as the clear audibility of voice, the legibility and good organisation of blackboard writing (or materials presented with slides or transparencies) and the clarity of explanation. Failing these, one tends more likely to be rated lower as an ineffective lecturer. Having achieved this and adding an interesting style of presentation and a friendly approachable manner, one tends more likely to be rated as an effective lecturer.

2. The written-in comments on response sheets

The written-in comments relating to the lecturers' strengths or weakness also confirmed this. Students made most comments on a lecturer's communication problems which had caused them difficulty in understanding the lectures. They would also comment on the lecturer whom they felt less enthusiastic and unapproachable. In contrast, students showed a very high appreciation of clear and lucid presentation, together with relevant practical examples and illustrations. Students seemed to like an interesting way of presentation and many students mentioned in their comments that they enjoyed the lecturer's having a sense of humour.

3. The results from participant observation

What do the observation data tell us about the differences between the effective lecturers and the ineffective lecturers ? They were observed to have much difference in (i) the audibility of voice and the quality of blackboard writing, (ii) focussing and (iii) uses of humour and asides. According to observation, Group III lecturers (ineffective lecturers) didn't speak loud enough or spoke towards the blackboard so that students couldn't hear them clearly. They wrote too much on the board and the writing was either too small or so disorganised that students had difficulty in seeing clearly.

Group I lecturers (effective lecturers) were found to make more frequent use of humour and asides than Group III lecturers such that the different atmosphere of classrooms could be easily perceived by the researcher. It seemed that uses of humour and asides has contributed to enhance affect, arousal and attention. With the Group III lecturers, the following behaviours happened more frequently : dozing, doodling (as noticed from analysing students' notes), chatting, interruption and restlessness.

It was also observed that Group I lecturers spent more time on focussing than Group III lecturers : most of them usually started the lecture by reviewing or summarising briefly the previous lecture content ; they frequently pointed out the main points by using outlines or organisers ; they tended to make more use of headings and subheadings or underlining the important points and they provided more connections between different parts of lectures.

Regarding the pace of lectures, there was not much difference in "lecturing pace index" between Group I and Group III lecturers, but Group III lecturers seemed to go more rapidly than Group I lecturers if only the spoken information was considered.

The total frequencies and length of wait-time were found to be very similar between Group I lecturers and Group III lecturers. Group I lecturers had greater frequencies and longer duration in wait-time when they were explaining things but Group III lecturers had greater frequencies and longer duration in wait-time when they were writing on the board and pausing for students to take down notes.

By combining students' responses on the questionnaires and data from participant observation, pen portraits of real lecturers in real situations can be drawn in terms of the information processing model proposed in **Section 3.1** (See Page 66). A lecturer sends forth lecture messages verbally, non-verbally and sometimes by using audio-visual aids. By attention students select the sensory input which they can focus on. If students have difficulty in seeing or hearing the lecture messages, the potential stimuli presented by the lecturer fail to become actual stimuli for students. In this case, the lecturer is more likely to be rated lower as an "ineffective lecturer".

Furthermore, attention fluctuates during a 50-minutes lecture in such a way that after twenty minutes, there is a marked decline in attention followed by a peak just before the lecture ends (Johnstone and Percival, 63). It seemed that Group I lecturers potentially bring about an arousal of students' interest by using humour and asides stressing the applications and uses of lecture materials. This cognitive stimulus seemed to have the function of holding students' interest and reversing the decline in attention and thus indirectly influencing students' overall perceptions that Group I lecturers were rated higher as "effective".

Despite the diversity of lecturer characteristics and lecture topics, common elements of "effective lecturing" are evident ; those are professional and personal skills and attitudes which can be identified in terms of the information processing model. The effective lecturers are able to get their messages across to students' sensory systems clearly, to structure and explain well in a concise way so as not to confuse students, to use humour and asides to maintain students' arousal of attention and to lecture at a reasonable pace.

5.4 The Influence of Lecturing Styles on Students' Note-taking Behaviours and Academic Performance

In the following section, both the quantitative and qualitative methods will be used to analyse the lecture notes collected from students in order to understand how the different lecturing styles influence the note-taking behaviours and the exam achievement of students who have different capacity and learning styles. The total number of lecture notes collected from twenty-eight students were 1341 sets and they were examined in terms of three indices : the total number of words, the total number of information units, the completeness percentage (See **Section 2.4.1** for detail, Page 43).

5.4.1 The Interaction of Lecturing Styles with Students' Working Memory Capacity

TABLE 5-11 shows the quantitative results from analysing the lecture notes of students who have been categorised into three groups of different working memory capacity. Further analysis taken by examining the content of lecture notes in terms of the format and the degree of elaboration (such as paraphrasing, abbreviation or personal organisation of lecture materials) showed that students apparently seemed to copy down blindly what appeared on the board, that is to say, they didn't use their own words to

TABLE 5-11. Quantitative Analysis of Lecture Notes according to their Working Memory Capacity X (I. U = Information Unit)

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4835	4497	4932	4583	4871	5322	4677	4729	5121	4698	4699	5125
Mean total I.U spoken & written		117	133	162	139	126	117	132	137	146	129	132	142
Mean total words on board		496	539	668	387	601	693	417	588	685	433	576	682
Mean total I.U on board		63	71	79	67	69	73	73	65	82	68	68	78
Mean of total words recorded	Low working memory (X = 4 or 5)	493	527	671	439	613	697	424	586	692	452	575	687
	Average working memory (X = 6)	515	579	684	482	637	716	463	606	714	487	607	705
	High working memory (X = 7)	565	604	723	497	718	739	482	633	757	515	652	740
Mean of total I.U recorded	Low working memory (X = 4 or 5)	79	84	88	86	79	67	97	88	81	87	84	79
	Average working memory (X = 6)	93	98	103	95	96	79	113	107	94	101	100	92
	High working memory (X = 7)	107	122	124	119	108	96	121	114	109	116	115	110
Mean of completeness	Low working memory (X = 4 or 5)	68 %	63 %	54 %	62 %	63 %	57 %	73 %	64 %	55 %	68 %	63 %	55 %
	Average working memory (X = 6)	79 %	74 %	64 %	68 %	76 %	68 %	86 %	78 %	64 %	78 %	76 %	65 %
	High working memory (X = 7)	91 %	92 %	77 %	86 %	85 %	82 %	92 %	83 %	75 %	92 %	87 %	78 %

elaborate upon critical points.

In most cases, the students with higher working memory capacity recorded more complete notes in terms of both the total words and the information units than the students with lower working memory capacity. **These results have confirmed the first research hypothesis** : " Students with higher working memory capacity will have more complete note-taking performance than students with lower working memory capacity." Results from the above detailed analysis showed that students didn't differ very much in recording what was put on the blackboard, but there was a markedly striking difference in recording the lecture messages spoken by lecturers.

For most students with lower working memory capacity, their notes were found to be almost an exact copy of blackboard writing. Occasionally, they would take down some extra lecture information but most times they seemed to be taking notes only verbatim. For students with higher working memory capacity, two students were found to take notes in their personal forms : one noted key words or concepts in a diagrammatic format (e.g. see Figure 5-2) and another used connections and summarisation to organise the lecture materials (e.g. see Figure 5-3). The rest of higher working memory students were found also to copy down the board writing but, in addition, they added more extra lecture messages spoken by lecturers.

The results from the above analysis allow us to identify four types of note-taking displayed by the students : BS - (Blackboard Signal Minus), BSO (Blackboard Signal Only), BS + (Blackboard Signal Plus) and EL (Elaboration). Among those four types, the first three are mostly involved in taking an approximate copy of blackboard and the printed materials on transparency without much processing of the lecture information.

TABLE 5-12 shows the number of students whose note-taking types can be identified. It seems that the students with lower working memory capacity tended more

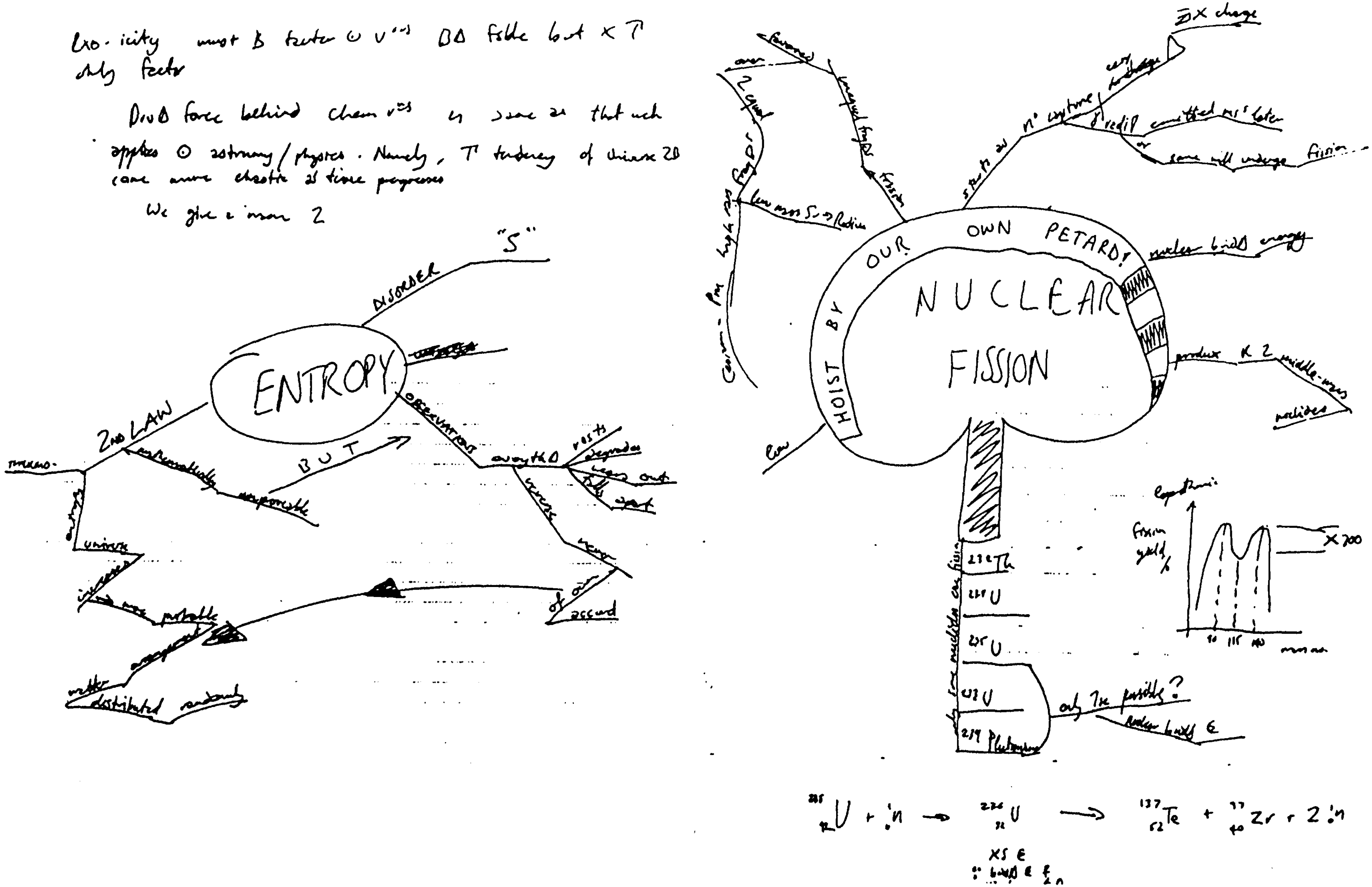


Figure 5-2 EL Type of Notes in a Diagrammatic Format

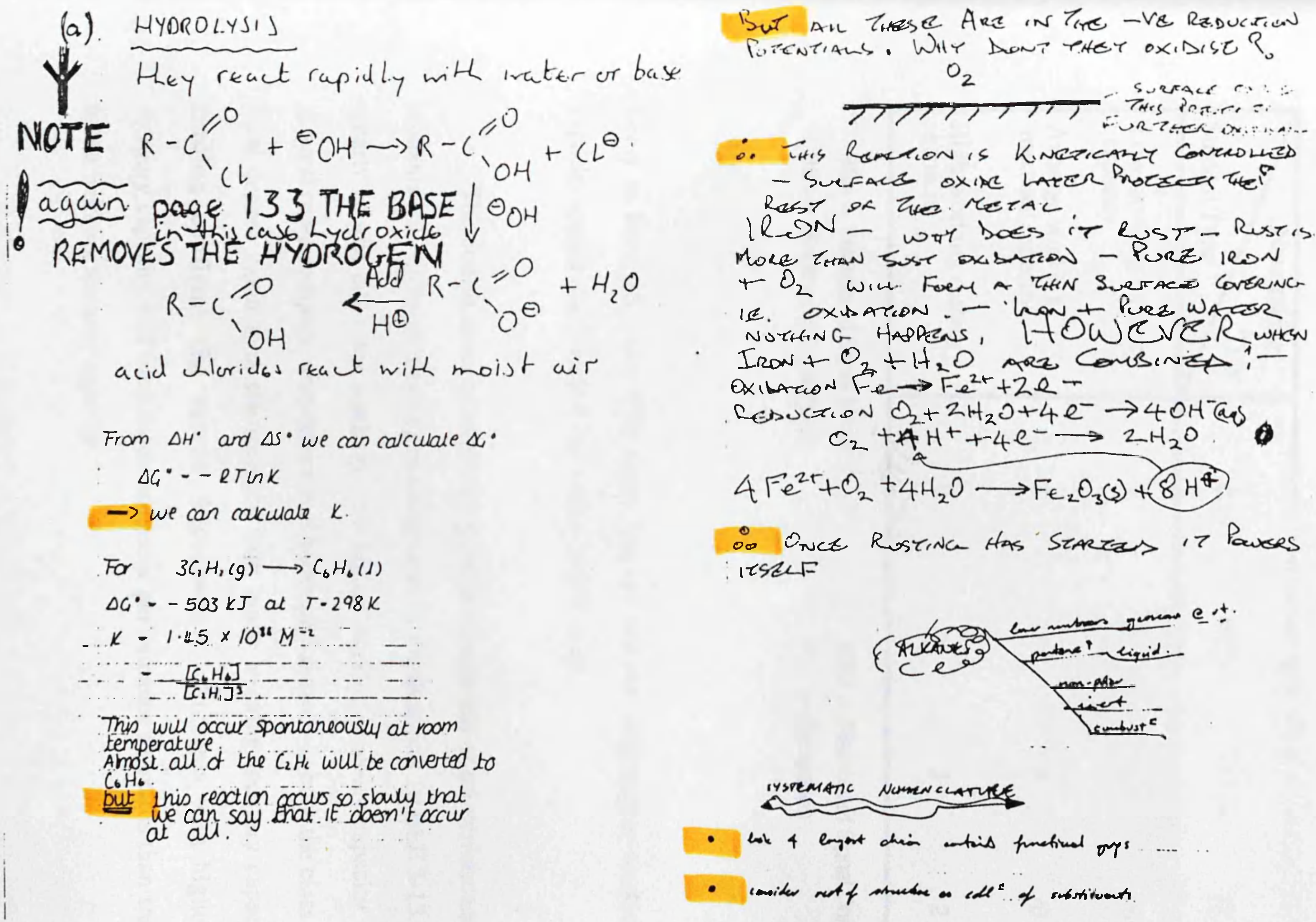


Figure 5-3. EL Type of Note-taking by Using Connections and Summarisation

TABLE 5-12. The Number of Students in Different Note-taking Types (classified according to their working memory capacity)

Student Type \ Note-taking Type	BS -	BSO	BS +	EL
Low working memory capacity	4	4	2	0
Average working memory capacity	1	7	4	0
High working memory capacity	0	1	3	2

*** BS - = Blackboard Signal Minus BSO = Blackboard Signal Only
BS + = Blackboard Signal Plus EL = Elaboration

likely to have BS - and BSO types, but the students with higher working memory capacity tended more likely to have BS + and EL types.

The comparisons of note-taking completeness and exam performance between students with different working memory capacity are shown in TABLE 5-13. As shown clearly in this table, the students with higher working memory capacity who are in general more complete note-takers, had better performance in both the class exams and final degree exam than the students with lower working memory capacity. **This finding confirms the second hypothesis** : " Students with higher working memory capacity will have better academic performance in exams than students with lower working memory capacity. "

TABLE 5-13. The Relationship between Working Memory Space and Exam Performance

Performance / Student Types	Mean score of 1st class exam	Mean score of 2nd class exam	Final results of Degree Exam
Low W.M (10 students)	51.6	37.6	Exempted --- 1 Pass --- 4 Failed --- 5
Average W.M (12 students)	64.8	52.6	Exempted --- 2 Pass --- 9 Failed --- 1
High W.M (6 students)	85.2	75.0	Exempted --- 4 Pass --- 2 Failed --- 0

*** W.M = Working Memory Space or Capacity

Since one of the main objectives of this present study is to look at how different lecturing styles influence the way students process lecture information in their working memory, several sets of notes were collected from Lecturer 9, whom students rated as "ineffective" and a large number of written-in comments showed that students had difficulty in recording lecture materials because of the lecturers' pace.

In one lecture, Lecturer 9 spent three minutes and forty-seven seconds talking about : (i) the relevance of food chemistry to human daily life, (ii) the current status of R

& D in food chemistry, (iii) quality factor of food, (iv) typical food package information, (v) water content in food, (vi) water activity and (vii) the way water molecules are bound in food. There were altogether 14 information units and 532 words conveyed by this lecturer. During this period, a transparency about "Typical Food Packaging Information" was shown on the projector. The rate of speech was 141 words per minute, which is faster than most lecturers. The lecturing pace index was 18.5 information units per five minutes, which is also more rapid than most lecturers. This seemed to be a high information density lecture in which students felt overloaded.

What the students wrote of this period of lecture presentation in their notes are listed below in Figure 5-4. It was noticed that students with lower working memory capacity recorded less completely either the content of "Typical Food Packaging Information" ,which was presented on the transparency (see **L 1** to **L 5**) or fragments of the verbal information (**L 6** to **L 9**). In contrast, students with higher working memory capacity recorded more information units by either taking down the presented materials plus extra verbal information (Compare the notes of **H 1** to **H 3**) or by summarising the key points (**H 4** and **H 5**).

In another lecture, Lecturer **8** - although rated as an "effective lecturer", when he was trying to explain to students what the "lattice energy" in an ionic solid means, he didn't write on the board but instead he dictated from his notes and asked the students to write down the definition of this term. The following quotes from students' notes illustrated the cognitive strain that was put on the working memory space of students with lower capacity (see Figure 5-5.).

As can be seen from this figure, the students with higher working memory capacity (**S 1** to **S 6**) didn't have any difficulty in following the dictation and they recorded both two definitions correctly. But in contrast, the students with lower working

L1: Typical food package information:

	Amount per 100g.
Energy	312 KJ / 74
Protein	4.7g
Carbohydrate	10.1g
(of which sugars)	2.4g
Fat	1.9g
(of which saturates)	0.3g
Sodium	0.5g
Dietary fibre	0.5g

The rest is water 82% is water in the food.

L2:

Cream	Amount per 100g.
Energy	312 kJ \ 74 kcal
Protein	4.7g
CHO (of which sugars)	10.1g (2.4g)
fat (of which saturates)	1.9g (0.3g)
Sodium	0.5g
Diety fibre	0.5g

The rest is water ~82%

Most food are mostly water.

L3: Typical Food Package Information

	amount per 100g
ENERGY	: 312 kJ / 74 kcal
PROTEIN	: 4.7g
CHO	: 10.1g
(sugars)	: (2.4g)
FAT	: 1.9g
(saturates)	: (0.3g)
SODIUM	: 0.5g
FIBRE	: 0.5g

82% of food is water.
This is not free but bound up in the food. Sugars have alot of water organised round about them.

L4: Typical Food Package Information

	Amount per 100g
Energy	312kJ / 74kcal
Protein	4.7g
Carbohydrate	10.1g
(of which sugars)	(2.4g).
Fat	1.9g
(of which saturates)	(0.3g).
Sodium	0.5g
Dietary Fibre	0.5g.

The total weight of this makes up approx 18g, the rest is comprised of water

Figure 5-4. The Extracts from Students with Lower Working Memory Capacity

L5:

TYPICAL FOOD PACKAGE INFORMATION

	Amount per 100g
Energy	312KJ / 74kcal
Protein	4.7g
Carbohydrate	10.1g
(of which sugars)	(2.4g)
Fat	1.9g
(of which saturates)	(0.3g)
Sodium	0.5g
Dietary Fibre	0.5g

L6: Fr Nutritional Informat per 100g

protein
carbs. (of which sugar)
fat (saturates)
Na
fibre

THE REST is H_2O

L7:

H_2O largest component of food - bound water

L8: Water content is quite high in most foods. Although it may not seem so.

L9: ... "language" ... is used

Figure 5-4 (contd.)

H1:

People more interested in what they eat. EEC barriers come down. (1992) - Quality factors must be broken down.

Typical food packaging Information

	Amount per 100g
Energy	312 kJ / 74 kcal
Protein	4.2 g
Carbohydrate (of which sugars)	10.1g (2.4g)
Fat (of which saturates)	1.9g (0.3g)
Sodium	0.5g
Dietary Fibre	0.5g

[80-2% of this package is H_2O] H_2O is the largest component of food eg potato 75% H_2O, turnip 90% H_2O, blamange 98% H_2O

but H_2O is bound - it is not runny

H2:

Typical Food Package Information

1) Energy
2) Protein
3) Carbohydrate (of which sugar)
4) Fat (of which saturates)
5) Sodium
6) Dietary Fibre

\+ Water

Water - largest component of ~~foods~~
e.g. Potato - 75% H_2O
Turnip 90% H_2O

↳ Water held in a reasonably rigid manner

H3:

vits, mins, pesticide residues

- people interested in what eat; 1992 - industry must compete.
- all quality factors balance out; R & D necessary
- properties of food types.

[illegible]

		Amount per 100g
	Energy	312 kJ / 74 kcal
not if boil.	Protein	4.7g
	Carbohydrate	10.1g
soluble	(of which sugars	(2.4g)
	Fat	1.9g
dairy / marg	(of which saturated)	(0.3g)
	Sodium	0.5g
	Dietary Fibre	0.5g

- 82% water - not package water
largest component of food
eg. 75% potato water, turnip 90%, gel 98% BUT bound water held rigid manner.

H4:

Lots of research has gone into Food Chemistry recently.

Typical Food package Information - See milk carton.

Add up g of info - per 100g - not 100g? worth - remainder is water.

Water is v. imp in food eg 90% Turnip is water

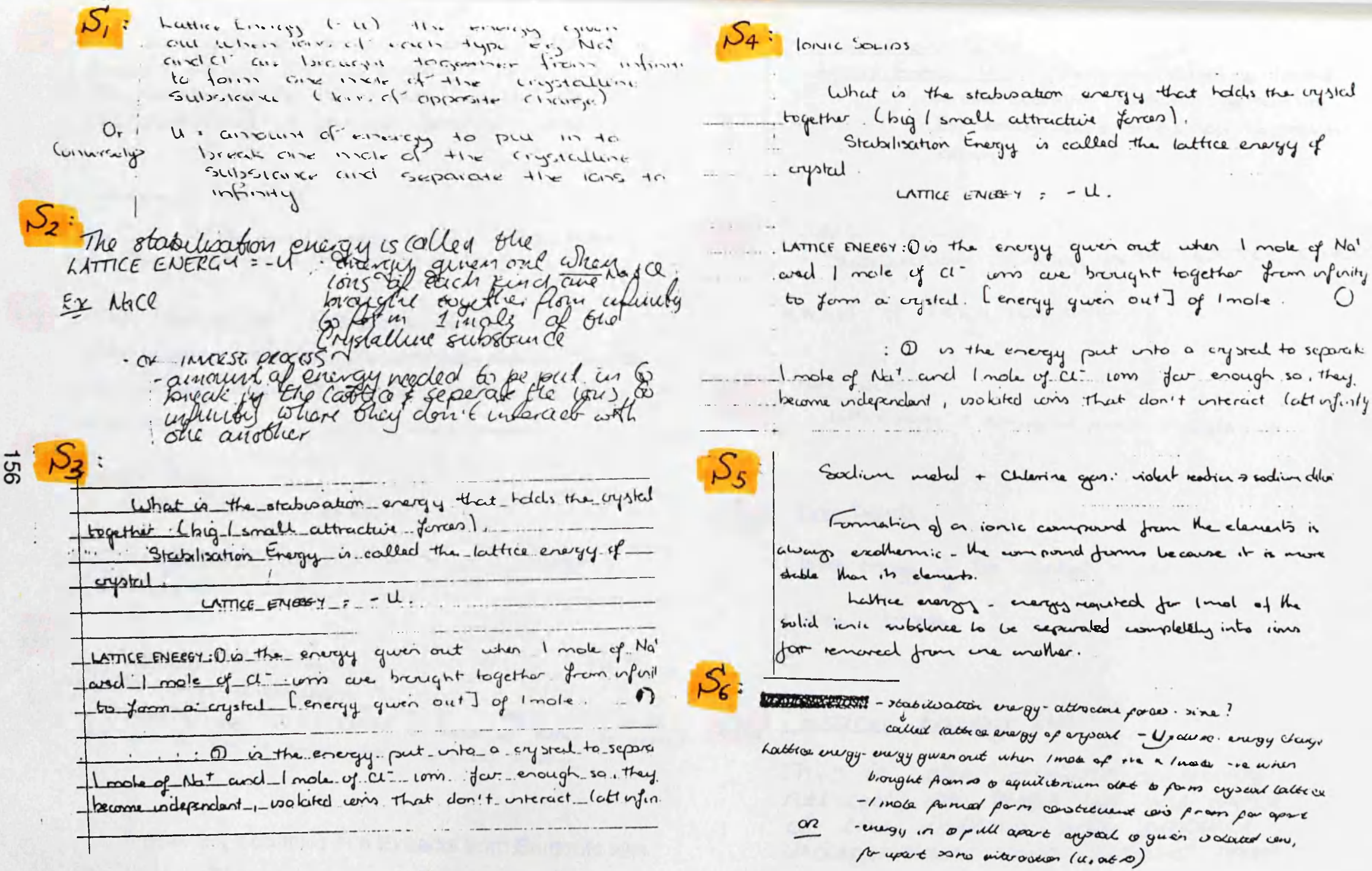
H5:

Relevant - Interest in what is being eaten
processing of food

Packaging Information - most of weight / 100g is water, but it is not free water. The rest is Protein, Carbohydrate, Fibre, Fat etc...

Figure 5-4 (contd.)

The Extracts from Students with Higher Working Memory Capacity



S1: Lattice Energy (-U) the energy given out when ions of each type e.g. Na^+ and Cl^- are brought together from infinity to form one mole of the crystalline substance (ions of opposite charge)

Or Conversely U = amount of energy to put in to break one mole of the crystalline substance and separate the ions to infinity

S2: The stabilisation energy is called the LATTICE ENERGY = -U : energy given out when ions of each kind are brought together from infinity to form 1 mole of the crystalline substance

Ex NaCl (Na^+ Cl^-)

- or inverse process
- amount of energy needed to be put in to break up the lattice & seperate the ions to infinity where they don't interact with one another

S3:

What is the stabisation energy that holds the crystal together (big / small attractive forces).

Stabilisation Energy is called the lattice energy of crystal.

LATTICE ENERGY : - U.

LATTICE ENERGY: (1) is the energy given out when 1 mole of Na^+ and 1 mole of Cl^- ions are brought together from infinity to form a crystal [energy given out] of 1 mole.

: (2) is the energy put into a crystal to separate 1 mole of Na^+ and 1 mole of Cl^- ions far enough so, they become independant, isolated ions that don't interact (at infin.

S4: Ionic Solids

What is the stabisation energy that holds the crystal together (big / small attractive forces).

Stabilisation Energy is called the lattice energy of crystal.

LATTICE ENERGY : - U.

LATTICE ENERGY: (1) is the energy given out when 1 mole of Na^+ and 1 mole of Cl^- ions are brought together from infinity to form a crystal. [energy given out] of 1 mole.

: (2) is the energy put into a crystal to separate 1 mole of Na^+ and 1 mole of Cl^- ions far enough so, they become independant, isolated ions that don't interact (at infinity

S5: Sodium metal + Chlorine gas: violent reaction → sodium chloride

Formation of an ionic compound from the elements is always exothermic - the compound forms because it is more stable than its elements.

Lattice energy - energy required for 1 mol of the solid ionic substance to be separated completely into ions far removed from one another.

S6: [redacted] - stabilisation energy - attractive forces - size?

called lattice energy of crystal - U, always energy change

Lattice energy - energy given out when 1 mole of +ve & 1 mole -ve ions brought from ∞ equilibrium state to form crystal lattice

- 1 mole formed from constituent ions from far apart

OR - energy in to pull apart crystal to given isolated ions, far apart zero interaction (U, at ∞)

Figure 5-5. The Extracts from Students with Higher Working Memory Capacity

S_7: The energy which makes a solid stable is known as the LATTICE ENERGY - U.
The energy given out when 1 mole of the substance is formed from its ions.

S_8: Structures of Ionic Solids
Lattice Energy, U, the amount of energy needed to break up 1 mole of the lattice and produce isolated ions at infinity

S_9: LATTICE - Energy, -U (stabilisation energy)
- Energy given out when the ions are brought together from infinity to give 1 mol of crystalline substance, or reverse.

S_{10}:
Lattice Energy, -U
$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$

Amount of energy required to break a crystal & form gaseous ions.

S_{11}: - STRUCTURES OF IONIC SOLIDS Lec 23.
Stabilisation energy - LATTICE ENERGY, U.
Amount of energy to be put in to break up 1mol lattice to separate the ions so they no longer interact with one another.

S_{12}: Structures of Ionic Solids
Lattice Energy, U. - The energy put in to split up 1 mole of an ionic substance so that all the ions are far enough apart so as not to reform again.

S_{13}: IONIC SOLIDS.
- Stabilization Energy is the LATTICE ENERGY -U.
Amount of Energy put into . . . .

S_{14}: IONIC SOLIDS
Lattice energy of the crystal makes it stable -U

S_{15}: Ionic Solids.
Lattice energy of the crystal : -U
when 1mole

S_{16}: Lattice Energy (U)
This is the amount of energy needed to break up one mole of the lattice and produce independant ions. isolated from

Figure 5-5 (contd.) The Extracts from Students with Lower Working Memory Capacity

memory capacity seemed to be unable to cope with the high cognitive strain, so they either recorded one definition only (**S 7** to **S 12**) or even left behind with unfinished sentences (**S 13** to **S 16**).

Similar examples were detected in many other cases where the information density was high and the lecturing pace was rapid. It seemed that the students with lower working memory capacity suffered more than the students with higher working memory capacity. When lecture messages with high information density were presented to students, high demands were placed on students' working memory and the students with lower working memory capacity were more likely to be hindered from making the most of their working memory space in that they took only verbatim notes or even missed many main points.

5.4.2 The Interaction of Lecturing Styles with Students' Cognitive Styles

The quantitative analysis of lecture notes from students of different cognitive styles was carried out and the results are shown in TABLE 5-14. A key finding of this primary analysis was that, there was not a big difference in the total number of words which appeared on the board but there was a marked difference in the total number of information units conveyed by the lecturer, between the Field-independent students and Field-dependent students.

It was found that writing information on the board is a very effective cue for having students record key ideas. Students involved in 16 different blocks of lectures recorded almost 93 % of information written on the board in their notes, but only 25 % of the critical lecture ideas spoken verbally. For the Field-dependent students, they didn't

TABLE 5-14. Quantitative Analysis of Lecture Notes according to their Cognitive Styles (I.U = Information Unit)

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4835	4497	4932	4583	4871	5322	4677	4729	5121	4698	4699	5125
Mean total I.U spoken & written		117	133	162	139	126	117	132	137	146	129	132	142
Mean total words on board		496	539	668	387	601	693	417	588	685	433	576	682
Mean total I.U on board		63	71	79	67	69	73	73	65	82	68	68	78
Mean of total words recorded	Field Dependent	517	558	659	418	617	686	498	617	692	478	597	679
	Field Neutral	523	586	674	439	635	714	433	603	674	465	608	687
	Field Independent	561	590	687	494	686	737	459	644	713	505	640	712
Mean of total I.U recorded	Field Dependent	79	73	77	78	75	76	89	73	79	82	74	77
	Field Neutral	88	72	84	74	81	89	85	92	84	82	82	86
	Field Independent	105	108	98	113	104	98	123	119	106	114	110	110
Mean of completeness	Field Dependent	68 %	55 %	48 %	56 %	59 %	64 %	67 %	53 %	54 %	64 %	56 %	55 %
	Field Neutral	75 %	54 %	52 %	53 %	64 %	76 %	64 %	67 %	58 %	64 %	62 %	62 %
	Field Independent	89 %	81 %	77 %	81 %	83 %	84 %	93 %	87 %	73 %	88 %	84 %	78 %

seem to have difficulty in recording the main points put on the board, but they did have difficulty in detecting what was the relevant key ideas to note down when the lecture messages were presented verbally. It was also found that if a verbal signpost or stress was used by the lecturer, the Field-dependent students were more likely to record that particular lecture messages.

Even Field-dependent students recorded a fairly similar number of lecture ideas from lecturer's board writing, but it was found that Field-independent students took notes that were more concise and contained fewer words and they didn't seem to copy in a complete sentence by omitting "the", "a" or "Be verbs" and by using abbreviations. On the contrary, Field-dependent students displayed less tendency to use abbreviations and took wordier notes and less efficient notes. It seemed that the Field-dependent students approached note-taking as a task of trying to write down as many words as possible.

TABLE 5-15 shows the note-taking types which students of different cognitive styles used during lectures. Most students are classified as "BSO type" since they only took verbatim notes; Field-dependent students' notes tended to be less complete because they missed most verbal lecture messages but Field-independent students' notes seemed to be more complete because they added extra verbal lecture messages to the lecture information put on the board. **This confirmed the third hypothesis** that " Field-independent students take more complete notes than the Field-dependent students ".

TABLE 5-16 shows the results of exam performance of students with different cognitive styles. Field-independent students' class exam scores and final degree exam performance were better than Field-dependent students'. **This finding supported the fourth research hypothesis** that " Field-independent students will have better performance in class exams and final degree exam results."

TABLE 5-15. The number of students in different note-taking types
(classified according to their cognitive styles)

Student Type \ Note-taking Type	BS -	BSO	BS +	EL
Field - Dependent (7 students)	4	2	1	0
Field - Neutral (12 students)	3	4	5	0
Field - Independent (9 students)	1	3	3	2

*** BS - = Blackboard Signal Minus BSO = Blackboard Signal Only
BS + = Blackboard Signal Plus EL = Elaboration

TABLE 5-16. The Relationship between Performance and Cognitive Style

Student Types \ Performance	Mean score of 1st class exam	Mean score of 2nd class exam	Final results of Degree Exam
Field - Dependent (7 students)	42.0	37.6	Exempted --- 1 Pass --- 2 Failed --- 4
Field - Neutral (6 students)	62.5	44.5	Exempted --- 1 Pass --- 4 Failed --- 1
Field - Independent (10 students)	63.8	59.0	Exempted --- 5 Pass --- 9 Failed --- 1

It would seem logical that these differences in performance would have partially resulted from differences existing between the kind of notes taken by Field-independent and Field-dependent learners. Consequently, the notes taken by students were further analysed to examine if any processing differences existed between these two groups of students.

One of the most important differences between the Field-dependent and the Field-independent students was that Field-dependent students tended to accept the organisation of the stimulus and therefore sometimes couldn't see which is really relevant. It has been found very often, that if the lecturer presented a table, a figure or a diagram and then explained the meaning or implications of it without writing on the board, Field-dependent students tended to spend time in drawing that table, figure or diagram instead of recording what was implied in it.

This is illustrated in the following figure (Figure 5-6), which describes the importance of "water activity". After the lecturer presented this table on the transparency and wrote a mathematical expression of water activity on the board, most Field-dependent students were found to have recorded this information on the board only without noting down its implications (**F 1** to **F 9**). In contrast, Field-independent students not only recorded the information on the board but also noticed that "Water is the main component in food and there is a minimum water activity for bacteria, yeasts and moulds to grow; in other words, the water in food plays a role in determining what micro-organisms grow." (see the notes of **F 10** to **F 13** for comparison).

Field-dependent students seemed to be more likely to display "functional fixity" (i.e. more rigid to the format used to process information). For example, one lecturer tried to explain the stability and aromaticity of benzene by using the data sheet of the heat of hydrogenation of double bonds. Extracts taken from students' notes show that Field-independent students seem to have more facility with tasks required in understanding

F1:

Water Activity

$$a_w = \frac{\text{VAP Pressure of soln (food)}}{\text{VAP Pressure of pure water}}$$

	H2O content	aw
Fresh meat	65%	0·98
Cheese	40%	0·97
Jam	33%	0·88
Salami	30%	0·83
Dried fruit	18%	0·76
Honey	20%	0·75

Minimum aw for growth.

Bacteria	0·91
Yeasts	0·88
Moulds	0·80

F2:

WATER ACTIVITY

$$a_w = \frac{\text{VAP PRESSURE OF SOLN (FOOD)}}{\text{VAP PRESSURE OF PURE WATER}}$$

	H_2O content	aw
FRESH MEAT	65 %	0·98
CHEESE	40 %	0·97
JAM	33%	0·88
SALAMI	30 %	0·83
DRIED FRUIT	18 %	0·76
HONEY	20 %	0·75

Minimum aw for growth

Bateria	0·91
yeast	0·88
Moulds	0·8

F3:

Water activity

$$a_w = \frac{\text{Vap. Pressure of solution (Food)}}{\text{Vap pressure of pure water}}$$

	H2O content	aw		H2O	aw
Fresh meat	65%	0.98	Jam	33%	0.88
Cheese	40%	0.97	Salami	30%	0.83
Honey	20%	0.75	Driedfruit	18%	0.76

Minimum aw for growth

Bacteria	0.91
Yeast	0.88
Moulds	0.80

— generally

F4:

Water Activity:

$$a_w = \frac{\text{vap of pressure of soln. food}}{\text{vap. pressure of pure water}}$$

	H_2O content %	aw
Fresh meat	65	0·98
Cheese	40	0·97
Jam	33	0·88
Salami	30	0·83
Driedfruit	18	0·76
Honey	20	0·75

Minimum aw for growth.

Bacteria	0·91
Yeast	0·88
Moulds	0·80

Figure 5-6.

Extracts Taken from Lecture Notes of Field-Dependent Students

F5: Water Activity - a_w

$$a_w = \frac{\text{vapour pressure of soln (food)}}{\text{vapour pressure of pure } H_2O}$$

	H_2O Content	a_w
Fresh meat	65%	0.98
Cheese	40%	0.97
Jam	33%	0.88
Salami	30%	0.83

Minimum a_w for

Bacteria	0.91
Yeast	0.88

F6: Water Activity.

$$a_w = \frac{\text{vap. pressure of soln (food)}}{\text{vap. pressure of pure water}}$$

	H_2O content	a_w
Fresh meat	65%	0.98
Cheese	40%	0.97
Jam	33%	0.88
Salami	30%	0.83
Dried fruit	18%	0.76
Honey	20%	0.75

Minimum a_w for growth.

Bacteria	0.91
Yeasts	0.88
Moulds	0.80

F7: WATER ACTIVITY

$$a_w = \frac{\text{Vap. Pressure of soln (FOOD)}}{\text{Vap. Pressure of pure water}}$$

MINIMUM A_w FOR GROWTH

BACTERIA	0.91
YEASTS	0.88
MOULDS	0.80

	H_2O CONTENT	a_w : PARTIAL PRESSURE OF PURE H_2O.
FRESH MEAT	65	0.98
CHEESE	40	0.97
JAM	33	0.88
DRIED FRUIT	18	0.76
HONEY	20	0.75

F8: Water Activity

$$a_w = \frac{\text{vapour pressure of soln. (food)}}{\text{vapour pressure of pure } H_2O}$$

	water content	a_w
FRESH MEAT	65%	0.98
CHEESE	40%	0.97
JAM	33%	0.88
SALAMI	30%	0.83
DRIED FRUIT	18%	0.76
HONEY	20%	0.75

F9: Water Activity

$$a_w = \frac{\text{VAP. PRESSURE OF SOLN. FOOD}}{\text{VAP. PRESSURE OF PURE WATER}}$$

	H_2O content	a_w
FRESH MEAT	65%	0.48
CHEESE	40%	0.47
JAM	33%	0.88
SALAMI	30%	0.83
DRIED FRUIT	18%	0.76
HONEY	20%	0.75

Minimum a_w for growth

BACTERIA	0.91
YEASTS	0.88
MOULDS	0.80

Figure 5-6 (contd.)

F10:

Water Activity

$a_w = \frac{\text{vap. pressure of soln (food)}}{\text{vap. pressure of pure water}}$ (taken as 1)

	H_2O content	a_w = water activity
fresh meat	65%	0.98
cheese	40 %	0.97
jam	33 %	0.88
salami	30 %	0.83
dried fruit	18 %	0.76
honey	20 %	0.75

nothing grows

minimum a_w for growth

bacteria	0.91	cheese↑
yeasts	0.88	jam↑
moulds	0.80	salami↑

b, yeast, m.o. in water

WATER is main component

F11:

Water activity

$a_w = \frac{\text{Vap press of soln (food)}}{\text{Vap press of pure water}}$

	H_2O content	a_w
fresh meat	65%	0.98
Jam	33%	0.88
Salami	30%	0.83
Dried fruit	18%	0.76
Honey	20%	0.75
Cheese	40%	0.97

Min aw for growth.

Water is the main componant for these to grow

F12:

Water Activity

$a_w = \frac{\text{VAP. Pressure of Soln (FOOD)}}{\text{VAP. Pressure of Pure Water}}$

Bacteria, Yeasts & Moulds will actively grow in water. Moulds most active at the lowest moisture levels.

	H_2O content	a_w
FRESH MEAT	65%	0.98
CHEESE	40%	0.97
JAM	33%	0.88
SALAMI	30%	0.83
DRIED FRUIT	18%	0.76
HONEY	20%	0.75

Minimum a_w for growth

BACTERIAS	0.91
YEASTS	0.88
MOULDS	0.80

(e.g. Fresh meat at 25°C, all the three will grow)

F13:

WATER ACTIVITY

	H_2O content	a_w
fresh meat	65%	0.98
cheese	40%	0.97
jam	33%	0.88
salami	30%	0.83
dried fruit	18%	0.76
honey	20%	0.75

$a_w = \frac{\text{Vp food}}{\text{Vp } H_2O}$

min. a_w 4 growth:

bacteria 0.91

yeast 0.88 ∴

moulds 0.80 ∴ won't grow ⊙ dried fruit

%k of H_2O ⊙ food : det's what microorgs grow

Figure 5-6 (contd.) Extracts Taken from Lecture Notes of Field-Independent Students more quickly the point of a joke than the Field-dependent students. This can be easily seen from a visual inspection of those extracts (Figure 5-7). Most of the Field-dependent students (**D 1** to **D 13**) recorded the blackboard writing verbatim without taking down what "Aromaticity" meant (they didn't seem to see the point of this interesting analogy, i.e., "Happiness" is called "aromaticity") and how the stability of benzene occurred due to the conjugation of p - electrons. In contrast, the field-independent students (see **I 1** to **I 6**) seemed to pick up the point by noting down the relatively important message conveyed verbally by the lecturer.

Those findings are consistent with the characteristics of Field-dependent individuals as having difficulty in actively abstracting and organising information that is presented as part of a larger conceptual field.

5.4.3 The Interaction of Lecturing Styles with Students of Different Motivational Styles

TABLE 5-17 shows the results of analysing the quantity of words and information units recorded in the lecture notes taken by students with different motivational styles. In general, the Achiever students recorded the most words, the Sociable students recorded the least words, with the Conscientious and the Curious students in between. As regards the total number of information units, both the Achiever and the Curious students recorded nearly the same amount and they seemed to have recorded more information units than the Conscientious and the Curious students.

Detailed analysis of the structure and format of lecture notes taken by students with different motivational styles showed (see TABLE 5-18), that the Achiever students tended to be more complete note-takers --- four out of six students were BS + and one

D1: "Happiness" called AROMATICITY.
Benzene does not like addition reactions - instead get substitution.

D2: "happiness" called aromaticity

D3: "Happiness" called Aromaticity
Benzene does not like addition

D4: "Happiness" called aromaticity.
Aromatic character of benzene makes it more stable.

D5: Benzene is "aromatic". It doesn't like losing its ring of electrons → it doesn't like addition rxns, instead we get substitution rxns.

D6: Benzene is very happy ("Aromatic") - doesn't like addition reactions

When benzene is "happy" - called aromaticity

Benzene is very happy "aromatic"

Figure 5-7.

Notes Taken by Field-Dependent Students

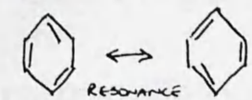
D7: Benzene is very happy - aromatic.
Doesn't like addition ~~reaction~~ instead substitutions

D8: Benzene - (v. stable happy) aromatic
doesn't like losing its ring of electrons ie addition reactions. any reactions taking place: substitution.

D9: "Happiness" is called AROMATICITY.
Benzene doesn't like addition reaction - instead it undergoes substitution.

D10: Benzene - is very happy
AROMATIC
doesn't like to lose its ring of electrons

D11:



RESONANCE

DOUBLE BONDS ARE CONJUGATED AND IN A RING.

CLOUD OF ELECTRONS ABOVE AND BELOW RING.

C-C OF ALL BONDS IS 1.39 Å

BENZENE - IS VERY HAPPY "AROMATIC". - DOESN'T LIKE

D12: Benzene is exceptionally happy
- "Aromatic" Doesn't like addition

D13: The happiness is called aromaticity.
Benzene does not like to add things to it - instead we get 'substitution' reactions.

I_1: Consider heat hydrog. ; stabilisation ↑↑ than that for conjugation (see sheet) (about 36 kcal)

benzene very 'happy' ☺ : 'happiness' called AROMATICITY

⇓ hence.

likes to remain so ; so addition not favourable.

I_2: Aromaticity is its stability

Benzene does not like addition reactions - Instead get Substitutes

I_3:

stabler by ~ 23 ☺

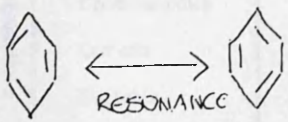
(conjugated).

stabler by 36 ☺ benzene restful we'll one we!

Aromaticity ⇒ stability
Benzene doesn't like to add things to it, addition reactions - instead you get substitution.

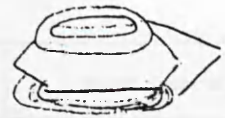
I_4: The energy given out by benzene is -49.8 Kcal (Benzene stab energy) but a molecule with 2 double bonds is less stable and has an energy of -54.9 Kcal. (2.3 Kcal)

Benzene is very happy "AROMATIC"



Double bonds are Conjugated and in a ring.

I_5: Benzene.



cloud of electrons above and below the benzene ring.

C—C of all the bonds is 1·39 Å
This is slightly longer than the normal C=C double bond.

DATA SHEET : hydrogenation of double and single bonds.

The energy produced by benzene is less than that produced when 2 double bonds are in conjugation.
Benzene shows a very large stabilisation
☺ very happy

If we add to the benzene ring it becomes less happy (stable) ☹

Benzene is very happy — aromatic.
It does not like losing its ring of electrons.
It does not like addition reactions — instead substitution reactions occur.

I_6: Stabilisation of benzene is due to ring act and due to conjugate bond + clouds of electrons.

Add things to benzene across double bond (≠ happy)

"Happiness" called aromaticity

Figure 5-7 (contd.) Notes Taken by Field-Independent Students

TABLE 5-17. Quantitative Analysis of Lecture Notes according to their Motivational Styles (I. U = Information Unit)

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4835	4497	4932	4583	4871	5322	4677	4729	5121	4698	4699	5125
Mean total I.U spoken & written		117	133	162	139	126	117	132	137	146	129	132	142
Mean total words on board		496	539	668	387	601	693	417	588	685	433	576	682
Mean total I.U on board		63	71	79	67	69	73	73	65	82	68	68	78
Mean of total words recorded	Achiever	583	615	707	549	623	716	506	635	732	546	624	718
	Conscientious	517	573	695	469	608	678	471	593	688	486	591	687
	Curious	489	581	649	434	519	639	398	512	644	440	537	644
	Sociable	426	547	658	399	457	587	424	533	652	416	512	632
Mean of total I.U recorded	Achiever	97	104	102	126	113	86	119	106	123	114	108	104
	Conscientious	85	76	81	88	78	75	89	76	84	85	77	80
	Curious	93	89	93	115	87	77	108	97	81	105	91	84
	Sociable	77	69	75	83	75	67	91	73	77	84	72	73
Mean of completeness	Achiever	83 %	78 %	63 %	91 %	90 %	74 %	90 %	77 %	84 %	88 %	82 %	74 %
	Conscientious	73 %	57 %	50 %	58 %	62 %	64 %	67 %	55 %	58 %	66 %	58 %	57 %
	Curious	79 %	67 %	57 %	83 %	69 %	66 %	82 %	71 %	55 %	81 %	69 %	59 %
	Sociable	66 %	52 %	46 %	60 %	60 %	57 %	69 %	53 %	53 %	65 %	55 %	52 %

TABLE 5-18. The Number of Students in Different Note-taking Types
(classified according to their motivational styles)

Student Type \ Note-taking Type	BS -	BSO	BS +	EL
Achiever (6 students)	1	0	4	1
Conscientious (11 students)	2	7	2	0
Curious (6 students)	1	4	0	1
Sociable (5 students)	0	5	0	0

*** BS - = Blackboard Signal Minus   BSO = Blackboard Signal Only
BS + = Blackboard Signal Plus   EL = Elaboration

and one EL was also found to have recorded more information units (not necessarily more words). The Sociable students tended to note down only what was put on the board with some occasional omissions. Most Conscientious students (7 out of 11 are BSO) were found to record mainly the blackboard writing from lecturers.

TABLE 5-19 shows the comparisons of the class exam scores and final degree exam performance of different students according their motivational styles. There are no simple patterns found in this analysis but the Sociable students have worse performance in both class exams than the other three groups of students, probably because they recorded less complete notes than the others.

From further analysis of students' lecture notes, different lecturing styles seemed to have profound influence in directing the Curious and the Sociable students to record the verbal lecture messages (see TABLE 5-17). It was detected that both the Achiever

TABLE 5-19. The Relationship between Motivational Styles and Exam Performance

Performance / Student Types	Mean score of 1st class exam	Mean score of 2nd class exam	Final results of Degree Exam
Achiever (6 students)	65.0	54.2	Exempted --- 1 Pass --- 4 Failed --- 1
Conscientious (11 students)	62.5	51.1	Exempted --- 4 Pass --- 6 Failed --- 1
Curious (6 students)	65.0	48.7	Exempted --- 1 Pass --- 3 Failed --- 2
Sociable (5 students)	56.8	43.6	Exempted --- 1 Pass --- 2 Failed --- 2

and the Conscientious students were not found to have much differences in note-taking completeness between the effective lecturers and the ineffective lecturers, but there appeared to be a tendency that noticeable differences existed in note-taking completeness between the effective lecturers and the ineffective lecturers for both the Curious and the Sociable students.

The data from interviewing the subjects showed that both the **Curious** and the **Sociable** students were more motivated by the effective lecturers that they paid more attention to what was being conveyed and so more information units were recorded by them. When students were responding to a question about why they had taken more notes in some lectures but taken fewer notes in others, several examples of dialogue that illustrate the perceptions they had about the lecturers which had influenced their note-taking behaviours are presented below :

"His lectures were very interesting that I tended to follow through all the time and picked up the interesting bits, something like the relevance of organic chemistry to daily life and the aside about the cosmetics was quite fun."
(on Lecturer **3**, one of Group I lecturers.)

"Lecturer's style of presentation - i.e. light hearted moments - made the course of lectures much more enjoyable and you can easily tell from his excitement of voice what should be taken down."
(on Lecturer **8**, one of Group I lecturers.)

"Such interest and dedication - gives a whole new dimension and meaning to chemistry, esp. the bit on the application of transition metal in bio-inorganic chemistry."
(on Lecturer **12**, one of Group I lecturers.)

"The best lecturer this year. He made the course seem general knowledge, i.e., giving everyday examples to put across the chemistry."
(on Lecturer **12** - a Group I lecturer.)

"The lecturer was boring enough and he jumped about too much, so not enough information was taken in."
(on Lecturer **10** --- Group III lecturer.)

"Far too fast - we all can't write at one hundred miles an hour, so I just jotted down what appeared on the board to make my life easier."
(on Lecturer **9**, a Group III lecturer.)

"I found the lecturer difficult to understand and I doubt if I have gained any knowledge whatsoever from this series of lectures, which I found became a task to attend."

(on Lecturer **10**, one of Group III lecturers.)

"Style of approach and patchy form of presentation made me realise the meaning of the word 'boredom', and I couldn't help giving up when lines after lines of mathematical equations came across."

(on Lecturer **6**, a Group III lecturer.)

"Fewer examples more carefully explained would get the points over better. Quantity does not necessarily mean quality so I only took the key points."

(on Lecturer **9** --- a Group III lecturer.)

"Dr. H showed a complete lack of enthusiasm and made no attempt to make it interesting. I found it difficult to sit through the whole lecture, so sometimes I had to borrow lecture notes from my friends."

(on Lecturer **5**, one of Group III lecturers.)

It seems that the **Achiever** students assume a sort of note-taking type (viz., BS +) to <u>minimise risk of failure and maximise the probability of success</u>, so they have developed a keen commitment to any lecture messages, in their view, to enhance the chance of success. As indicated from their notes, they seldom missed out important points and it was found that most of them used a signalling system, such as circling or bracketing, underlining or coloured pen to highlight the examinable part which had been selectively cued by lecturers.

It also has been noticed that the **Curious** students tended to have a preference for seeking supplementary materials, latest developments of chemistry or the applications of chemistry theory because in many cases they were found to have recorded more such lecture messages in their notes than the Conscientious and the Sociable students.

For example, in one lecture about the development and applications of polymers, the lecturer spent about four minutes in getting across his message. He presented the material on the transparency and didn't write anything on the blackboard. After the lecture, notes were collected and examined, and it was found that only 14 out of 28 students (50 % of the sample) noted down something about this. Among those fourteen students, **1** (20 %) was Sociable, **5** (80 %) were Curious, **4** (36 %) were Conscientious and **4** (67 %) were Achiever. The high percentage of the Curious students in recording this information might highlight one of the features of them. The following excerpts taken from students arranged by the motivational styles demonstrate this interesting point (see Figure 5-8).

As it was indicated in TABLE 5-17 and TABLE 5-18, the **Sociable** students recorded less complete notes than the other three types of students in terms of total number of words and total number of information units. Further analysis showed that they tended to have recorded more errors that other students and dropped out most complex diagrams or figures. They seldom took down the lecture messages transmitted verbally by Group III lecturers and would sometimes take down something conveyed verbally by Group I lecturers.

A few fragments taken from lecture notes of the Sociable students may illustrate the sketchy, terse way of note-taking, with occasional intrusive doodling (Figure 5-9).

5.4.4 The Note-taking Performance and Gender Differences

The quantitative analysis of lecture notes according to students' gender is given in TABLE 5-20. Women students tended to take more notes than male students both in total number of words and total number of information units.

A further examination of all the lecture notes taken by male and female students

Achiever :

... Polymers

... strongest most imp. chemicals in industry – great practical importance.

e.g. car 29 – parts on polymers – rapid increase

petrol tanks, (cellulose), materials

rel. young science.

Developments in 3 sections

RUBBER — 1823, 1839 → useful polymeric products

CELLULOSE (natural) — 1862 NITRATE, 1894 ACETATE

PHENOL + FORMALDEHYDE (man-made) — 1907

ALKENES, STYRENE, VINYL CHLORIDE etc. — ~1935 on

WHOLLY MANMADE POLYMERS

Also – nomenclature non-systematic

POLYMERS : eg RUBBER → CELLULOSE → USEFUL PLASTIC MATERIALS (FROM NATURAL POLYMERS)

SYNTHETIC POLYMERS : Phenol, formaldehyde, ALKENES, STYRENE, VINYL CHLORIDE.

Concept of the MACROMOLECULE AS A Linear chain

Macromolecules. I.

Rubber — 1823, 1839 → useful polymer product

Cellulose — 1862 Nitrate, 1894 Acetate

Phenol + Formaldehyde — 1907

Alkenes, Styrenes, Vinyl chloride etc — ~1935 on

Wholly man made polymers

from natural polymers

Rubber — 1823 (Macintosh's waterproof cotton), 1839 (Vulcanisation)

Cellulose — 1862 Nitrate, 1894 Acetate

wholly man-made

Phenol + formaldehyde — 1907

Alkenes, Styrene, Vinyl-chloride etc — 1935

useful plastic materials

1922 Concept of Macromolecule as a linear chain

Conscientious

MACROMOLECULES I.

Natural polymers (plastics)

RUBBER — 1823 – Macintosh (..) , 1839 – Vulcanisation

CELLULOSE — 1862 – Nitrate, 1894 – Acetate

PHENOL FORMALDEHYDE — 19..

ALKENES, STYRENE, VINYL CHLORIDE etc — 1935 on

Useful plastic materials

MACROMOLECULES

FIRST PLASTICS (ie POLYMERS) CAME FROM NATURAL POLYMERS.

RUBBER

1823
1839

CELLULOSE

1862 NITRATE

ACETATE

USEFUL PLASTIC MATERIALS

1907

1935 ON

PHENOL + FORMALDEHYDE

WHOLLY MAN MADE

ALKENES
STYRENE
VINYL CHLORIDE
ETC.

RUBBER

1823
1839

useful plastic materials

CELLULOSE

1862 Nitrate
1894 ACETATE

phenol + formaldehyde

1907

ALKENE
STYRENE
VINYL
CHLORIDE

1935

Curious :

From natural polymers

RUBBER

1820-30

CELLULOSE

1862 Nitrate
1894 Acetate

FORMALDEHYDE

ALKENES
STYRENE
VINYL CHLORIDE etc

USEFUL PLASTIC MATERIALS

POLYMERS

RUBBER

1823
1839

CELLULOSE

1862 NITRATE
1894 ACETATE

USEFUL POLYMERIC PRODUCT

PHENOL + ALDEHYDE

1907

WHOLLY MAN MADE POLYMERS

1935

ALENES
STYRENE
VINYL CHLORIDE
etc

is synthetical

POLYMERS

Natural Rubber — both from natural polymers.

1823

1839

Cellulose.

1862 Nitrate.
1894 Acetate.

Useful Plastic materials.

Man-made

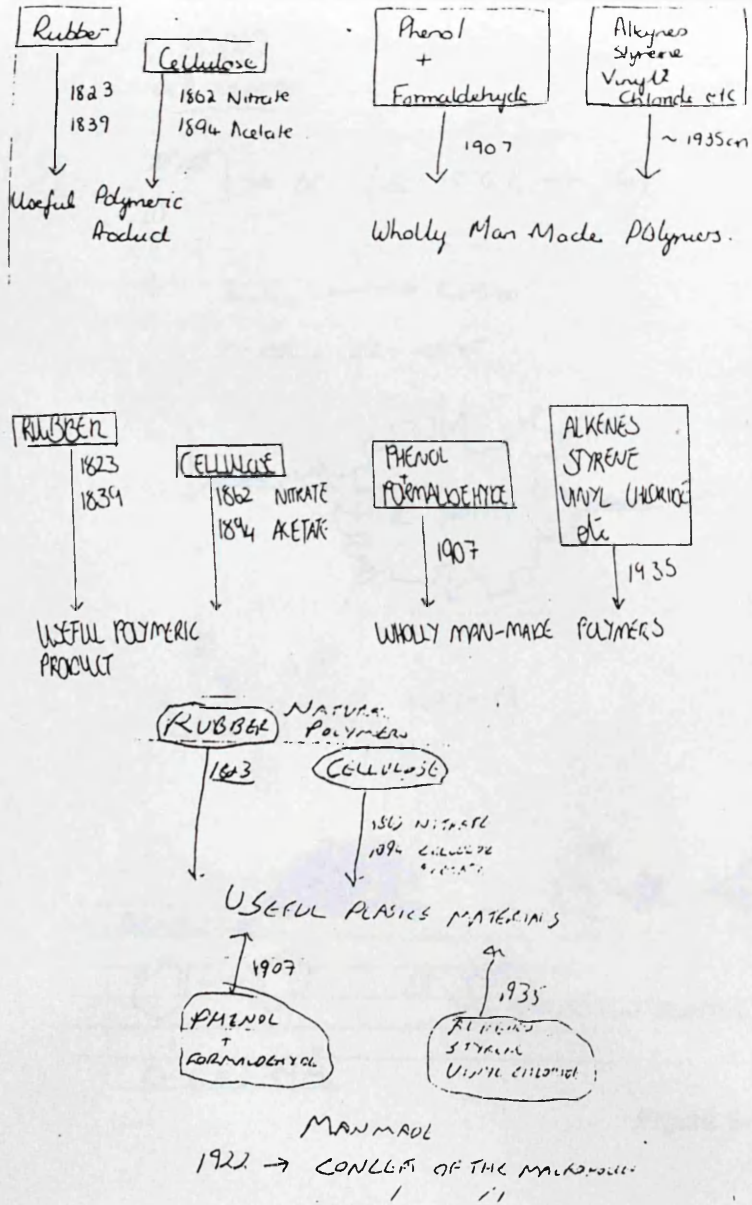
Phenol + Formaldehyde.

1907

Alkenes
Styrene.
Vinyl Chloride

1935 on

1922 → concept of the macromolecules as a Linear Chain.



Plastics are now a major part of industry -ca

Sociable :

1922 concept of Macromolecules

Nomenclature - Learn trivial names on handout

Figure 5-8.

The Lecture Notes Arranged according to Different Motivational Styles

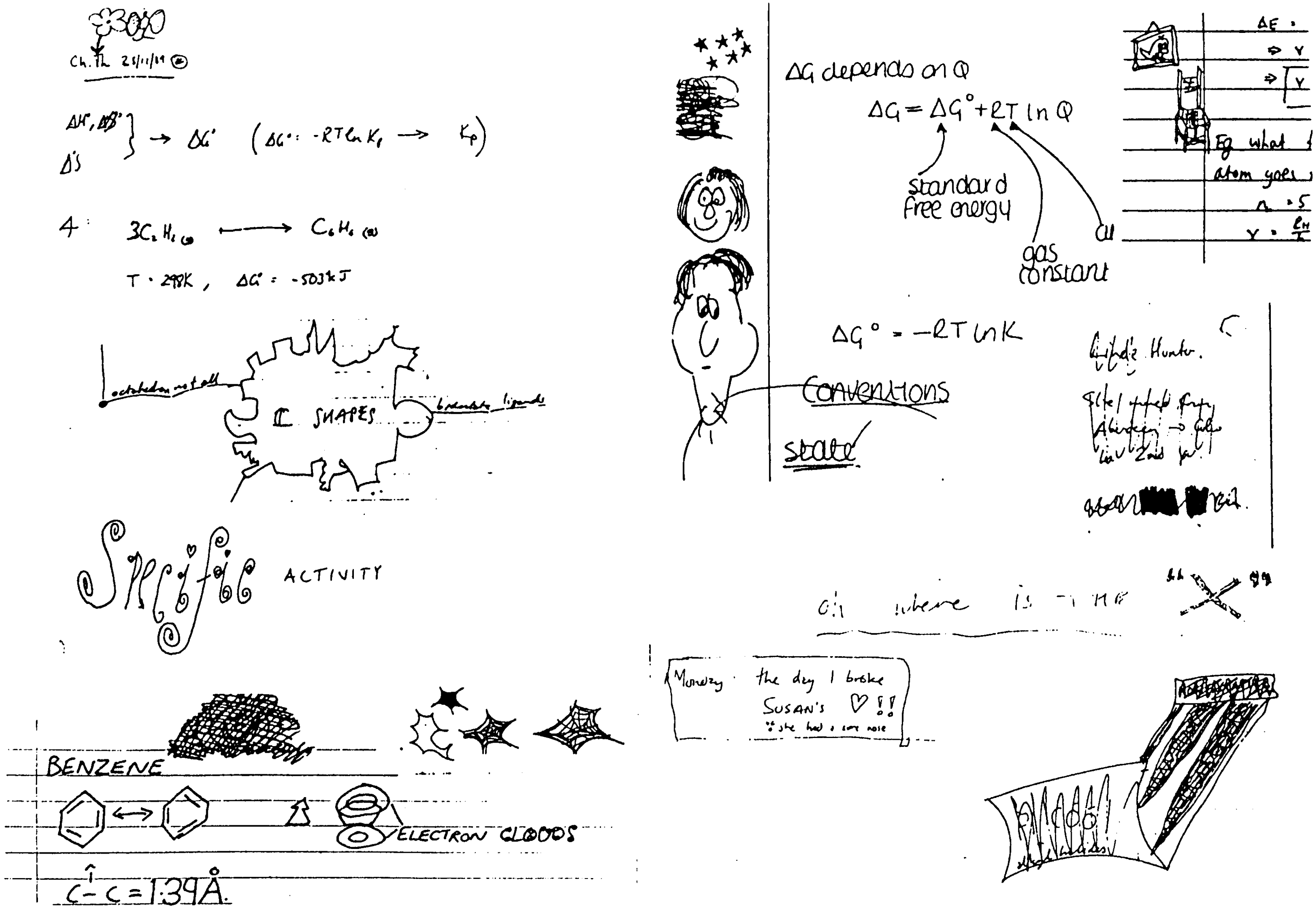


Figure 5-9. The Lecture Notes Taken from the Sociable Students

TABLE 5-20. Quantitative Analysis of Lecture Notes according to their Gender Difference (I.U = Information Unit)

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4835	4497	4932	4583	4871	5322	4677	4729	5121	4698	4699	5125
Mean total I.U spoken & written		117	133	162	139	126	117	132	137	146	129	132	142
Mean total words on board		496	539	668	387	601	693	417	588	685	433	576	682
Mean total I.U on board		63	71	79	67	69	73	73	65	82	68	68	78
Mean of total words recorded	Male Students	487	552	676	466	587	668	447	594	658	506	561	673
	Female Students	543	602	691	496	598	683	481	611	740	471	619	697
	Whole Sample	517	579	684	482	593	676	465	603	702	487	592	686
Mean of total I.U recorded	Male Students	87	84	90	78	84	72	89	88	75	91	89	79
	Female Students	91	80	88	87	86	76	102	95	86	87	83	83
	Whole Sample	89	82	89	83	85	74	96	92	81	89	86	81
Mean of completeness	Male Students	74 %	63 %	55 %	56 %	67 %	61 %	67 %	64 %	51 %	66 %	65 %	56 %
	Female Students	78 %	60 %	54 %	63 %	68 %	65 %	77 %	69 %	59 %	73 %	66 %	59 %
	Whole Sample	76 %	62 %	55 %	60 %	67 %	62 %	73 %	67 %	55 %	70 %	65 %	57 %

indicated that the BSO type of note-taking (i.e. recording the blackboard signal only) was the most popular practice among students despite the gender difference (see TABLE 5-21). The reason why female students took more complete notes was : (i) some of them tended to write down the whole sentence instead of main points; even that which appeared on the board was in fact more concise ; and (ii) they took down more lecture messages sent forth verbally.

The relationship between note-taking and test performance among different gender of students was further explored and the results are shown in TABLE 5-22. Male students scored better than female students in both class exams in spite of less complete note-taking, but there was not much difference in the final degree exam.

On the occasions when the lecturer dictated instead of putting the lecture messages on the board, women were found to record more copiously (verbatim) than men (some of the men tried to take main points and some lagged behind with unfinished sentence). It seems to suggest that female students are more capable of taking verbal messages than male students.

A very characteristic feature of female students was that many of them liked to take wordier notes than male students. In the following example, the lecturer put on the board the lecture segment : (i) two general structures of amino acids, (ii) elimination of one water molecule between those two amino acids to form a peptide bond, (iii) the hydrogen bonding. Then he spent about 10 minutes on explaining the meaning of primary structure, the secondary structure and the tertiary structure of protein molecules without writing anything else on the board.

A marked difference existed between male and female students, as illustrated in

TABLE 5-21. The number of students in different note-taking types
(classified according to their gender)

Gender \ Note-taking Type	BS -	BSO	BS +	EL
Male (13 students)	1	9	1	2
Female (15 students)	3	7	5	0

*** BS - = Blackboard Signal Minus BSO = Blackboard Signal Only
BS + = Blackboard Signal Plus EL = Elaboration

TABLE 5-22. The Relationship between Performance and Gender Difference

Gender \ Performance	Mean score of 1st class exam	Mean score of 2nd class exam	Final results of Degree Exam
Male (13 students)	69.9	52.3	Exempted --- 4 Passed --- 7 Failed --- 2
Female (15 students)	56.2	47.8	Exempted --- 3 Passed --- 8 Failed --- 4

the extracts from students' notes (see Figure 5-10). **F 1** to **F 9** are the notes taken by female students and **M 1** to **M 9** are the notes taken by male students. As can be seen from these extracts, almost all women students recorded completely what was put on the board (Notice the notes which they took were very colloquial and in fact **F 2**, **F 3**, **F 4**, **F 5** and **F 7** were taking down some fragments of the verbal lecture message). Moreover, they also recorded a lot of information units of the primary structure, the secondary structure and the tertiary structure. In contrast, male students jotted down what was put on the board very concisely, and recorded either the terms only (**M 1**, **M 3**, **M 5**, **M 6** and **M 8**) or the main points (**M 2**, **M 4**, **M 7** and **M 9**) instead of taking down the verbal form of information.

5.5 The Results of Immediate Recall Test

In order to understand to what extent students had processed and understood the material taught during the lecture, an immediate recall test (see Appendix 17, Page 382) was given to **135** students who attended the lecture on the topic "the shapes and the structures of metal complexes". After collecting all the completed answer sheets, the lecturer helped to mark them and returned the raw scores to the researcher.

The mean scores and standard deviations for every item were calculated and then the percentages of students who had scored above the average were also determined. The results are shown in TABLE 5-23. It is clear from this table that in every item more than half the students scored lower than the mean score. When checked with the lecturer involved, he was not satisfied with students' performance.

It seemed to suggest that learning during lectures is much more demanding than it has ever been thought. Students have to listen to the lecturer carefully, to select the

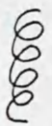
F1:

$HO_2C-\underset{H}{\overset{R}{C}}-N=\overset{OH}{C}-\overset{R}{CH}-C$ peptide bond has no free rotation

$HN-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\|}{C}}-\overset{H}{N}-H$

primary structure - the most fundamental structural level.
Tertiary structure - refers to the way in which the entire protein molecule is coiled into an overall 3d structure.

Secondary structure: The way in which peptide level backbone are converted into a regular pattern.



Existing as a coil Hydrogen bonds exist between peptide bonds and forming an α - helix (rope like structure e.g. wool hair)

$$\begin{array}{c} | \qquad\quad | \\ C=O\cdots H-N \\ | \qquad\quad | \\ N-H\cdots O=C \\ | \qquad\quad | \end{array}$$

hydrogen bond holds

Hydrogen can shift - but remain reasonable stable - known as secondary structure or α : β-pleat held together in sheet form (silk)

H_2N alanine glycine COOH →primary structure
(sequence)
-order of amino acids, joined by peptide

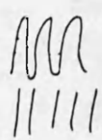
could be same or diff. (reversed)

$$\begin{array}{c|c} C=O & H-N \\ N-H.. & O=C \end{array}$$

- get H-bonding
- in polymers, → strong, add strength to polymer accumulate to give effect.
- H could move to join O; now between N & C
- delocalise on having.
- H bonding effect, interaction at peptide

SECONDARY STRUCTURE

2 main ways of H bonding in polymer



(i) continuous strand

(ii) separate aligned

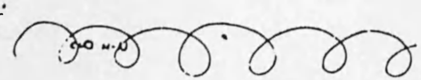
C=O H-N
N-H O=C

called β-pleat (both these forms)

~3.5 per turn up

used for cell walls, membranes.

same type in bodily protein rope like - called α helix



F2:

... order of AA along chain from N ... round amino end. (ie H_2N)

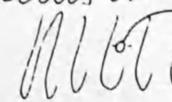
$$\begin{array}{c} | \qquad\quad | \\ C=O\cdots H-N \\ | \qquad\quad | \\ N-H\cdots O=C \\ | \qquad\quad | \end{array}$$

This H-bonding which has a stabalising effect on the polymer.

H bonding: H can shift from one gp to another whilst still allowing the polymer to remain stable

2° structure:

This results in



within which H bonding occurs throughout by β pleat

It can also occur within an α - helix.

3° Structure: dependant on R groups where the range of functions is from acid to

CH_2CO_2
$(CH_2)_4-NH_3^+$ } bonding giving proteins its diverse properties

F3:

Primary Structure - order of AAs along a chain of protein
- Start on Amino end ⇒ to carboxylic end

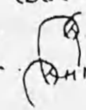
$$\begin{array}{c} | \qquad\quad | \\ C=O\cdots H-N \\ | \qquad\quad | \\ N-H\cdots O=C \\ | \qquad\quad | \end{array}$$

H bonding can take place between strands. H can shift from group to group giving delocalising effect. This is the Secondary Structure of a protein.

Pleated form - β pleat - protein held together in a Sheet form. (like cell membrane etc)

Can also get H bonding along the chain

α Helix



H bonding

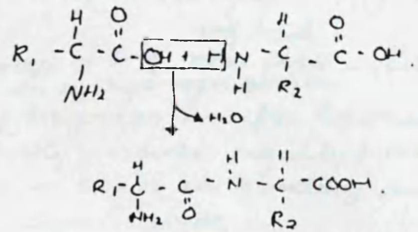
Hair in α Helical form. About 17 strands together to make 1 hair

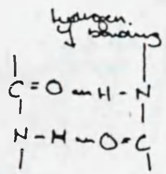
Tertiary structure depends on R groups.
R groups from Acid functions to basic functions

$CH_2CO_2^-$ to $(CH_2)_4-NH_3^+$.

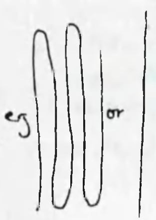
R groups give proteins their properties.

F4:

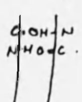




→ It could be that this is a protein that is convoluted or going in the possible direction eg

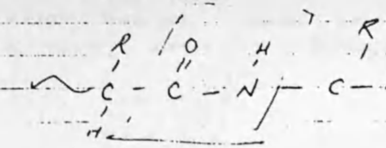


Hydrogen bonding means the hydrogen could move between the nitrogen and the carbonyl group. This gives the protein strength. This hydrogen bonding effect is known as secondary structure.
Primary structure is the order of amino acids in a protein
This is known as a B. pleat



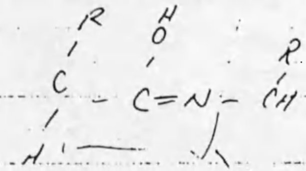
F5:

peptide bond.



single bond implies free rotation - but this does not imply.

where you have a single bond you have free rotation about the bond.
No free rotation about a double bond.



→ small amount of double bondedness.

Primary structure - sequence of AAs
hydrogen bonding - hydrogen can transfer between H and carbonyl groups.
Secondary structure.
β pleat

F6:

H ≠ C=O C=O no H.

Amide and C=O NH.

Can have sep. strands where H bonding in pleated structure
Can have rope like structure H bond takes place in rope. scenario of α helix.

F7:

order of aminoacids - primary structure of protein chan
Alanine . . . . / . Glycin   primary structure
sequence of amino acids.

$C=O \cdots H-N$
$N-H \cdots O=C$

β pleat
(pleated structure)
proteins aligned

diff strand

hydrogen bonding takes place - quite alot of strength is given by hydrogen bonding.
Hydrogen can move from one structure to other fairly
"happily" - gives rigidity + strength..
this is known as secondary structure - interaction at peptide bonds.

β-pleat $C=O \cdots NH$ $NH \cdots O=C$

coiled protein
peptide bonds
hydrogen bonding taking place

α - Helix
rope like
(structure)
gives strength

one form of secondary structure - use for building blocks membrane.

F8:

STRUCTURE OF PROTEIN.
PRIMARY STRUCTURE - ORDER OF AMINO ACIDS ALONG CHAIN.
SECONDARY STRUCTURE - BONDING BETWEEN PORTIONS OF PROTEIN STRANDS.

$C=O \cdots H-N$
$N-H \cdots O=C$
Hydrogen bonding

↳ β PLEAT

↳ α HELIX

TERTIARY STRUCTURE - DEPENDS ON R GROUP.

F9:

Primary Structures
NH - Alanine ... Glycine COOH
hydrogen bonding
$C=O \cdots H-N$
$N-H \cdots O=C$
or

Hydrogen Bonding Effect: Secondary Structure
β pleat - prod align $C=O \cdots NH$
Hydrogen bonds take place
in a coil too
(α helix)

$HN-C-C-N-$ (with R, O, H)

Primary structure of a protein.

$C=O \cdots H-N$ — can set up a resonance.
$N-H \cdots O=C$

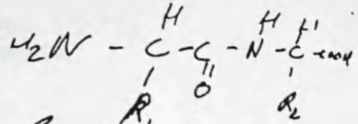
hydrogen bonding

β PLEAT

Secondary structure

Figure 5-10 Notes Taken by Female Students

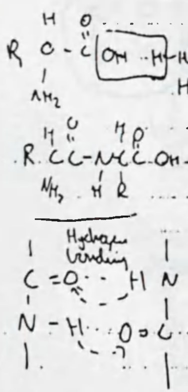
M1: PROTEIN

Primary Structure 

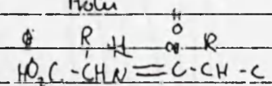
Protein forms a β pleat ie to surround a cell.

Secondary structure: helical arrangement α-helix

M2:



Rolin



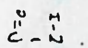
no free rotation

the order of aminoacids in Rolin is known as the primary structure

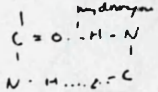
this is known as the secondary structure of aminoacid

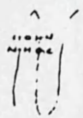
M3: PROTEINS

Made from amino acids. All proteins have the peptide bond

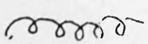


hydrogen bonding



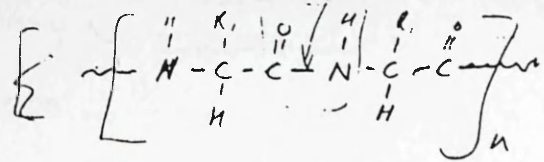


β pleat.



α helix

M4:



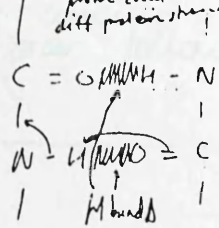
NO FREE ROT^N ABOUT DOUBLES

BUT ALSO X ROT^N " PEPTIDE BOND

CERTAIN AMOUNT DOUBLEBOND CHARACTER

(trace of enol form)

M5:

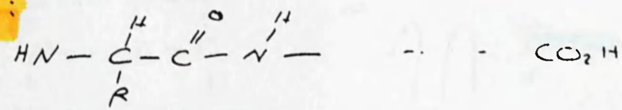


H can transfer between carbonyl & amine group

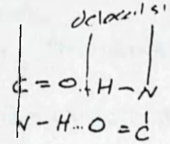
gives rigidity

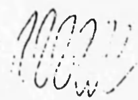
H goes btw 2 groups. ⇒ integrity

M6:

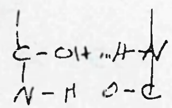


PRIMARY STRUCTURE.



β PLEAT 

SECONDARY STRUCTURE



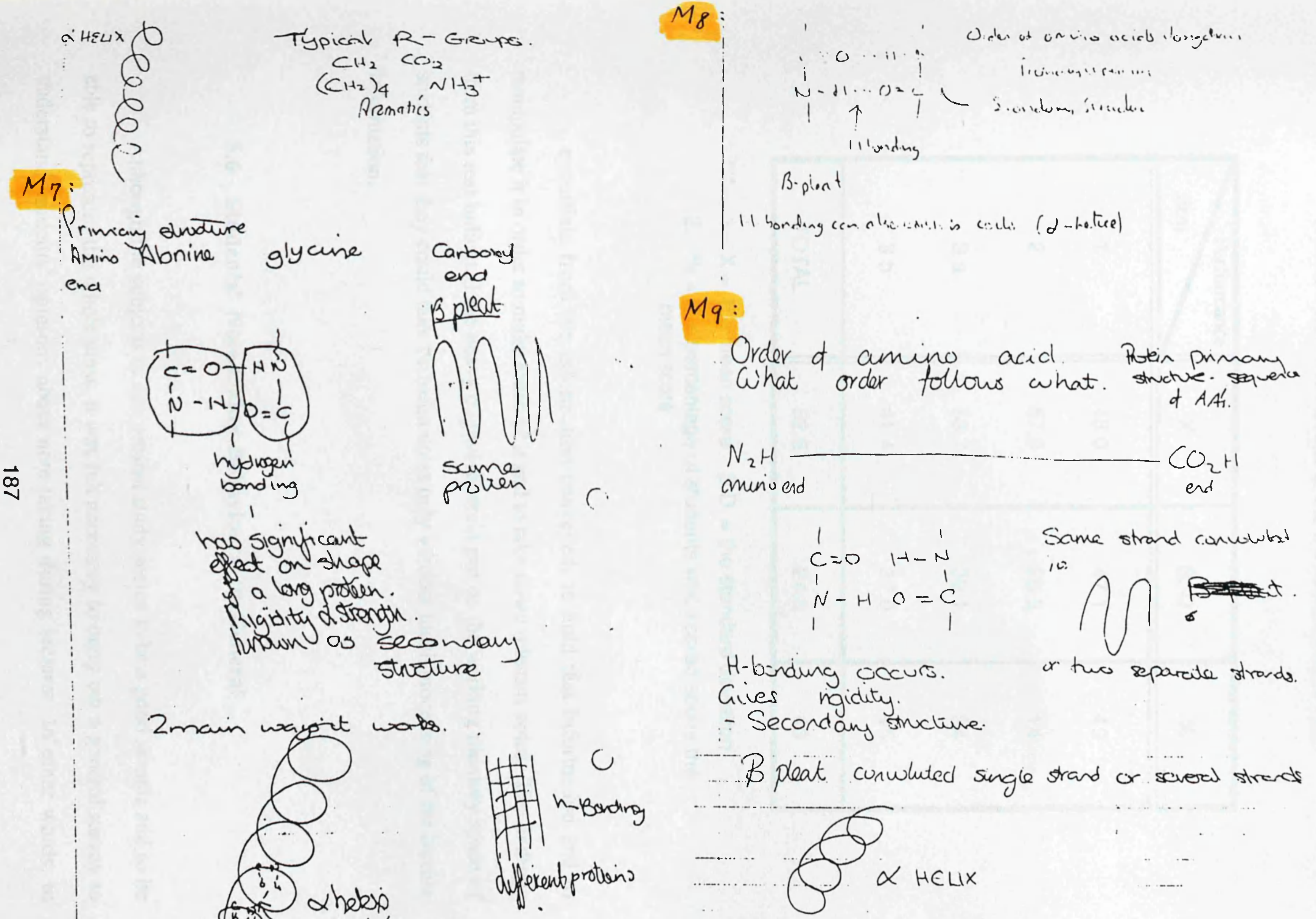


Figure 5-10 (contd.) Notes Taken by Male Students

TABLE 5-23. The Results of the Immediate Recall Test

Item \ Performance	X	S. D	%
1	48.0	47.1	49
2	57.9	26.5	14
3 a	63.7	39.1	24
3 b	41.4	37.0	45
TOTAL	52.5	24.5	43

*** 1. X = the mean score S.D. = the standard deviation
2. % = the percentage of students who scored above the mean score

essentials from the information conveyed, to hold that information and to manipulate it in order to make sense of it and to take down relevant notes. The findings from this test indicated the heavy cognitive strain put on the working memory space of students that they could take verbatim notes only without much processing of the lecture information.

5.6 Students' Note-taking Behaviours In General

Although the subjects of this present study seems to be a good sample and to be able to represent the whole class, it was felt necessary to carry out a general survey to understand students' opinions about note-taking during lectures. In other words, to round off this study it was decided to administer a survey questionnaire to the whole class (See Appendix 19, Page 387). This questionnaire consists of five questions with several sample optional choices to induce students to express their views.

In this survey, students were asked about the purpose of note-taking during lectures, their opinions about having complete handouts, how they select the essential lecture information to take down, how they use the lecture notes and for what purpose, and any features of lectures that they would like to see changed to enable them to take satisfactory notes.

On the first and second weeks of the third term, the questionnaire sheets were distributed to each student when they went into the lab. Students were then requested to write their responses to those five questions and the researcher immediately collected the completed questionnaire sheets before the laboratory started. A total of 457 questionnaires were collected (The response rate was 89 %) and 19 were found to be spoiled or blank, so **438** questionnaires were used for analysis. The results are tabulated as follows (TABLE 5-24).

TABLE 5-24. The Results of Note-taking Questionnaire

The Results of 438 Questionnaire Sheets (1989)

Item Questions	*Percentage*
1. The purpose of note-taking during lectures	
(a) To concentrate.	27
(b) To have something as a record	69
(c) Other ideas	4

2. The opinion about note-taking as opposed to having complete printed handout

(a)	Can't understand lecture and take notes at the same time	34
(b)	Handouts are not in my own language or style	62
(c)	I like to write in my way or language	9
(d)	I like printed handouts	41

3. When taking notes, the way to get down "the essentials"

(a)	Take down what is on the board only	43
(b)	Get "signals" from the lecturer about what is important	67
(c)	Write down as much as possible	19
(d)	Don't know what is important	11
(e)	Others	5

4. How to use the notes

(a)	Supplement them from the textbook	46
(b)	Never look at them till exam time	8
(c)	They are the main source of my revision material	72
(d)	Rewrite them	23

5. The features of lectures students like to see changed to enable them to take satisfactory notes.

[A] About lecturer's personality

(1)	Liven up the lecturers	5
(2)	More enthusiastic	9
(3)	More approachable	7
(4)	Not monotonous	8
(5)	Louder, clear voice	17

[B] About lecturing methods

(1)	Give the objectives for the lectures	5

(2) Put headings and subheadings --------------------------	11
(3) Need introduction, preview and guidelines ------------------	5
(4) Review and summarise -------------------------------	13
(5) Point out main points (say clearly what to take down, and give indication of what is relevant) -------------------------	41
(6) Better and bigger writing on the board ---------------------	33
(7) Don't talk and use OHP, slides at the same time --------------	13
(8) Don't talk and write at the same time ----------------------	37
(9) More time for copying down the lecture material --------------	29
(10) Go at a slower pace --------------------------------	39
(11) Speak slowly to allow note-taking ----------------------	24
(12) More time for asking questions ------------------------	3
(13) Less writing and more explaining ----------------------	23
(14) Explanations should be sketchy, concise and less digression ------	12
(15) Speak clearly, logically and coherently and don't jump around -----	31
(16) Put new names, formulae and terminology on board ------------	7
(17) Use different Audio-visual Aids ------------------------	23
(18) Give the page number of references and textbooks ------------	13
(19) Give the exam material hints ------------------------	19
(20) More handouts -------------------------------	27
(21) Give the handouts of diagrams ----------------------	14
(22) More demonstrations -----------------------------	7
(23) More examples --------------------------------	18
(24) More talkback - like tutorials ------------------------	2

*** _Since students might have more than one response in each item, the total percentage may exceed 100 %._

Based upon the research findings from the sample and the results from the above questionnaire, some conclusions could be drawn :

(1) Note-taking was a very common activity of students. Often, what the lecturer was writing on the blackboard was all they had in mental focus (*Perception of importance*).

(2) Most students felt that listening to the lecturer and taking notes simultaneously was very demanding, thus resulting in taking verbatim notes only and neglecting most lecture messages transmitted verbally (*Self - protection against working memory overload*).

(3) The processing of lecture information did not appear to be in-depth; students were attending to, but not actively processing or working on the information conveyed by the lecturers (*Self - protection against working memory overload*).

(4) Information processing was also frequently punctuated by shifts in attention. Students' information processing in this present study was basically passive rather than active. There were exceptions, with several students using diagrammatic network or logical connections to structure their personally meaningful forms of the lecture information.

(5) One point worth noting is that low processing could be related to the purposes which students expected lectures to serve (*Perception*).
From the interview and the results of the questionnaire, more conscientious students appeared to be more concerned about identifying what ought to be learnt than about learning on the spot. They appeared more intent on recording the detailed factual information to aid subsequent study and preparation for exam than attempting to learn during lectures. They used lectures primarily to answer the question: What do I need to know for assessment purpose ? For them learning for retention appeared to be mainly a post-lecture activity in an out-of-class content (*Self - protection against*

working memory overload).

(6) Both implicit and explicit cues were used by students to get down "the essentials" of a lecture content. These cues included : (i) the blackboard writing (the most obvious and most effective one), (ii) lecturer' verbal stress or signpost, (iii) lecturer reiteration of a point, (iv) the non-verbal cues such as knocking on the bench or using the pointer and (v) longer than usual time spent on a topic or detailed handouts.

CHAPTER SIX

The Planning and Administration of the Third Phase of the Study

6.1 Problems and Hypotheses

Since students' rating of courses and lecturers has been carried out within the Chemistry Department for two full sessions and we have had access to larger number of lecturers, students and course types, it was thus intended to test the following hypotheses :

Hypothesis 1 Students' ratings provide reliable measures of overall lecturing performance.

Hypothesis 2 Students' perceptions of a lecturer's lecturing performance are as expected in terms of Information-Processing Theory.

Hypothesis 3 Students will take more verbatim notes when they attend the lectures given by ineffective lecturers under one of the following situations : (i) rapid lecturing pace; (ii) low instructional cues; (iii) low focussing and (iv) shorter wait-time.

In order to compare the note-taking behaviours and performance of a particular type of learner with different working memory capacity in various lectures, the following hypotheses were also tested :

Hypothesis 4 The students with higher working memory capacity will take more complete notes than the students with lower working memory capacity.

Hypothesis 5 The students with higher working memory capacity will have better performance in class exam than the students with lower working memory capacity.

Hypothesis 6 The field-dependent students will be less complete note-takers than the field-independent students.

Hypothesis 7 The field-dependent subjects will have lower scores in class exam than the field-independent subjects.

Hypothesis 8 The achiever and the conscientious students will have more complete note-taking than the curious and the sociable students.

Hypothesis 9 The achiever and the conscientious students will have higher scores in class exam than the curious and the sociable students.

Hypothesis 10 Female students will be more complete note-takers than male students.

Hypothesis 11 Female students will perform better in class exam than male students.

6.2 Looking at Lecturers through the Eyes of Students

From October 1990 to March 1991, students' ratings of courses and lecturers were carried out by means of the newly revised version of the rating scale --- special response sheets printed in two colors and in mark-sense format (see Appendix 13, Page 357). In this questionnaire, each factor was examined by at least two questions to allow us to check for internal consistency. If the students' response was capricious, it would show up in statistical clashes within each dimension, resulting in low correlations.

The evaluation was continued throughout the whole period for every block of lectures and for every lecturer by random samples (the number of students ranged from 36 to 256 respectively) of all the students attending the First-year Ordinary Chemistry course. A total of 1174 student response sheets were finally collected, with 13 lecturers involved. It was noticed that, in general, there were very few spoiled sheets and the response rates of questionnaire were usually very high, ranging from 87 % to 96 %.

Throughout this period, all the processing of the student responses was done entirely by computer, thus increasing the accuracy of scoring and expediting the return of results to the lecturers.

The use of the mark-sense forms was also monitored throughout the whole session. We have noted, for example, that the mark-sense reader is quite fussy about what it will accept. If students have not been careful enough in marking their responses, this can result in an excessive number of "No Response" entries in the computer print-out. Some of the staff have expressed concern when the "No Response" entries exceeded 20% or more of the total.

On such occasions, we have reprocessed the entire set of response sheets by hand, and we have shown that the failure of the mark-sense reader to pick up some responses has made no significant difference to the overall result - in other words, the "missing responses" have exactly the same pattern as that shown in the print-out. We repeated this test on several occasions, always with the same result (MacGuire, 11).

6.3 Looking at Lecturers through the Participant Observation

The lecturing behaviours of 13 lecturers for this course were observed by using the "*Observation Schedule for Lecturing Behaviours*" (Appendix 3, Page326). The ratings were mainly concerned with : (i) the audibility of voice and the quality of blackboard writing, (ii) uses of humour and asides, (iii) giving instructional cues, (iv) wait-time and (v) focussing and (vi) the lecturing pace.

There were altogether 79 lectures, divided into 13 blocks given by 12 different lecturers (One of them taught two different blocks of lecture course). Lectures were given to about 250 students in a theatre with a capacity for 400 and each lecture duration was 50 minutes. Due to the large class size, it was divided into two teaching groups taught by the same lecturer, one in the morning and another in the afternoon.

Three lectures were randomly chosen from each lecturer and all the frequencies of lecturing behaviours which were concerned with the above variables were investigated and coded. In addition, the observed lecture was tape-recorded and transcribed so that the information units, frequencies and length of pauses and verbal cues could be determined and the transcripts were also used for the cross check on the other variables observed.

6.4 Looking at Lecturers through the Eyes of Staff Members

From 1988 to 1991, the staff in the Department of Chemistry have been using our student rating forms for nearly three full sessions. At the end of the second term (March 1991), we carried out a detailed survey of staff opinions of student rating of courses and lecturers within this department.

It was intended to investigate if the accuracy of students' perceptions of a lecturer's performance, (as measured by the average ratings awarded, and by the number and the nature of written-in comments), would match the lecturers' impressions of their own lecturing effectiveness.

We produced a list of 60 statements sub-divided into eight categories to seek the opinions of staff members about the student evaluation exercise. Since the task of rating all 60 statements would take too long, we then created three separate questionnaire forms, each having 30 statements, randomly arranged (Appendix 22 , Page 410). These different questionnaire forms were issued randomly to all academic staff in the Chemistry Department and the staff were allowed to make formal comments about students' rating of courses and lecturers.

6.5 Investigation of Students' Note-taking Behaviours

6.5.1 Subjects

Subjects were obtained through the cooperation of the class-head of the First-year Ordinary Chemistry course at the Chemistry Department, University of Glasgow. All subjects were randomly selected from the name list of students who registered in the above course.

This produced a total subject pool of 35, from which three subjects were eventually dropped out because of missing data. Of the 32 subjects for whom complete scores were available, 15 were male and 17 were female.

6.5.2 Criterion Measures

The criterion measure for X-space (the working memory capacity) was the Digit Backward Test, adapted from the standardised procedure for adults developed by Jensen (152).

The criterion measure for cognitive style, i.e., field-dependence / field-independence was the HFT (Hidden Figures Test).

Finally, the classification of students into different motivational styles was carried out by asking the subjects to respond to the "*Motivational Style Selection Grid*" (see **Section 4.4.2.2**, and Page 101).

6.5.3 The Procedure

All tests were administered in groups of four to six students. Since commercial versions of these tests are not available, the procedures involved are described as follows.

6.5.3.1 Selecting the Student Sample

In October 1990 when the first term started, the name list of all first year science students who registered in the Ordinary Chemistry course (total 519), was used to select a random sample of 35 students. Later they were contacted in a small group basis (from 4 to 6 students in a group) and after giving their consent to cooperate in this study, they were immediately given all the above tests. At first, they were "warmed up" by the Digit Forward Test and then the Digit Backward Test which took about 7 minutes. And subsequently, they were given the Hidden Figures Test and the Motivational Style Test, which lasted 30 minutes.

There were 35 students who were selected for the sample but one dropped out due to illness and two of them were also dropped out because they didn't hand in their lecture notes since the very beginning, so the total number of student sample was 32.

6.5.3.2. Measurement of Working Memory Capacity

In the Digit Backward Test, both the instructions and the actual series were tape-recorded. A warm-up period was presented first by using the Digit Forward Test, in which subjects were asked to repeat, in succession, from two-digit series through to eight-digit series. The rate of presentation was one digit per second.

Following this warm-up, subjects were asked to repeat, again in succession but this time in reverse order, from two-digit series to eight-digit series. In order to obtain a DBT score that could be regarded as a valid measure of working memory space, students had to be tested under rigorously controlled conditions.

And the results of the present test are as follows :

Category	Number of students
Low Working Memory Capacity ------------------ *(X = 4 or 5)*	*12*
Average Working Memory Capacity -------------- *(X = 6)*	*15*
High Working Memory Capacity ------------------ *(X= 7 or 8)*	*8*

6.5.3.3 Measure of Students' Degree of Field-dependence and Field-independence

The Hidden Figures Test was administered to all the 35 students targeted as the sample. The subjects were requested to identify and outline the specific simple shape which has been embedded in the complex figures. There are altogether 18 complex figures, with two additional complex figures to serve as examples.

From this sample, **11** students who scored in the top third of the distribution on the Hidden Figure Test ($\geq$ 14) were categorised as field-independent subjects. **8** students who scored in the bottom third of the distribution ($\leq$ 9) were categorised as the field-dependent subjects; and the other **16** students who scored in between were categorised as field-neutral subjects.

6.5.3.4 Classification of Students' Motivational Styles

The Motivational Style Test - a selection grid, was used to assign a student to a particular motivational style. The subjects were asked to select optionally up to five descriptions which they felt most closely fitted their own feelings about learning.

In this grid, there are sixteen statements which are composed of four categories of motivational attitudes, with four items in each category. By inspecting the response clusters, it is possible to categorise a student into a specific motivational style. The results of this test are shown as follows :

Motivational style		Number of students
Achiever (A)	----------------------------------	*6*
Conscientious (Con)	----------------------------------	*16*
Curious (Cu)	----------------------------------	*8*
Sociable (S)	----------------------------------	*5*

6.5.3.5 The Sample and the Whole Class

The student sample was subdivided into different groups according to their working memory space, field-dependent / field-independent style and motivational style as shown in TABLE 6-1.

Since the evaluation of lecturers was carried out by random samples instead of the whole class, it was necessary to check the reliability of the results of students' ratings. In October, the rating was carried out among the whole class and the sample of this present study respectively. The results have the same patterns of overall rating and there are no significant differences found between them (TABLE 6-2).

Similar exercises have been carried out on several occasions and the results showed that the overall rating by a random sample of students of more than 30 is almost the same as the overall rating by the whole class. And it has also been found in all of these cases, the subjects of the study always have the same patterns as other samples of whole class.

Besides, the gender percentages (male : 47 %, female : 53 %) of the subjects and the whole class (male 49 %, female 51 %) showed no significant differences either. As regards the first class exam scores, the subjects have an average of 53.3 and the average of whole class is 54.0 , there is no significant difference found between them.

To sum up, the subjects selected in this present study could be seen as representative of the whole class.

6.5.3.6 Inspection of Students' Lecture Notes

After the subjects had completed the three tests, the researcher made arrangements with them about how their lecture notes should be collected. From the second week in

TABLE 6-1. Classifying the 32 Students into Different Groups

Working Memory Capacity	Cognitive Style	Student	Motivational Style			
			A	Con	Cu	S
LOW (X = 4 X = 5)	FD (3)	S 1		V		
		S 2		V		
		S 3		V		
	FN (4)	S 4	V			
		S 5			V	
		S 6		V		
		S 7		V		
	FI (5)	S 8				V
		S 9		V		
		S 10		V		
		S 11		V		
		S 12		V		
MIDDLE (X = 6)	FD (3)	S 13		V		
		S 14		V		
		S 15		V		
	FN (2)	S 16		V		
		S 17			V	
	FI (3)	S 18	V			
		S 19			V	
		S 20				V
HIGH (X = 7)	FD (3)	S 21	V			
		S 22		V		
		S 23				V
	FN (3)	S 24		V		
		S 25			V	
		S 26	V			
	FI (6)	S 27				V
		S 28			V	
		S 29			V	
		S 30			V	
		S 31	V			
		S 32		V		

*** Cognitive Styles : FD = Field Dependent FN = Field Neutral FI = Field Independent

Motivational Styles : A = Achiever Con = Conscientious

Cu = Curious S = Sociable

TABLE 6 - 2. Comparison of the Overall Rating between the Sample and the Whole Class

DATE = 3 / 11 / 90 COURSE = L 1 N = 32

(Observed values -- the response of the sample N = 32)

	1	2	3	4	5	TOTAL
ITEM 1	1	3	23	5	0	32
ITEM 2	0	3	16	11	1	31
ITEM 3	1	7	18	4	2	32
ITEM 4	1	9	17	5	0	32
ITEM 5	5	6	13	7	1	32
ITEM 6	5	20	4	3	0	32
ITEM 7	0	4	11	14	2	31
ITEM 8	1	10	13	6	2	32
ITEM 9	0	13	12	4	2	31
ITEM 10	1	15	8	7	1	32
ITEM 11	3	11	12	4	2	32
ITEM 12	2	6	12	8	4	32
ITEM 13	1	3	12	5	10	32
ITEM 14	0	5	11	8	8	32
ITEM 15	3	8	11	5	5	32
ITEM 16	2	1	10	13	6	32
ITEM 17	0	5	11	11	5	32
ITEM 18	1	11	5	3	2	32
ITEM 19	0	5	18	6	3	32
ITEM 20	1	17	12	2	0	32
ITEM 21	3	20	9	0	0	32
ITEM 22	3	4	10	13	2	32

(Expected values -- calculated from the whole class N = 487)

	1	2	3	4	5	TOTAL
ITEM 1	1	5	19	6	1	32
ITEM 2	0	3	19	8	1	31
ITEM 3	1	6	17	7	2	32
ITEM 4	1	7	18	5	1	32
ITEM 5	3	10	13	5	1	32
ITEM 6	4	17	6	4	1	32
ITEM 7	1	4	13	11	2	31
ITEM 8	1	9	12	8	2	32
ITEM 9	2	12	11	5	1	31
ITEM 10	2	12	11	5	2	32
ITEM 11	3	10	13	4	2	32
ITEM 12	1	8	10	10	3	32
ITEM 13	2	3	8	11	8	32
ITEM 14	1	3	6	14	8	32
ITEM 15	2	9	11	7	3	32
ITEM 16	2	5	8	13	4	32
ITEM 17	0	4	11	11	6	32
ITEM 18	2	13	11	5	1	32
ITEM 19	0	4	16	8	4	32
ITEM 20	2	17	11	2	0	32
ITEM 21	7	17	7	1	0	32
ITEM 22	4	5	10	10	3	32

$\Sigma (\chi)^2$
2.1
1.5
1.2
0.8
3.7
2.3
1.3
0.7
0.2
3.4
0.2
2.6
6.3
7.0
2.5
4.7
0.4
4.1
1.3
0.6
4.2
1.7

*** There is no significant difference found in any response item between the sample and the whole class.

the first term, the lecture notes of the subjects were collected from time to time without prior warning, sometimes in the afternoon after the students had attended the morning lecture and sometimes the next day.

Since the way students used their lecture notes was a very important factor in this present study, the whole sets of students' lecture notes were once again collected at the end of the first term for further examination.

By attending the lecture, the researcher obtained an exact copy of what appeared on the blackboard and the materials presented with audio-visual aids. The above materials were analysed into information units and used to check those each student had recorded.

The tape-recording of each lecture was transcribed so that the information units presented verbally could be analysed and used to check those which each student had recorded in his / her notes.

At least three sets of lecture notes (from each lecturer) were borrowed from all the subjects and xeroxed for examination. The content of these lecture notes is summarised as follows :

Lecturer 1 (Thermodynamics)

1. Hess's Law and average bond dissociation energy.
2. Direction of change and entropy change.
3. The Second Law of Thermodynamics.

Lecturer 2 (Atoms and Molecules I)

1. Formal charge and electrical dipole moment.
2. Electronegativity and Lewis formulae for pclyatomic molecule.
3. The application of Lewis formulae to write the molecular

structure.

Lecturer 3 (Organic Chemistry I)

1. Systematic nomenclature of alkanes and chirality and configuration.
2. Racemate and enantiomers; Preparation and property of alkyl halides.
3. Alcohols and the property of alkenes.

Lecturer 4 (Atoms and Molecules II)

1. The electronic structure of atoms and energy levels in the H atom.
2. Electromagnetic radiation and Rydberg equation.
3. Line spectra and spectra of many electron atoms.

Lecturer 5 (Chemical Kinetics)

1. Average reaction rate and the unit of reaction rate.
2. Reaction rate and rate law.
3. Temperature dependence of reaction rate.

Lecturer 6 (Phase Equilibria)

1. Surface tension and dynamic equilibrium.
2. Phase diagrams and relative lowering of boiling point.
3. Osmotic pressure and its application.

Lecturer 7 (Inorganic Chemistry I)

1. Inert gases : occurrence, uses and compounds.
2. Disproportionation reactions, interhalogens, polyhalides and oxyacids of halogens.
3. Nitrogen group and oxygen group.

Lecturer 8 (Organic Chemistry II)

1. Ester and its derivatives.
2. The structure, property and reactions of benzene.
3. Carboxylic acid and its derivatives.

6.6 Diary-Interview with Students

In order to understand what students actually do with their lecture notes and how they make use of the product of note-taking, the diary-interview method was adopted in our research from November 1990.

Prior arrangements were made such that at least two interviews with each subject were taken during the whole period. Each interview lasted from 10 - 30 minutes respectively in which the researcher enquired of the particular student such things as :

(1) Any specific problems found in that subject's lecture notes to check whether any note-encoding had been used when taking notes.

(2) Any individual difficulties in following lectures due to lecturing conditions in a specific lecturer's course.

(3) What they have done to the recorded notes.

(4) How they have made use of the notes.

6.7 Students' Note-taking Behaviours In General

Although the 32 students seemed to be a random sample being representative of the whole class, it was felt more appropriate to undertake a general survey in order to understand what the students in general feel about note-taking during lectures. The questionnaire is composed of five questions with several sample optional choices to induce students to express their views (see Appendix 19, Page 387).

In this survey, students were asked about the purpose of note-taking during lectures, their opinions about having complete handouts, how they select the essential lecture information to take down, how they use the lecture notes and for what purpose, and any features of lectures that they would like to see changed to enable them to take satisfactory notes.

On the eighth and ninth weeks of the first term, the questionnaire sheets were distributed to each student when they went into the lab. Students were then requested to write their responses to those five questions and the researcher immediately collected the completed questionnaire sheets before the laboratory started.

A total of 427 questionnaire sheets was distributed and 353 questionnaire sheets were returned. After inspection, 34 questionnaire were found to be spoiled or blank and so they were not used for analysis. Finally 319 questionnaire sheets were examined and the response rate was 75 %.

CHAPTER SEVEN

Testing Hypotheses and Results

7.1 Students' Perceptions of the Effectiveness of Lecturers

In the following section, the accuracy of students' perceptions of a lecturer's performance, as measured by the average ratings awarded, and by the number and the nature of written-in comments, would be compared with the participant observation ratings by the researcher and also subjected to the judgement from lecturers' own impressions of overall lecturing effectiveness.

7.1.1 Testing Hypothesis 1

For convenience, the hypothesis was restated as follows:
"Students' ratings provide reliable measures of overall lecturing performance."

7.1.1.1 Data Analysis and Results

For each separate lecturer, the actual and percentage frequency of the student response, for each rating on the rating scale, was calculated for all **22** statements appearing on the sheet. For example, a typical summary data table such as **Lecturer 1** is shown in TABLE 7-1.

As stated in a previous analysis (Chapter Two), for the ordinal scale of categories, it is more appropriate and more valid to use the Chi-Square (χ^2) test and the Spearman Rank Order correlation coefficient (r_0), to make comparisons between the lecturers. Because in this rating scale, each factor was examined by at least two questions to allow us to check for internal consistency. If the student response was capricious, it would show up in statistical clashes within each dimension resulting in low correlations.

TABLE 7-1. A Typical Data of the Lecture Course - L 1

DATE = 25 / 10 / 90 COURSE = L 1 N = 463

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	16	72	279	86	9	462
ITEM 2	0	40	282	123	12	457
ITEM 3	9	92	242	95	24	462
ITEM 4	8	103	266	74	10	461
ITEM 5	42	141	197	70	12	462
ITEM 6	58	248	90	59	9	464
ITEM 7	18	54	195	160	23	450
ITEM 8	18	128	174	113	28	461
ITEM 9	27	178	161	75	13	454
ITEM 10	22	180	160	70	25	457
ITEM 11	46	127	186	61	27	447
ITEM 12	17	113	137	141	47	455
ITEM 13	11	50	119	156	120	456
ITEM 14	11	50	90	201	109	461
ITEM 15	22	130	159	107	40	458
ITEM 16	26	70	122	187	58	463
ITEM 17	4	56	161	160	82	463
ITEM 18	31	181	158	70	21	461
ITEM 19	6	50	227	112	59	454
ITEM 20	27	239	160	29	3	458
ITEM 21	114	234	99	9	2	458
ITEM 22	50	76	138	117	62	443

(Percentage values)

	1	2	3	4	5	TOTAL
ITEM 1	3	16	60	19	2	100
ITEM 2	0	9	62	27	2	100
ITEM 3	2	20	52	21	5	100
ITEM 4	2	22	58	16	2	100
ITEM 5	9	31	43	14	3	100
ITEM 6	13	53	19	13	2	100
ITEM 7	4	12	43	36	5	100
ITEM 8	4	28	37	25	6	100
ITEM 9	6	39	35	17	3	100
ITEM 10	5	40	35	15	5	100
ITEM 11	10	28	42	14	6	100
ITEM 12	4	25	30	31	10	100
ITEM 13	2	11	26	35	26	100
ITEM 14	2	11	20	43	24	100
ITEM 15	5	28	35	23	9	100
ITEM 16	6	15	26	40	13	100
ITEM 17	1	12	35	34	18	100
ITEM 18	7	39	34	15	5	100
ITEM 19	1	11	50	25	13	100
ITEM 20	6	52	35	6	1	100
ITEM 21	25	50	22	2	1	100
ITEM 22	11	17	32	26	14	100

The procedure for testing the statistical significance of all twenty-two items for the 13 separate lecturers and the inter-correlations between the twenty-two statements on the student response sheet was described as follows :

(1) Calculating the composite totals for the whole course by using the completed response sheets which had been collected from students during the period of the third phase study. TABLE 7-2 shows the results of calculation. This norm was used as a datum line against which individual lecturer ratings were then compared.

(2) Computing the expected frequencies for all 22 items by using the observed frequencies (viz. the actual frequencies, such as in TABLE 7-2). For

instance, we can use the actual frequencies for item **1** (for the 1098 students given in TABLE 7-2) to calculate the expected frequencies for item **1** (for the 462 students in TABLE 7-1). The expected frequencies will be (462 / 1098) times the actual frequencies (i.e. '29', '204', '655', '175' and '35') given in TABLE 7-2, and the results are : '12', '86', '275', '74' and '15' respectively.

TABLE 7-2. The Composite Totals for the Whole Course

DATE = 27 / 3 / 91 COURSE = All N = 1121

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	29	204	655	175	35	1098
ITEM 2	11	111	701	249	22	1094
ITEM 3	49	221	664	132	28	1094
ITEM 4	56	363	483	148	46	1096
ITEM 5	90	223	334	312	132	1091
ITEM 6	128	594	231	110	36	1099
ITEM 7	43	101	346	475	117	1082
ITEM 8	51	304	481	209	46	1091
ITEM 9	116	501	320	112	34	1083
ITEM 10	82	480	354	123	49	1088
ITEM 11	66	254	538	143	64	1065
ITEM 12	154	379	239	210	101	1083
ITEM 13	167	278	242	226	168	1081
ITEM 14	111	249	224	321	187	1092
ITEM 15	116	408	290	186	88	1088
ITEM 16	62	121	222	463	226	1094
ITEM 17	48	220	419	267	142	1096
ITEM 18	128	490	321	106	41	1086
ITEM 19	128	313	419	140	82	1082
ITEM 20	126	609	287	53	16	1091
ITEM 21	241	559	238	43	9	1090
ITEM 22	89	138	261	292	283	1063

(Percentage values)

	1	2	3	4	5	TOTAL
ITEM 1	3	19	60	15	3	100
ITEM 2	1	10	64	23	2	100
ITEM 3	4	20	61	12	3	100
ITEM 4	5	33	44	14	4	100
ITEM 5	8	20	31	29	12	100
ITEM 6	12	54	21	10	3	100
ITEM 7	4	9	32	44	11	100
ITEM 8	5	28	44	19	4	100
ITEM 9	11	46	30	10	3	100
ITEM 10	8	43	33	11	5	100
ITEM 11	6	24	51	13	6	100
ITEM 12	14	36	22	19	9	100
ITEM 13	15	27	22	21	15	100
ITEM 14	10	23	21	29	17	100
ITEM 15	11	37	27	17	8	100
ITEM 16	6	11	20	42	21	100
ITEM 17	4	20	39	24	13	100
ITEM 18	12	44	30	10	4	100
ITEM 19	12	29	38	13	8	100
ITEM 20	12	56	26	5	1	100
ITEM 21	22	51	22	4	1	100
ITEM 22	8	13	25	27	27	100

TABLE 7-3 shows the results of calculating the expected frequencies for all 22 items. (The observed frequencies are, of course, the same as the actual frequencies shown in TABLE 7-1).

(3) Calculating the value of Chi-square for each item in TABLE 7-3 by using the following formula

$$\chi^2 = \Sigma \{ (O - E)^2 / E \}$$

where O = the observed value

and E = the expected value

TABLE 7-3. The Observed Frequencies and the Expected Frequencies of the Lecture Course - L1

DATE = 27 / 3 / 91 COURSE = L 1 N = 463

(Observed values)

	1	2	3	4	5	TOTAL
ITEM 1	16	72	279	86	9	462
ITEM 2	0	40	282	123	12	457
ITEM 3	9	92	242	95	24	462
ITEM 4	8	103	266	74	10	461
ITEM 5	42	141	197	70	12	462
ITEM 6	58	248	90	59	9	464
ITEM 7	18	54	195	160	23	450
ITEM 8	18	128	174	113	28	461
ITEM 9	27	178	161	75	13	454
ITEM 10	22	180	160	70	25	457
ITEM 11	46	127	186	61	27	447
ITEM 12	17	113	137	141	47	455
ITEM 13	11	50	119	156	120	456
ITEM 14	11	50	90	201	109	461
ITEM 15	22	130	159	107	40	458
ITEM 16	26	70	122	187	58	463
ITEM 17	4	56	161	160	82	463
ITEM 18	31	181	158	70	21	461
ITEM 19	6	50	227	112	59	454
ITEM 20	27	239	160	29	3	458
ITEM 21	114	234	99	9	2	458
ITEM 22	50	76	138	117	62	443

(Expected values)

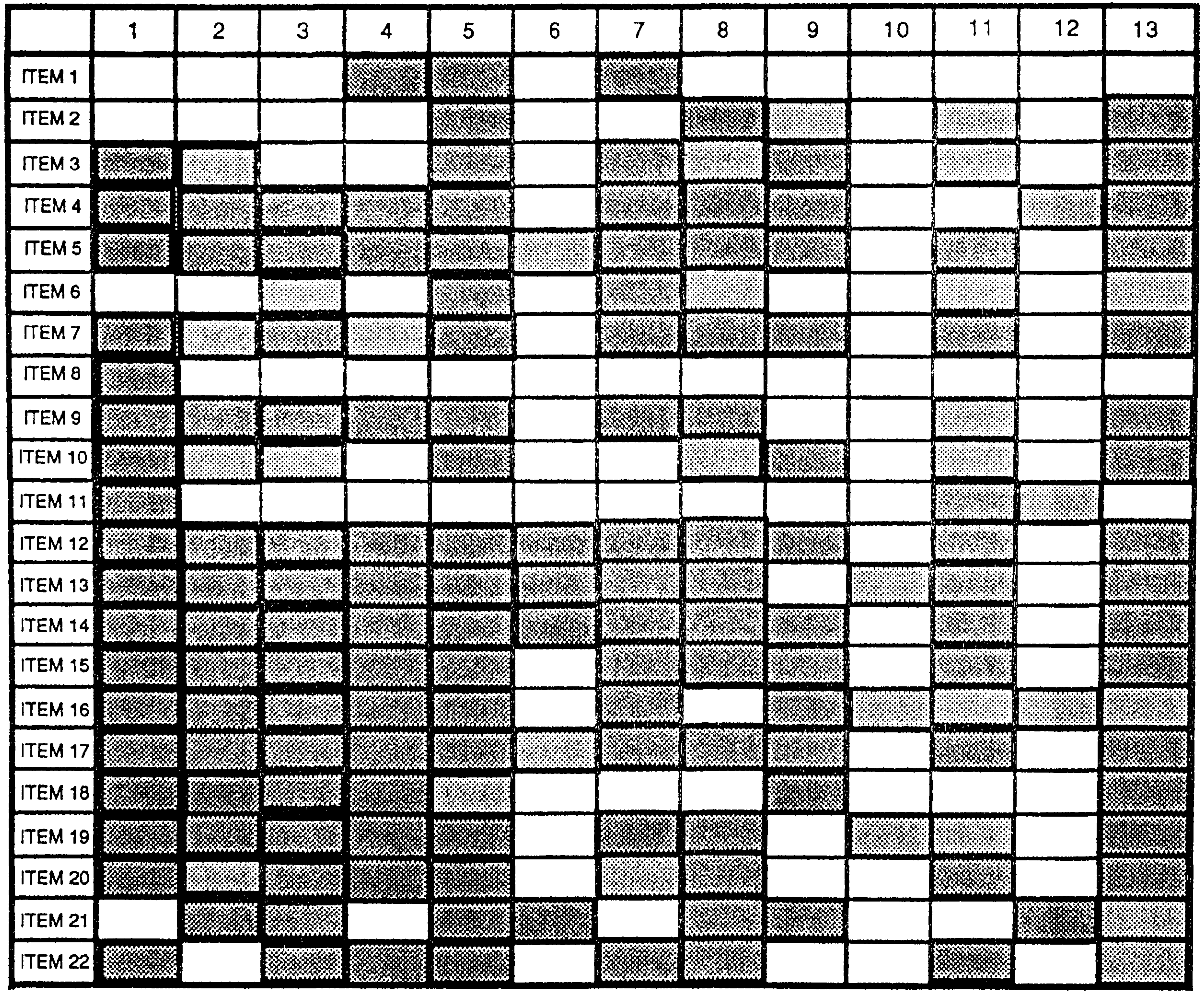
	1	2	3	4	5	TOTAL
ITEM 1	12	86	275	74	15	462
ITEM 2	5	46	293	104	9	457
ITEM 3	21	93	280	56	12	462
ITEM 4	24	153	203	62	19	461
ITEM 5	38	94	142	132	56	462
ITEM 6	54	251	98	46	15	464
ITEM 7	18	42	143	198	49	450
ITEM 8	22	128	204	88	19	461
ITEM 9	49	210	134	47	14	454
ITEM 10	34	202	148	52	21	457
ITEM 11	28	107	225	60	27	447
ITEM 12	66	159	100	88	42	455
ITEM 13	71	117	102	95	71	456
ITEM 14	47	105	95	135	79	461
ITEM 15	49	172	122	78	37	458
ITEM 16	26	51	94	196	96	463
ITEM 17	20	93	177	113	60	463
ITEM 18	54	208	137	45	17	461
ITEM 19	54	131	176	59	34	454
ITEM 20	53	256	120	22	7	458
ITEM 21	101	235	100	18	4	458
ITEM 22	37	58	108	122	118	443

TABLE 7-4 shows the levels of significance of all **22** items for the **13** separate Lecturer **1, 2, 3** ... and **13**. In this table, the shadings are used to highlight those lecturers who were significantly different from what would be expected if all of the lecturers were of the same quality (i.e., the overall norm).

(4) Estimating the "measurement of agreement" (i.e. the percentage bias) for each item by ignoring any ' 3 ' ratings and calculating the value of { ('4' + '5') - ('1' + '2') }. Because students were asked to rate the given 22

TABLE 7 - 4. The Levels of Significance of All 22 Items for 13 Separate Lecturers

(→ significant at the 0.01 level, and → significant at the 0.05 level)



items on the assumption that, unless it said otherwise, a rating of ' 5 ' indicated strong agreement, and a rating of ' 1 ' indicated strong disagreement, a high positive rating in an item (i.e. strong agreement) indicated that a lecturer is rated as good in that particular item.

For items **1**, **2** and **3**, the <u>optimum rating</u> would be ' 3 ' or " about right ", so the "measurement of agreement" was calculated as the value of { '3' - ('1' + '2' + '3' + '4') }.

And for items **5**, **7**, **16** and **22**, because of the wording of the statement, the polarity of rating was actually reversed, in other words, a negative rating is in fact better than a positive rating. The overall "measurement of agreement" for the 22 items is shown in TABLE 7-5.

(5) Arranging the lecturers in a rank order by using the information given in TABLE 7-5. For the items belonging to the same dimension, the "measurement of agreement", going from positive values through zero to negative values, should be supposed to predict the same rank order. TABLE 7-6 shows the results of rank orders based upon the "percentage bias" values.

(6) Calculating the Spearman rank order correlation coefficient, r_0, to estimate the degree of inter-correlation between each item in the response sheet, using the rank orders given in TABLE 7-6.

The formula for the Spearman rank order correlation coefficient is :

$$r_0 = 1 - \Sigma \{ 6 d^2 / N (N^2 - 1) \}$$

where d = the numerical difference between corresponding ranks

N = the sample size (i.e. 13 in this case)

The results are shown in TABLE 7-7 and the significant results are shown by shading in this table. From a visual inspection of this table, it is clear that the block of eleven statements which refer to <u>Lecturer Characteristics</u> (i.e. the statements **12, 13, 14** ... and **22**) are all strongly related to each other, and also to Statements **1, 2** and **4.**

TABLE 7-5. The Overall "Measurement of Agreement" for the 22 Items for All the 13 Lecturers

	1	2	3	4	5	6	7	8	9	10	11	12	13
ITEM 1	+ 20	+ 46	+ 38	+ 22	- 36	+ 8	+ 24	+ 18	+ 22	+ 10	+ 22	+ 36	+ 24
ITEM 2	+ 24	+ 36	+ 30	+ 29	+ 14	+ 42	+ 26	+ 26	+ 22	+ 38	+ 12	+ 30	+ 78
ITEM 3	+ 4	+ 64	+ 54	+ 18	- 38	+ 20	+ 78	+ 16	- 42	+ 42	+ 58	+ 18	+ 96
ITEM 4	+ 6	+ 54	+ 65	+ 72	- 60	+ 3	+ 69	+ 68	- 31	+ 38	+ 50	- 16	+ 72
ITEM 5	+ 23	- 68	- 91	- 78	+ 82	+ 10	- 71	- 87	+ 29	- 36	- 81	+ 8	- 73
ITEM 6	+ 51	+ 63	+ 69	+ 78	- 19	+ 39	+ 93	+ 58	+ 23	+ 65	+ 81	+ 23	+ 86
ITEM 7	- 25	- 71	- 74	-58	+ 18	- 50	- 85	- 77	- 15	- 56	- 75	- 35	- 73
ITEM 8	+ 1	+ 27	+ 13	+ 12	+ 21	+ 18	- 9	+ 33	- 7	+ 18	+ 17	0	+ 26
ITEM 9	+ 25	+ 77	+ 77	+ 86	- 17	+ 39	+ 68	+ 83	+ 37	+ 52	+ 63	+ 29	+ 85
ITEM 10	+ 25	+ 64	+ 66	+ 53	- 20	+ 42	+ 57	+ 69	- 1	+ 41	+ 63	+ 20	+ 81
ITEM 11	+ 18	+ 25	+ 26	+ 24	+ 21	+ 5	- 8	- 2	- 10	- 21	- 20	- 18	- 8
ITEM 12	- 12	+ 82	+ 88	+ 92	- 80	+ 10	+ 77	+ 88	- 35	+ 35	+ 94	+ 6	+ 85
ITEM 13	- 48	+ 54	+ 87	+ 76	- 62	- 8	+ 69	+ 92	- 19	+ 56	+ 90	+ 12	+ 98
ITEM 14	- 54	+ 39	+ 78	+ 54	- 88	- 49	+ 49	+ 81	- 71	0	+ 71	- 32	+ 65
ITEM 15	+ 1	+ 62	+ 76	+ 84	- 71	+ 12	+ 72	+ 67	- 21	+ 41	+ 79	- 5	+ 83
ITEM 16	- 32	- 88	- 90	- 90	- 1	- 56	- 75	- 65	0	- 41	- 58	- 6	- 83
ITEM 17	- 39	+ 11	+ 53	+ 28	- 70	- 38	+ 20	+ 54	- 53	- 9	+ 53	- 29	+ 64
ITEM 18	+ 26	+ 74	+ 73	+ 94	+ 18	+ 56	+ 55	+ 56	+ 10	+ 67	+ 45	+ 23	+ 94
ITEM 19	- 26	+ 56	+ 91	+ 69	- 39	+ 40	+ 64	+ 94	+ 23	+ 59	+ 85	+ 36	+ 75
ITEM 20	+ 51	+ 84	+ 90	+ 94	- 10	+ 68	+ 87	+ 87	+ 53	+ 59	+ 71	+ 41	+ 94
ITEM 21	+ 72	+ 81	+ 88	+ 80	- 10	+ 50	+ 81	+ 96	+ 41	+ 65	+ 85	+ 35	+ 94
ITEM 22	- 12	- 50	- 82	- 82	+ 39	- 25	- 78	- 75	- 25	- 31	- 73	- 29	+ 76

TABLE 7-6. The Rank Order of the 13 Lecturers Involved in This Lecture Course

	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13
ITEM 1	9	1	2	7	13	12	4.5	10	7	11	7	3	4.5
ITEM 2	10	4	5.5	7	12	2	8.5	8.5	11	3	13	5.5	1
ITEM 3	11	3	5	8.5	12	7	2	10	13	6	4	8.5	1
ITEM 4	9	6	5	1.5	13	10	3	4	12	8	7	11	1.5
ITEM 5	11	7	1	4	13	10	6	2	12	8	3	9	5
ITEM 6	9	7	5	4	13	10	1	8	11.5	6	3	11.5	2
ITEM 7	11	6	4	7	13	9	1	2	12	8	3	10	5
ITEM 8	10	2	8	9	4	5.5	13	1	12	5.5	7	11	3
ITEM 9	12	4.5	4.5	1	13	9	6	3	10	8	7	11	2
ITEM 10	10	4	3	7	13	8	6	2	12	9	5	11	1
ITEM 11	5	2	1	3	4	6	8.5	7	10	13	12	11	8.5
ITEM 12	11	6	3.5	2	13	9	7	3.5	12	8	1	10	5
ITEM 13	12	8	4	5	13	10	6	2	11	7	3	9	1
ITEM 14	11	7	2	5	13	10	6	1	12	8	3	9	4
ITEM 15	10	7	4	1	13	9	5	6	12	8	3	11	2
ITEM 16	10	3	1.5	1.5	12	8	5	6	13	9	7	11	4
ITEM 17	11	7	3.5	5	13	10	6	2	12	8	3.5	9	1
ITEM 18	10	3	4	1.5	12	6.5	8	6.5	13	5	9	11	1.5
ITEM 19	12	8	2	5	13	9	6	1	11	7	3	10	4
ITEM 20	11	6	3	1.5	13	8	4.5	4.5	10	9	7	12	1.5
ITEM 21	8	5.5	3	7	13	10	5.5	1	11	9	4	12	2
ITEM 22	12	7	1.5	1.5	13	10.5	3	5	10.5	8	6	9	4

TABLE 7 - 7. The Inter-correlations Between Each of the of 22 Items for the Whole Course

([dark shading] → significant at the 0.01 level, and [light shading] → significant at the 0.05 level)

	ITEM 1	ITEM 2	ITEM 3	ITEM 4	ITEM 5	ITEM 6	ITEM 7	ITEM 8	ITEM 9	ITEM 10	ITEM 11	ITEM 12	ITEM 13	ITEM 14	ITEM 15	ITEM 16	ITEM 17	ITEM 18	ITEM 19	ITEM 20	ITEM 21	ITEM 22
ITEM 1		0.24	0.55	0.42	- 0.42	0.42	-0.39	-0.21	0.42	0.44	0.19	0.36	0.36	0.40	0.39	-0.51	0.42	0.33	0.31	0.43	0.38	-0.53
ITEM 2			0.51	0.33	-0.15	0.21	-0.12	-0.33	0.39	0.39	0.08	0.13	0.26	0.17	0.25	-0.40	0.29	0.69	0.19	0.38	0.17	-0.25
ITEM 3				0.64	-0.55	0.81	-0.70	0.18	0.56	0.70	-0.05	0.57	0.63	0.56	0.68	-0.66	0.65	0.64	0.54	0.62	0.59	-0.60
ITEM 4					-0.80	0.87	-0.80	0.17	0.93	0.83	0.21	0.80	0.83	0.81	0.92	-0.88	0.87	0.81	0.78	0.94	0.83	-0.89
ITEM 5						-0.72	0.87	-0.22	-0.82	-0.86	-0.13	-0.94	-0.92	-0.99	-0.86	0.82	-0.93	-0.63	-0.97	-0.81	-0.87	0.90
ITEM 6							-0.81	-0.02	0.73	0.72	-0.06	0.76	0.78	0.72	0.90	-0.74	0.78	0.65	0.72	0.80	0.74	-0.81
ITEM 7								-0.17	-0.74	-0.85	0.02	-0.81	-0.85	-0.90	-0.78	0.72	-0.86	-0.51	-0.89	-0.75	-0.86	0.82
ITEM 8									0.33	0.48	0.23	0.26	0.31	0.30	0.15	-0.25	0.34	0.45	0.21	0.30	0.38	0.01
ITEM 9										0.85	0.24	0.85	0.85	0.83	0.89	-0.88	0.87	0.86	0.83	0.96	0.80	-0.88
ITEM 10											0.20	0.81	0.89	0.90	0.81	-0.82	0.93	0.75	0.88	0.85	0.96	-0.76
ITEM 11												0.10	-0.11	0.07	0.13	-0.05	0.01	0.36	0.39	0.30	0.16	-0.17
ITEM 12													0.89	0.93	0.93	-0.82	0.90	0.68	0.92	0.82	0.81	-0.84
ITEM 13														0.95	0.87	-0.71	0.99	0.65	0.96	0.83	0.88	-0.84
ITEM 14															0.85	-0.77	0.97	0.62	0.98	0.81	0.91	-0.86
ITEM 15																-0.87	0.89	0.78	0.84	0.92	0.80	-0.89
ITEM 16																	-0.77	-0.87	-0.74	-0.90	-0.74	0.88
ITEM 17																		0.69	0.95	0.86	0.92	-0.85
ITEM 18																			0.62	0.83	0.62	-0.70
ITEM 19																				0.82	0.89	-0.85
ITEM 20																					0.82	-0.91
ITEM 21																						-0.74
ITEM 22																						

There are also strong negative correlations between the above statements and Statement 5, referring to the overall rating for the lecturer. When one realises, for Statement **5**, a rating of ' 1 ' was "very poor", then a negative correlation is easily explained.

7.1.1.2 Checking the Reliability of Students' Ratings

Reliability involves the consistency, dependency or stability of data.

(1) From the above analysis, the inter-correlations between the statements within any one factor dimension were extremely high (typically greater than 0.70), indicating that students' rating of the course and the lecturers was reliable.

(2) TABLE 7-8 shows the results of consistency check which were carried out on the data for Lecturer **1**, data from the morning group were processed separately from data from the afternoon group. A visual inspection of the results has verified that different students from the same class show a high level of agreement in their ratings of a given lecture course and that lecturer.

(3) Since one of the lecturers contributed to two different lecture blocks of lecture (i.e., block 8 and block 11 were taught by the same lecturer), students' ratings on the same lecturer on two different blocks of lecture were found very similar as seen from the *bar charts* of lecturer performance in Figure 7-1.

(4) Because this revised rating scale has been used for nearly two full sessions, it is possible to compare the lecturing performance of the same lecturers in two classes of different academic years. When data in session 1989-1990 presented in CHAPTER FIVE (PP. 122 - 123), where the profiles of the lecturers shown as bar charts, are compared with the profiles of the same lecturers in this session, their ratings on the two different classes are found to be very similar. For example, Lecturers **2, 3, 4, 7, 8 (11)** and **13**, who received higher ratings as "effective lecturers" in session 1989-1990 also

TABLE 7-8. Data of the Lecture Course - L 1 (Morning Class)

DATE = 25 / 10 / 90 COURSE = L 1 N = 256

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	10	43	151	47	5	256
ITEM 2	0	17	157	70	8	252
ITEM 3	2	51	135	51	13	252
ITEM 4	4	56	146	36	8	250
ITEM 5	25	78	106	34	9	252
ITEM 6	26	137	53	33	6	255
ITEM 7	10	24	101	96	16	247
ITEM 8	12	67	105	50	18	252
ITEM 9	21	96	83	44	6	250
ITEM 10	14	105	77	41	15	252
ITEM 11	21	71	102	28	20	242
ITEM 12	10	65	71	74	26	246
ITEM 13	7	23	62	85	75	252
ITEM 14	7	27	49	106	60	249
ITEM 15	16	62	86	57	24	245
ITEM 16	12	36	69	100	34	251
ITEM 17	2	31	84	86	48	251
ITEM 18	19	100	81	37	13	250
ITEM 19	5	25	118	57	38	243
ITEM 20	20	124	90	11	2	247
ITEM 21	65	126	53	4	1	249
ITEM 22	30	47	67	58	37	239

(Percentage values)

	1	2	3	4	5	TOTAL
ITEM 1	4	17	59	18	2	100
ITEM 2	0	7	62	28	3	100
ITEM 3	1	20	54	20	5	100
ITEM 4	2	22	58	14	4	100
ITEM 5	10	31	42	13	4	100
ITEM 6	10	54	21	13	2	100
ITEM 7	4	10	41	39	6	100
ITEM 8	5	27	42	20	6	100
ITEM 9	8	38	33	18	3	100
ITEM 10	6	42	31	16	5	100
ITEM 11	9	29	42	12	8	100
ITEM 12	4	26	29	30	11	100
ITEM 13	3	9	25	34	29	100
ITEM 14	3	11	20	43	23	100
ITEM 15	7	25	35	23	10	100
ITEM 16	5	14	27	40	14	100
ITEM 17	1	12	33	34	20	100
ITEM 18	8	40	32	15	5	100
ITEM 19	2	10	49	23	16	100
ITEM 20	8	50	36	4	2	100
ITEM 21	26	50	21	2	1	100
ITEM 22	13	20	28	24	15	100

Data of the Lecture Course - L 1 (Afternoon Class)

DATE = 25 / 10 / 90 COURSE = L 1 N = 207

(Actual values)

	1	2	3	4	5	TOTAL
ITEM 1	6	29	128	39	4	206
ITEM 2	0	23	125	53	4	205
ITEM 3	7	41	107	44	11	210
ITEM 4	8	43	120	38	2	211
ITEM 5	17	63	91	36	3	210
ITEM 6	32	111	37	26	3	209
ITEM 7	8	30	94	64	7	203
ITEM 8	6	61	69	63	10	209
ITEM 9	6	82	78	31	7	204
ITEM 10	8	75	83	29	10	205
ITEM 11	25	56	84	33	7	205
ITEM 12	7	48	66	67	21	209
ITEM 13	4	27	57	71	45	204
ITEM 14	4	23	41	95	49	212
ITEM 15	6	68	73	50	16	213
ITEM 16	14	34	53	87	24	212
ITEM 17	2	25	77	74	34	212
ITEM 18	12	81	77	33	8	211
ITEM 19	6	20	109	55	21	211
ITEM 20	7	115	70	16	3	211
ITEM 21	49	108	46	4	2	209
ITEM 22	20	29	71	59	25	204

(Percentage values)

	1	2	3	4	5	TOTAL
ITEM 1	3	14	62	19	2	100
ITEM 2	0	11	61	26	2	100
ITEM 3	3	20	51	21	5	100
ITEM 4	4	20	57	18	1	100
ITEM 5	8	30	43	18	1	100
ITEM 6	15	53	18	13	1	100
ITEM 7	4	15	46	32	3	100
ITEM 8	3	29	33	30	5	100
ITEM 9	3	40	39	15	3	100
ITEM 10	4	37	40	14	5	100
ITEM 11	12	27	41	16	4	100
ITEM 12	3	23	32	32	10	100
ITEM 13	2	13	28	35	22	100
ITEM 14	2	11	19	45	23	100
ITEM 15	3	32	34	23	8	100
ITEM 16	7	16	25	41	11	100
ITEM 17	1	12	36	35	16	100
ITEM 18	6	38	36	16	4	100
ITEM 19	3	9	52	26	10	100
ITEM 20	3	55	33	8	1	100
ITEM 21	23	52	22	2	1	100
ITEM 22	10	14	35	29	12	100

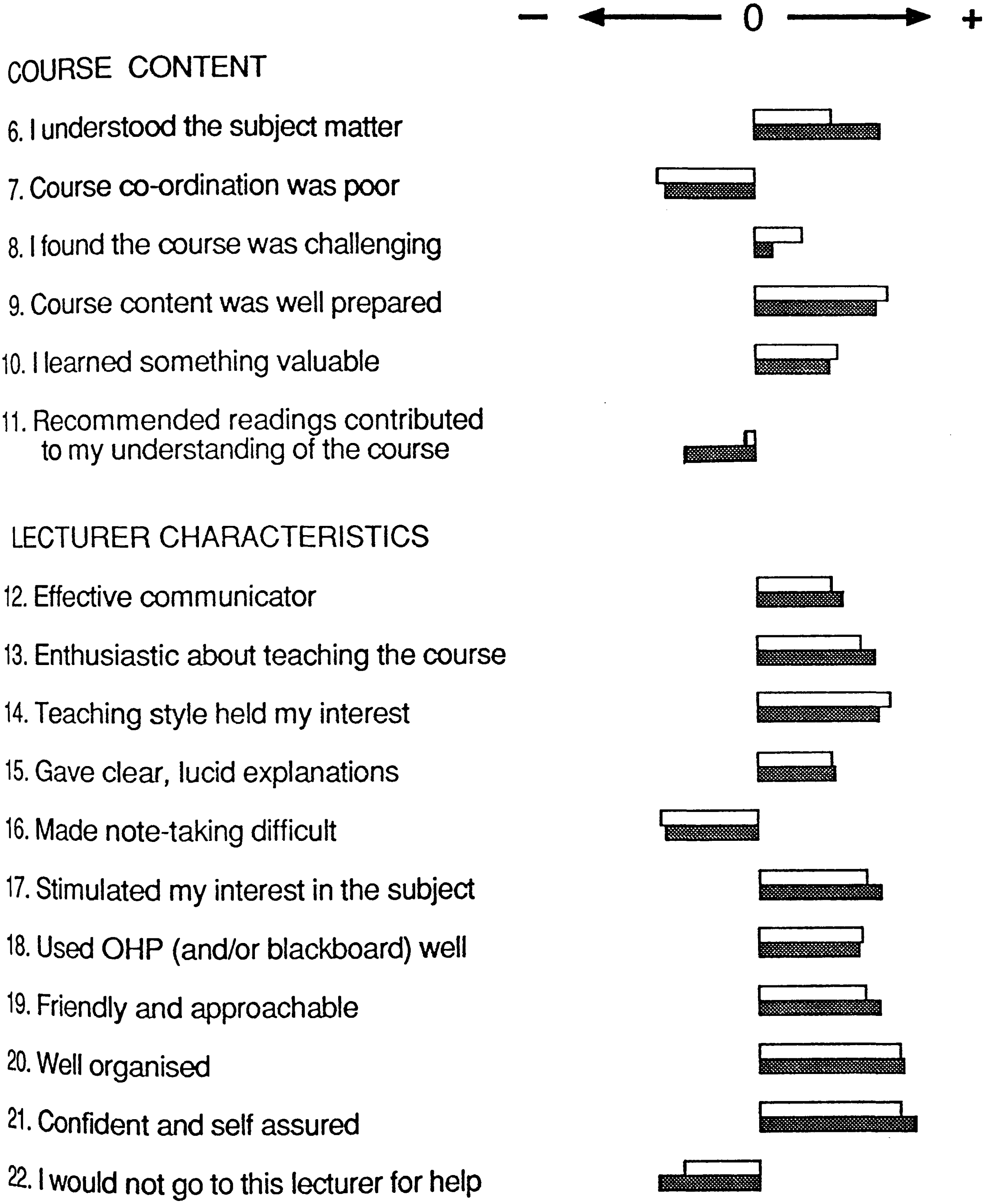


Figure 7-1. The Similar Performance 'Profiles' of the Same Lecturer on Two Different Lecture Courses

received higher ratings as "effective lecturers" in session 1990-1991.

Likewise, Lecturers **5**, **9** and **12**, who received lower ratings last year also received lower ratings this year.

Based upon the above conclusions, it seems to suggest that **Hypothesis 1** *"Students' ratings provide reliable measure of overall lecturing performance "* is correct in the context of this present study.

7.1.2 Testing Hypothesis 2

There doesn't seem to be a single criterion of effective teaching, however, for students to be able to learn from lectures, they must rely heavily on attending to, taking in and "making sense" of the information being conveyed orally or audio-visually. It follows naturally in this section to test **Hypothesis 2 :**

" Students' perceptions of a lecturer's performance are as expected in terms of Information Processing Theory ".

7.1.2.1 Written-in Comments from Students' Response Sheets

In **Part C** of the response sheet, a space was provided and students were invited to write down their comments on the course or the teaching if they felt unable to express their opinions through the fixed responses only. In total **394** different written-in comments were collected from the thirteen lecture courses. It was found again that the overall ratings awarded to a lecturer were clearly related to the number of students who felt the need to write comments, and so the lowest rating ones (Lecturers **1**, **5**, **9** and **12**) received the greatest number of comments.

In almost most cases the comments were positively helpful even when critical because they highlighted some particular feature of the course or some characteristics of the lecturers. All the written-in comments were further analysed by using the categories in **Section 2.1.4** (Page 34). The results are shown in TABLE 7-9 in which the frequency distribution of student comments was classified by the fifteen categories. Detailed comparisons between the "effective lecturers" and the "ineffective lecturers" were also made to understand what factors resulted in students' different ratings.

The following findings were obtained from this analysis :

(1) On the whole, about three quarters of those written-in comments were negative (292 out of 394, 75 %) in the sense that students pinpointed the problems which had caused them <u>difficulty</u> in following the lecturers. Students seemed to pay more attention to the <u>Lecturer Characteristics</u> (67 %) than to the <u>Lecture Course</u> itself (33 %). In general, Group I lecturers (i.e. the effective lecturers) received fewer comments than Group III lecturers (i.e. the ineffective lecturers).

(2) Regarding the nature of comments, Group I lecturers - the more effective ones received more positive comments, but in contrast, most of the comments awarded to Group III lecturers - the less effective ones, were negative.

(3) As seen from this table, the greatest number of negative comments in some categories revealed that Group III lecturers were rated as "ineffective" because :

[I] they had problems in communication skills, such as the audibility of voice or the quality of blackboard writing (12 % + 15 % = 27 %).

[II] their lecturing pace was perceived to be so rapid that students felt left behind (11 % negative comments were awarded to them).

[III] they were perceived not to be able to give clear and lucid explanations.

TABLE 7 - 9. Frequency (f) Distribution of Student Written-in Comments

Category	Written-in comments										
	positive			positive+negative			negative			total	
	f			f			f			f	%
	L I	L II	L III	L I	L II	L III	L I	L II	L III		
Lecturer characteristics											
1. Attitude	4	2	1	2	1	1	3	6	17	37	9
2. Stimulation	3	1	0	2	3	0	2	2	12	25	6
3. Personality	5	2	0	2	2	1	1	3	15	31	8
4. Board writing	2	0	1	3	2	1	4	6	39	58	15
5. Voice	0	0	0	2	1	1	0	8	35	47	12
6. Pace	3	2	1	3	3	2	3	4	22	43	11
7. Improvement	0	0	0	0	1	1	0	2	7	11	3
8. Lecture overall	3	0	0	1	1	0	0	0	4	9	2
9. Others	0	0	0	0	0	0	1	1	3	5	1
Total	20	7	3	15	14	7	14	32	154	266	67
Lecture Course											
10. Content	3	0	0	1	1	0	0	1	8	14	4
11. Materials	3	1	2	1	0	2	1	3	8	21	5
12. Structure	4	2	1	3	2	2	1	6	22	43	11
13. Previous knowledge	0	0	0	0	1	1	2	6	28	38	10
14. Overall course	3	1	0	0	1	1	0	0	4	10	2.5
15. Others	0	0	0	0	0	0	0	0	2	2	0.5
Total	13	4	3	5	5	6	4	16	72	128	33

*** L I = Effective Lecturers, L II = Average Lecturers and L III = Ineffective Lecturers.

[IV] their teaching styles were felt to be less interesting.

[V] they were perceived to be less enthusiastic about teaching.

A great number of actual responses taken from the written-in comments highlighted the following aspects of students' perceptions of ineffective lecturers :

Blackboard Writing

"Lecturer should improve his teaching by giving better set of notes on board."

"Should write more key words and definitions on blackboard."

"Use blackboard better !"

"Write more understandably on OHP and board."

"He was writing a bit unintelligible, notes on board a bit scrappy and over the place."

"Handwriting should be made more legible."

"Write more, clearer comments on the board to emphasise key points."

"Write coherent notes on board!"

"Clearer, better structured notes given by the lecturer."

"The notes to go along with what he says could be better presented and not so mixed up."

"I prefer the lecturer to write clearly on the board and dictate notes."

"Write larger on the blackboard."

"Writing on board should be larger and clearer to cater for those at the back of the lecture theatre."

"The lecturer's writing was poor - illegible writing !"

"Better notes."

Voice Audibility

"Speech could have been a bit clearer."

"Lecturer's voice was monotonous, lectures were boring!"

"Lecturer less monotone in voice."

"The lecturer was very difficult to understand due to her accent."

"A lot of time I found her voice quite difficult to understand."

"It was very hard to understand this lecturer and also it was hard to hear her."

"Some sort of microsystem is needed as the lecturer is not heard very clear at the back."

Lecturing Pace

"Pick up the pace so that students don't fall asleep. Don't leave long pause in the middle of sentences."

"A slightly faster pace would make it less dull."

"Lecturer should speed up a bit to get all the work done instead of pruning on about irrelevant subjects."

"Talk slower so we can have time to take notes."

"He goes too fast, doesn't explain well at all. Just goes ahead and writes on board without saying what and why he is doing it."

"He went too fast, a bit difficult to understand."

"Better explanation of course content, not rushed."

Style of Presentation

"The lecturer should present the course material in a more coherent fashion."

"He doesn't make anything clearer, and doesn't stimulate my interest in the subject whatsoever."

"Be more organised and not so boring."

"Not so boring and a more organised and interesting manner."

"Should make lectures more interesting and understandable."

"Clearer presentation of work - better explanations of derivation of equations,

etc."

"More continuity, less jumping about."

"Better teaching structure, and clearer links between points being made."

"The lecturer needs to explain subjects in more detail, better introduction required."

"Lecturer should repeat and summarise main points."

"Explaining everything more clearly instead of just giving confusing statements."

"... the lecturer who I thought was very poor in approach to this subject and did not present in an interesting way."

"The lack of examples was confusing."

"Instead of just standing in front of a board, dictating a set of notes, an attempt should have been made to give clear explanations."

Attitude

"The lecturer should be enthusiastic about Chemistry. He shows no interest, and made me also show no interest, and in fact - he put me to sleep."

"The lecturer couldn't hold my interest. He seemed unenthusiastic about lecturing us."

"More enthusiasm needed to keep my attention."

"The lecturer involved made the course matter exceedingly boring to the extent everyone was dozing off at 10 A.M. in the morning. More enthusiasm !"

"The lecturer was not enjoyable and concentrating on the lecture I found difficult."

"The lecturer was unapproachable and did not present the course in an interesting manner."

"He could sound more interested in the course."

"Lecturer could try to be friendlier rather than dictatorial."

"If the lecturer had shown more enthusiasm and if she had a sense of humour,

our interest might have been stimulated by this topic."

"Perhaps a more enthusiastic and happier lecturer could make the rather boring subject more interesting."

"She was very cold and often aggressive to the class."

(4) Group I lecturers received very few such comments. Such comments as they had seemed to suggest that they were rated higher as "effective" because :

[I] they had better communication skills.

[II] they had more interesting styles of presentation which held students' interest.

[III] they were perceived to be more enthusiastic about teaching.

[IV] they had better interactions with students.

The following excerpts from students' comments pointed out their strengths as the "effective lecturers" :

"Demonstrations and experiments in lectures appreciated. I really enjoyed them very much."

"For practically the first time, I could clearly see the connection between Chemistry and life. Fantastic !"

"The best presented course so far, well explained already."

"It was really a pleasure to be part of this lecturer's class."

"Lecturer's style of presentation was so interesting that I felt the course of lectures much more enjoyable indeed."

"The lecturer explained the subject very well, very decent, down to the earth about Chemistry knowledge."

(5) In conclusion, from the different nature of the above written-in comments awarded to Group III lecturers, it seems to indicate : the inadequacy in the basic communication skills and the inability to handle the pace of lecturing are the essential criteria fro being rated as an "ineffective lecturer" by students. Those lecturers who had caused difficulty in students' cognitive perceptions tended more likely to be rated lower, i.e., the ineffective lecturers.

In addition to the basic communication skills and the ability to handle the pace of lecturing, the power to motivate students' interest, the expertise to present the material in a clear and lucid way and the capacity for interaction with students are also important criteria for Group I lecturers to be rated higher as the "effective lecturers".

7.1.2.2 The Findings from the Staff Members

The staff members' view on the student evaluation of lecturing were collected by using the questionnaire "**Student evaluation of teaching - the staff view**". 51 questionnaires were circulated and finally **43** were completed and returned, the response rate was 84 %. All the statements from three different but equivalent questionnaires were combined together into a full list of 60 statements classified into 8 categories. The results are shown in Appendix 23, Page 417 .

In general, staff think that "*Students learn more from reviewing their lecture notes than from making them*" (**84** % of staff agreed to Item 13). They also agree that "*Students expect a lecturer to be able to lecture well*" (**66** % agreed to Item 14).

A very interesting finding came from their views about "What students expect of a lecture or lecturer" (**Category** C in this list). Regarding the purpose of lecture, all of them held the view that "*Students think the lecturer should provide all you need to know for passing the exams*". So far as the presentation style is concerned, they agreed that (i) "*The lecturer should make the course interesting and one the students enjoy attending*" (**99 %**); (ii) "*Students are unimpressed by the lecturer who merely reads from notes*" (**92 %**); (iii) "*Students are most impressed by the lecturer who can 'package' the main points in ways which are easy to grasp*" (**92 %**) and (iv) "*Science students tend to attach considerable importance to the 'systematic organisation of the subject matter*'" (**80 %**).

As a matter of fact, these views could be justified in terms of Information Processing theory. The interesting style of presentation motivates the students and holds their attention to the lecture, to "package the main points in ways which are easy to grasp" is to reduce the information load in the working memory and to discriminate the relevant "signal" from the irrelevant "noise".

As for the student ratings in general, the staff results might not be clear-cut, but most of them have in common the following opinion :

(i) *Students have a right to make judgements about the quality of teaching they encounter* (**86 %**).

(ii) *Student ratings are greatly influenced by the personal 'charisma' of the lecturer* (**70 %**).

(iii) *Student ratings can provide useful feedback to lecturers about their teaching* (**81 %**).

Detailed analysis and discussion of the results is still proceeding and will be published (see Johnstone and MacGuire, 153). But the overall staff's view on the student evaluation on lecturing at least partly confirmed that students' perceptions about lecturers are accurate in terms of information processing.

7.1.2.3 The Findings from the Participant Observation

From the previous observation study described in **Section 2.2** (Page 38), the main distinctions in lecturing behaviours between the "effective lecturers" and the "ineffective lecturers" have been detected in the following cognitively orienting stimulus factors : (i) the use of humour and asides, (ii) the audibility of voice and the quality of blackboard writing, (iii) giving instructional cues, (iv) focussing, (v) wait-time and (vi) the lecturing pace.

Observations were made of 13 lecturers, with two lectures randomly selected from each lecturer and so a total of 26 sets of observer's ratings were obtained. The researcher judged and coded the presence of all the overt behaviours representative of the above factors, which had been identified from the literature and served as indicators of that particular lecturing performance on the Observation Schedule of Lecturing (Appendix 3 , Page 326).

An exact copy was taken from the blackboard writing, materials presented on slides or transparencies for every lecture observed and any distributed printed material, handouts or course objective sheets were all collected and used to analyse the factors such as : focussing and giving instructional cues.

All the audio-recorded tapes of observed lectures were transcribed and used to code the occurrence and length of period of the factors such as : the use of humour and asides, the verbal instructional cues and the lecturing pace index (i.e., the number of information units in every five minutes).

Regarding the audibility of voice and the quality of blackboard writing, a five-point rating scale was used instead of quantitative indices. When observing the lecturers, the researcher sat either on the left-hand side or on the right-hand side of the last row of seats in turn and asked the students sitting nearby if they could hear or see clearly. Students' written-in comments were also used to compare with the observer's ratings.

TABLE 7-10 shows the results from the participant observation data. The performance in the above factors between Group I lecturers and Group III lecturers is compared and described as follows :

(1) The Audibility of Voice and the Quality of Blackboard Writing

In general, Group I lecturers were frequently observed to start their lectures by checking whether the students at the back row or side rows could hear them or see the blackboard writing clearly, but this sort of reminding hardly occurred among Grouup III lecturers.

Group I lecturers were found to lecture more expressively, in other words, their voices was more energetic, vivid and had more inflections. On the contrary, Group III lecturers lectured in a less expressive way, i.e., their voices were more monotonous and dull. One of them had such a strong accent that many students found it difficult to understand the lecturer. Another did not lecture fluently and paused too frequently in the middle of sentences. Two of them spoke towards the board when they were writing on it and their voices were found to tail off.

The effective lecturers (i.e. Group I ones) were found to write less on the board than the ineffective lecturers. They tended to write main points and definitions instead of writing lengthy paragraphs with complete sentences. In contrast, three of the Group III lecturers spent much time in writing on the board or presenting the transparencies which students had to copy down. It was also noticed that Group III lecturers did not write large enough or clearly enough and they used side boards without considering whether students could see them clearly from the back or from the sides.

TABLE 7 - 10. The Results of Participant Observation

Cognitively-Orienting Factors	Mean Values of Measurement		
	Group I Lecturers	Group II Lecturers	Group III Lecturers
Quality of Blackboard writing	More headings Large enough Fewer complaints	Fairly well	Less structured Two not clear More complaints
Voice Audibility	Loud enough More expressive	Middle	Not clearly heard Less expressive
Wait-time	3.8 Sec	3.3 Sec	3.7 Sec
Focussing	8.4	5.2	2.7
Giving Instructional -- Cues < Board writing	53	67	76
Giving Instructional -- Cues < Verbal and Nonverbal	16	9	5
Use of Humour and Asides	7.8	3.7	2.2
Mean of the Total Lecturing Pace Index	15.4	16.3	17.7

** 1. No quantitative measure was taken for the audibility of voice and the quality of blackboard writing, the method of rating was described in the text.

2. The lecturing pace index is the number of information units in every five minutes.

(2) Giving Instructional Cues

From the above table, there was not much difference in the total frequencies of giving instructional cues among the lecturers. Group I lecturers tended to use verbal and non-verbal cues more frequently than Group III lecturers, but Group III lecturers were found to use blackboard writing more frequently than Group I lecturers.

(3) The Use of Humour and Asides

It was detected that there was a remarkable difference in using the humour and asides between the effective lecturers and the ineffective lecturers. The results from TABLE 7-10 indicated that Group I lecturers used humour and asides much more frequently than Group III lecturers, with an average frequency about three times as that was used by Group III lecturers. It was also detected that the atmosphere of their lectures were perceived to be more light-hearted and from time to time an outburst of laughter could be heard during the lectures.

(4) Wait-time

From the results of analysing the transcripts, there were an average of 67 pauses for Group I lecturers and an average of 78 pauses for Group III lecturers in a lecture duration of fifty minutes. The mean length of wait-time were 3.8 seconds, 3.3 seconds, and 3.7 seconds for Group I, Group II and Group III lecturers respectively. There doesn't seem to be any noticeable differences in the wait-time between lecturers.

When the materials were put on the blackboard, most of the lecturers were observed to pause long enough for the students to take down notes. But it was found that when the materials were presented on slides or transparencies, Group III lecturers tended to cram too many things into a single sheet and didn't pause long enough for the students to take down the main points.

One of Group III lecturers did pause very often but he did so in the middle of sentences and this made it difficult to concentrate. Group I lecturers were found to pause more frequently and longer when they were talking, sometimes asking questions for responses and sometimes inviting students' opinions.

(5) Information Units

As can be seen from TABLE 7-11, the average number of total information units spoken and written were 140 for Group I lecturers, 138 for Group II lecturers and 125 for Group III lecturers respectively. Quantitatively, the differences in the total number of information units conveyed in those three groups of lecturers are negligible.

It was also found that, in general, group III lecturers put more words or complete sentences on the board and paused for students to take down notes, so there was not sufficient time spent in explanations. For group I lecturers, it was found that they tended to use key words or main points on the board only and then spent more time in explanations.

(6) Lecturing Pace

The pace of a lecture was measured in this study by the "lecturing pace index" - the average of the total number of information units in every five minutes. The higher the lecturing pace index, the more rapid the lecturer. The average of lecturing pace indices between the effective lecturers and the ineffective lecturers didn't show much difference. But it was found that Group III lecturers spent more time in writing on the board and less time in explanations. If this was taken into account, Group III lecturers seemed to go at a faster pace than Group I lecturers.

7.1.3 Checking the Accuracy.of Students' Perceptions of a Lecturer's Performance

The results of the above study can be concluded as follows :

1. Student ratings on response sheets

From students' ratings of the courses and lecturers, it is obvious that for most students, the essential criteria for an effective lecturer is the basic communication skills such as the clear audibility of voice, the legibility and good organisation of blackboard writing (or materials presented with slides or transparencies) and the clarity of explanation. Failing these, one tends more likely to be rated lower as an ineffective lecturer. Having achieved this and adding an interesting style of presentation and a friendly approachable manner, one tends more likely to be rated as an effective lecturer.

2. The written-in comments on response sheets

The written-in comments relating to the lecturers' strengths or weakness also confirmed this. Students made most comments on a lecturer's communication problems which had caused them difficulty in understanding the lectures. They would also comment on the lecturer whom they felt less enthusiastic and unapproachable. In contrast, students showed a very high appreciation of clear and lucid presentation, together with relevant practical examples and illustrations. Students seemed to like an interesting way of presentation and many students mentioned in their comments that they enjoyed the lecturer's having a sense of humour.

3. The results from the opinion of staff members

Although lecturers have their own criteria of effective teaching, most of them agree that students expect a lecturer to be able to lecture well. According to their responses to **Category C** in the "**Student evaluation of teaching - the staff view**"questionnaire, they recognised the importance of motivating students in the lecture and a great majority of them agreed that to package the lecture information in ways which are easy to grasp and to present the subject material in a systematic organisation are also very important to students. They argued that student ratings are greatly influenced by the personal charisma of the lecturer and, overall, most of them agreed that student ratings can provide useful feedback to lecturers about their teaching.

4. The results from participant observation

What do the observation data tell us about the differences between the effective lecturers and the ineffective lecturers ? They were observed to have differences in (i) the audibility of voice and the quality of blackboard writing, (ii) focussing and (iii) uses of humour and asides. According to observation, Group III lecturers (ineffective lecturers) didn't speak loud enough or spoke towards the blackboard so that students couldn't hear them clearly. They wrote too much on the board and the writing was either too small or so disorganised that students had difficulty in seeing the writing clearly.

Group I lecturers (the effective lecturers) were found to make more frequent use of humour and asides than Group III lecturers such that the different atmosphere of classrooms could be easily perceived by the researcher. It seemed that the use of humour and asides has contributed to enhance affect, arousal and attention. With the Group III lecturers, the following student behaviours occurred more frequently : dozing, doodling (see Figure 7-2, as found and taken from students' notes), chatting, interruption and restlessness.

It was also observed that Group I lecturers spent more time on focussing than Group III lecturers : most of them usually started the lecture by reviewing or summarising briefly the previous lecture content ; they frequently pointed out the main points by using outlines or organisers ; they tended to make more use of headings and subheadings or underlining the important points and they provided more connections between different parts of lectures.

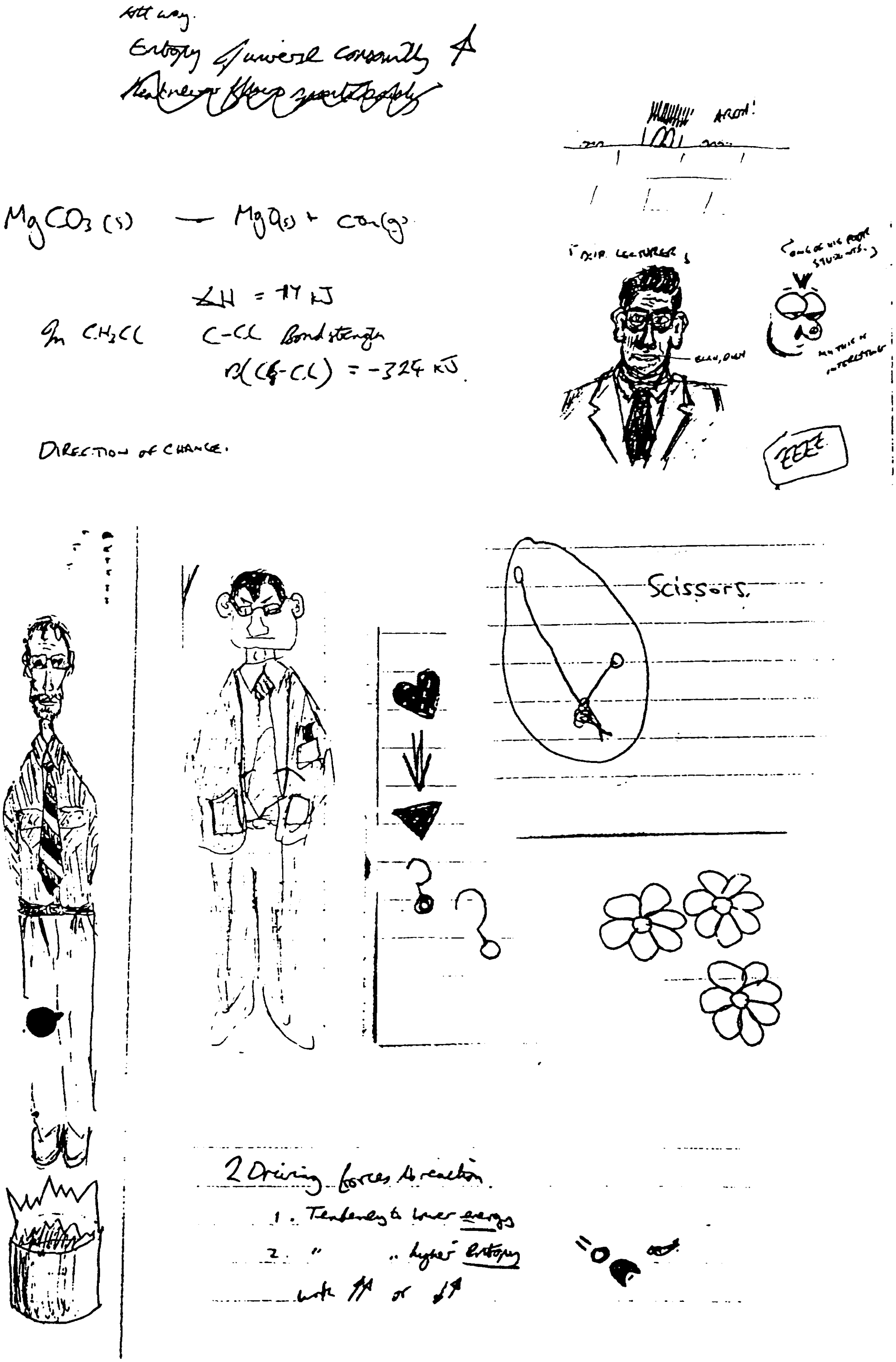


Figure 7-2. Doodling Found in Students' Notes

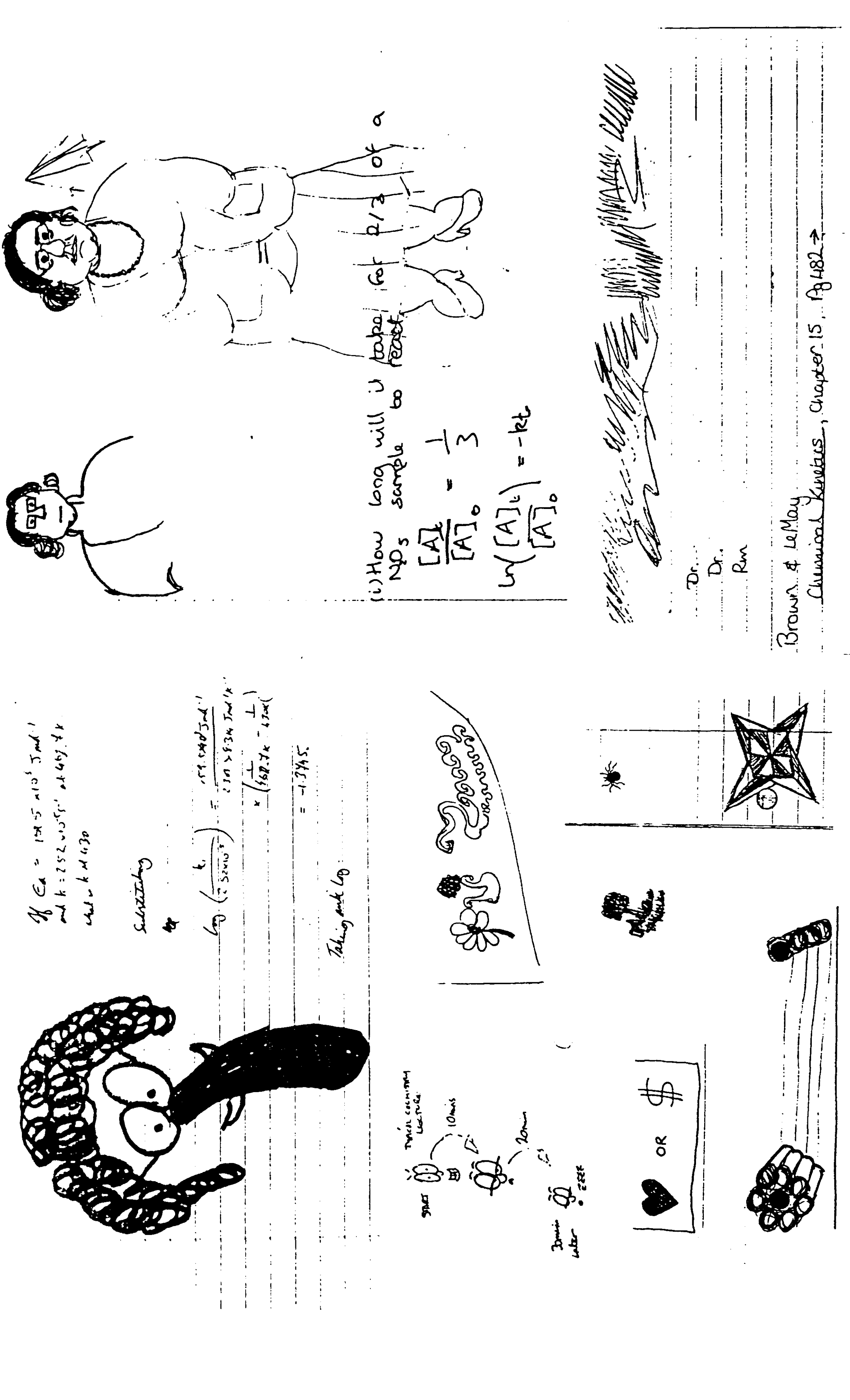


Figure 7-2 (contd.) Doodling Found in Students' Notes

Regarding the pace of lectures, there was not much difference in "lecturing pace index" between Group I and Group III lecturers, but Group III lecturers seemed to go more rapidly than Group I lecturers if only the spoken information was considered.

The total frequencies and length of wait-time were found to be very similar between Group I lecturers and Group III lecturers. Group I lecturers had greater frequencies and longer duration in wait-time when they were explaining things but Group III lecturers had greater frequencies and longer duration in wait-time when they were writing on the board and pausing for students to take down notes.

By combining students' responses and staff members' opinion on the questionnaires and data from participant observation, pen portraits of real lecturers in real situations can be drawn in terms of the information processing model proposed in **Section 3.1** (See Page 66). A lecturer sends forth lecture messages verbally, non-verbally and sometimes by using audio-visual aids. By attention students select the sensory input which they can focus on. If students have difficulty in seeing or hearing the lecture messages, the potential stimuli presented by the lecturer fail to become actual stimuli for students. In this case, the lecturer is more likely to be rated lower as an "ineffective lecturer".

Furthermore, attention fluctuates during a 50-minutes lecture in such a way that after twenty minutes, there is a marked decline in attention followed by a peak just before the lecture ends (Johnstone and Percival, 63). It seemed that Group I lecturers potentially bring about an arousal of students' interest by using humour and asides stressing the applications and uses of lecture materials. This cognitive stimulus seemed to have the function of holding students' interest and reversing the decline in attention and thus indirectly influencing students' overall perceptions that Group I lecturers were rated higher as "effective".

Despite the diversity of lecturer characteristics and lecture topics, common elements of "effective lecturing" are evident ; those are professional and personal skills and attitudes which can be identified in terms of the information processing model. The effective lecturers are able to get their messages across to students' sensory systems clearly, to structure and explain well in a concise way so as not to confuse students, to use humour and asides to maintain students' arousal of attention and to lecture at a reasonable pace.

Based upon Information Processing Theory, **Hypothesis 2** *"Students' perceptions of the lecturer's performance are as expected in terms of Information Processing Theory"* seemed to be correct.

7-2 The Relationship Between Working Memory Capacity and Note-taking

7.2.1 Testing Hypotheses 4 and 5

To uncover the interaction of lecturing styles with students' working memory capacity, the following hypotheses were restated and tested :

Hypothesis 4 *The students with higher working memory capacity will take more complete notes than the students with lower working memory capacity.*

Hypothesis 5 *The students with higher working memory capacity will have better performance in the class exam than the students with lower working memory capacity.*

7.2.1.1 Analysis and Results

Both the quantitative and qualitative methods were used to analyse students' lecture notes. The total number of lecture notes collected from thirty-two subjects were 873 sets and they were subjected to the following analyses :

(1) Quantitative analysis : the content of notes were examined in terms of three indices, i.e., the total number of words, the total number of information units the completeness percentage (See **Section 2.4.1** for detail, Page 43).

(2) Qualitative analysis : the content of lecture notes were further analysed in terms of structure, format, elaboration and the degree of processing.

TABLE 7-11 shows the results from quantitative analysis of the lecture notes from students who have been categorised into three groups of different working memory capacity. From this table, it can be seen that in all cases, the students with higher working memory capacity recorded more complete notes in terms of both the total words and the information units than the students with lower working memory capacity.

Detailed inspection by qualitative analysis showed that :

(1) Students didn't differ very much in recording the lecture information that appeared on the blackboard, but there was a markedly striking difference in recording the lecture message spoken by lecturers.

(2) If students' lecture notes are investigated in terms of quantity and quality, four types of note-taking could be identified among students : BS - (Blackboard Signal Minus), BSO (Blackboard Signal Only), BS + (Blackboard Signal Plus) and EL (Elaboration). The first three types are mostly involved in taking an approximate copy of the blackboard writing and the printed materials on transparency without much processing of the lecture information. The last type of students used diagrammatic organisation or paraphrasing to structure their personal view of lectures.

TABLE 7-11. ***Quantitative Analysis of Lecture Notes according to their Working Memory Capacity X (I. U = Information Unit)***

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4763	4889	4951	4962	4813	5218	4894	4957	5437	4873	4886	5202
Mean total I.U spoken & written		135	124	113	148	117	104	136	173	159	140	138	125
Mean total words on board		532	422	539	603	535	429	623	618	666	586	525	545
Mean total I.U on board		82	95	57	103	93	60	93	138	108	93	109	75
Mean of total words recorded	Low working memory (X = 4 or 5)	539	419	541	617	534	431	634	629	662	597	527	545
	Average working memory (X = 6)	547	426	535	624	553	438	651	642	677	607	540	550
	High working memory (X = 7)	562	471	558	689	577	447	673	681	685	641	576	563
Mean of total I.U recorded	Low working memory (X = 4 or 5)	91	94	61	111	95	54	97	136	102	100	108	72
	Average working memory (X = 6)	98	102	75	123	103	73	114	145	117	112	117	88
	High working memory (X = 7)	126	117	98	137	106	82	120	149	128	128	124	103
Mean of completeness	Low working memory (X = 4 or 5)	67 %	76 %	54 %	75 %	81 %	52 %	71 %	79 %	64 %	71 %	78 %	58 %
	Average working memory (X = 6)	73 %	82 %	66 %	83 %	88 %	70 %	84 %	84 %	74 %	80 %	85 %	70 %
	High working memory (X = 7)	93 %	94 %	87 %	93 %	91 %	79 %	88 %	86 %	81 %	91 %	90 %	82 %

TABLE 7-12 shows the number of students whose note-taking types can be identified. It seems that the students with lower working memory capacity tended more likely to use BS- and BSO types, but the students with higher working memory capacity tended more likely to have BS+ and EL types.

TABLE 7-12. The Number of Students in Different Note-taking Types (classified according to their working memory capacity)

Student Type \ Note-taking Type	BS -	BSO	BS +	EL
Low working memory capacity	3	5	3	0
Average working memory capacity	2	6	5	1
High working memory capacity	0	2	4	1

*** BS - = Blackboard Signal Minus   BSO = Blackboard Signal Only

BS + = Blackboard Signal Plus   EL = Elaboration

(3) For most students with lower working memory capacity, their notes were found to be about an exact copy of the blackboard writing with occasional omissions. Occasionally, they recorded some extra verbal lecture information but most times they took verbatim notes only.

For students with higher working memory capacity, most of them copied down the blackboard writing entirely and in addition, they captured more extra lecture messages orally conveyed by lecturers.

According to the above analyses, these findings seem to confirm **Hypothesis 4** that *"Students with higher working memory capacity will take more complete notes than the students with lower working memory capacity"*.

7.2.1.2 Working Memory Capacity and Class Exam Score

The note-taking completeness and class exam performance were compared among students with different working memory capacity. TABLE 7-13 shows the results of this investigation. As seen clearly from this table, the students with higher working memory capacity (who are in general more complete in taking notes), had higher scores in the class exam than the students with lower working memory capacity. Those results support **Hypothesis 5** : *"The students with higher working memory capacity will have better performance in the class exam than the students with lower working memory capacity"*.

TABLE 7 - 13. The Relationship Between Exam Performance and Students' Working Memory Capacity

Performance / Student Types	Mean score of 1st class exam
Low W.M (X = 4, X = 5) (11 students)	47.5
Average W.M(X = 6) (14 students)	57.0
High W.M (X = 7) (7 students)	64.3

*** W.M = Working Memory Space or Capacity (representad by X)

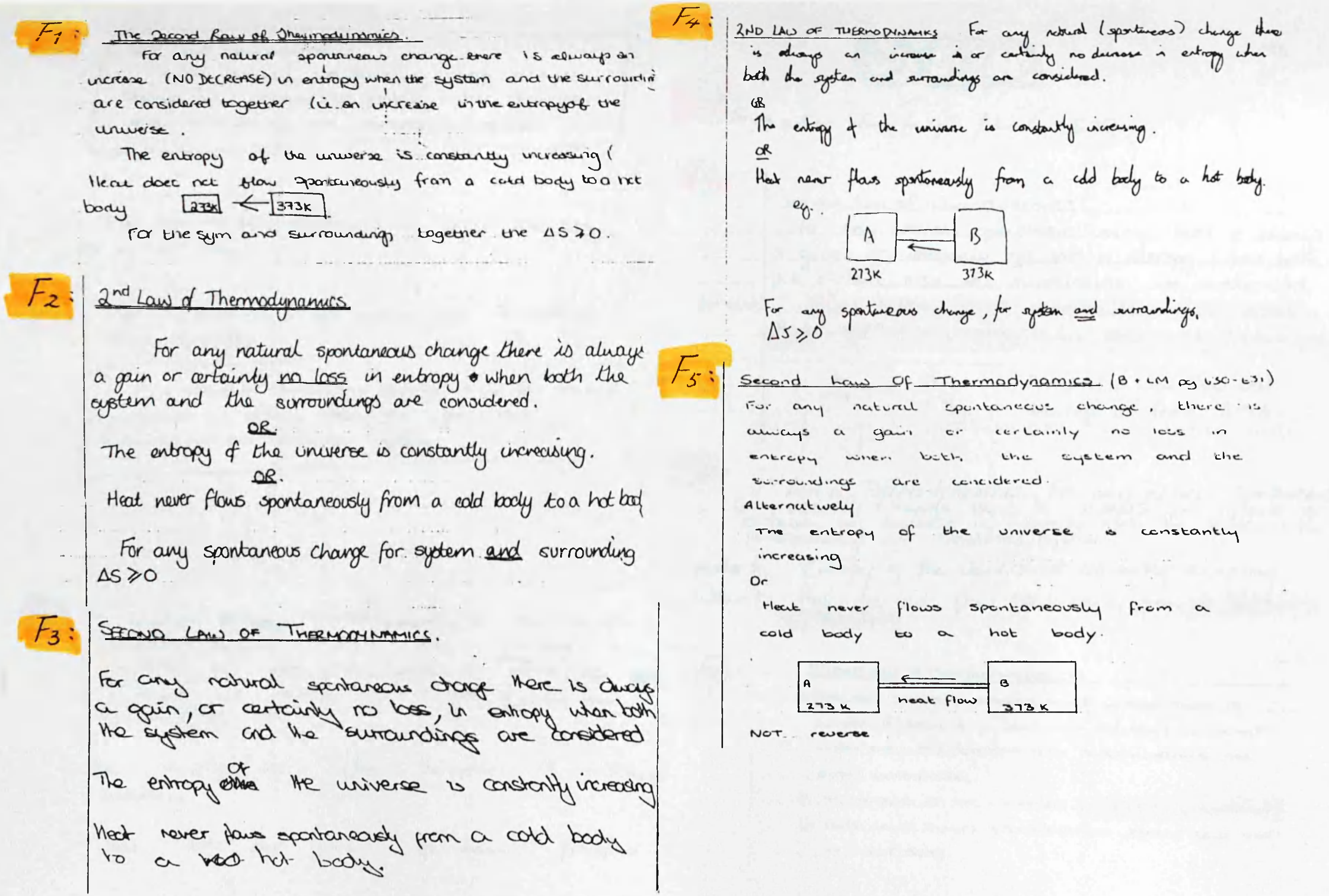
7.2.2 The Interaction of Lecturing Styles with Students' Working Memory Capacity

7.2.2.1 Testing Hypothesis 3

In order to understand how different lecturing styles interact with students' working memory capacity to the extent that students have different note-taking types, several sets of lecture notes were collected both from the effective lecturers **L2, L4, L7** and **L8** and the ineffective lecturers **L1, L5** and **L 9.**

In the situations that lecturers dictated the definitions of technical terms without writing on the blackboard, a greater cognitive strain hindered the students with lower working memory capacity from taking the complete lecture information. For example, in one of his lectures, **Lecturer 1** interpreted the Second Law of Thermodynamics in several ways. He dictated different versions of defining this law and requested students to take them down, the following extracts from students' notes show the differences between students of different working memory capacity (Figure 7-3).

As can be seen in this figure, **F 1** to **F 5** are the extracts from the notes of students with higher working memory capacity, these notes are more complete because they are the exact recordings of the lecture messages dictated and explained by the lecturer when subjected to the comparison with the transcript of the tape-recording. A total of **13** students (**62 %** of the 21 students who have higher working memory capacity) were found to record this section successfully. But in contrast, **F 6** to **F 12** - the extracts taken from the notes of students with lower working memory capacity demonstrate the incompleteness in one way or another. **F 6** to **F 9** are not complete in that those students were unable to either record all the dictation or take down some verbal explanations. **F 10** to **F 12** are not complete because **F 10** made a wrong logical connections between



F1: The Second Law of Thermodynamics.

For any natural spontaneous change there is always an increase (NO DECREASE) in entropy when the system and the surroundings are considered together (i.e. an increase in the entropy of the universe.

The entropy of the universe is constantly increasing (

Heat does not flow spontaneously from a cold body to a hot body 273K ← 373K

For the sym and surroundings together the ΔS ≥ 0.

F2: 2nd Law of Thermodynamics

For any natural spontaneous change there is always a gain or certainly no loss in entropy when both the system and the surroundings are considered.

OR

The entropy of the universe is constantly increasing.

OR

Heat never flows spontaneously from a cold body to a hot body

For any spontaneous change for system and surrounding ΔS ≥ 0

F3: SECOND LAW OF THERMODYNAMICS.

For any natural spontaneous change there is always a gain, or certainly no loss, in entropy when both the system and the surroundings are considered

The entropy of the universe is constantly increasing

Heat never flows spontaneously from a cold body to a hot body.

F4: 2ND LAW OF THERMODYNAMICS For any natural (spontaneous) change there is always an increase or certainly no decrease in entropy when both the system and surroundings are considered.

OR

The entropy of the universe is constantly increasing.

OR

Heat never flows spontaneously from a cold body to a hot body.

eg.

A 273K ← B 373K

For any spontaneous change, for system and surroundings, ΔS ≥ 0

F5: Second Law of Thermodynamics (B + LM pg 630-631)

For any natural spontaneous change, there is always a gain or certainly no loss in entropy when both the system and the surroundings are considered.

Alternatively

The entropy of the universe is constantly increasing

Or

Heat never flows spontaneously from a cold body to a hot body.

A 273 K ← heat flow B 373 K

NOT reverse

Figure 7-3. The Extracts from Students with Higher Working Memory Capacity

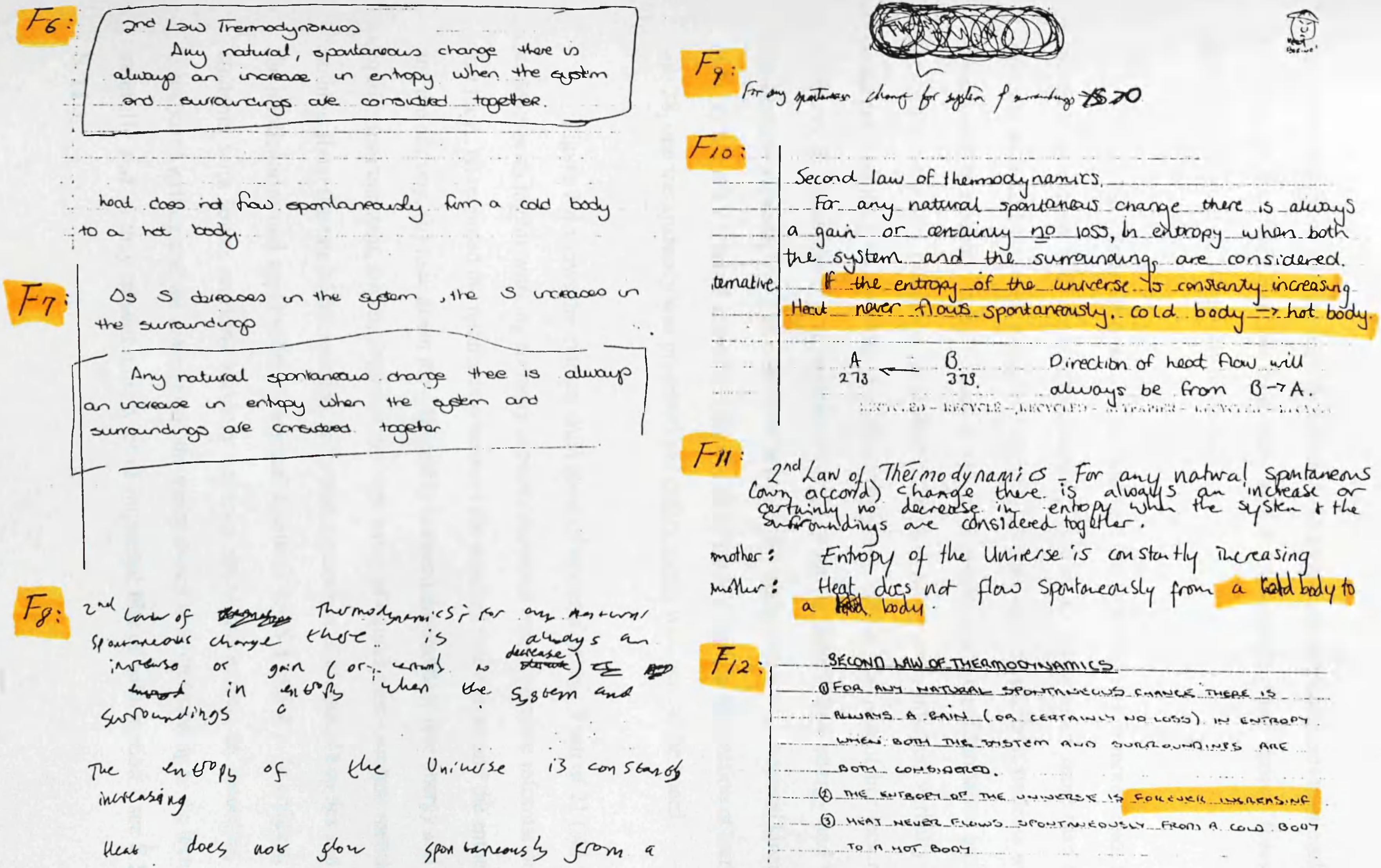


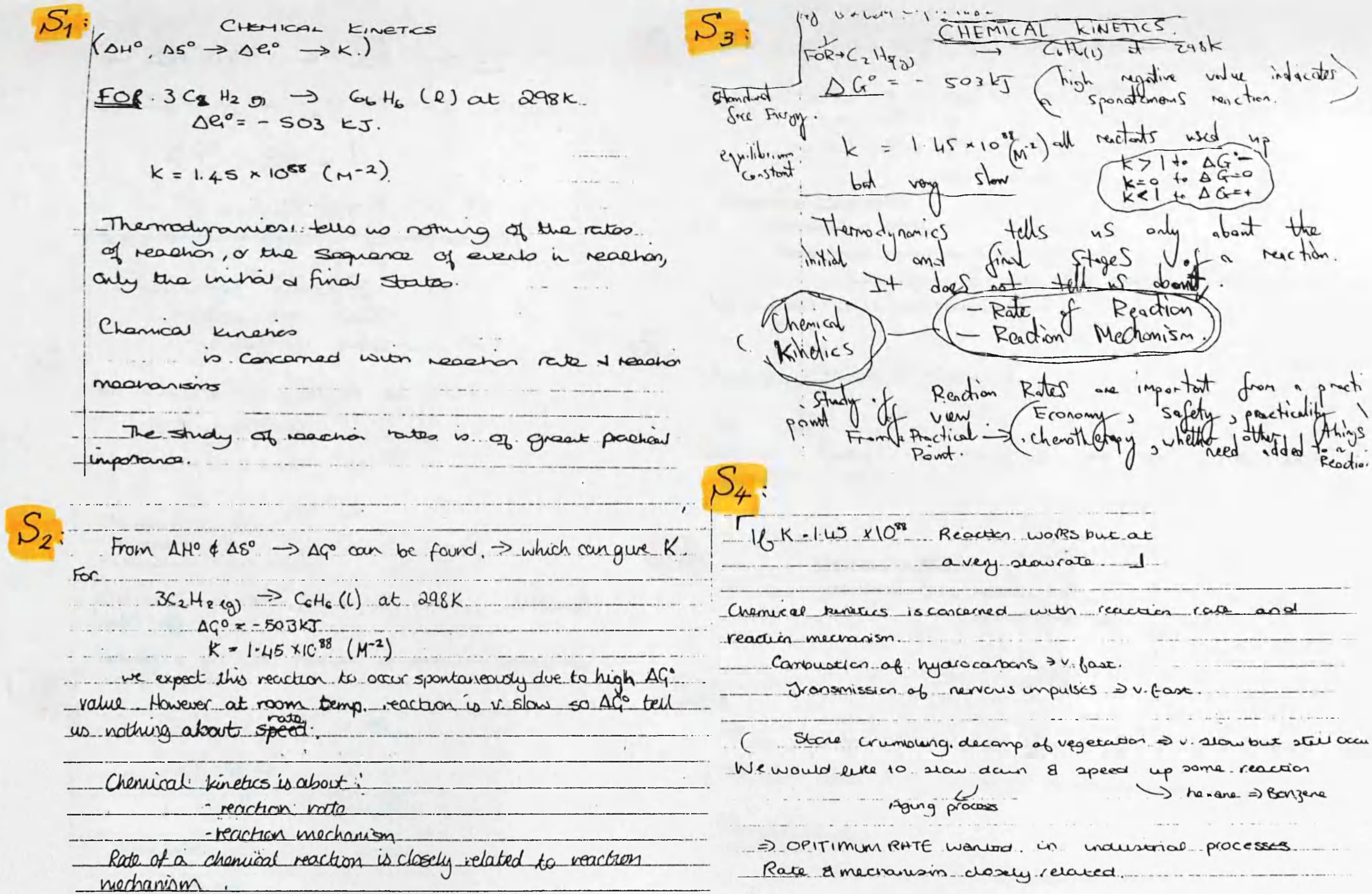
Figure 7-3 (contd.) The Extracts from Students with Lower Working Memory Capacity

the second definition and the third definition; **F 11** contained an ambiguous relationship between the hot body and the cold body and **F 12** wrongly took down "forever increasing" instead of "constantly increasing".

When the information load is too high and the lecturing rate is more rapid, the students with lower working memory capacity seemed to suffer much more than the students with higher working memory capacity. Under such conditions, students with lower working memory capacity usually were able to take down the information put on the board only and missed a great deal of lecture messages conveyed verbally by lecturers, resulting in an extremely incomplete note-taking. In one of her lectures, **Lecturer 5** spent about five minutes in explaining (i) Gibb's free energy and the equilibrium constant, (ii) The distinction between thermodynamics and chemical kinetics and (iii) What is chemical kinetics? The total information units in this section of lecture was 28, one transparency was presented and <u>eighty words</u> were put on the board.

Figure 7-4 shows the extracts from some of students' notes. 9 out of 21 (43 %) students with higher working memory capacity recorded more complete information in that they : (i) recorded the relationship between the standard free energy and the enthalpy and the entropy, (ii) took down the relationship between the standard free energy and the equilibrium constant, (iii) noticed that the high value of equilibrium constant mentions nothing about the rate of this reaction, (iv) noted the context of chemical kinetics and (v) the implications and application of chemical kinetics (see **S 1** to **S 4**). In contrast, the students with lower working memory capacity spent much time in recording the blackboard writing and the materials on the transparency without listening to the lecturer carefully and so they missed quite a lot of important bits of information (see **S 5** to **S 11**).

Similar examples were found in many other cases where the information density



S1:

CHEMICAL KINETICS

(ΔH^o, $\Delta S^o \rightarrow \Delta G^o \rightarrow K$.)

FOR $3C_2H_2(g) \rightarrow C_6H_6(l)$ at 298K.

$\Delta G^o = -503$ kJ.

$K = 1.45 \times 10^{88}$ (M^{-2})

Thermodynamics: tells us nothing of the rates of reaction, or the sequence of events in reaction, only the initial & final states.

Chemical kinetics is concerned with reaction rate & reaction mechanisms

The study of reaction rates is of great practical importance.

S2:

From ΔH^o & $\Delta S^o \rightarrow \Delta G^o$ can be found, → which can give K.

For

$3C_2H_2(g) \Rightarrow C_6H_6(l)$ at 298K

$\Delta G^o = -503$ kJ

$K = 1.45 \times 10^{88}$ (M^{-2})

we expect this reaction to occur spontaneously due to high ΔG^o value. However at room temp. reaction is v. slow so ΔG^o tell us nothing about ~~speed~~ rate.

Chemical kinetics is about:

- reaction rate
- reaction mechanism

Rate of a chemical reaction is closely related to reaction mechanism.

S3:

CHEMICAL KINETICS.

FOR $C_2H_2(g) \rightarrow C_6H_6(l)$ at 298K

Standard free Energy: $\Delta G^o = -503$ kJ (high negative value indicates spontaneous reaction.)

equilibrium constant: $k = 1.45 \times 10^{88} (M^{-2})$ all reactants used up but very slow

$k > 1$ to $\Delta G -$
$k = 0$ to $\Delta G = 0$
$k < 1$ to $\Delta G = +$

Thermodynamics tells us only about the initial and final stages of a reaction.

It does not tell us about:

Chemical Kinetics
- Rate of Reaction
- Reaction Mechanism.

Study of Reaction Rates are important from a practical point of view.

From Practical Point → Economy, safety, practicality, chemotherapy, whether need other things added to a Reaction.

S4:

If $K = 1.45 \times 10^{88}$ Reaction works but at a very slow rate.

Chemical kinetics is concerned with reaction rate and reaction mechanism.

Combustion of hydrocarbons ⇒ v. fast.

Transmission of nervous impulses ⇒ v. fast.

Stone crumbling, decomp of vegetation ⇒ v. slow but still occur

We would like to slow down & speed up some reaction

Aging process

hexane ⇒ Benzene

⇒ OPTIMUM RATE wanted in industrial processes.

Rate & mechanism closely related.

Figure 7-4. The Extracts from Students with Higher Working Memory Capacity

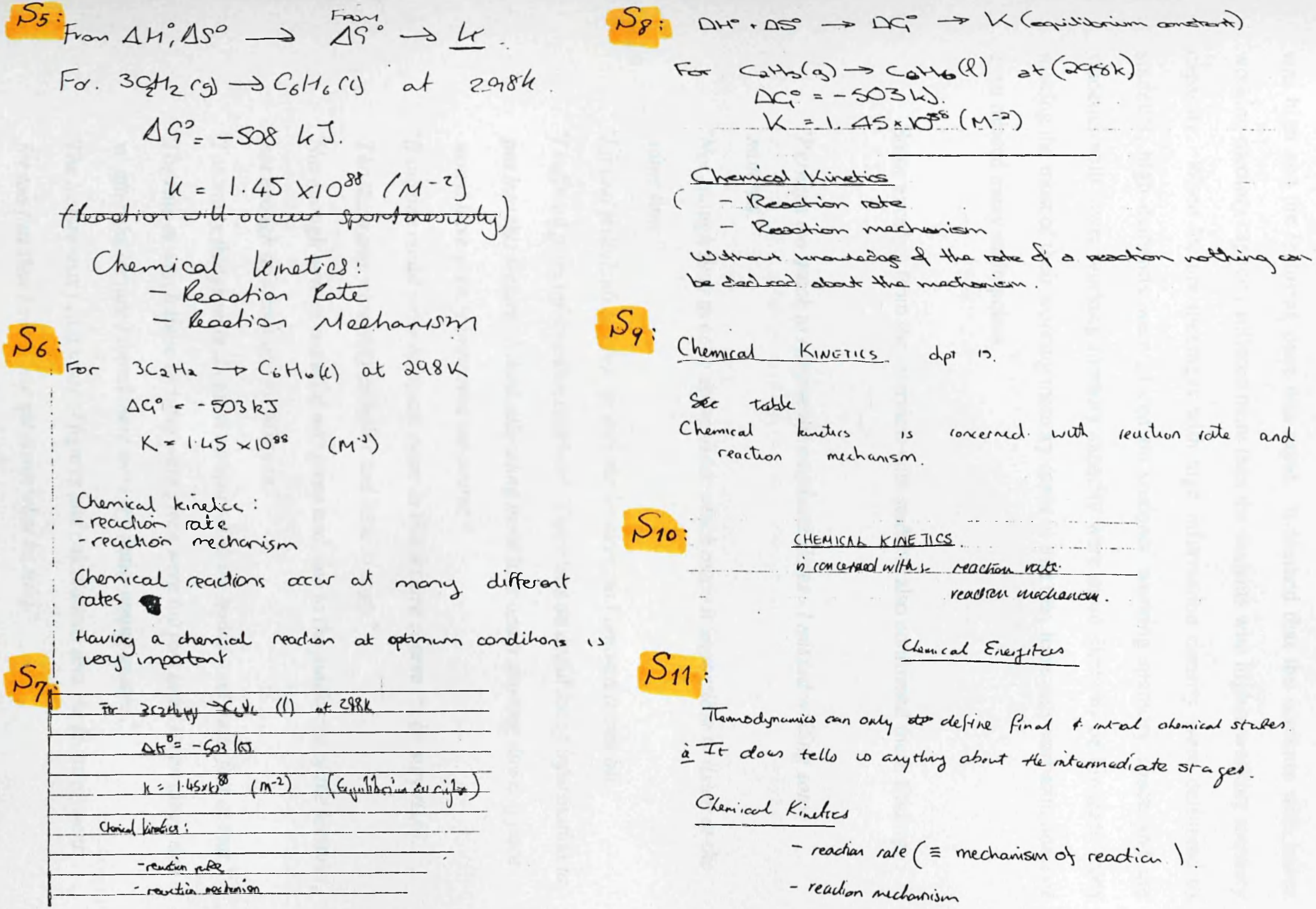


Figure 7-4 (contd.) The Extracts from Students with Lower Working Memory Capacity

was high and the lecturing pace was rapid. It seemed that the students with lower working memory capacity suffered more than the students with higher working memory capacity. When lecture messages with high information density were delivered to students, high demands were placed on students' working memory space and the students with lower working memory capacity were more likely to be hindered from making the most of their working memory space in that they took only verbatim notes or even missed many main points.

Some excerpts from the interview with students also confirmed these findings :

"Perhaps too quick to remove the overhead slides - I missed writing some material."

"Not enough time to copy down slides which made it impossible to listen at the same time."

"I found it difficult to keep up with the lecturer, so I omitted a wee bit."

"I suffered from information overload. There was an awful lot of information to put into this lecture. I think allocating more time and a slowing down of pace would have greatly improved the course."

"If anyone could write adequate notes in this lecture course I'd be surprised. The diagrams were very complex and hard to copy."

"Not enough written material was given and, due to the quickness of the lecturer, not enough information was taken in."

"Too many things were dictated without using the board, and quite fast at that."

"The rate at which these lectures were given were too fast to be taken down and so after the lecture I found there were too many empty spaces."

"The lecture was just a mass of figures and calculations and the lecturer went far too fast that I could not get down what he said."

Based upon the above research findings, **Hypothesis 3** seems to be confirmed, i.e., *"Students will take more verbatim notes when they attend the lectures given by ineffective lecturers under one of the following situations : (i) rapid lecturing pace; (ii) low instructional cues; (iii) low focussing and (iv) shorter wait-time.*

7.3 The Relationship Between Field-dependent / Field-independent Style and Note-taking

7.3.1 Testing Hypotheses 6 and 7

The note-taking behaviours of the students classified by their cognitive styles were explored and the following two hypotheses were thus tested :

Hypothesis 6 *The field-dependent students will be less complete note-takers than the field-independent students.*

Hypothesis 7 *The field-dependent subjects will have lower scores in class exam than the field-independent subjects.*

7.3.1.1 Analysis and Results

The quantitative analysis was first carried out to inspect students' notes by using the above three indices : (i) the total number of words, (ii) the total number of information units and (iii) the completeness percentage. Subsequently, the lecture notes were analysed qualitatively to check if there had been any evidence of processing.

TABLE 7-14 shows the results from quantitative analysis of lecture notes from students with different cognitive styles. In general, field-independent students noted down more completely than the field-dependent students in all of those three indices.

TABLE 7-14. Quantitative Analysis of Lecture Notes according to their Cognitive Styles (I.U = Information Unit)

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4763	4889	4951	4962	4813	5218	4894	4957	5437	4873	4886	5202
Mean total I.U spoken & written		135	124	113	148	117	104	136	173	159	140	138	125
Mean total words on board		532	422	539	603	535	429	623	618	666	586	525	545
Mean total I.U on board		82	95	57	103	93	60	93	138	108	93	109	75
Mean of total words recorded	Field Dependent	541	425	536	622	545	428	632	621	673	598	530	546
	Field Neutral	544	434	542	631	548	435	648	643	669	608	542	549
	Field Independent	565	462	553	677	571	449	675	688	691	639	574	564
Mean of total I.U recorded	Field Dependent	89	97	55	108	97	59	101	141	111	99	112	75
	Field Neutral	110	99	79	119	101	68	113	144	116	114	115	88
	Field Independent	128	115	101	139	108	84	118	147	125	128	123	104
Mean of completeness	Field Dependent	66 %	78 %	49 %	73 %	83 %	57 %	74 %	82 %	70 %	71 %	81 %	60 %
	Field Neutral	81 %	80 %	70 %	80 %	86 %	65 %	83 %	83 %	73 %	81 %	83 %	70 %
	Field Independent	95 %	93 %	89 %	94 %	92 %	81 %	87 %	85 %	79 %	91 %	89 %	79 %

Further inspection of the content of students' lecture notes showed that :

(1) There was not much difference between field-dependent and field-independent students in recording what appeared on the blackboard in terms of both the total number of words and information units. But a striking difference has been detected among them in recording the lecture messages conveyed orally by the lecturers.

In all the different blocks of lectures investigated, students were found to take down an average of 95 % of information written on the board in their notes, but only 32 % of the critical lecture ideas sent forth verbally.

(2) Both the field-independent and the field-dependent students almost recorded an approximate copy of the lecture material put on the board or on the transparency. With regard to the lecture message conveyed orally by the lecturers, field-independent students were found to record more such lecture ideas than the field-dependent students.

(3) If a verbal signpost or stress was used by the lecturer, the field-dependent students were more likely to record that particular lecture information as the field-independent students.

(4) It was also noticed that field-independent students tended to take more concise notes which contained fewer words than the field-dependent subjects even though they had recorded almost the same information.

Field-independent students tended to use more abbreviations and symbols but field-dependent students seldom did so, on the contrary they seemed to like to write down as many words as possible.

The note-taking types used by field-dependent and field-independent students were identified and the results are shown in TABLE 7-15. More than half of the students utilised "BSO type", in other words, most times they took verbatim notes only. Field-dependent students' notes tended to be less complete because they missed most verbal lecture messages, but in contrast, field-independent students' notes seemed to be more complete because they also recorded many extra verbal lecture messages in addition to what appeared on the board.

TABLE 7-15. The number of students in different note-taking types (classified according to their cognitive styles)

Student Type \ Note-taking Type	BS -	BSO	BS +	EL
Field - Dependent (6 students)	3	2	1	0
Field - Neutral (16 students)	2	6	7	1
Field - Independent (10 students)	1	3	4	2

*** BS - = Blackboard Signal Minus BSO = Blackboard Signal Only
BS + = Blackboard Signal Plus EL = Elaboration

Combined together, these results support **Hypothesis 6 :** *The field-dependent students will be less complete note-takers than the field-independent students.*

7.3.1.2 Cognitive Styles and Class Exam Performance

The scores obtained by students with different cognitive styles are presented in TABLE 7-16. Field-independent students (who were found to be more complete note-takers) have higher mean scores than the field-dependent students in the class exam. This finding confirms the research hypothesis - **Hypothesis 7** : *"The field-dependent subjects will have lower scores in the class exam than the field-independent subjects"*.

TABLE 7-16. The Relationship between Exam Performance and Cognitive Style

Student Types \ Performance	Mean score of 1st class exam
Field - Dependent (6 students)	46.2
Field - Neutral (16 students)	54.5
Field - Independent (10 students)	62.1

7.3.2 The Interaction of the Lecturing Styles with Students' Cognitive Styles

It seems logical to suppose that the differences in performance would have partly resulted from differences existing between the kind of notes taken by field-independent and field-dependent students. Therefore, students' notes were subsequently subjected to further examination to see if there were any processing differences between those two groups of students.

It was found that <u>writing information on the board</u> is a <u>very effective cue</u> for having students record the key ideas such that the field-dependent students recorded almost as high percentage of blackboard information as the field-independent students. It was also detected that if a verbal signpost or stress was used by the lecturer, the field-dependent students were more likely to record that particular lecture message.

But there has been a marked difference between the field-dependent and the field-independent students in recording the lecture messages associated with a table, a figure or a diagram. It was found very frequently that, when a table, a figure or a diagram was presented, the field-dependent students tended more likely to concentrate on taking down the detailed information of that part of material without paying much attention to what the lecturer intended to get across by verbal explanations. They tended to accept the organisation of that stimulus only and therefore missed what actually was really relevant.

Figure 7-5 illustrates one of those examples. The **Lecturer 4** presented "the Hydrogen Atom Emission Spectrum" on the transparency and then tried to explain what those lines meant and how they came into existence. Most field-dependent students (**F1** to **F 9** in this figure) were found to record this diagram in great detail but didn't note down what those lines meant and how they occurred. In contrast, most field-independent students also recorded this diagram, but they tended to recognise the point of this diagram by noting down some important lecture ideas conveyed verbally by the lecturer, such as : (i) the lines get closer and closer and that a band limit exists and (ii) different series arise due to the electronic transitions between different states of energy levels (see **F 10** to **F 15** for comparison).

Moreover, field-dependent students seemed to process information in a rigid way, in other words, they are more likely to display "functional fixity". For instance, in one of his lectures, Lecturer **8** tried to explain the stability of carboxylate ion due to the delocalisation of p - electrons. He based his argument on the fact that two C - O bonds in

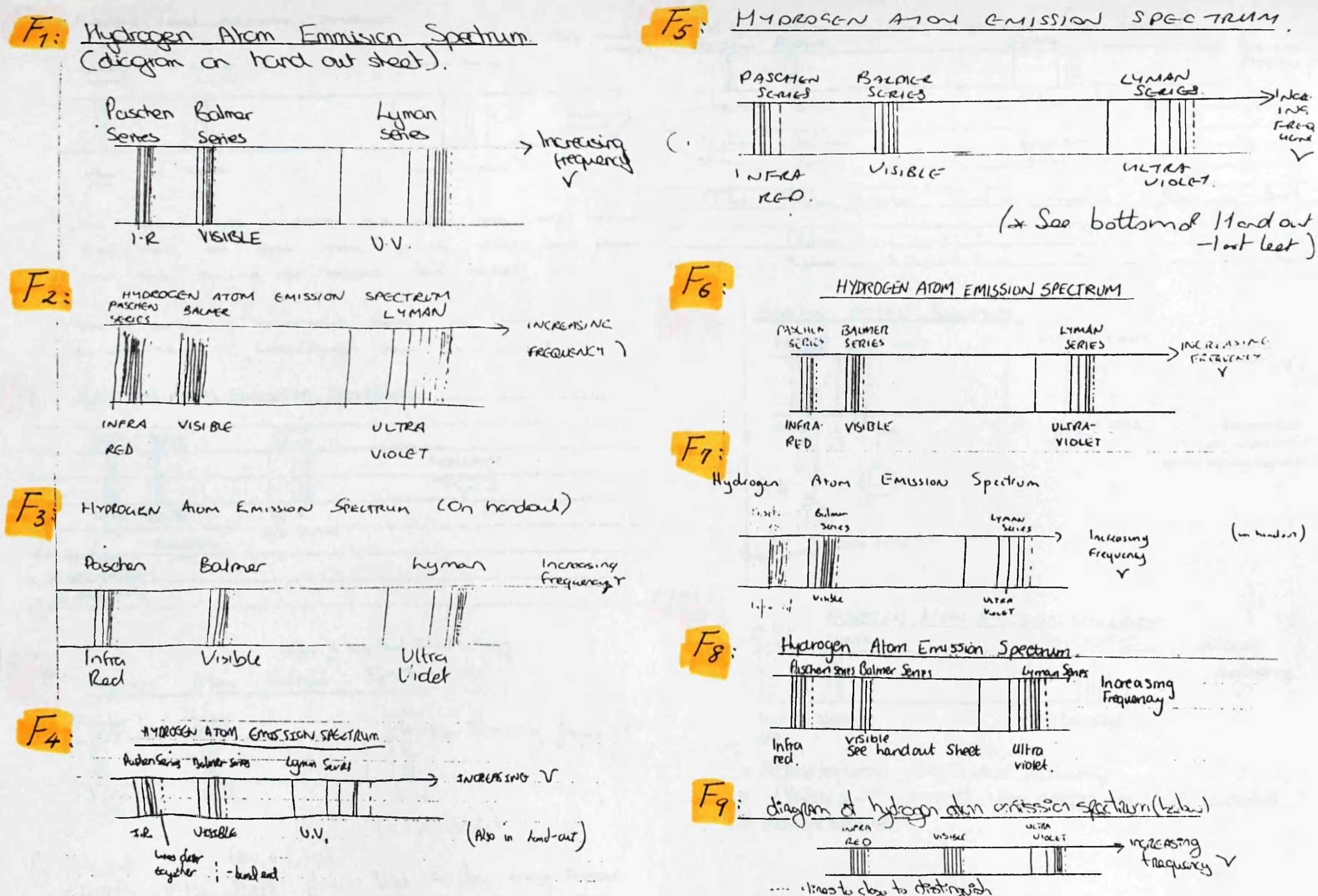


Figure 7-5. Notes Taken by Field-Dependent Students

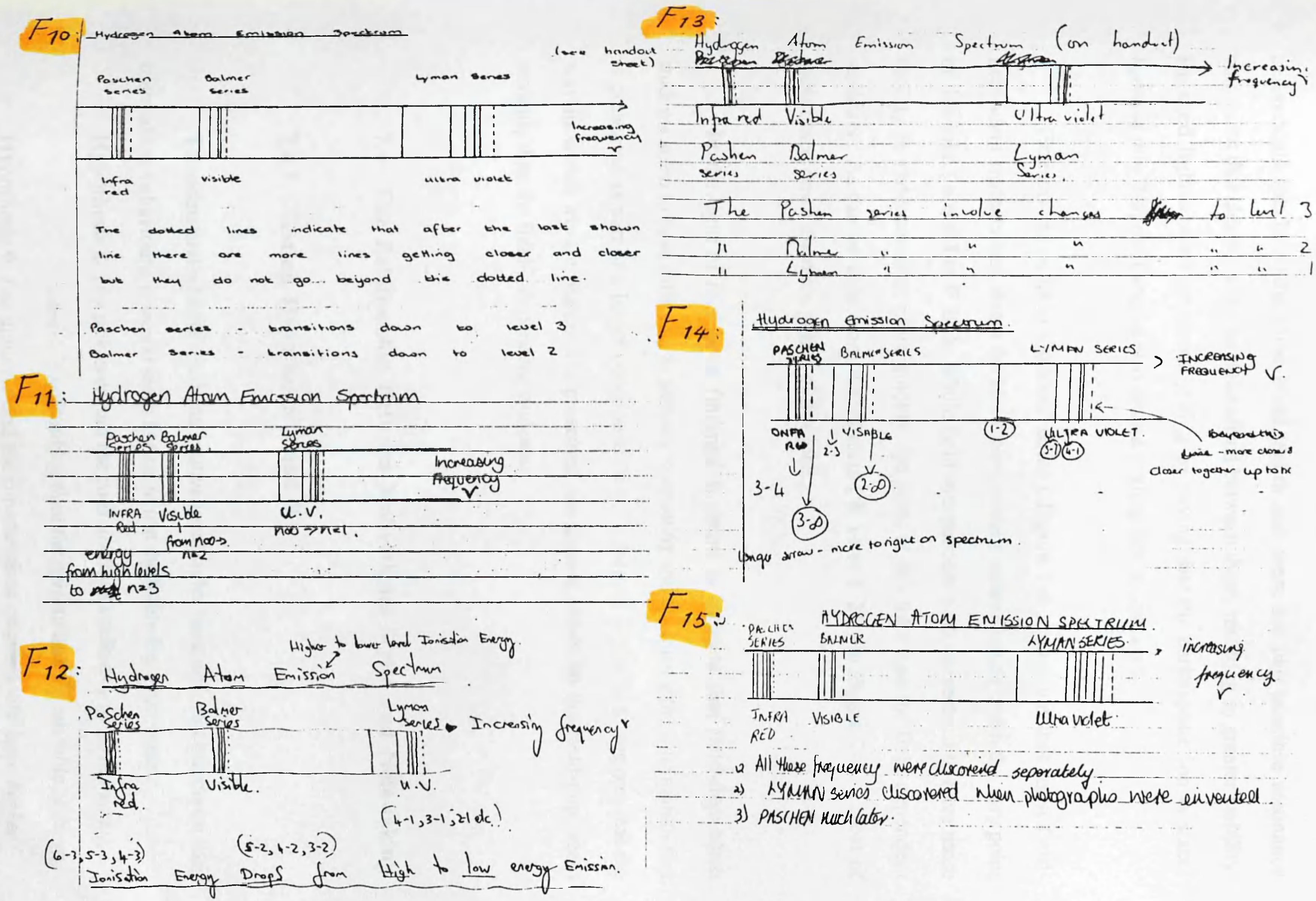


Figure 7-5 (contd.) Notes Taken by Field-Independent Students carboxylate ion have the same bond length and there are two possible resonance structures that electrons can be delocalised between them, resulting in greater stability. He used light-hearted comment, joking by saying that the carboxylate ion is stable because it is "Happy" (and he also drew a smiling face to stress it).

Extracts taken from students' notes (Figure 7-6) indicate that most field-dependent students took down the blackboard writing without noting down the very point of this joke (see **F 1** to **F 10**). While field-independent students seemed to have more facility in understanding, more quickly, the point of this joke than the field-dependent students. As can be seen from the extracts (**F 11** to **F 21**) in Figure 7-6 , most of them noted down the main points of this joke.

In the light of the above findings, it seems to indicate that field-dependent students seem to have difficulty in actively abstracting and organising the information that is presented as part of a larger conceptual field. It follows logically to suggest that the way in which lecture material is presented has greater effect on the field-dependent students than the field-independent students.

7.4 The Relationship Between Motivational Styles and Note-taking

7.4.1 Testing Hypotheses 8 and 9

To understand whether students' motivational styles have different effects on their note-taking behaviours, it would seem logical to test the following hypotheses :

Hypothesis 8 *The achiever and the conscientious students will have more complete note-taking than the curious and the sociable students.*

Hypothesis 9 *The achiever and the conscientious students will have higher*

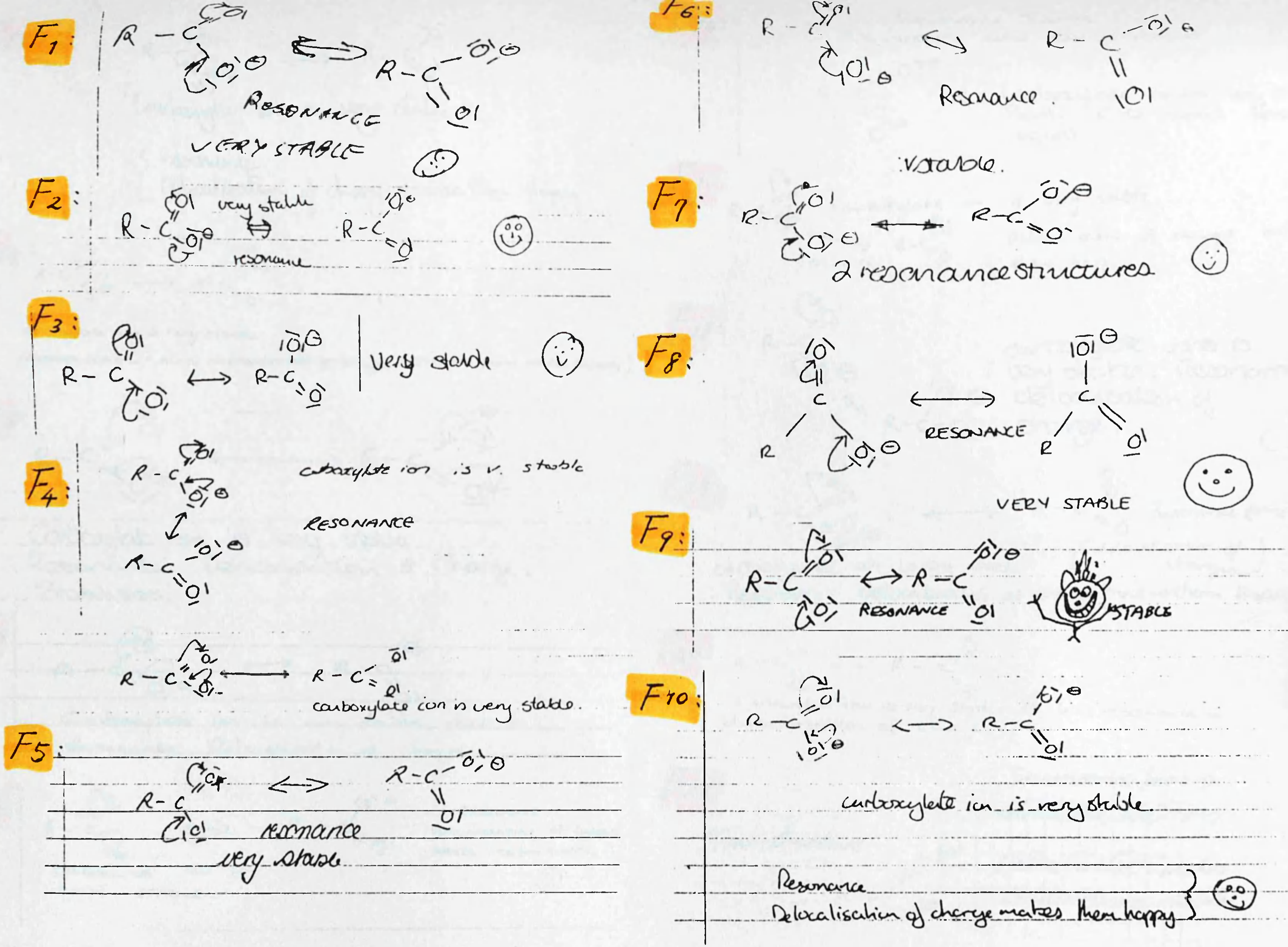


Figure 7-6. Extracts Taken from Lecture Notes of Field-Dependent Students

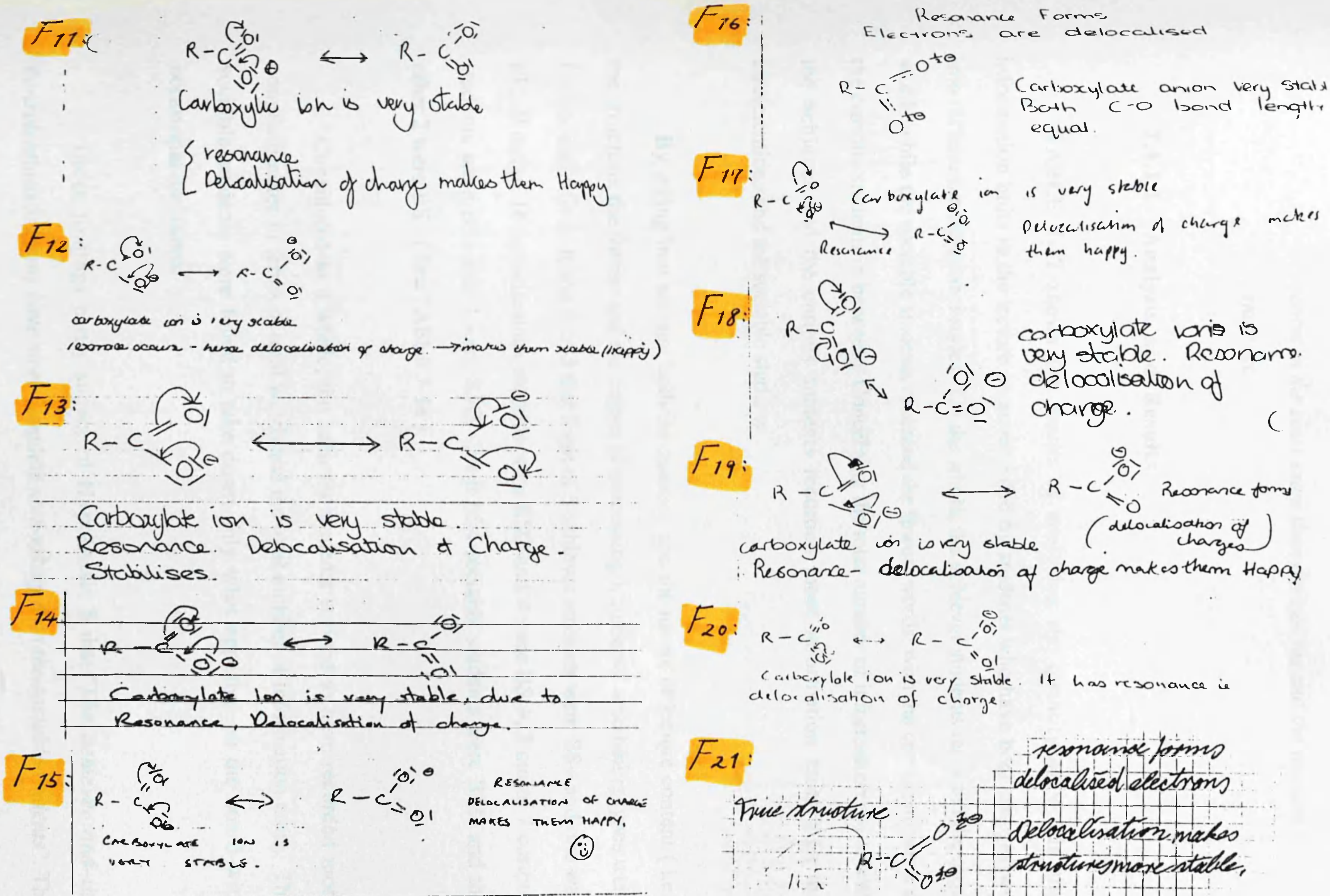


Figure 7-6 (contd.) Extracts Taken from Lecture Notes of Field-Independent Students *scores in the class exam than the curious and the sociable students.*

7.4.1.1 Analysis and Results

TABLE 7-17 shows the results of analysing the quantity of words and information units in the lecture notes recorded by students who have been categorised into different motivational styles. On the whole, the achiever students recorded the most words while the sociable students recorded the fewest words, with the conscientious and the curious students in between. Concerning the total number of information units, both the achiever and the curious students recorded more information units than the conscientious and the sociable students.

By taking into account both the quantity and the nature of lecture content (i.e., the structure, the format and the degree of processing), students' note-taking types were further identified. It was found that 3 out of 5 achiever students were BS+ and one was EL, 9 out of 16 conscientious students were BSO and 4 were BS +, 2 out of 7 curious students were BS+ and 3 were BSO, 2 out of 4 sociable students were BSO and the other 2 were BS - (See TABLE 7-18).

Considered as a whole, the achiever students seemed to have recorded more complete notes in terms of total words and the total number of information units. The sociable students were found to take down only what appeared on the board with occasional omissions.

These findings partly supported **Hypothesis 8** that *"The achiever and the conscientious students have more complete note-taking than the sociable students"*. The curious students were also found to take an approximate copy of what was put on the

TABLE 7-17. Quantitative Analysis of Lecture Notes according to their Motivational Styles (I. U = Information Unit)

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4763	4889	4951	4962	4813	5218	4894	4957	5437	4873	4886	5202
Mean total I.U spoken & written		135	124	113	148	117	104	136	173	159	140	138	125
Mean total words on board		532	422	539	603	535	429	623	618	666	586	525	545
Mean total I.U on board		82	95	57	103	93	60	93	138	108	93	109	75
Mean of total words recorded	Achiever	608	453	576	648	592	457	686	670	713	647	572	582
	Conscientious	536	427	545	609	544	433	652	627	677	599	533	552
	Curious	571	448	537	655	575	448	674	656	692	633	559	559
	Sociable	518	408	531	605	529	418	578	616	654	567	518	534
Mean of total I.U recorded	Achiever	129	118	102	133	107	87	121	153	131	128	126	107
	Conscientious	101	98	94	125	101	68	118	141	114	115	113	92
	Curious	125	116	72	131	103	64	129	144	116	128	121	84
	Sociable	87	95	54	109	94	52	93	135	107	96	108	71
Mean of completeness	Achiever	96 %	95 %	90 %	90 %	91 %	84 %	89 %	88 %	82 %	91 %	91 %	86 %
	Conscientious	75 %	79 %	83 %	84 %	86 %	65 %	87 %	82 %	72 %	82 %	82 %	74 %
	Curious	93 %	94 %	64 %	89 %	88 %	62 %	95 %	83 %	73 %	91 %	88 %	67 %
	Sociable	64 %	77 %	48 %	74 %	80 %	50 %	68 %	78 %	67 %	69 %	78 %	57 %

TABLE 7-18. The number of students in different note-taking types
(classified according to their motivational styles)

Student Type \ Note-taking Type	BS -	BSO	BS +	EL
Achiever (5 students)	1	0	3	1
Conscientious (16 students)	3	9	4	0
Curious (7 students)	1	3	2	1
Sociable (4 students)	2	2	0	0

*** BS - = Blackboard Signal Minus BSO = Blackboard Signal Only
BS + = Blackboard Signal Plus EL = Elaboration

board, but they recorded many extra lecture messages conveyed verbally by the lecturers, such as demonstrations and supplementary materials.

7.4.1.2 Motivational Styles and Class Exam Performance

TABLE 7-19 shows the class exam scores of students classified according to their motivational styles. From a visual inspection of this table, one can clearly see that both the achiever and the curious students have higher mean scores than the conscientious and the sociable students. The differences between the achiever, the curious and the conscientious students were not very large, but the sociable students have the lowest mean score than the other three groups of students, probably because they recorded less complete notes. This finding also partly supported **Hypothesis 9** : *The achiever and the conscientious students will have higher scores in the class exam than the sociable students"*, but didn't confirm the prediction about the performance of the curious students.

TABLE 7-19. The Relationship between Performance and Motivational Styles

Student Types \ Performance	Mean score of 1st class exam
Achiever (5 students)	64.7
Conscientious (16 students)	51.6
Curious (7 students)	62.8
Sociable (4 students)	45.4

7.4.2 The Interaction of Lecturing Styles with Students' Motivational Styles

In general, the note-taking types of the Achiever and the Conscientious students were more consistent across different blocks of lectures than the Curious and the Sociable students (see Table 7-17 for comparison). The former two types of students seemed to assume the sort of BS + (Blackboard Signal Plus) note-taking type, namely - they not only recorded all the materials put on the board but also noted down a great number of lecture messages conveyed verbally by lecturers. From the above table, it is clear that they seldom missed out the main points because they recorded both the written and the spoken lecture information.

On the contrary, both the Curious and the Sociable students seemed to be greatly affected by the lecturing styles. The data from interviewing the subjects showed that both the Curious and the Sociable students were <u>less motivated</u> by the <u>ineffective lecturers</u> that they seldom paid great attention to what was being orally conveyed and most times, they only recorded verbatim notes with occasional omissions. When asked about why they had taken more notes in some lectures but taken fewer notes in others, they commented that the lecturing style played a crucial role for them to determine whether they were going to listen carefully or <u>switch off</u> (extracted from the dialogue with one of the students).

The following excerpts taken from the dialogue of diary-interview with the Curious and the Sociable students illustrate the perceptions they had about the lecturers which had affected their note-taking behaviours :

> *"New lecturer - that doesn't talk such crap. Extremely boring! "* (Translation : "Give us a new lecturer who will not talk such crap.")
> (**On Lecturer 5**, one of the ineffective lecturers. In addition, it was found that after third lecture of this block, less than half of the whole class kept on coming to lectures).
>
> *"This lecturer made the subject exceedingly difficult to understand, and I am sure it is not really as boring as it was made out to be. I didn't take much note but instead read the textbook".*

(On **Lecturer 1**, an ineffective lecturer).

"I DO NOT UNDERSTAND ANYTHING ABOUT XXX - help !"

(On **Lecturer 5**, and this student took very little notes).

"The lecturer showed no interest and enthusiasm at all, and in fact he put me to sleep."

(On **Lecturer 1**, and this student borrowed lecture notes of the course from his friend and xeroxed them).

"He didn't give good set of notes on board, only jumped around and around, and I really didn't know what to take down."

(On **Lecturer 12**, an ineffective lecturer).

"The lecturer involved used the transparencies far too much and he made this course exceedingly boring to the extent I was dozing off at 10 AM in the morning."

(On **Lecturer 9**, an ineffective lecturer).

"His voice was very monotonous and his pace was too slow that many students fell asleep."

(On **Lecturer 9**, one of the ineffective lecturers).

"He rambled around here and there, you just can't figure out what he was talking about that I lost my attention."

(On **Lecturer 12**, an ineffective lecturer).

"He went too fast, especially when he was presenting the transparency, obviously I could not write down every word said."

(On **Lecturer 12**, an ineffective lecturer).

7.5 The Relationship Between Gender Differences and Note-taking

7.5.1 Testing Hypotheses 10 and 11

For convenience, the above hypotheses are restated here :

Hypothesis 10 *Female students will be more complete note-takers than male students.*

Hypothesis 11 *Female students will perform better in the class exam than male students.*

7.5.1.1 Analysis and Results

The results from quantitative analysis of lecture notes according to students' gender are given in TABLE 7-20. Female students recorded more complete notes both in terms of total words and total number of information units.

BSO types of note-taking were identified to be the commonest method used by both male and female students (See TABLE 7-21). Female students tended more likely to use BS+ (9 out of 17, 53 %) because they recorded more extra verbal lecture messages.

The above results confirmed **Hypothesis 10** , i.e., *Female students will be more complete note-takers than male students.*

7.5.1.2 Gender Differences and Class Exam Performance

The performance of male and female students in the class exam was compared and the results are shown in TABLE 7-22. Male students have higher mean score than female students in spite of their less completeness in note-taking. This contradicted the prediction of **Hypothesis 11** : *Female students will perform better in class exam than male students.*

TABLE 7-20. *Quantitative Analysis of Lecture Notes according to their Gender Difference (I.U = Information Unit)*

		1st lecture			2nd lecture			3rd lecture			Overall lectures		
		Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
Mean total words spoken		4763	4889	4951	4962	4813	5218	4894	4957	5437	5437	4873	5202
Mean total I.U spoken & written		135	124	113	148	117	104	136	173	159	140	138	125
Mean total words on board		532	422	539	603	535	429	623	618	666	586	525	545
Mean total I.U on board		82	95	57	103	93	60	93	138	108	93	109	75
Mean of total words recorded	Male Students	538	429	527	631	533	418	641	614	649	603	525	531
	Female Students	585	482	587	655	598	450	665	661	722	635	580	586
	Whole Sample	563	457	558	644	567	435	654	639	688	620	554	560
Mean of total I.U recorded	Male Students	96	94	64	113	98	56	107	134	112	105	113	77
	Female Students	124	120	79	136	109	96	124	151	129	128	127	101
	Whole Sample	111	108	72	125	104	77	116	143	121	117	118	90
Mean of completeness	Male Students	71 %	76 %	57 %	76 %	84 %	54 %	78 %	77 %	70 %	75 %	82 %	61 %
	Female Students	92 %	96 %	70 %	92 %	93 %	92 %	91 %	87 %	81 %	91 %	92 %	80 %
	Whole Sample	82 %	87 %	64 %	84 %	89 %	74 %	85 %	83 %	76 %	84 %	86 %	72 %

TABLE 7-21. The number of students in different note-taking types
(classified according to their gender)

Note-taking Type / Gender	BS -	BSO	BS +	EL
Male (15 students)	3	7	3	2
Female (17 students)	2	6	9	0

*** BS - = Blackboard Signal Minus BSO = Blackboard Signal Only
BS + = Blackboard Signal Plus EL = Elaboration

TABLE 7-22. The Relationship between Exam Performance and Gender Difference

Performance / Gender	Mean score of 1st class exam
Male (15 students)	60.2
Female (17 students)	51.1

7.5.2 The Interaction of Lecturing Styles with Students' Gender Differences

Female students were found to be more likely to assume the BS + type of note-taking and their note-taking behaviours were more consistent across different lecturers, in other words, they were less affected by the lecturers' style of presentation when taking notes. In comparison, male students were more likely to record more information when they attended more interesting lectures but tended to take verbatim or less complete notes when they attended less interesting lectures.

Female students were found to take more copious notes than male students. Comparatively, female students tended to write down the whole sentence (wordier notes) instead of the main points; even that which appeared on the board was in fact more concise. For example, on one occasion, **Lecturer 7** was explaining the meaning of "unit cell" by simple definition and several examples. He put on the board the following words : "Unit cell - simplest basic repeat unit , could be cubes, cuboids, in principle any solid shape that won't leave spaces". And then he started to explain by presenting diagrams of some examples on the transparency.

Some fragments of notes taken from students illustrate the marked difference between women and men students (Figure 7-7). **W 1** to **W 11** are the notes taken by female students and a visual inspection of those notes clearly indicate that they contain not only the blackboard writing but also some of the verbal lecture messages. It is worth notice that several female students recorded the definition of "unit cell" by following the lecturer's spoken words. **M 1** to **M 13** are the notes of male students; they seemed to be the approximate copy of the blackboard writing and a little extra information but they were more concise.

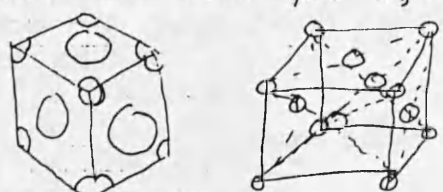
W1:

Unit cell.
The order characteristic of crystalline solids allows us to convey a picture of an entire crystal by looking at only a small part of it. We can think of the solid as being built up by stacking together identical building blocks, just like building a wall by stacking individual identical bricks. The repeating unit of a solid - the crystalline 'brick' - is known as the UNIT CELL. The repeating units - cubes cuboids etc must pack together leaving no spaces.

W2:

B&LeMay. pp 360 364

BUILDING UNITS OF CRYSTALLINE SOLIDS
MOLECULES, IONS OR COVALENTLY BONDED UNITS.
UNIT CELL - DESCRIBES A PATTERN AND THE WAY IT REPEATS WITHIN A SOLID. SIMPLEST BASIC REPEAT UNIT WHEN FITTED TO GETER WILL FORM THE 3DIMENTIONAL STRUCTURE.
THEY CAN BE ANY SHAPE THAT WHEN STACKED TO GETER WILL NOT LEAVE GAPS - eg CUBES, PRISMS
eg METHANE



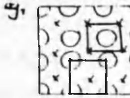
W3:

UNIT CELL - describes the pattern and the way it repeats in the solid.
Out of the pattern we can take a basic repeat unit. Pattern repeats in 3d (not just 2d).
Simplest basic repeat unit when stacked togetr in 3 direction gives solid reqd.

W4:

pg 360
c.f. wallpaper pattern.

Consider - unit cell (describes pattern and way it repeats) OR REPEATING UNIT
- often more than one way - more than 1 basic unit.
- in crystal, repeats in 3D
- blocks instead of tiles
- each one UNIT CELL

eg  both unit describe pattern x.

UNIT CELL - simplest basic repeat unit which when stacked tog. other, forms solid
- can be cuboids, hexagonal prisms, cubes, etc.
- generally, any shape packed together without leaving spaces (not

W5:

How we describe geometric arrangement?
Unit cell describes pattern and arrangement.
In 2 dimensionals we could take basic unit ie repeat unit (flat repeating tiles)
In crystal pattern repeats itself in 3 dimensions form.
These unit cells are either cuboid, hexagonal prisms, ~~[illegible]~~ can be any solid shape which when packed together wouldn't leave any space (ie not spheres).

Methane
Methane - cuboid structure.
The boundaries of the cell cut the molecules at the corners for methane - molecules are roughly spherical and touch each other at some point.
Lines on diag don't represent chemical merely put in to represent geometrical shape of the molecule.

[Unit cells] - p ~~317~~ 360
p 364

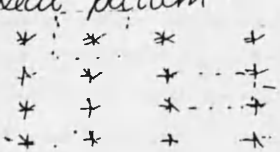
Brown & LeMay.

Figure 7-7. Notes Taken by Female Students

W6: – Unit cell of the crystal is the smallest unit of the crystal. It can vary for any given pattern. but is always the same area and when repeated, it creats the pattern. (see pg 360) It is the repeat pattern.
† To make it easier to see the arrangement of the molecules the unit cell can be drawn with the molecules shrunk.

W7: Unit cell – Simplest basic repeat unit placed in a 3D way to make up the cuboid but can be any solid shape which leaves no spaces. The ~~lurke~~ lines on the diagram don't represent bond they only indicate actual shape of cuboid Unit cells (360 + 364)

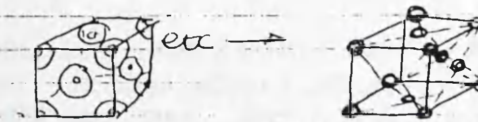
W8: UNIT CELL
2D ⟶ (e.g. wallpaper has a repeat pattern) repeats in vertical & horizontal directions
· we can take the shape which represents the repeat pattern



usually pick the repeat pattern from the centre of the crystal.

R.R. – can be any shape as long as it fits into itself again without leaving any space
B & he M p.360

W9: Unit cell (repeating pattern generating the regular structure within the crystal) This repeating pattern may be shown in different arrangements although the area & shape are still the same (Tiles pattern in 2-D) In 3-D these can eg be cuboid but when packed the repeat unit must be displayed with no area/v eg at low temp – solid CH_4.



face centred cube

W10: UNIT CELL – describes the pattern & the way it repeats.

These units can be cuboid in fact it can be any solid shape which can pack together without leaving space.

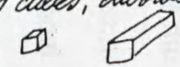
W11: The unit cell – the repeated Pattern that exists in a real 2 dimensional
ie repeated Pattern in a wallpaper
The repeat Pattern can be any shape provided the shapes can fit together without leaving spaces between them e. a square, triangular, hexagonal
See B + LeM pg 360

Figure 7-7 (contd.) Notes Taken by Female Students

M1: Units cells can be cuboid, hexagonal prisms.
In principle they can be any solid shape that can pack together without leaving voids
eg. spheres wouldn't work

M2: Unit cell describes pattern. There are often cuboids, hexagonal prisms
Face centre cubic structure (molecules in the middle of each face

M3: B&LeMay p360
Unit cell
three dimensional repeat patterns cubes, cuboids



M4: ~~Solids types (4)~~
Unit cell (repeating pattern which generates regularity in solid)

M5: UNIT CELL - repeating pattern which regulates structure in a crystal.
FACE CENTRE CUBIC STRUCTURE - e.g. methane
(Molecules at corners and at centre of the cube.
B & LeMay 4th Edn p.360, 364. Unit cell

M6: Unit cells - cubes, cuboids

in principle any solid shape that won't leave spaces.

Structure of methane - face centred cube
(spacefilling molecule)
lines on diagram do not represent chemical bonds

M7: Unit cell.
Simplest basic repeat unit placed in a 3.d way to make up the cuboid.

M8: The UNIT CELL is the repeating structure.
e.g. METHANE (the face-centred cubic structure).
SEE BROWN & LEMAY: P.360 (METHANE: P.364).

M9: molecules, ions, covalently bonded atoms - 'building units'
Unit Cell - describes pattern & the way it repeats in a crystal
simplest repeat unit. often cube, cuboid, hexagonal prisms.
- in principle any solid shape that can pack without leaving spaces between adjacent units
(phase centred)

M10: UNIT CELL p317 B.L.M. Diagram p317 B.L.M.
The simplest basic repeat unit. Usually cubes or cuboids or prisms. They pack together without leaving any spaces

M11: Unit cell: regular pattern, reproducing the pattern over and over again

M12: unit cell - simplest basic repeat unit ~~although~~
- cuboids, hexagonal prism
although any shape is ~~[illegible]~~ packable leaving no space.

M13: UNIT CELL shape repeated in structure
Can see this in wall paper.

Figure 7-7 (contd.) Notes Taken by Male Students

On the occasions when the lecturer dictated instead of writing the lecture information on the board, female students were found to record more completely (copiously) than male students. Male students were more likely to take key points with some lagging behind, resulting in unfinished sentences. For example, when requested to take down the different versions of "the Second Law of Thermodynamics", female students didn't seem to have great difficulty in taking the whole paragraph of dictations (15 out of 17, namely 88 % of female students recorded it correctly), in contrast, male students tended to miss some words or didn't follow closely enough so that several inaccuracies were recorded (7 out of 15 recorded it copiously, 2 used abbreviations and 6 missed certain part or made wrong logical connections). Figure 7-8 illustrates this comparison, **F 1** to **F 6** are women students' notes and **M 1** to **M 7** are men students' notes.

7.6 Students' Note-taking Behaviours In General

Although the subjects of this present study seems to be a good sample and to be able to represent the whole class, it was felt necessary to carry out a general survey to understand students' opinions about note-taking during lectures. In this survey, students were asked about the purpose of note-taking during lectures, their opinions about having complete handouts, how they select the essential lecture information to take down, how they use the lecture notes and for what purpose, and any features of lectures that they would like to see changed to enable them to take satisfactory notes.

On the eighth and ninth weeks of the first term, the questionnaire sheets (see Appendix 19, Page 387) were distributed to each student when they went into the lab. Students were then requested to write their responses to those five questions and the researcher immediately collected the completed questionnaire sheets before the laboratory started.

F1: Second Law

For any natural spontaneous change there is always a gain, or certainly no loss, in entropy when both the system and the surroundings are considered.

The entropy of the universe is constantly increasing

Heat never flows spontaneously from a cold body to a hot body

F2: 2nd Law of Thermodynamics

" From any natural spontaneous change there is always an increase or gain or certainly no decrease in Entropy when the system & the surroundings are considered together.

The entropy of the universe is constantly increasing"

~~Defn~~ Heat does not flow spontaneously from a cold body to a hot body.

F3: 2nd Law is defined as follows:-

" for any natural spontaneous change there is always an increase (certainly no decrease) in entropy when the system and the surroundings are considered together."

Other defns

" The entropy of the universe is constantly increasing"

" heat does not flow spontaneously from a ~~hot~~ cold body to a ~~cold~~ hot body"

F4: SECOND LAW.

for any natural spontaneous change there is always a gain (or centaintly no loss) in enthropy when both the system & the surroundings are considere.

Enthropy of the universe is constantly increasing.

Heat never flow spontaneously from a cold body to a hot body

F5: SECOND LAW

For any natural spontaneous change, there is always a gain - or certainly no loss - in entropy when both the system + the surroundings are concerned.

(The entropy of the universe is constantly increasing)
(Heat never flows spontaneously from a cold body to a hot body)

F6: SECOND LAW THERMO: For any natural spontaneous change there is always a gain, or certainly no loss in entropy when both the system and the surroundings are considered.
The entropy of the universe is constantly increasing.
Heat never flows spontaneously from a cold body to a hot body

Figure 7-8. Women Students' Notes

M1: second law of thermodynamics. For any natural spontaneous change there is always a gain or certainly no loss in entropy when both the system and the surroundings are considered.
~~For~~
Alternative statement
The entropy of the universe is constantly increasing
or
Heat never flows spontaneously

M2: 2nd Law of thermodynamics
"for any natural spontaneous change there is always an increase (or certainly no decrease) in entropy when the system and the surrounding area consider together.
Note the entropy of the universe is constantly increasing.

M3: (1) SECOND LAW
For any natural spontanious change there is always a gain or certainly no loss in entropy when both the system and the surroundings are considered

OR ....

THE ENTROPY OF THE UNIVERSE IS CONSTANTLY INCREASING!

M4: SECOND LAW :- For any natural spontaneous change there is always a gain or certainly no loss in Entropy when both the system and surrounding are considered.
Alternatively
(1) The entropy of the universe is constantly increasing
(2) Heat never ~~flows~~ flows spontaneously from a cold body to a hot body.

M5: 2nd Law Thermodynamics
Any natural, spontaneous change there is always an increase in entropy when the system and surroundings are considered together.

heat does not flow spontaneously from a cold body to a hot body.

M6: As S decreases in the system, the S increases in the surroundings

Any natural spontaneous change there is always an increase in entropy when the system and surroundings are considered together

M7: 2nd Law of ~~thermodyn~~ Thermodynamics; for any natural spontaneous change there is always an increase or gain (or certainly no decrease) ~~in~~ ~~in~~ in entropy when the System and surroundings

The entropy of the Universe is constantly increasing

Heat does not flow spontaneously from a

Figure 7-8 (contd.) Men Students' Notes

A total of **427** questionnaire sheets was distributed and 353 questionnaire sheets were returned. After inspection, 34 questionnaire were found to be spoiled or blank and so they were not used for analysis. Finally **319** questionnaire sheets were examined and the response rate was **75 %.** The results are tabulated as follows (TABLE 7-23).

TABLE 7-23. The Results of Note-taking Questionnaire

The Results of 319 Questionnaire Sheets (1990)

Item Questions	*Percentage*
1. The purpose of note-taking during lectures	
(a) To concentrate	23
(b) To have something as a record	76
(c) Other ideas	1
2. The opinion about note-taking as opposed to having complete printed handout	
(a) Can't understand lecture and take notes at the same time	26
(b) Handouts are not in my own language or style	68
(c) I like to write in my way or language	3
(d) I like printed handouts	21
3. When taking notes, the way to get down "the essentials"	
(a) Take down what is on the board only	49
(b) Get "signals" from the lecturer about what is important	55
(c) Write down as much as possible	11
(d) Don't know what is important	5
(e) Others	2
4. How to use the notes	

(a) Supplement them from the textbook ---------------------- 53

(b) Never look at them till exam time ----------------------- 3

(c) They are the main source of my revision material --------------- 56

(d) Rewrite them ---------------------------------- 17

5. The features of lectures students like to see changed to enable them to take satisfactory notes.

[A] About lecturer's personality

(1) Liven up the lecturers ------------------------- 2

(2) More enthusiastic ---------------------------- 2

(3) More approachable ---------------------------- 3

(4) Not monotonous ------------------------------ 2

(5) Louder, clear voice ---------------------------- 10

[B] About lecturing methods

(1) Give the objectives for the lectures ------------------- 2

(2) Put headings and subheadings --------------------- 7

(3) Need introduction, preview and guidelines --------------- 9

(4) Review and summarise ------------------------- 17

(5) Point out main points (say clearly what to take down, and give indication of what is relevant) --------------------- 39

(6) Better and bigger writing on the board ---------------- 27

(7) Don't talk and use OHP, slides at the same time ----------- 19

(8) Don't talk and write at the same time ----------------- 26

(9) More time for copying down the lecture material ----------- 37

(10) Go at a slower pace --------------------------- 34

(11) Speak slowly to allow note-taking ------------------ 23

(12) More time for asking questions -------------------- 5

(13) Less writing and more explaining ------------------- 29

(14)	Explanations should be sketchy, concise and less digression ------	16
(15)	Speak clearly, logically and coherently and don't jump around -----	34
(16)	Put new names, formulae and terminology on board ------------	5
(17)	Use different Audio-visual Aids -------------------------	16
(18)	Give the page number of references and textbooks ------------	21
(19)	Give the exam material hints -------------------------	10
(20)	More handouts -----------------------------------	30
(21)	Give the handouts of diagrams -----------------------	10
(22)	More demonstrations ------------------------------	2
(23)	More examples ----------------------------------	10
(24)	More talkback - like tutorials ------------------------	4

*** _Since students might have more than one response in each item, the total percentage may exceed 100 %._

Based upon the research findings from the sample and the results from the above questionnaire, some conclusions could be drawn :

(1) Note-taking was a very common activity of students. Often, what the lecturer was writing on the blackboard was all they had in mental focus (*Perception of importance*).

(2) Most students felt that listening to the lecturer and taking notes simultaneously was very demanding, thus resulting in taking verbatim notes only and neglecting most lecture messages transmitted verbally (*Self - protection against working memory overload*).

(3) The processing of lecture information did not appear to be in-depth; students were attending to, but not actively processing or working on the information conveyed by the lecturers (*Self - protection against working memory overload*).

(4) Information processing was also frequently punctuated by shifts in attention.

Students' information processing in this present study was basically passive rather than active. There were exceptions, with several students using diagrammatic network or logical connections to structure their personally meaningful forms of the lecture information.

(5) One point worth noting is that low processing could be related to the purposes which students expected lectures to serve (*Perception*). From the interview and the results of the questionnaire, more conscientious students appeared to be more concerned about identifying what ought to be learnt than about learning on the spot. They appeared more intent on recording the detailed factual information to aid subsequent study and preparation for exam than attempting to learn during lectures. They used lectures primarily to answer the question : What do I need to know for assessment purpose ? For them learning for retention appeared to be mainly a post-lecture activity in an out-of-class content (*Self - protection against working memory overload*).

(6) Both implicit and explicit cues were used by students to get down "the essentials" of a lecture content. These cues included : (i) the blackboard writing (the most obvious and most effective one), (ii) lecturer' verbal stress or signpost, (iii) lecturer reiteration of a point, (iv) the non-verbal cues such as knocking on the bench or using the pointer and (v) longer than usual time spent on a topic or detailed handouts.

(7) It appears that "cue seeking" could well be significant for field-dependent students' success in learning from lectures. The best illustrations of this was the following comments taken from interview diary with several field-dependent students who constantly sought cues for distinguishing between "relevant" (or "significant") material and "irrelevant" (or "non-significant") material.

"The lecturer was droning on about the irrelevant subjects all the time and I just can't grab the point. He should write more key words and definitions on the blackboard."

"Better teaching structure, and clearer links between points being made."

"Lecturer should repeat and summarise the main points."

"I suggest that lecturers could give key points of what was learned in class at the end of each lesson."

"He should make more notes of important subject headings and linkings on the blackboard to give the students a guideline to what information is important to take notes on, since we obviously cannot write down every word said."

"Less proofs; there was a mass of equations which I really couldn't see the key point of them. She should highlight the essential equations."

"When naming things, block capitals were often used. This made me difficult to decide where to separate words and use the capital letters."

"The lecturer didn't give much indication of what he was talking about. I still do not know what these lectures are about. He missed out important working leaving me baffled."

"The blackboard notes were a bit abstract and random and the headings were not too clear."

"The lecturer didn't write any titles on the board - just fragmented information and then he moved on."

(8) In response to an item question in the questionnaire, every student responded that after attending a lecture, s(he) intended to do subsequent follow-up work. But it was found two months later, just three weeks before the class exam, 14 of those 32 students (less than half of the sample !) had not even read through their lecture notes and handouts nor had they done any subsequent reading.

CHAPTER EIGHT

Summary, Conclusion and Suggestions

This present study has focussed on issues of practical importance namely, how a lecturer could be effective in transmitting the subject matter and how students should learn and take notes during a lecture. From the empirical findings and the theoretical orientations, some implications for lecturing and note-taking are apparent. Also apparent are implications for future research which intends to investigate the cognitive processes underlying the mechanism of lecturing and note-taking.

8.1 Summary of the Results

A. Student Evaluation of Lecturing

1. Students' ratings provided reliable measure of overall lecturing performance in the context of this present study.
   - (i) The inter-correlations between the statements within any one factor dimension were very high, indicating that students' rating of the course and the lecturers was reliable.
   - (ii) Repeated data consistency checks have verified that different students from the same class show a high level of agreement in their ratings of a given lecture course.
   - (iii) The same lecturers' performances on the same lecture courses, rated by two different classes from two academic years were found to be very similar, indicating the reliability of students' ratings.

2. Students' perceptions of a lecturer's performance were as expected in terms of Information Processing Theory.

(i) Student ratings on response sheets

The essential criteria for an effective lecturer are the basic communication skills such as the clear audibility of voice, the legibility and good organisation of blackboard writing (or materials presented with slides or transparencies) and the clarity of explanation. Failing these, one tends more likely to be rated lower and classed as an ineffective lecturer. Having achieved this and adding an interesting style of presentation and a friendly approachable manner, one tends more likely to be rated as an effective lecturer.

(ii) The written-in comments on response sheets

Students made most comments on a lecturer's communication problems which had caused them difficulty in understanding the lectures. They would also comment on the lecturer whom they felt less enthusiastic and unapproachable. In contrast, students showed a very high appreciation of clear and lucid presentation, together with relevant practical examples and illustrations. Students seemed to like an interesting way of presentation and many students mentioned in their comments that they enjoyed the lecturer's having a sense of humour.

(iii) The results from the opinion of staff members

Although lecturers have their own criteria of effective teaching, most of them agreed that students expect a lecturer to be able to lecture well. They recognised the importance of motivating students in the lecture and a great majority of them agreed that to package the lecture information in ways which are easy to grasp and to present the subject material in a systematic and organised way are also very important to students. They argued that student ratings are greatly influenced by the personal charisma of the lecturer but, overall, most of them agreed that student ratings can provide useful feed back to lecturers about their teaching.

(iv) The results from participant observation

The effective lecturers and the ineffective lecturers were observed to have marked differences in (i) the audibility of voice and the quality of blackboard writing, (ii) focussing and (iii) uses of humour and asides. The ineffective lecturers didn't speak loud enough or spoke towards the blackboard so that students couldn't hear them clearly. They wrote too much on the board and the writing was either too small or so disorganised that students had difficulty in seeing the writing clearly.

3. There were three kinds of lecturers or lecturing styles identified in this lecture course : the effective lecturers, the average lecturers and the ineffective lecturers.
4. If students have difficulty in seeing or hearing the lecture messages, the potential stimuli presented by the lecturer fail to become actual stimuli for students. In this case, the lecturer is more likely to be rated lower as an "ineffective lecturer".
5. The effective lecturers potentially brought about an arousal of students' interest by using humour and asides stressing the applications and uses of lecture materials, thus holding students' interest and reversing the decline in attention and so indirectly influencing students' overall perceptions that they were rated higher as "effective".
6. Despite the diversity of lecturer characteristics and lecture topics, common elements of "effective lecturing" were found; these are professional and personal skills and attitudes which were identified in terms of the Information Processing Model. The effective lecturers are able to get their messages across to students' sensory systems clearly, to structure and explain well in a concise way so as not to confuse students, to use humour and asides to maintain

students' arousal of attention and to lecture at a reasonable pace.

B. Note-taking during lectures

1. Students' note-taking behaviours in general

(1) One of the remarkable features was the high agreement between what students actually noted down. Over 90% of the lecture material such as the definitions, names and words written on the blackboard were noted by all the students.

(2) Most students' notes were very similar both in content and approach. They seemed to concentrate their attention by taking notes continually of what was put on the board while many students neglected most of the lecture messages conveyed verbally by lecturers.

(3) Much of what had been recorded was a series of written work on the board or some oral segments identical with lecturers' own words. In other words, most of students' lecture notes were a verbatim copy but without much processing of the information.

(4) Four note-taking types were found to be used by the students involved in this study : BS - (Blackboard Signal Minus), BSO (Blackboard Signal Only), BS + (Blackboard Signal Plus) and EL (Elaboration). But in most cases, lecture information was almost recorded verbatim without any enrichment by later processing.

(5) In all the three groups of students selected as the samples investigated in three different academic years, the note-taking behaviours of most students demonstrated a high consistency across the majority of lectures over an extended period of eight months.

(6) It was apparent that terse note-taking is disfunctional, the students who took more complete notes benefited more in exam performance.

(7) Female students took more complete notes than their male classmates, but they didn't have better performance in exams.

(8) Although students intended to do subsequent follow-up work after attending lectures, it was found many of them failed to do so.

2. The interaction of lecturing styles with students' note-taking

(1) The lecturing styles had a great bearing upon the students' note-taking. In this particular course, students recorded on average over 90 % of the lecture materials put on the board or transparencies but less than 35 % of the lecture messages conveyed verbally by the lecturers.

(2) The inaccuracies in students' notes were identified and the occasions on which students were more likely to make mistakes were when : copying diagrams, numerical figures, equations, items on the OHP's or slides and any later corrections or additions.

(3) Not all the blackboard writing was recorded by students. Items which tended to be neglected were roughly in the following order : demonstrations, examples of applications or new discoveries, overall sequence of logical arguments, meaning of new technical terms or symbols, reasons for steps between equations and diagrams.

4. Interaction of lecturing and students' working memory capacity

(1) Students with lower working memory capacity tended to take verbatim notes only or even missed many main points under one of the following situations : (i) rapid lecturing pace, (ii) low instructional cues, (iii) low focussing and (iv) shorter wait-time.

(2) The notes taken by students with lower working memory capacity were found to be an exact copy of the blackboard writing with occasional omissions. Occasionally, they recorded some extra verbal lecture

messages but most times they took verbatim notes only.

(3) For students with higher working memory capacity, most of them copied down the blackboard writing entirely, and in addition, they captured more extra lecture messages orally conveyed by lecturers.

(4) In general, the students with higher working memory capacity took more complete notes than the students with lower working memory capacity in terms of the total number of words and the information units.

(5) The students with higher working memory capacity had better performance in exams than the students with lower working memory capacity.

5. Interaction of lecturing styles with students' cognitive (FD / FI) styles

(1) There was not much difference between field-independent and field-dependent students in recording what appeared on the blackboard, but a marked difference was detected between them in recording the lecture messages conveyed orally by lecturers.

(2) If a verbal signpost or stress was used by the lecturer, the field-dependent students were more likely to record that particular piece of lecture information than the field-independent students.

(3) It was also noticed that field-independent students tended to take more concise notes which contained fewer words than the field-dependent subjects even though they had recorded almost the same information. Field-independent students tended to use more abbreviations and symbols but field-dependent students seldom did so; on the contrary they seemed to like to write down as many words as possible.

(4) Field-dependent students' notes tended to be less complete because they missed most verbal lecture messages, but in contrast, field-independent students' notes seemed to be more complete because they also recorded many extra verbal lecture messages in addition to what appeared on the board.

(5) Field-independent students (who were found to be more complete note-takers) have higher mean scores than the field-dependent students in the class exams.

(6) It was found that <u>writing information on the board</u> is a <u>very effective cue</u> for having students record the key ideas such that the field-dependent students recorded almost as high percentage of blackboard information as the field-independent students.

(7) There has been a marked difference between the field-dependent and the field-independent students in recording the lecture messages associated with a table, a figure or a diagram. It was found very frequently that, when a table, a figure or a diagram was presented, the field-dependent students tended to concentrate on taking down the detailed information of that part of material without paying much attention to what the lecturer intended to get across by verbal explanations. They tended to accept the organisation of that stimulus only and therefore missed what actually was really relevant.

(8) Field-dependent students seemed to process information in a rigid way, in other words, they are more likely to display "functional fixity".

(9) Field-dependent students seem to have difficulty in actively abstracting and organising the information that is presented as part of a larger conceptual field.

(10) It was found that the way in which lecture material is presented has greater effect on the field-dependent students than the field-independent students.

<u>3. Interaction of lecturing styles with students' motivational styles</u>

(1) On the whole, the achiever students recorded the most words while the sociable students recorded the fewest words, with the conscientious and the curious students in between.

(2) Concerning the total number of information units, both the achiever and the curious students recorded more information units than the conscientious and the sociable students.

(3) The achiever students seemed to have recorded more complete notes in terms of total words and the total number of information units. The sociable students were found to take down only what appeared on the board with occasional omissions.

(4) Both the achiever and the curious students had higher mean scores than the conscientious and the sociable students. The differences between the achiever, the curious and the conscientious students were not very large, but the sociable students had the lowest mean score than the other three groups of students.

(5) In general, the note-taking types of the Achiever and the Conscientious students were more consistent across different blocks of lectures than the Curious and the Sociable students The former two types of students seemed to assume the sort of BS + (Blackboard Signal Plus) note-taking type, namely - they not only recorded all the materials put on the board but also noted down a great number of lecture messages conveyed verbally by lecturers.

(6) Both the Curious and the Sociable students seemed to be greatly affected by the lecturing styles. They were <u>less motivated</u> by the <u>ineffective lecturers</u> that they seldom paid great attention to what was being orally conveyed and most times, they only recorded verbatim notes with occasional omissions.

(7) The **Achiever** students seemed to assume the BS + note-taking type to minimise risk of failure and maximise the probability of success. They seldom missed out important points and it was found that most of them used a signalling system, such as circling or bracketing, underlining or coloured pen to highlight the examinable part which had been selectively cued by

lecturers.

(8) It also has been noticed that the **Curious** students tended to have a preference for seeking supplementary materials, latest developments of chemistry or the applications of chemistry theory because in many cases they were found to have recorded more such lecture messages in their notes than the Conscientious and the Sociable students.

6. Interaction of lecturing styles with students' gender differences

(1) Female students recorded more complete notes both in terms of total words and total number of information units.

(2) Male students had higher mean score than female students in spite of their less completeness in note-taking.

(3) Female students were found to be more likely to assume the BS + type of note-taking and their note-taking behaviours were more consistent across different lecturers, in other words, they were less affected by the lecturers' style of presentation when taking notes.

(4) In comparison, male students were more likely to record more information when they attended more interesting lectures but tended to take verbatim or less complete notes when they attended less interesting lectures.

(5) Female students were found to take more copious notes than male students. Female students tended to write down the whole sentence (wordier notes) instead of the main points.

(6) On the occasions when the lecturer dictated instead of writing the lecture information on the board, female students were found to record more completely (copiously) than male students. Male students were more likely to take key points with some lagging behind, resulting in unfinished sentences.

8.2 The Educational Implications for Lecturers

Based upon the empirical findings from this present study and the theoretical considerations from Information Processing Theory, a variety of information dispensing strategies with specific guidelines are presented for lecturers to follow to maximise the effectiveness in their lecturing:

A. Preparing the lecture

(1) Define the purpose -- the easiest way to start is to write down the objectives of each lecture and give them to the students.

(2) Identify the content

<i> Start with what students have known - avoid making assumptions about knowledge obtained from previous lectures and courses. Make sure of what the students know and build your lecture on that.

<ii> Teach only the essentials - delete all the unnecessary material and never attempt to cram too much information in a single lecture.

<iii> Structure your material by using an outline or a "mind map" such as that shown in Figure 8-1 (Adopted from Johnstone, 154).

<iv> Search for illustrative examples of key points.

<v> Prepare the audio-visual aids such as slides or transparencies, or models, demonstrations etc.

<vi> Appropriate jokes, humourous asides or cartoons with low information content may also be collected for use during this period.

(3) Finalise the lecture plan - the rough content plan must be transformed into a linear structure which follows a logical sequence (The plan also includes notations for the inclusion of the above instructional aids).

B. Presenting the lecture

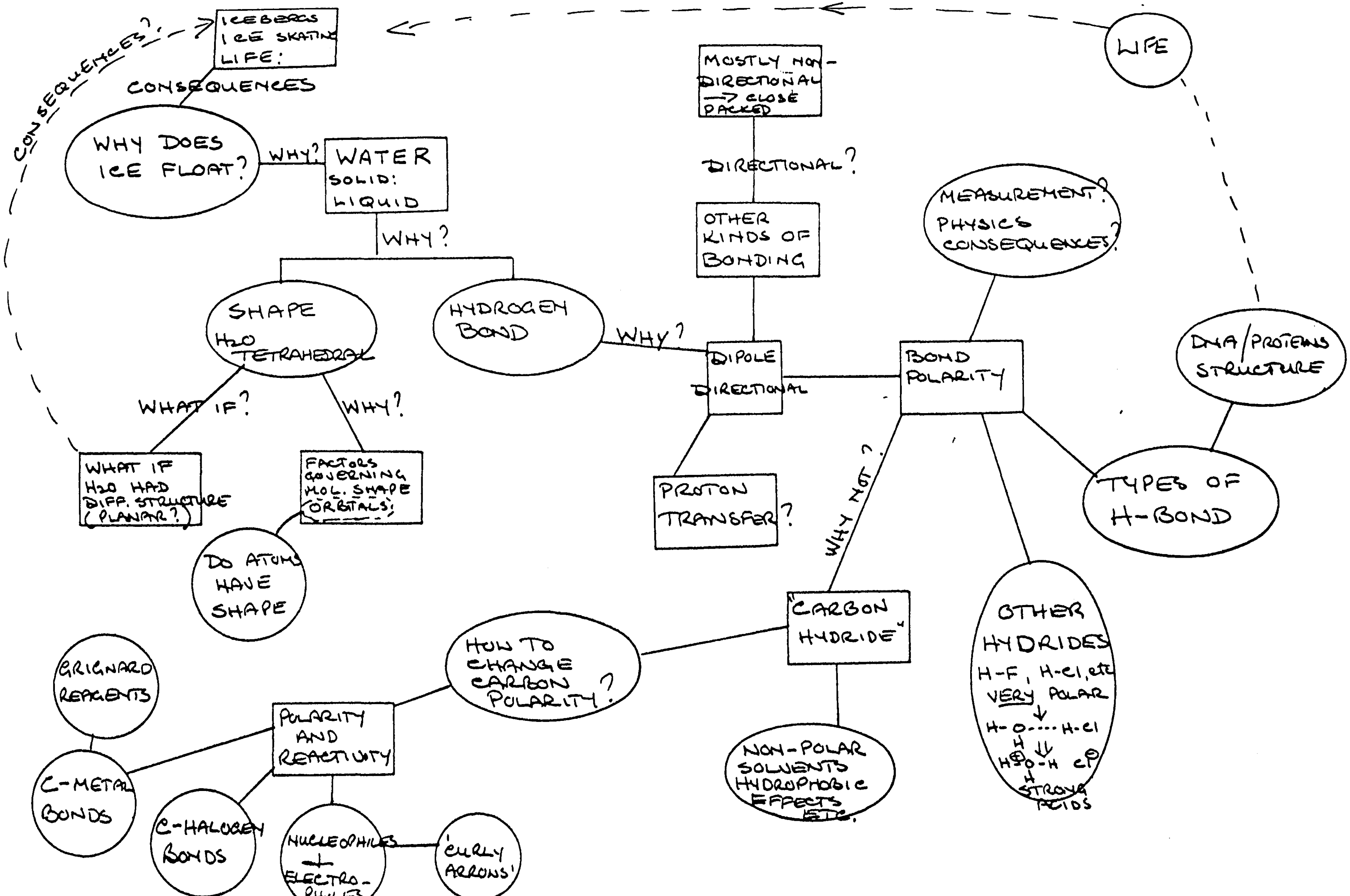


Figure 8-1. A 'Mind Map' Used by a Lecturer

(1) Start the lecture by the following three important things :

<i> Set up the audio-visual aids or any instructional aids and make sure they are working properly.

<ii> Check the audibility of your voice and the quality of your blackboard writing by asking students to confirm it and use the microphone if necessary.

<iii> Provide a preview of information prior to an explanation - you can use the overview, introduction as the advance organiser.

(2) Structure and clarify the process of presentation by :

<i> presenting the information within a step-by-step lecture sequence to avoid jumping around and overloading students with too much information at a time.

<ii> writing appropriate amount of information in a legible way on the blackboard. Such focussing as underlining, dictating headings and subheadings is useful in achieving this.

<iii> Stressing important points during explanations by signalling transitions between segments of lecture information, employing verbal markers of importance or "verbal signposts" or reiterating the difficult or important important points.

<iv> providing for brief pauses (3 - 5 seconds) at appropriate times during your talk so that students can try to digest the newly received information.

(3) Vary the format of presentation and hold students' attention - you must be sensitive to students' degree of arousal and their motivation to learn by :

<i> changing the format of presentation by using the appropriate audio-visual aids or demonstrations.

<ii> using the humour, asides or illustrative examples.

<iii> asking questions by doing this in a non-threatening way.

(4) Close the lecture - at the end of the lecture presentation, you could review

and summarise the main points of previously given information. One approach used by one of the effective lecturers is using the postorganiser like a "spider web" (Fig 8-2.). Another approach would involve students in the reviewing process by asking them to summarise key points in their own words or to recall precise ideas.

C. Additional techniques for motivating students

(1) Variations in your manner and style - the manner and style are basic factors of personality which may be very difficult to change, but you can try to use voice inflection or modulating the pitch, pause after making a point, slow down the rate of speech, maintain the eye contact with students and move away occasionally from the lectern to create a less formal relationship.

(2) Encouraging students' active participation - avoid asking "Are there any questions?" and not hearing any, again assuming that everyone understands. Instead, prepare a question in the form of exercise or example, which can be projected as a slide or an overhead transparency. Ask students to answer it and later follow-up by explaining or giving the answer.

(3) The appropriate use of the audio-visual aids :

<i> The frequency of occurrences in a lecture should not be too high, five to eight seem to be appropriate.

<ii> The format of a slide or a transparency - the size of writing should be large enough when projected, not too much information crammed into a single sheet, and the contrast between the writing and the background should be clear enough.

<iii> The way of presentation - never turn off all the lights such that students get annoyed, leaving the dim lights on during presentation. Ask first students to listen to you carefully and then give them time to record it.

<iv> The purpose of that presentation should be clearly stated and the

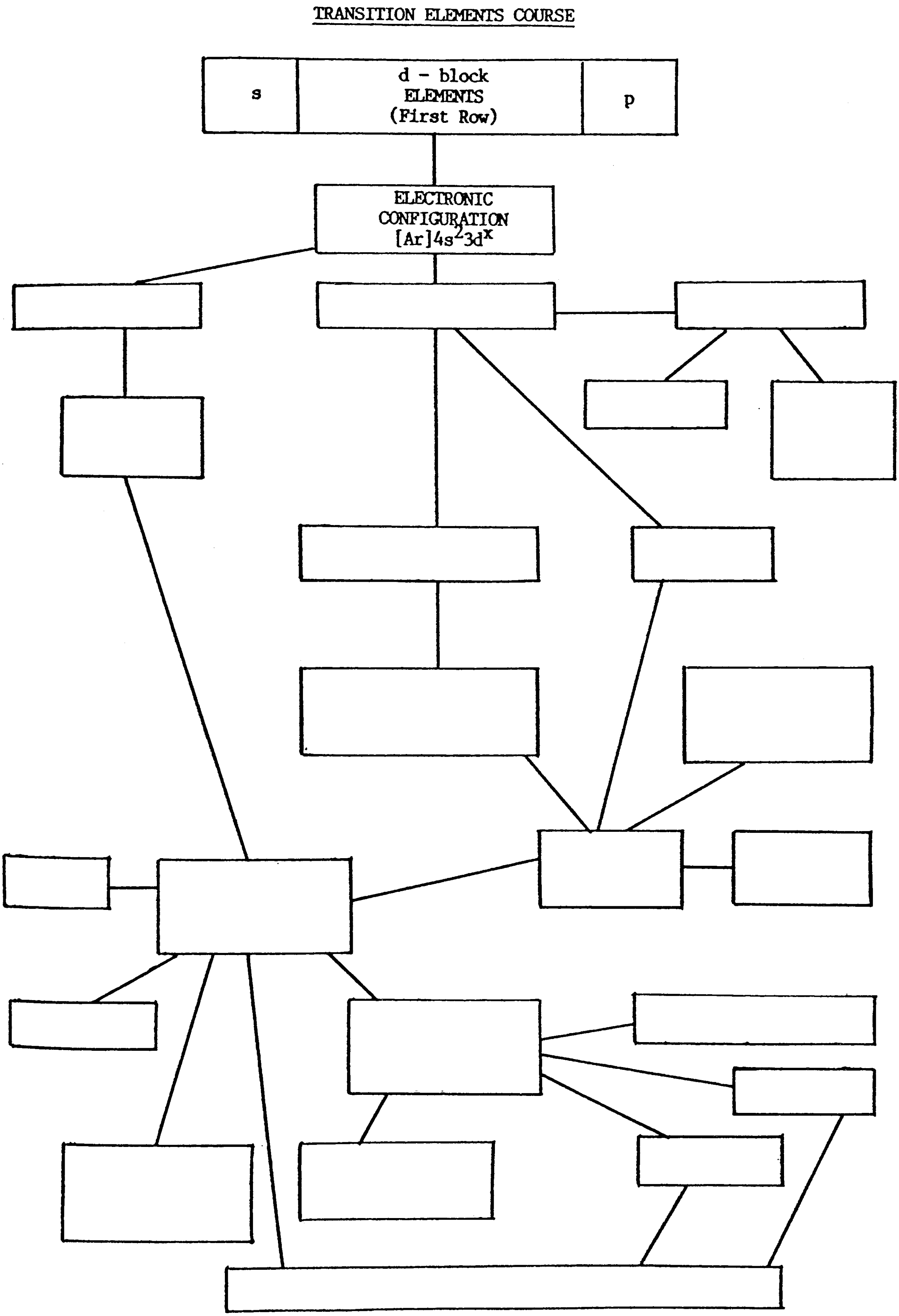


Figure 8-2. The "Spider's Web" Used by a Lecturer for Summarisation

conclusion must be summarised or put on the blackboard.

<v> The duration of presentation - if the information presented is too complicated, a copy of that material should be given to students in advance so that they can concentrate on listening. If you think that the presented material is very important that students have to record it down, give them sufficient time to do so and check by asking students if they have finished recording.

8.3 The Educational Implications for Students

According to the simple model of Information Processing in Chapter Three (see Page 66), this section contains guidelines on ways of making the most of learning from lectures. Such learning involves listening, observing, summarising and note-taking during a lecture, and note-making, revision and thinking afterwards.

A. Preparing to learn

(1) Refresh your knowledge of the topic by quickly reviewing notes taken from the previous lecture and relevant books.

(2) Jot down question which you think might be covered in this lecture by glancing over the course objectives (This would help you very much in detecting important and relevant lecture information and make note-taking easier).

B. Getting involved in the lectures

(1) Listen, observe and try to understand by following the lecturers.

(2) Pay attention to the signal systems, such as verbal signposts or non-verbal

but intentional cues like underlining or pointing at one certain part.

(3) Prevent your attention wandering during a lecture by actively concentrating on what is being said and by taking notes.

(4) Take your personally meaningful notes by selecting the essentials and organising them into some sort of order or pattern; especially pay great attention to the verbal information which has proved liable to be easily neglected.

(5) Never try to write down every word the lecturer says, since this is generally impossible, and not even useful as you will be missing out on the analytical aspect of note-taking. Try to follow the structure of the lecture and pick up the main points in the form of information unit rather than to take copious notes.

(6) Beware the colourful phrases or analogies used by lecturers. In your notes, label them clearly to show they are analogies, not a definition, and take down the correct explanations after listening carefully.

(7) When coming across recording a diagram, a table or a figure :

<i> If it is available in a book or handout, do not attempt to copy it but instead, follow and note the explanation.

<ii> If it is not available and very important, simplify it as much as you can and note down the explanation.

(8) Sometimes you may need to get down a definition verbatim, or a process formula or the steps of a proof which are not readily available in textbooks. Use as many abbreviations as possible. Compare notes of these immediately after the lecture. Ask the lecturer to clarify difficult points, if necessary.

C. Revision and learning after lectures

(1) Don't just re-write the lecture notes. Instead, try to reconstruct and to analyse the lecture using the notes taken during it and the extra information you've got from textbooks or other sources.

(2) Make the notes permanently memorable and meaningful by using coloured pens, boxes, arrows, flow diagrams and summary charts. The better organised the notes, the easier they are to understand, recall or relearn.

(3) Try to think and organise your knowledge by linking a series of lecture notes together to see the relationships between them.

8.4 Suggestions for Further Research

Previous research has investigated lecturing and note-taking separately and thus lacks utility. Rather than divide these two processes, a unified model based upon the Information Processing Theory has been advanced as a research vehicle in this study and it needs to be further refined in order to be of generally practical use.

It is evident from this research that the cognitively orienting stimulus factors, the working memory capacity, the field-dependent / field-independent styles, the motivational styles and the examination expectancy are all important variables which influence students' note-taking behaviours. It is suggested that further research should be done to explore these factors in detail.

More sophisticated methods for analysing and classifying the lecture notes are needed to be constructed such that they are sensitive to the different variations of the degree of processing in students' notes. The criterion test of categorising students' motivational attitudes - "The Motivational Styles Test", should be further refined in order to be more reliable and more valid for such purposes.

In addition, other research approaches such as illuminative evaluation (Parlett and Hamilton, 155), the case study approach (Stenhouse, 156) should be adopted by future researchers in this area. More correlational studies should be taken to determine and confirm the relationship between the cognitively orienting stimulus variables of lecturing and the cognitively orienting response variables of note-taking. And finally, if possible, the experimental techniques should be used to confirm and detail the association between lecturing and note-taking described in this study.

8.5 Conclusion

Clearly the figures we have reported here remain specific to this lecture course and to these students, and it would be dangerous to indulge in predictions based on the strength of this present study. Nevertheless, the results do suggest a number of cognitive factors which, if appropriately noted, would produce a greater match between lecturers' teaching and students' learning, and could thus improve the effectiveness and the efficiency of this particular teaching method.

To sum up, the following conclusions were drawn :

Instructionally, from this study the lecturer needs to consider further the role of his lecturing effectiveness. A lecturer taking into account the suggestions from this present research, will think more carefully about his teaching objectives, possible ways of achieving them, and techniques of avoiding the unnecessary hindrances in order to achieve his goals. This can possibly lead to more effective lecturing.

Empirically, note-taking is related to performance especially in naturally occurring situations, and notes should be as complete and efficient as possible in terms of the quantity and quality, stressing the key points.

Theoretically, research guided by Information Processing Theory may reveal both the lecturer's cognitive process of transmitting lecture messages and students' cognitive processing of those messages (note-taking and learning) during a lecture.

Methodologically, researchers must carry out further correlational and experimental studies by manipulating the cognitive factors which have been uncovered in this study.

REFERENCES

1. A. S. Batchelder and F. Keane, *Journal of Classroom Interaction.*, 1977, 13(1), 33 - 43.
2. M. J. Dunkin, *Higher Educational Research and Development.*, 1983, 2(1), 63 -78.
3. D. Bligh et al, *Methods and Techniques in Post-Secondary Education.* Educational Studies and Documentation, No. 31. UNESCO : Paris, 1980.
4. H. H. Remmers, *School and Society.*, 1928, 28, 759 - 760.
5. H. H. Remmers in *The Appraisal of Teaching in Large Universities,* McKeachie (ed), pp. 17 - 23. Ann Arbor : The University of Michigan, 1958.
6. H. W. Marsh, *Journal of Educational Psychology.*, 1983, 75, 150 - 166.
7. H. W. Marsh, *International Journal of Educational Research.*, 1987, 11(3), 253 - 388.
8. H. W. Marsh, *Journal of Educational Psychology.*, 1984, 75, 707 - 754.
9. H. W. Marsh, *British Journal of Educational Psychology.*, 1982, 52, 77 - 95.
10. M. B. Ormerod and W. I. Moore, *International Journal of Science Education.*, 1987, 9, 459 - 466.
11. A. H. Johnstone and P. R. P. MacGuire, *Chemeda* ., 1990, 29, 29 - 38.
12. P. C. Abrami, L. Leventhal and R. P. Perry, *Review of Educational Research.*, 1982, 52, 446 - 464.
13. J. A. Kulik and C. C. Kulik in *Research on Teaching : Concepts, Findings and Implications,* P. L. Peterson and H. J. Walberg (eds), Berkeley, California : McCutcheon, 1979.
14. C. R. Cooper, *Journal of Classroom Interaction.*, 1981, 16, 27 - 37.

15. D. M. Medley and H. E. Mitzel in *Handbook of Research on Teaching*, N. L. Gage (ed). Rand McNally, 1963.

16. N. A. Flanders and A. Simon in *Encyclopedia of Educational Research*, R. L. Ebel (ed). New York : Macmillan, 1969.

17. C. N. Power, *Studies in Science Education.*, 1977, 4, 1 - 30.

18. J. F. Eggleston, M. Galton and M. E. Moore, *A Science Teaching Observation Schedule*. London : Macmillan / Schools Council, 1975.

19. P. A. Cranton, *The Evaluation and Interpretation of Student Ratings of Instruction*. Montreal : McGill University, Centre for Teaching and Learning Services, 1979.

20. L. Shulman, *Development of a Category Observation System for the Analysis of Video-taped Class Sessions*. Montreal : McGill University, Centre for Learning and Development, 1975.

21. N. A. Flanders, *Analysing Teaching Behaviours*, Reading, Mass : Addison Wesley, 1970.

22. W. Tomic, *Journal of Classroom Interaction.*, 1989, 24(1), 5 - 14.

23. J. Stallings and D. Kaskowitz, *Follow through Classroom Observation Evaluation (1972 - 1973)*. Menlo Park, CA : SRI International, 1974.

24. F. J. Di Vesta and G. S. Gray, *Journal of Educational Psychology.*, 1972, 63, 8 - 14.

25. J. Hartley and I. K. Davies, *Programmed Learning and Educational Technology.*, 1978, 15, 207 - 224.

26. C. C. Crawford, *Journal of Educational Research.*, 1925, 12, 282 - 291.

27. C. C. Crawford, *Journal of Educational Research.*, 1925, 12, 379 - 386.

28. M. J. A. Howe, *Journal of Educational Research.*, 1977, 64, 61 - 63.

29. E. G. Aiken, G. S. Thomas and W. A. Shennum, *Journal of Educational Psychology.*, 1975, 67, 439 - 444.

30. E. A. Locke, *Journal of Educational Research.*, 1977, 77, 93 - 99.

31. K. A. Kiewra, *Instructional Science.*, 1987, 16, 233 - 249.

32. P. Weener, *Instructional Science.*, 1974, 3, 51 - 74.

33. J. McLeish in *The Psychology of Teaching Methods*, N. L. Gage (ed). NSSE, Chicago University Press, 1976.

34. D. L. Peters, *Journal of Educational Psychology.*, 1972, 63, 276 - 280.

35. G. S. Thomas, E. G. Aiken and W. A. Shennum, *Further Investigations of Coding / Rehearsal Strategies during a Segmented Lecture Format.* NPRDC TR 76 - 15, Navy Personnel Research and Development Centre, San Diego, California, 1975.

36. M. J. A. Howe and J. Godfrey, *Student Notetaking as an Aid to Learning*. Exeter University Teaching Services Department, Exeter, 1977.

37. K. A. Kiewra and S. L. Benton, *Contemporary Educational Psychology.*, 1988, 13, 33 - 44.

38. M. J. A. Howe, *Educational Researcher.*, 1974, 16, 222 - 227.

39. J. L. Fisher and M. B. Harris, *Psychological Reports.*, 1974, 35, 384 - 386.

40. G. O. Einstein, J. Morris and S. Smith, *Journal of Educational Psychology.*, 1985, 77(5), 522 - 532.

41. K. A. Kiewra, *Reading Improvement.*, 1984, 21, 145 - 149.

42. L. Cohen and M. Holliday, *Statistics for Social Scientists : An Introductory Text with Computer Programs in BASIC*. Reprinted. London : Harper & Row Ltd, 1984.

43. P. R. P. MacGuire, *Students' Ratings of University Lecture Courses.* Report of Centre for Science Education, University of Glasgow, 1990.

44. D. G. Elmes, B. H. Kantowitz and H. L. Roediger, *Research Methods in Psychology* (3rd ed.). St. Paul, MN : West Publishing Company, U.S.A., 1989.

45. J. R. Anderson, *Cognitive Psychology and its Implications.* San Francisco : W. H. Freeman, 1980.

46. M. J. A. Howe, *Journal of Educational Research.*, 1970., 63, 285.

47. M. J. A. Howe, *Bulletin of the British Psychological Society.*, 1975, 23, 158 - 161.

48. K. A. Kiewra, *College Student Journal.*, 1984, 17, 381 - 385.

49. J. R. Anderson and L. M. Reder in *Levels of Processing in Human Memory*, L. S. Cermak and F. I. M. Craik (eds). Hillsdale, NJ : Erlbaum, 1979.

50. B. S. Stein and J. D. Bransford, *Journal of Verbal Learning and Verbal Behaviour.*, 1979, 18, 769 - 777.

51. J. L. Fisher and M. B. Harris, *Journal of Educational Psychology.*, 1973, 65, 321 - 325.

52. K. A. Kiewra and H. J. Fletcher, *Human Learning.*, 1984, 4, 73 - 77.

53. K. A . Kiewra, *Notetaking and Review : The Research and its Implications.* Unpublished Manuscript. Logan: Utah State University, 1982.

54. R. J. Pepper and R. E. Mayer, *Journal of Educational Psychology.*, 1978, 70, 514 - 522.

55. R. E. Mayer, *The Promise of Cognitive Psychology.* San Francisco : Freeman, 1981.

56. H. S. Ladas, *Educational Psychologist.*, 1980, 15(1), 44 - 53.

57. P. H. Lindsay and D. A. Norman, *Human Information Processing.* New York and London : Academic Press, 1977.

58. A. H. Johnstone and H. El-Banna, *Education in Chemistry.*, 1986, 23(3), 80 - 84.

59. G. Brown, *Lecturing and Explaining.* London : Methuen & CO. Ltd, 1978.

60. S. K. Reed, *Cognition : Theory and Applications*, 2nd ed. Pacific Grove, California : Brooks / Cole Publishing Company, 1987.

61. I. Roth and J. Frisby, *Perception and Representation : A Cognitive Approach*. - (Open Guide to Psychology). Milton Keynes : Open University Press, 1986.

62. A. J. Sanford, *Cognition and Cognitive Psychology*. - (Weidenfeld psychology series). London : Weidenfeld and Nicolson, 1985.

63. A. H. Johnstone and F. Percival, *Education in Chemistry*., 1976, 13(2), 49 - 50.

64. G. A. Miller, *The Psychological Review*., 1956, 63(2), 81 - 97.

65. M. Scardamalia, *Child Psychology*., 1977, 48, 28 - 37.

66. R. C. Atkinson and R. M. Shiffrin in *The Psychology of Learning and Motivation : Advances in Research and Theory, Vol.2*, K. W. Spence and J. J. Spence (eds), pp. 89 - 195. New York : Academic Press, 1968.

67. J. Greene, *Memory, Thinking and Language*. London : Methuen & Co. Ltd., 1987.

68. J. R. Anderson, *The Architecture of Cognition*. London : Harvard University Press, 1983.

69. E. Tulving in *Organisation of Memory*, E. Tulving and W. Donaldson (eds), pp. 381 - 403. New York : Academic Press, 1972.

70. M. Bassey, *Learning Methods in Tertiary Education*. Nottingham Regional College of Technology internal paper., 1968.

71. D. M. Yorke, *Patters of Teaching*. London : Direct Design (Bournemouth) Ltd Printers / Council for Educational Technology, 1981.

72. R. C. Anderson, *Review of Educational Research*., 1970, 40, 349 - 371.

73. M. J. A. Howe and L. Singer, *British Journal of Educational Psychology*.,1975, 45, 52 - 61.

74. C. A. Carrier and A. Titus, *American Educational Research Journal*., 1981, 18(4), 385 - 397.

75. D. Bligh, *What's the Use of Lectures*? Harmondsworth : Penguin Books,

1972.

76. S. Erdle, H. G. Murray and J. P. Rushton, *Journal of Educational Psychology.*, 1985, 77(4), 394 - 407.

77. R. Browning, *APA Monitor.*, 1977, February, Pages 1 and 32.

78. H. Gilliland and H. Mauritsen, *Reading Teacher.*, 1971, 24, 753 - 756; 761.

79. P. A. Cranton and W. Hillgartner, *The Canadian Journal of Higher Education.*, 1981, 11(1), 73 - 81.

80. A. H. Johnstone, F. Percival and N. Reid, *Studies in Higher Education.*, 1981, 6, 77 - 84.

81. F. Percival, Ph D thesis, University of Glasgow, 1976.

82. P. Tamir, *European Journal of science Education.*, 1984, 6(3), 209 - 216.

83. K. C. Wise and J. R. Okey, A Meta-analysis of Various Science Teaching Strategies on Achievement. Paper presented at the annual meeting of the National Association of Research in Science Teaching, Fontana, Wisconsin, U.S.A., 1982.

84. C. M. Clark, R. W. Marx, N. G. Stayrook, N. L. Gage, P. L. Peterson and P. H. Winne, *Journal of Educational Psychology.*, 1979, 71, 534 - 552.

85. G. Brown, *Learning from Lectures : a Programme for Students* (sponsored by the Nuffield Foundation), University of Nottingham,1978.

86. A. K. Korman, *Organisational Behaviour* (revised edition of Instructional and Organisational Psychology), Englewood Cliffs, N.J.: Prentice-Hall, 1977.

87. N. Ford, *Review of Educational Research.*, 1981, 51, 345 - 377.

88. M. B. Rowe, *Journal of Psycholinguistic Research.*, 1974, 3, 203 - 223.

89. M. B. Rowe, *Journal of Research in Science Teaching.*, 1974, 2, 263 - 279.

90. J. H. Lake, Doctoral Dissertation, Rutgers University, 1973; J. H. Lake,

Dissertation Abstracts International., 1973, 34, 6476 - A.

91. K. G. Tobin, *Journal of Research in Science Teaching.*, 1980, 17, 469 - 475.

92. K. G. Tobin and W. Capie, *Journal of Educational Psychology.*, 1982, 14, 441 - 454.

93. B. O. Anderson, Doctoral Dissertation, University of Minnesota, 1978; B. O. Anderson, *Dissertation Abstracts International.*, 1978, 39, 3493 A.

94. J. P. Riley II, The Effects of Teachers' Wait-time and Cognitive Questioning Level on Pupil Science Achievement. A paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston, April, 1980.

95. H. S. Ladas, *Summarising Research : A Case Study of the Literature of Note Taking on Lecture.* Manuscript submitted for publication, 1979.

96. J. Hartley and H. Fuller, *Visual Education.*, 1971, August / September, 39 - 41.

97. H. Maddox and E. Hoole, *Educational Review.*, 1975, 28, 17 - 30.

98. J. C. Moore, *Journal of Experimental Education.*, 1968, 4, 69 - 72.

99. J. P. Noble and B. M. Frank, *Journal of Experimental Education.*, 1986, 22, 28 - 33.

100. J. K. Davis and H. J. Klausmeier, *Journal of Educational Psychology.*, 1970, 61, 423 - 430.

101. A. H. Johnstone and A. J. B. Wham, *Education in Chemistry.*, 1982, 19(3), 71 - 73.

102. W. Johnson in *Listening : Readings*, Dunkin (ed). Metuchen, N.J. : Scarecrow Press, 1966.

103. L. K. Cook and R. E. Mayer in *Cognitive Strategy Research: Educational Applications,*M. Pressley and J. R. Leven (eds), pp. 87 - 131. New York: Springer - Verlag, 1983.

104. S. M. Roshal, *Effects of Learner Representation in film - mediated Perceptual - Motor Learning*. (Tech. Rep. SDC. 269 - 7 - 5), The Penn State College, The Instructional Film Research Program, December, 1950.

105. O. R. Anderson and M. T. Lee, *Science Education.*, 1975, 59, 127 - 138.

106. R. T. White, *Learning Science*. Oxford : Basil Blackwell Ltd, 1988.

107. C. D. Bennink, *Journal of Research in Personality.*, 1982, 10, 267 - 280.

108. F. J. Di Vesta, *Educational Technology.*, 1972, 12, 34 - 39.

109. B. M. Frank, *Journal of Research in Personality.*, 1983, 17, 89 - 96.

110. J. Hartley and M. Trueman, *Bulletin of the British Psychological Society.*, 1978, 31, 37 - 39.

111. A. Baddeley and G. Hitch in *Advances in Learning and Motivation (Vol. 8),* G.Bower (ed).New York : Academic Press, 1974.

112. P. J. Barber, *Applied Cognitive Psychology*. London : Methuen & Co. Ltd., 1988.

113. E. Hunt, C. Lunneberg and J. Lewis, *Cognitive Psychology.*, 1975, 7, 194 - 227.

114. D. C. Berliner, Aptitude - Treatment Interactions in Two Studies of Learning from Lecture Instruction. Paper presented at the meeting of the American Educational Research Association, New York, 1971.

115. S. L. Benton, R. G. Kraft, J. A. Glover and B. S. Plake, *Journal of Educational Psychology.*, 1984, 76, 820 - 834.

116. D. C. Berliner, Effects of test-like events and notetaking on learning from lecture instruction. Paper presented to the American Psychological Association, Washington, DC,1969.

117. F. J. Di Vesta and S. G. Gray, *Journal of Educational Psychology.*, 1973, 64, 278 - 287.

118. G. L. Claxton in *Framework for Teaching*, Open University Course, EP 228, Unit 4. Milton Keynes : Open University Press, 1988.

119. H. A. Murray, *Explorations in Personality.* New York : Oxford University Press, 1938.

120. A. Maslow, *Motivation and Personality,* 2nd ed. New York : Harper and Row, 1970.

121. C. Ames and R. Ames, *Journal of Educational Psychology.*, 1984, 76, 535 - 556.

122. G. L. Claxton in *Adolescent Development and School Science*, P. Adey et al. (eds.). London : King's College Centre for Educational Studies, 1988.

123. P. Jackson, M. Silberman and B. Wolfson, *Journal of Educational Psychology.*, 1969, 60, 22 - 27.

124. C. Power, *A Multivariate Model for Studying Person - Environment Interactions in the Classroom.* Technical Report No. 99. Columbia, MO : Centre for Research in Social Behaviour, University of Missouri, 1974.

125. T. L. Good and C. N. Power, *Curriculum Studies.*, 1976, 8(1), 45 - 60.

126. L. Adar, *A Theoretical Framework for the Study of Motivation in Education.* Jerusalem : School of Education, The Hebrew University, 1969.

127. A. Hofstein and R. F. Kempa, *European Journal of Science Education.*, 1985, 7(3), 221 - 229.

128. R. F. Kempa and M. Martin Diaz, *International Journal of Science Education.*, 1990, 12(2), 195 - 203.

129. M. Martin Diaz, MA dissertation, University of Keele, 1989.

130. E. Orbach, *Simulations and Games.*, 1979, 10, 3 - 40.

131. R. F. Kempa and M. Martin Diaz, *International Journal of Science Education.*, 1990, 12(2), 205 - 216.

132. H. A. Witkin, C. A. Moore, D. R. Goodenough and P. W. Cox, *Review of Educational Research.*, 1977, 47, 1 - 64.

133. D. R. Goodenough, *Psychological Bulletin.*, 1976, 83(4), 675 - 694.

134. H. A. Witkin, P. K. Oltman, E. Raskin and S. A. Karp, *Manual for Embedded Figure Test, Children's Embedded Figures Test and Group Embedded Figures Test.* Palo Alto, CA : Consulting Psychologists Press, Inc., 1971.

135. J. Shymansky and J. Yore, *The Journal of Research in Science Teaching.*, 1980, 17, 369 - 382.

136. B. M. Strawitz, *Journal of Research in Science Teaching.*, 1984, 21, 133 - 141.

137. A. Lourdusamy, Doctoral Thesis, University of Keele, 1981.

138. L. F. Annis, *Journal of Educational Psychology.*, 1979, 71, 620 - 626.

139. B. M. Frank, *American Educational Research Journal.*, 1984., 21(3), 669 - 678.

140. J. A. Robinson and C. D. Bennink, *Journal of Research in Personality.*, 1978, 12, 439 - 449.

141. B. M. Frank, *Journal of Educational Research.*, 1988, 81(3), 143 - 148.

142. K. A. Kiewra and B. M. Frank, *Contemporary Educational Psychology.*, 1986, 11, 253 - 263.

143. K. A. Kiewra, N. F. DuBois, D. Christian and A. McShane, *Journal of Educational Psychology.*, 1988, 80, 595 - 597.

144. H. A. A. M. El-Banna, Ph D thesis, University of Glasgow, 1987.

145. L. J. Cronbach, *Essentials of Psychological Testing.* (3rd ed.) New York : Harper and Row, 1970.

146. F. F. Al - Naeme, unpublished work, University of Glasgow, 1991.

147. J. Pascual-Leone, *Manual for FIT : Figural Intersection Test.* Unpublished manuscript. Ontario : York University, 1974.

148. J. M. Johnson, *The Figural Intersection Test (FIT) : A Measure of Mental (M) Attentional Energy.* Unpublished manuscript. Ontario : York University, 1982.

149. R. Case, *Cognitive Psychology.*, 1974, 6, 544 - 573.

150. D. H. Zimmerman and D. L. Wieder, *Urban Life.*, 1977, 5(4), 479 - 499.

151. J. W. Marlin, *Journal of Higher Education.*, 1987, 58, 704 - 716.

152. A. R. Jensen, *Individual differences in learning : interference factor.* Final Report, Office of Education (Cooperative Research Project No. 1897), 1964.

153. A. H. Johnstone and P. R. P. MacGuire, unpublished work, 1991.

154. A. H. Johnstone, unpublished work (tutorial instructions for staff members), University of Glasgow, 1991.

155. M. Parlett and D. Hamilton in *Evaluating Education : issues and methods,* R. J. L. Murphy and H. Torrance (eds). London : Harper and Row / The Open University, 1982.

156. L. Stenhouse in *Evaluating Education : issues and methods,* R. J. L.Murphy and H. Torrance (eds). London : Harper and Row / The Open University, 1982.

APPENDICES

S_1:

Electrochemistry

Concerned with the properties and applications of transfer of electrons

Redox reactions   Brown Lemay Ch 20 (651-687)

Problem: chemical energy into electrical energy   vice versa

~~Thermodynamics~~ Storage batteries (cells)

Solar energy conversion

Photosynthesis

Nerve impulses

* Electrical ~~[illegible]~~ → electrolysis

purifying metals (extracting)

chlorine gas

electroplating

+ Corrosion (Rusting)

Metabolism

Cell phones → meant to be wrong

* Chemical energy into electrical energy

Voltaic cells (electrochemical cells)

$Zn_{(s)} + CuSO_{4(aq)} \rightarrow$ goes black, but instead of $Cu_{(s)}$ $ZnSO_{4(aq)}$

why black → because of so very fine particles

48% a piece of zinc re-purified by electrolysis → expensive

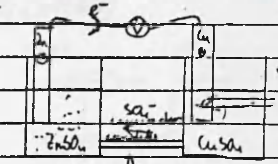
$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$ because SO_4 doesn't take place in reaction

$Cu^{2+} + 2e^- \rightarrow Cu$ reduced

$Zn \rightarrow Zn^{2+} + 2e^-$ oxidised

The Daniell cell   discovered by accident

$Zn \rightarrow Zn^{2+} + 2e$ need complete circuit to get current



ions will be reduced   1V either end

$Cu^{2+} + 2e \rightarrow Cu$

or gel (Agar + KCl)

salt bridge (conducts electricity, but doesn't allow mixing (fills))

RECYCLED - RECYCLE - RECYCLE - ALTPAPIER - RECYCLED - RECYCLE

can't go on forever: eventually, run out of zinc or copper

become dissolving away

What determines the voltage?

What determines direction of electron flow?

Electricity, charge, energy etc. $1.602 \cdot 10^{-19}$ C

Unit of charge : Coulomb C   e = ~~$1.6 \cdot 10^{-19}$~~ C

1 mole of electrons charge: 1 Faraday = N.e = 96500 C

Electric current (I) = rate of flow of charge

$1A = 1$ coulomb sec^{-1}

Electrical potential (voltage, emf) - volt

⊖ -q   ⊕   work = energy = q · E

1J = 1C · 1V

Potential E

S_2:

Chemical rxns that involve the transfer of electrons - REDOX. [balancing redox rxns, half rxns etc. (reverse)]

Electron transfer - electricity.

Chemical E ⇌ Electrical E.

Typical applications.

(Ec → Ee) - storage batteries (cells), solar energy conversion systems, photosynthesis, nerve impulses

(Ee → Ec) - Electrolysis,

Corrosion (rusting), metabolism.

VOLTAIC CELLS - (electrochemical cells.)

eg $Zn_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + ZnSO_{4(aq)}$

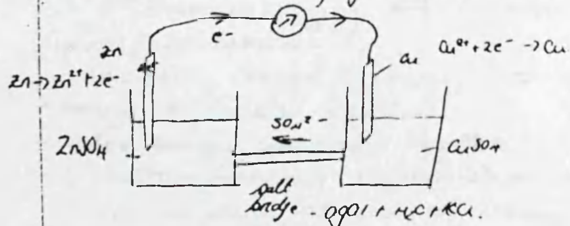
$Zn_{(s)} + Cu^{2+} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

Zn is being oxidized.

Cu is being reduced.

half rxns -
$Zn \rightarrow Zn^{2+} + 2e^-$ (oxdn)
$Cu^{2+} + 2e^- \rightarrow Cu$ (redn)

The Daniell Cell: - (trying to separate both rxns)

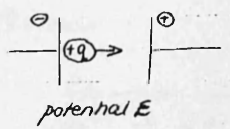


Electricity can be carried by anything that will carry charge.

What is it that determines voltage?
Can electron flow be predicted?

Electricity, Charge, Energy etc.
unit of charge - coulomb C
charge on one electron - $e = 1.602 \times 10^{-19}$ C.
charge on 1 mole of electrons - FARADAY (F) $e \times N_A$
$= 1.602 \times 10^{-19}$
$\times 6 \times 10^{23} = 96000$ C

Electric Current (I) - rate of flow of charge (wire etc)
1 Amp = 1C/s
Electric Potential - (voltage, EMF) volts. (V)
Energy (joules)



$E(\text{Wd}) = q \times E$.

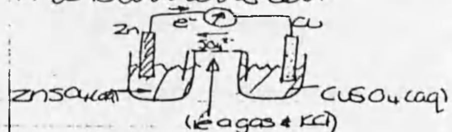
1 J remove 1C across a potential of 1V.
(1J = 1C × 1V)

S3:

Electrochemistry Lecture 1

Chemical Energy ↔ Electrical Energy
$E_{chem} \leftrightarrow E_{el}$: Storage Battery (cells)
Solar Energy conversion (Pl
Nerve Impulses
$E_{el} \leftrightarrow E_{chem}$: Electrolysis (Purificat^n, Extr
& Electroplating of metals)
Voltaic Cells (Electrochem. cells)
$Zn(s) + CuSO_4(aq) \leftrightarrow Cu(s) + ZnSO_4(aq)$
But the SO_4^{2-} ion doesn't take part in the reaction (spectator ion)
$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$
$Cu^{2+} + 2e^- \rightarrow Cu$ Reduc
$Zn \rightarrow Zn^{2+} + 2e^-$ Oxidise

The Daniell Cell



$Zn \rightarrow Zn^{2+} + 2e^-$
$Cu^{2+} + 2e \rightarrow Cu$

Electricity, Charge and Energy.

Unit of charge = coulombs.
charge on e^- = (1.602×10^{-19}) C
1 mole of e^-: 1F = N_{Ae} = $(6 \times 10^{23}) \times (1.602 \times 10$
= 96500 C.
Electrical current (I) = rate of flow of ch
1 Ampère = 1 coulomb per second.
Electrical Potential (V) volts
1 Volt = 1 Joule per coulomb

S4:

Electrochemistry

[B&L - Ch20 p651-687]

Chemical reactions that involve transfer of electrons.
Redox reactions.
[Balancing Redox reactions
method of half reactions
→ revise from B&L p434-449.

'Electricity' – Electron transfer
Conversion of chemical energy to electrical energy and vice versa.

Chemical energy $\rightleftharpoons$ electrical energy

Typical applications:-
Converting chemical energy into electrical energy
- storage batteries (cells)
- solar energy conversion systems.
(photosynthesis (certain steps involve this chemical energy $\rightleftharpoons$ electrical energy conversion ....
also nerve impulses involve this)

Conversion of electrical energy to Chemical energy
- electrolysis
corrosion (rusting)
metabolism

Voltaic cells or (electrochemical cells).

eg:- $Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO(aq)$.
spontaneous reaction.

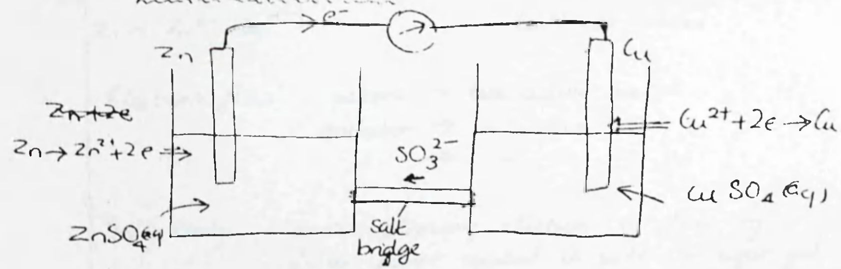
$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$.
Zn loses $2\bar{e}$ $\longrightarrow$ oxidised
Cu^{2+} gains $2e^-$ $\longrightarrow$ reduced

This transfer of electrons consequences in electrical charge.

Half - Reactions :-

$Zn \longrightarrow Zn^{2+} + 2\bar{e}$ oxidation process.
$Cu^{2+} + 2\bar{e} \longrightarrow Cu$ reduction process.

THE DANIELL CELL



Separating two half reactions and producing a current
(salt bridge - allows current to flow but doesn't allow solutions to mix). - a gel (AgAl + KCl)
Sulphate ions flow along salt bridge.

What direction of chemical Reaction?

~~ELECTROLYTE~~
ELECTRICITY, CHARGE, ENERGY etc.

Unit of electrical charge = Coulomb C.
Charge on 1 electron, e = 1.602×10^{-19} C.
Charge on 1 mole of electrons
= 1 Faraday F

S5

Redox – transfer of electrons
balancing redox equations
method of half reactions

eg. $Hg^{2+} + e^- \rightarrow Hg^+$; $Sn^{2+} \rightarrow Sn^{4+} + 2e^-$ $\Big\}$ $2Hg^{2+} + 2e^- \rightarrow 2Hg^+$; $Sn^{2+} \longrightarrow Sn^{4+} + 2e^-$
overall reacn $2Hg^{2+} + Sn^{2+} \rightarrow 2Hg^+ + Sn^{4+}$

Electron transfer - "electricity"
Chemical energy $\rightleftharpoons$ electrical energy.

TYPICAL APPLICATIONS

Chemical → Electrical — storage batteries (cells), solar energy conversions, photosynthesis

Electrical → Chemical — electrolysis, corrosion (rusting), metabolism

Volt cells (electrochemical cells) – no power source.

eg. $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$.

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$.

Zn loses $2e^-$ → oxidation

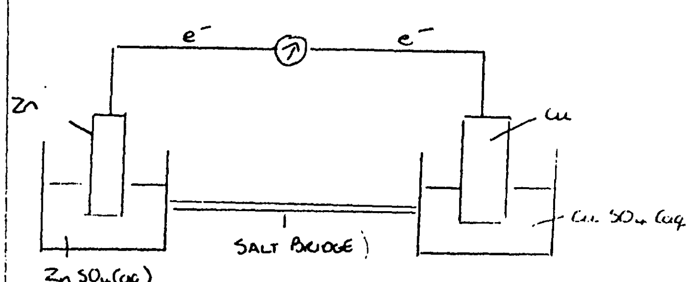
Cu^{2+} gains $2e^-$ → reduction.

Half reactions

$Zn \rightarrow Zn^{2+} + 2e^-$ oxidation

$Cu^{2+} + 2e^- \rightarrow Cu$. reduction

The Daniell Cell



$Zn \rightarrow Zn^{2+} + 2e^-$ $\qquad$ $Cu^{2+} + 2e^- \rightarrow Cu$.

Electrons flow — active → less active metal.
oxidation → reduction
$+ \rightarrow -$

Salt Bridge – device allowing electrons to flow eg. filter paper soaked in salt or agar gel with H_2O and KCl. Solutions do not mix.

ELECTRICITY, CHARGE, ENERGY.

Unit of charge coulomb C.

charge on $1e^- = 1.602 \times 10^{-19}$ C

charge of 1 mole of electron

$= 1$ Faraday (F)

$= e \times N_A$

$= 1.602 \times 10^{-19} \times 6 \times 10^{23}$

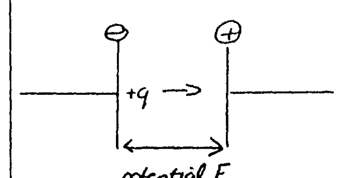
$= 96500$ C.

electric current (I) = rate of flow of charge.

$1A = 1Cs^{-1}$.

electrical potential (voltage E.M.F) = volts (V).

Energy (J)



Energy $= qE$ (work done).

$1J = 1C \times 1V$.

S_6:

Brown + Lemay Chapter 20 (pp 651 - 687).

= Reactions were electrons are transferred

Oxidation, Reduction - Redox equations.
[Balancing redox equations, ½-reactions]
[B + Lemay - pg 134 - 141 ?]

Electron Transfer → "Electricity"
Chemical energy ⇌ electrical energy.

Typical Applications :-

Chem → electrical : storage batteries (cells)
Solar energy conversion systems
(Photosynthesis)
nerve impulses

Elect → Chem - electrolysis
+ corrosion (rusting)
Metabolisms (oxidation)

<u>Voltaic cells</u> (Electrochemical cells)

eg $Zn_{(s)} + CuSO_{4(aq)} \longrightarrow Cu_{(s)} + ZnSO_{4(aq)}$
spontaneous reaction.

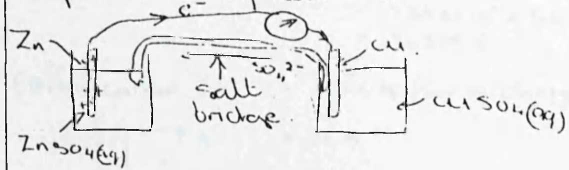
$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

Zn loses 2 electrons → oxidised
Cu^{2+} gains 2 electrons → reduced.

<u>Half reactions</u>

$Zn \longrightarrow Zn^{2+} + 2e$ oxidation.
$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$ reduction

<u>The Daniell cell</u>
seperate 2 half reactions.



Salt bridge : ionic - stops 2 liquids from meeting. ie agar and KCl.

$Zn \rightarrow Zn^{2+} + 2e^-$ $Cu^{2+} + 2e^- \rightarrow Cu.$
Ions move along salt bridge ie SO_4^{2-}

<u>Electricity</u>, <u>Charge</u>, <u>Energy</u> etc

Unit of charge coulombs (C)
Charge on 1 electron $e = 1 \cdot 602 \times 10^{-19}$ C.
Charge of 1 <u>mole</u> of electrons.

⇒ 1 Faraday (F)

$e \times N_A$
$= 1 \cdot 602 \times 10^{-19} \times 6 \times 10^{23}$
$= 96{,}500$ C

S7:

<u>Electrochemistry</u> Chap 19 (554-591) B&LeM

Electrochemistry deals with transfer of electrons. ie Redox.

electron transfer → electricity.

We are concerned with transferring chemical e → electric energy and electrical energy → chemical energy.

<u>Typical applications.</u>

chem → elec : Batteries.
Solar energy conversion Systems.
Photosynthesis involves chem e → elec C.

<u>Elec → chem</u>

Electrolysis.
Corrosion.
Metabolism. [Food gets oxidised, electrons used in the body].

<u>VOLTAIC CELLS</u> (electrochemical cells)

eg. $Zn_{(s)} + CuSO_{4\,(aq)} \longrightarrow Cu_{(s)} + ZnSO_{4\,(aq)}$

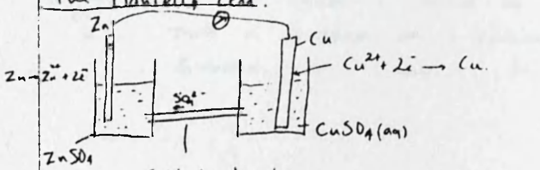
$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} \quad Cu_{(s)}$

Zn loses $2e^-$ → oxidised.
Cu^{2+} gains $2e^-$ → reduced.

<u>Half reactions</u>

$Zn \longrightarrow Zn^{2+} + 2e^-$ oxidation
$Cu^{2+} + 2e \longrightarrow Cu$ reduction

<u>The Daniells cell.</u>



Salt bridge to complete the circuit. (gel: agar H_2O/KCl)

<u>Electricity</u>, <u>Charge</u>, <u>energy</u> etc

Unit of electrical charge : coulomb C

Charge of 1 electron $e = 1.602 \times 10^{-19}$ C

Charge of 1 mole of electrons = 1 Faraday F

$= \underline{e \times N_A}$

$= 1.602 \times 10^{-19} \times 6 \times 10^{23}$

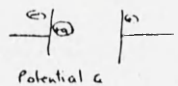
$= 96500$ C

Electric current (I) = Rate of flow of charge

1 A $= 1 C s^{-1}$

electrical potential (voltage; emf) - measured in volts

Energy measured in joules (J).



Energy (work done) $= qE$

1 Joule = 1 c × 1 v

S8:

TRANSFER OF ELECTRONS OCCUR ⟹ REDOX REACTIONS.

BALANCING REDOX REACTIONS } SEE B+LeMay
METHOD OF HALF REACTIONS }

ELECTRON TRANSFER ⟹ ELECTRICITY

CHEMICAL ENERGY CAN BE CONVERTED IN VARIOUS WAYS TO ELECTRICAL ENERGY AND VICE VERSA.

TYPICAL APPLICATION:

CHEMICAL → ELECTRICAL :- STORAGE BATTERIES (CELL)
SOLAR ENERGY CONVERSION SYSTEMS
PHOTOSYNTHESIS.
NERVE IMPULSES

ELECTRICAL → CHEMICAL :- ELECTROLYSIS.

VOLTAIC CELLS (ELECTROCHEMICAL CELLS)

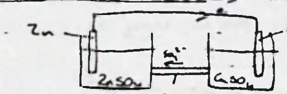
$\rightarrow$ $Zn(s)$ + $CuSO_4(aq)$ $\rightarrow$ $Cu(s)$ + $ZnSO_4(aq)$

$Zn(s)$ + $Cu^{2+}(aq)$ $\rightarrow$ $Zn^{2+}(aq)$ + $Cu(s)$

$Zn(s)$ LOSES 2 ELECTRONS $\rightarrow$ OXIDISED.

$Cu^{2+}(aq)$ GAINS 2 ELECTRONS $\rightarrow$ REDUCED

THE DANIELL CELL



salt bridge – agar gel + H_2O + KCl.

$Zn \rightarrow Zn^{2+} + 2e^-$

$Cu^{2+} + 2e \rightarrow Cu$

ELECTRICITY CHARGE ENERGY RELATIONSHIPS.

UNIT OF ELECTRICAL CHARGE = COULOMB, C.

CHARGE ON ONE ELECTRON = 1.6×10^{-19} C.

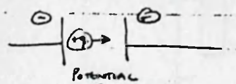
" – 1 mole of " = $1.6 \times 10^{-19} \times 6 \times 10^{23}$ = 96500 C

ELECTRICAL CURRENT (I) = RATE OF FLOW OF CHARGE.

1A = 1 C s^{-1}

ELECTRICAL POTENTIAL (VOLTAGE, emf) IS MEASURED IN VOLTS.

ENERGY MEASURED IN JOULES (J)



ENERGY = qE

Potential E.

IT TAKES 1 JOULE OF ENERGY TO TAKE A CHARGE OF 1 COULOMB ACROSS A POTENTIAL OF 1 VOLT. ie 1 J = 1C × 1V

cold fusion – X

S9:

Brown & LeMay (4^{th} Ed) Chapter 20 (pp651–687) Biophysical Chemistry

-properties & applications of reactions involving transfer of electrons i.e. oxidation / reduction REDOX

[balancing redox reactions, method of half reactions
Revise. B + LeMay pp444–449]

why? many redox / biological app.

involve REDOX

[redacted] → "electricity"

problem, conversion chemical energy ⇌ electrical energy *

[redacted]:

chem → electrical; storage batteries (cells); chem. reaction occurring; car.

solar energy conversion

photosynthesis (certain steps)

neurophysiology – nerve impulses ← redox take place → electrical signal.

electrical → chemical; electrolysis – chlorine, sodium (plating, purification)

+ corrosion (rusting)

metabolism – based on oxidation

(food eat in O_2 oxidised – redox reaction to harvest) [redacted] · basis storage batteries.

Crudon head with Zinc — eg. $Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$

spontaneous · deposit on plate

Al rings

Zn produced electrolyte – electricity – expensive

$ZnSO_4$, $CuSO_4$ strong electrolytes – dissociate completely ; SO_4^{2-} spectator ion

$$Zn(s) + Cu^{2+}(aq) \longrightarrow Cu(s) + Zn^{2+}(aq)$$

Zn loses $2e^-$ ⟹ oxidised
Cu^{2+} gains $2e^-$ ⟹ reduced } change ox. state

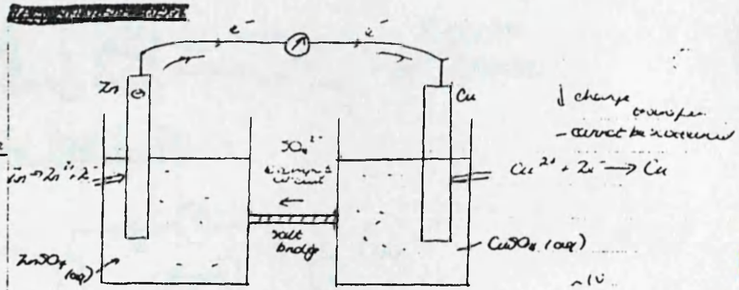
- reaction produces electric current – but not useful as done:
(zinc → $CuSO_4$; need some form separation)

Half-Reactions : $Zn \longrightarrow Zn^{2+} + 2e$ ...OXIDATION
$Cu^{2+} + 2e^- \longrightarrow Cu$ REDUCTION

want to get current from e^- flow – need sep. reactions so flow
e^-s not direct · through external circuit → source energy (batteries)
– sep. compartments.

[redacted]

need to complete circuit



salt bridge – electricity flows, solns don't mix :
· use filter paper soaked in salt
or gel : Agar in H_2O/KCl

electrons used with Cu^{2+} ; electricity in form any charge.
SO_4^{2-} repelled from right to left, so completing circuit

reaction continues under either reactant depleted: Zn dissolved, all Cu^{2+} ...
chemical ⟶ electrical energy ; used to drive devices

What determines voltage produced ? sign ? How much energy !
Is there limit ? What direction reaction ?

[redacted]

unit of electric charge · coulomb C

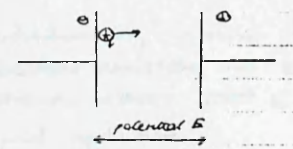
charge on 1 electron $e = 1.602 \times 10^{-19}$ C (-ve)

charge on 1 mole of electrons = 1 FARADAY (F)
$= e \times N_A$
$= 1.602 \times 10^{-19} \times 6 \times 10^{23}$
$= 96,500$ C

electric current (I) = Rate of flow of charge (+ve or -ve)
$1A = 1Cs^{-1}$

electric potential (voltage ; emf) – measured in volts (V)

energy measured in joules (J) (from whatever source)



Energy (work done) = qE
$1J = 1C \times 1V$
(energy when 1 coulomb across 1 volt)
-ve. ← -q → attraction
= CHARGE × POTENTIAL DIFFERENCE

S10 : Transfer of electrons – REDOX

(Brown & Lemay Chap 20 Pg 651-687)

Balancing Redox reactions, method of half reactions
(Rev Pg 434-44)

1. Chemical energy $\longleftrightarrow$ Electrical energy

2. Electrical energy $\longleftrightarrow$ Chemical energy

examples on 1. are: STORAGE BATTERIES (cells)
SOLAR ENERGY CONVERSION
PHOTOSYNTHESIS
NERVE IMPULSES.

examples on 2 are Electrolysis (Purification, Extraction, Electroplating)
Corrosion (Rusting of Iron)
Metabolism (eating Food etc).

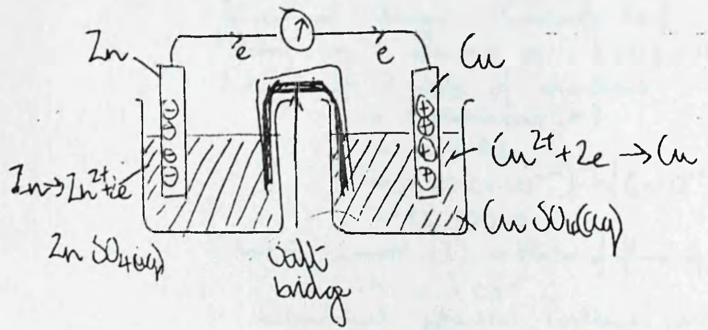
A. <u>VOLTAIC CELLS (electrochemical cells)</u>

$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$

or $Zn(s) + Cu^{2+}(aq) \longrightarrow Cu(s) + Zn^{2+}(aq)$ REDOX

half Reactions:
$Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu(s)$ REDUCTION
$Zn(s) \longrightarrow Zn^{2+}_{(aq)} + 2e^-$ OXIDATION

B <u>THE DANIELL CELL</u>



C) <u>SOME RELATIONSHIPS BETWEEN ELECTRICITY CHARGE, ENERGY etc.</u>

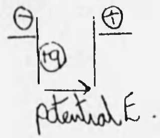
Unit of Charge is the ~~Coul~~ Coulomb (C)

<u>Charge on electron (e)</u> = -1.602×10^{-19} C

<u>Charge on 1 mole of electrons</u> = 1 Faraday
$= N_A e$
$= 6 \times 10^{23} \times 1.6 \times 10^{-19}$
$= 96,500$ C

<u>Electrical Current (I)</u> = Rate of Flow of Charge
1A = 1C sec^{-1}

Electrical Potential (Voltage, emf, p.d.) – Volts.



Work done = Transfer of energy = qE.

ie 1J = 1C × 1V

ie 1V = 1 JC^{-1}

S11:

Electrochemistry involves transfer of electrons. - REDOX
ELECTRON TRANSFER → "ELECTRICITY"
CHEMICAL ENERGY ⇌ ELECTRICAL ENERGY

Typical applications
Chem → Elect. e.g. Storage Batteries (cells)
Solar energy conversion systems
(Photosynthesis)
(Nerve impulses)

Elect. → Chem. Electrolysis

Other important examples: (Rusting) – corrosion
Metabolism

Voltaic Cells (electrochemical cells)

e.g. $Zn_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + ZnSO_{4(aq)}$

$Zn_{(s)} + Cu^{2+}_{(aq)} \rightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

Zn LOSES TWO e^- → Oxidised

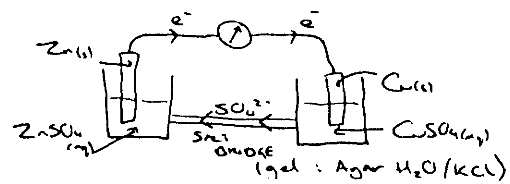
Cu GAINS TWO e^- → Reduction

Half reactions:

$Zn \rightarrow Zn^{2+} + 2e^-$ Oxidation

$Cu^{2+} + 2e^- \rightarrow Cu$ Reduction

Daniell cell



$Zn_{(s)} \rightarrow Zn^{2+} + 2e^-$

$Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$

Salt bridge completes circuit – the SO_4^{2-} ions migrate across – attracted by the Cu^{2+}.

Electricity charge, energy etc.

Unit of charge: Coulomb (C)

Charge on 1 electron $e^- = 1.602 \times 10^{-19}$ C

Charge of 1 mole of electrons

$= 1$ FARADAY (F)

$= e \times N_A$

$= (1.602 \times 10^{-19}) \times (6 \times 10^{23})$

$\approx 96\,500$ C

Electric current (I) = Rate of flow of charge

$1A = 1\ Cs^{-1}$

Electrical potential (voltage, EMF)

APPENDIX 2

The Questionnaire - Student Evaluation of Teaching (1988 version)

GLASGOW UNIVERSITY CHEMISTRY DEPARTMENT 1988-89

You are asked to rate statements about the course and the lecturer on a '1 ... 5' scale. Unless it says otherwise, you may assume that

a rating of '5' indicates strong agreement
a rating of '1' indicates strong disagreement.

Please indicate your rating for each item by circling ONE response only.

COURSE CONTENT

1.	I found the course intellectually challenging and stimulating	1 2 3 4 5
2.	The course content was well prepared and carefully explained	1 2 3 4 5
3.	Good use was made of models, demonstrations, OHP's and handouts	1 2 3 4 5
4.	The textbook helped me understand the lecture topics	1 2 3 4 5
5.	Adequate textbook references were provided	1 2 3 4 5
6.	The course assumed previous knowledge which I did not possess[§]	1 2 3 4 5
7.	For me, the pace of this course was 1.too slow ... 3.about right ... 5.too fast	1 2 3 4 5
8.	Overall, I would rate this course as 1.excellent ... 3.average ... 5.poor	1 2 3 4 5

LECTURER CHARACTERISTICS

9.	The lecturer was enthusiastic about teaching the course	1 2 3 4 5
10.	The lecturer's style of presentation held my interest	1 2 3 4 5
11.	The lecturer gave clear, lucid explanations	1 2 3 4 5
12.	The lecturer was readily accessible to students	1 2 3 4 5
13.	I would go to this lecturer for help in the future	1 2 3 4 5
14.	Overall, I would rate this lecturer a 1.poor ... 3.average ... 5.excellent	1 2 3 4 5

[§] *If this was a problem for you, use this space to say what knowledge you lacked.*

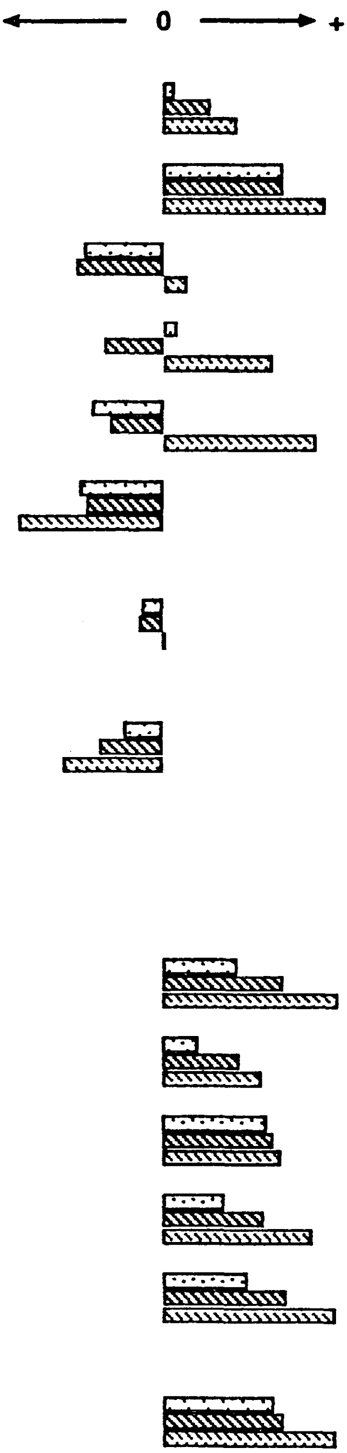
APPENDIX 3

The Observation Schedule of Lecturing

Categories	Lecturer's overt behaviours	
Use of Humour and Asides	1. Telling jokes. 2. Funny stories. 3. Humorous comments. 4. Illustrating data with personal anecdotes. 5. Real case presentations or applications.	
Voice-audibility	Loudness and intonation.	
Blackboard writing	Legibility, organisation (headings) and size.	
Giving Instructional cues	1. Verbal signposts. 2. Non-verbal cues. 3. Blackboard writing.	
Focussing	1. Setting instructional objectives. 2. Summarising. 3. Outlining or overviewing. 4. Heading and subheading (or numbering). 5. Use of organisers etc.	
Wait-time	Pause or short periods of silence.	
Lecturing pace	Informational units.	

APPENDIX 4

The Profiles of Lecturers' Performance



COURSE CONTENT

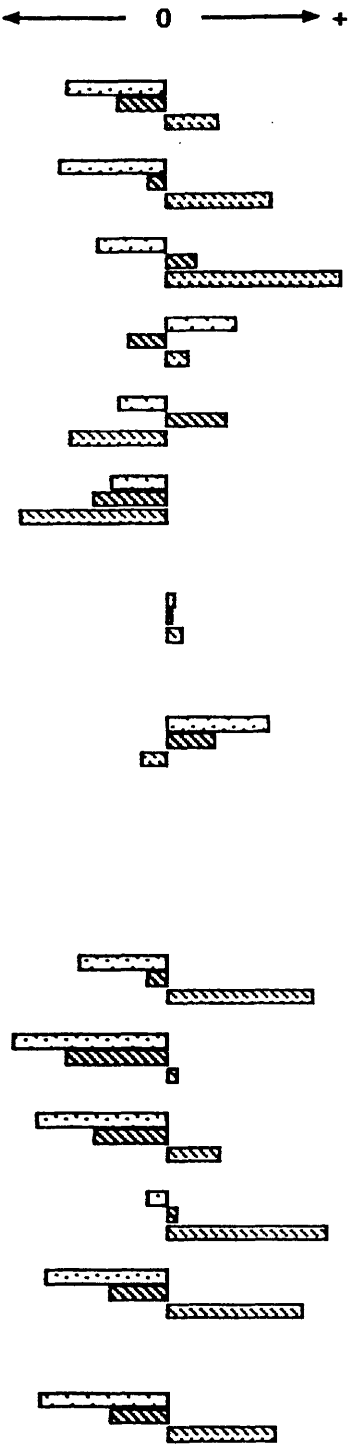
1. I found the course intellectually challenging and stimulating
2. The course content was well prepared and carefully explained
3. Good use was made of models, demonstrations, OHP's and handouts
4. The textbook helped me understand the lecture topics
5. Adequate textbook references were provided
6. The course assumed previous knowledge which I did not possess
7. For me, the pace of this course was
   1. too slow ... 3. about right ... 5. too fast
8. Overall, I would rate this course as
   1. excellent ... 3. average ... 5. poor

LECTURER CHARACTERISTICS

9. The lecturer was enthusiastic about teaching the course
10. The lecturer's style of presentation held my interest
11. The lecturer gave clear, lucid explanations
12. The lecturer was readily accessible to students
13. I would go to this lecturer for help in the future
14. Overall, I would rate this lecturer as
    1. poor ... 3. average ... 5. excellent

Figure 2-2. 'Profiles' for Lecturers (□ = K, ▧ = D, ▨ = B)

COURSE CONTENT



1. I found the course intellectually challenging and stimulating

2. The course content was well prepared and carefully explained

3. Good use was made of models, demonstrations, OHP's and handouts

4. The textbook helped me understand the lecture topics

5. Adequate textbook references were provided

6. The course assumed previous knowledge which I did not possess

7. For me, the pace of this course was
   1. too slow ... 3. about right ... 5. too fast

8. Overall, I would rate this course as
   1. excellent ... 3. average ... 5. poor

LECTURER CHARACTERISTICS

9. The lecturer was enthusiastic about teaching the course

10. The lecturer's style of presentation held my interest

11. The lecturer gave clear, lucid explanations

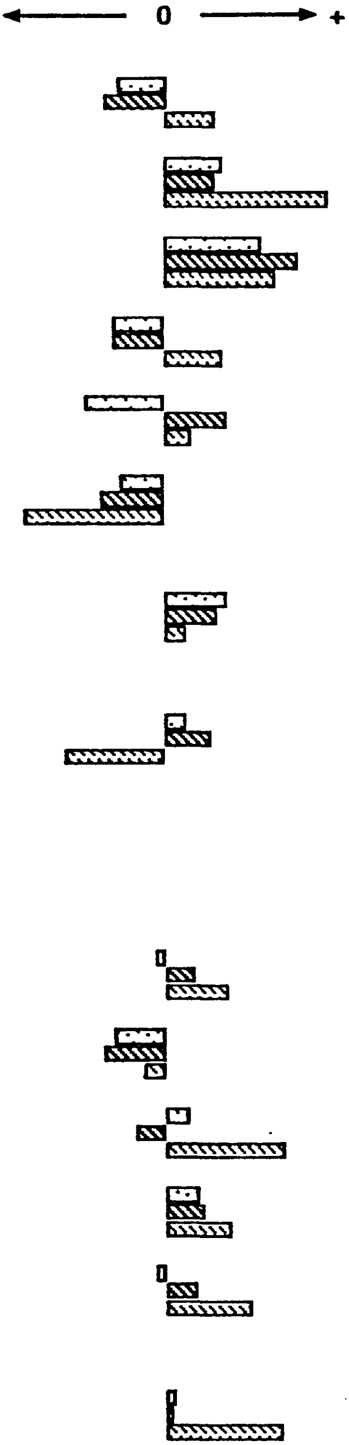
12. The lecturer was readily accessible to students

13. I would go to this lecturer for help in the future

14. Overall, I would rate this lecturer as
    1. poor ... 3. average ... 5. excellent

Figure 2-3. 'Profiles' for Lecturers (= C, = E, = L)

COURSE CONTENT



1. I found the course intellectually challenging and stimulating

2. The course content was well prepared and carefully explained

3. Good use was made of models, demonstrations, OHP's and handouts

4. The textbook helped me understand the lecture topics

5. Adequate textbook references were provided

6. The course assumed previous knowledge which I did not possess

7. For me, the pace of this course was
   1. too slow ... 3. about right ... 5. too fast

8. Overall, I would rate this course as
   1. excellent ... 3. average ... 5. poor

LECTURER CHARACTERISTICS

9. The lecturer was enthusiastic about teaching the course

10. The lecturer's style of presentation held my interest

11. The lecturer gave clear, lucid explanations

12. The lecturer was readily accessible to students

13. I would go to this lecturer for help in the future

14. Overall, I would rate this lecturer as
   1. poor ... 3. average ... 5. excellent

Figure 2-4. 'Profiles' for Lecturers (☐ = F, ▧ = G, ▨ = H)

APPENDIX 5 — *Data consistency*

DATE = 18 - 10 - 88 COURSE = A / A N = 252

(Morning group)

	1	2	3	4	5	TOTAL
ITEM 1	2	11	47	33	5	98
ITEM 2	2	7	16	46	29	100
ITEM 3	2	9	28	43	18	100
ITEM 4	3	8	34	34	16	95
ITEM 5	3	6	15	35	41	100
ITEM 6	38	25	18	8	9	98
ITEM 7	4	6	78	7	4	99
ITEM 8	15	31	39	12	1	98
ITEM 9	4	4	20	49	23	100
ITEM 10	2	8	23	41	24	98
ITEM 11	3	8	14	40	34	99
ITEM 12	3	5	34	33	19	94
ITEM 13	4	5	19	40	31	99
ITEM 14	1	1	19	47	31	99

DATE = 18 - 10 - 88 COURSE = A / A N = 165

(Afternoon group)

	1	2	3	4	5	TOTAL
ITEM 1	1	15	44	35	4	99
ITEM 2	2	6	30	38	24	100
ITEM 3	2	17	29	31	21	100
ITEM 4	2	10	37	37	10	96
ITEM 5	3	5	19	47	25	99
ITEM 6	38	27	15	12	7	99
ITEM 7	5	7	78	5	5	100
ITEM 8	12	24	53	9	1	99
ITEM 9	2	7	33	42	16	100
ITEM 10	6	12	29	38	15	100
ITEM 11	2	7	27	40	24	100
ITEM 12	1	6	34	42	13	96
ITEM 13	1	5	29	41	24	100
ITEM 14	1	3	30	44	22	100

DATE = 23 - 11 - 88 COURSE = A / C N = 224

(Morning group)

	1	2	3	4	5	TOTAL
ITEM 1	35	29	22	9	4	99
ITEM 2	33	32	23	9	3	100
ITEM 3	24	30	26	16	4	100
ITEM 4	8	7	31	32	20	98
ITEM 5	22	23	30	16	8	99
ITEM 6	28	19	29	12	10	98
ITEM 7	14	16	39	13	16	98
ITEM 8	2	8	27	22	40	99
ITEM 9	31	27	27	10	5	100
ITEM 10	56	27	11	3	3	100
ITEM 11	45	28	17	5	5	100
ITEM 12	15	14	45	12	9	95
ITEM 13	48	23	18	5	6	100
ITEM 14	43	27	23	4	3	100

DATE = 23 - 11 - 88 COURSE = A / C N = 140

(Afternoon group)

	1	2	3	4	5	TOTAL
ITEM 1	31	31	19	13	6	100
ITEM 2	38	22	32	8	0	100
ITEM 3	25	27	33	12	3	100
ITEM 4	7	12	30	30	21	100
ITEM 5	30	20	33	10	7	100
ITEM 6	24	27	29	5	13	98
ITEM 7	11	8	46	20	15	100
ITEM 8	0	7	31	21	41	100
ITEM 9	34	28	26	9	3	100
ITEM 10	60	26	12	1	1	100
ITEM 11	50	23	19	7	0	99
ITEM 12	13	18	49	10	4	94
ITEM 13	52	19	22	5	2	100
ITEM 14	44	24	30	2	0	100

DATE = 01 - 02 - 89 COURSE = A / G N = 222

(Morning group)

	1	2	3	4	5	TOTAL
ITEM 1	2	5	41	41	10	99
ITEM 2	1	4	11	53	31	100
ITEM 3	5	26	41	17	9	98
ITEM 4	3	13	47	29	5	97
ITEM 5	10	19	28	19	20	96
ITEM 6	32	31	23	9	4	99
ITEM 7	2	5	84	7	2	100
ITEM 8	17	44	25	12	2	100
ITEM 9	2	3	4	40	50	99
ITEM 10	2	3	18	44	33	100
ITEM 11	1	4	10	44	41	100
ITEM 12	2	1	19	31	44	97
ITEM 13	2	1	9	32	55	99
ITEM 14	0	1	6	49	43	99

DATE = 01 - 02 - 89 COURSE = A / G N = 108

(Afternoon group)

	1	2	3	4	5	TOTAL
ITEM 1	6	11	45	28	7	97
ITEM 2	2	5	17	52	22	98
ITEM 3	8	14	49	18	10	99
ITEM 4	6	14	46	24	5	95
ITEM 5	12	17	23	19	27	98
ITEM 6	29	23	31	10	5	98
ITEM 7	1	9	78	7	5	100
ITEM 8	14	40	32	13	0	99
ITEM 9	1	4	5	50	40	100
ITEM 10	4	9	16	49	21	99
ITEM 11	1	3	24	46	24	98
ITEM 12	1	2	17	39	35	94
ITEM 13	3	4	6	41	44	98
ITEM 14	0	1	6	57	33	97

DATE = 17 - 02 - 89 COURSE = A / H N = 193

(Morning group)

	1	2	3	4	5	TOTAL
ITEM 1	14	25	46	11	3	99
ITEM 2	6	10	39	35	10	100
ITEM 3	3	13	18	35	31	100
ITEM 4	15	22	46	8	2	93
ITEM 5	24	32	22	11	7	96
ITEM 6	21	20	35	15	6	97
ITEM 7	3	4	59	19	14	99
ITEM 8	4	18	46	24	7	99
ITEM 9	6	26	41	20	6	99
ITEM 10	20	29	28	17	5	99
ITEM 11	5	18	40	28	6	97
ITEM 12	6	11	51	21	4	93
ITEM 13	14	19	36	20	7	96
ITEM 14	7	17	48	22	5	99

DATE = 17 - 02 - 89 COURSE = A / H N = 91

(Afternoon group)

	1	2	3	4	5	TOTAL
ITEM 1	15	23	44	12	6	100
ITEM 2	4	15	31	30	20	100
ITEM 3	8	9	16	34	33	100
ITEM 4	21	14	45	9	2	91
ITEM 5	23	36	20	11	5	95
ITEM 6	25	20	36	12	4	97
ITEM 7	2	7	43	25	23	100
ITEM 8	9	18	35	25	13	100
ITEM 9	10	21	33	29	4	97
ITEM 10	18	32	25	15	9	99
ITEM 11	8	17	38	21	15	99
ITEM 12	1	5	49	31	7	93
ITEM 13	12	16	35	25	7	95
ITEM 14	9	22	34	27	7	99

APPENDIX 6 — *Sample response forms*

STUDENT INPUT FOR TEACHING

You are being asked to help us assess and improve our teaching courses. Please fill in this questionnaire during the lecture. The questionnaire is anonymous so you may be completely frank.

LECTURER :

TOPIC :

COMPARING THIS COURSE TO OTHERS YOU HAVE HAD please place a tick on the following scale.

LECTURE PRESENTATION

How clearly was the lecture presented ?

UNCLEARLY - - - - - VERY CLEARLY

How orderly and logical was the arrangement of the material ?

NOT AT ALL - - - - - VERY MUCH

Overall, how would you rate the lecturer ?

EXCELLENT - - - - - POOR

LECTURE CONTENT

How interesting did you find the content matter of the course ?

VERY INTERESTING - - - - - UNINTERESTING

How difficult did you find the course material ?

VERY DIFFICULT - - - - - VERY EASY

How did you find the pace at which the material was covered ?

TOO FAST - - - - - TOO SLOW

How well did this course follow on from previous courses you have had at school or University ?

NO CONNECTION - - - - - VERY WELL

(If appropriate) What is your opinion of the recommended text(s) for this course ?

POOR - - - - - EXCELLENT

What is your overall rating of this course ?

EXCELLENT - - - - - POOR

This is a pilot questionnaire. ARE THERE ANY OTHER QUESTIONS YOU WOULD HAVE LIKED US TO ASK ? If so, how would you have answered them ?

COMMENTS

The University of Adelaide
Advisory Centre for University Education

STUDENT EVALUATION OF TEACHING

This questionnaire seeks information about your experience of this teacher and this course.

Please answer each question accurately. If you feel you cannot answer a particular question leave it out and go to the next question. Your responses are anonymous.

Circle the number which most closely corresponds to your view about each statement.

Thank you for your assistance with this evaluation.

COURSE.. LECTURER..

PART A

1 How do you feel about the content of this course?

Very Positive	Positive	Neutral	Negative	Very Negative
1	2	3	4	5

2 All things considered, how would you rate this staff member's effectiveness as a university teacher?

Very Poor	Poor	Satisfactory	Good	Very Good
1	2	3	4	5

3 How would you describe the workload in this course?

Very Light	Light	Reasonable	Heavy	Very Heavy
1	2	3	4	5

4 The pace at which this course is being presented is...

Too Fast	Fast	About Right	Slow	Too Slow
1	2	3	4	5

5 How would you describe the degree of difficulty of this course?

Very Easy	Easy	Reasonable	Difficult	Very Difficult
1	2	3	4	5

PART B

Please indicate the extent to which you agree or disagree with the following statements by circling the appropriate number.

Course Characteristics	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
6 I understand the subject matter	1	2	3	4	5
7 This course is being poorly co-ordinated	1	2	3	4	5
8 The course is challenging	1	2	3	4	5
9 Assessment methods are fair	1	2	3	4	5
10 Course materials are well prepared	1	2	3	4	5
11 Proposed aims of course are being implemented	1	2	3	4	5
12 I am learning something valuable	1	2	3	4	5
13 Recommended readings contribute to understanding in the course	1	2	3	4	5
Teacher Characteristics					
14 Communicates effectively	1	2	3	4	5
15 Teaching style makes note-taking difficult	1	2	3	4	5
16 Enthusiastic about teaching this course	1	2	3	4	5
17 Stimulates my interest in this subject	1	2	3	4	5
18 Interested in students	1	2	3	4	5
19 Accessible to students outside classes	1	2	3	4	5
20 Encourages students to express ideas	1	2	3	4	5
21 Well organised	1	2	3	4	5
22 Confident	1	2	3	4	5
23 Clear explanations given	1	2	3	4	5

PART C

24 What improvements to the course, or to the teaching, could you suggest?
Please PRINT your comments, to preserve anonymity, on the back of this sheet.

Thank you for answering this questionnaire. Please return it as directed.

APPENDIX 7 *Students' written-in comments*

Lecturer A

"Give more time to subject so note taking slower and able to read what you are writing, and not having to concentrate solely on getting everything down."

"Could write a little neater."

"Writing could be neater. Write slightly slower."

"Better blackboards"

"If the lecturer could write more clearly on the blackboard. Writings hard to read at times."

"Boards are difficult to read when written on in white chalk."

"To go slower and write more clearly."

"Could talk louder while at the board, though others okay."

"Lecture was GoGo in offering assistance - better examples could be used. Clean the board."

"Less use of side blackboards (sight restrictions.)"

"Less blackboard work (write slower) and more detailed explanations, otherwise just give us photocopied sheets."

"There is no need to write down a set of notes on the blackboard. This slows down the progress through the course. More could be covered or time could be used to review at the end if lecturer didn't spend time writing down a set of notes for the students to copy."

"I think the lecturer should write a little slower."

"Go a bit slower and write more clearly."

"Go a bit slower and write clearer."

"Lecturers should take time to explain a topic so we could understand it before he/she dictates the lecture notes. VERY IMPORTANT."

"Rather than writing complicated wordy phrases on the board without explaining then properly, he should take more time to explain it."

"Lecturer should try and explain what he is writing instead of giving examples at end."

"More explaining on subject topic on blackboard and less rushed."

"Good teaching style - summarised each lecture at end."

"The initial few lectures could be covered more quickly, leaving more time for the latter lectures which seemed a bit more complicated."

"It may be helpful if the lecturer could write a little more clearly."

"I thought that this part of course was perfect! NO change."

"Not so much difficult as too rushed. If you pause for a second to read what you've written you end up lagging behind in the lecture. Slow down a little!"

"It is difficult to write down his notes and concentrate on his explanations all at the same time. I found he went very fast. But notes were very good."

"Diagrams not always clear. Blackboard is sometimes hard to read."

Lecturer B

"No improvements required."

"The lecturer could smile every now and then"

"He could sound more interested in the course."

"Explain when people aren't writing."

"Explain points more thoroughly."

"He goes too fast, doesn't explain well at all. Just goes ahead and writes on board without saying what and why he is doing it."

"He went too fast, but gaved good notes. A bit difficult to understand."

"The course could be easier."

"More homework, not enough examples."

"Very direct and compulsive - could be more informal. More physical simple illustrations."

"Could give some worked examples to see if we can do calculations of shapes of molecules and then go through questions with correct method."

Lecturer C

" I found the lecturer difficult to understand and (the lecturer) appeared to think it was sufficient to simply write numbers and equations on the board with no real explanation as to how they were obtained.
Without the help of the textbook, I doubt if I have gained any knowledge whatsoever from this series of lectures, which I found became a task to attend."

" Very hard to hear if sitting at back of lecture theatre - and sometimes sitting at back is unavoidable."

" It would have been helpful to have a summary of the course (or a flow chart) so you could follow it without being confused with all the equations and calculations."

" Mathematical equations were understandable, but where these equations came from are about as easy to find as the Hanging Gardens of Babylon.
Style of approach and patchy form of presentation provided no foundation on which to build the subject or the topics contained within the subject. Not only did this assumption cause confusion, but (it) also made me realise the meaning of the word ' boredom '. "

" I could not understand the subject as I could not understand what (the lecturer) was saying. "

" I couldn't understand (this lecturer) half the time. "

Lecturer D

" Best lecturer so far ! "

" It was a pleasure to be part of this (lecturer's) class. "

" Lecturer's style of presentation - i.e. light hearted moments - made the course of lectures much more enjoyable."

" (The lecturer) plunged into many topics without giving quick summaries of (previous) knowledge (the lecturer) assumed we already held. Not everyone has done higher or CSYS Chemistry. "

" The lecturer gave book references for a book I did not have. "

Lecturer E

" (There was a) problem - (this lecturer) doesn't talk loud enough ! "

" Fewer examples more carefully explained would get the points over better. Quantity does not necessarily mean quality, especially when dealing with complex subjects. "

Lecturer F

" Please do not assume that everyone has an A-level in Chemistry or CSYS (Chemistry). After only having done Higher (Chemistry) this whole course is much too confusing to understand. "

" Very decent (lecturer who was) down to earth about Chemistry knowledge. No text references (were given), but (they) were not necessary. (The lecturer) covered (the) subject well. "

Lecturer G

" Perhaps Dr. (G) should write just a little bigger on the board. "

" Writing was rather small and therefore rather difficult to read. "

" It would be better if (the lecturer) wrote bigger and not so squashed up. "

" Writing was a bit difficult to read, especially today."

" Writing could be a lot bigger and clearer. "

" The lecturer's writing tended to get smaller as the lecture went on. "

" I found it hard to read (the lecturer's) writing. "

" The writing on the board was too small and was difficult to read. "

" Lecturer wrote too small. "

" Sometimes (the lecturer) wrote too small on the blackboard. "

" Best lecturer I've had ! "

" Dr. (G) was the best lecturer so far in the course. "

" (Dr. G is) a very nice man, but could be a bit confusing with all the new alkyl compounds but especially with non - systematic naming e.g. acetate, formaldehyde, etc. "

" When naming things, block capitals (were) often used. This made it difficult to decide whether to separate words and use capital letters. "

" (The lecturer's) use of trivial names was confusing to most people - especially me. "

" Nice man, boring topic ! "

" Organic chemistry isn't interesting — (we) seem to be doing the same thing again and again. "

Lecturer H

" The lecturer did not give enough time to copy notes. "

" Perhaps too quick to remove overhead slides — missed writing some material. "

" A little longer was required to copy OHP notes ! "

" Too fast — not enough time given to write down what was on the overhead projector. "

" Not enough time to copy down slides which made it impossible to listen at same time. "

" The lecturer removed the OHP's too soon. "

" The lecturer never gave enough time to copy down notes. "

" (The lecturer) lectures too fast ! "

" Far too fast — we all can't write at one hundred miles an hour — slow down please ! "

" (The lecturer) should slow down a little. Too much use was made of slides and not enough of blackboard ! "

" I found it difficult to keep up with (the lecturer), especially when (the lecturer) was using overheads. "

" Too much writing on the board. I spent too much time copying (the lecturer's) writing to listen to (the lecturer) speaking. "

" (The lecturer should) leave more time for copying stuff down. Perhaps (the lecturer could) speak up a bit — (the lecturer) was a shade on the quiet side. Otherwise (the lecturer) was OK ! "

" (The lecturer's) delivery (was) rather too rapid when using overhead projector. "

" (The lecturer made) good use of AV apparatus — (it was) very smoothly operated. I liked the handout."

" (The lectures were) very well prepared (but the lecturer gave) little or no explanations. (There was) too much (material) on the OHP. (The lectures were) too fast. "

" The lecturer could have spoken with a little more volume. (The lecturer's) writing on sheets for overhead projector was far too small. "

" (The lecturer's) writing was too small — especially on (overhead) projector. "

" (The lecturer) writes too small and removes overheads too quickly. "

" The lecturer's writing was too small. (The lecturer) didn't leave the overheads on for long enough. (The lecturer) also spoke too quietly. "

" I couldn't read (the lecturer's) writing. "

" (The lecturer's) writing on board (was) far too small. Not enough time (was given) when showing slides to write things down. "

" The writing on the overheads was too small to read. It may have helped if some lights had been put out. "

" (The lecturer) should have dimmed the lights when using the overhead projector. (The size of the) type was extremely difficult to read. Also there wasn't enough time to copy down notes from the board before sheets were removed. "

" Diagrams on overhead (projector) were blurred and unclear. Lecturer's voice was too quiet. "

" Dr. (H) showed a complete lack of enthusiasm . . . and made no attempt to make it interesting. "

" (The lectures suffered from) information overload. (There was) an awful lot of information to put into 3 lectures. (Allocating) more time and a slowing down of (the) pace would have greatly improved the course.
Having (the) handout before the course started would also have been a help. "

" If anyone could write adequate notes in these lectures I'd be surprised. The diagrams were complex and hard to copy.
The lecturer gave no adequate explanations and — to use this lecturer's favourite word — things were not OK. "

" Even though the lecturer went very fast, and (as a result) much information was missed, I found you had to think for yourself, and read up to understand, a lot more than usual. I found this advantageous.
(This) lecturer should be in the theatre — his voice projects well. "

" The projection onto the screen was too small. "

" (I) couldn't read the OHP's (because) the typing was far too small. "

" (I) couldn't read most of the stuff put up on the OHP (and) not enough notes were given. "

" (The lecturer went) too fast. "

" (I) could not handle the pace. "

" The lecturer spoke too fast and did not write enough notes down. "

" (The lecturer was) too fast and not enough notes (were given). "

" I had no knowledge of biology and was utterly confused by every part of the lectures. "

" The course seemed to assume an intimate knowledge of sugars. "

" The topic was interesting enough, but the lecturer jumped about too much and didn't give sufficient notes. "

" Not enough written material was given and, due to the quickness of the lecturer, not enough information was taken in. "

" The lecturer was basically not very good. No text (book) references were given. There was virtually no use (made) of the blackboard. Almost everything was dictated, and quite fast at that. "

" Rather than lecturing in a systematic way, in an enthusiasm for the subject, the lecturer jumped around the subject, going off on numerous irrelevant tangents and thus making the course much harder to follow. At the end of the day, I had to dissect the relevant information from my notes. "

" The course was very interesting, but the lecturer did not give (any) summaries (or) explanations. "

" I thought the lecturer was good, but (I) found it hard to work out what (the lecturer) was lecturing about at times. "

" Not enough time was spent on clarifying certain points within the course. "

" (At the end, I) didn't know what I was supposed to know for the course and what was just aside information. "

" In this course, it may have been helpful to have an an introduction rather than straight in at the deep end. The basic structure of proteins is still confused.
No reference (was given) to any book. (It) would have been helpful to know what books to look in. "

" (The lecturer) couldn't have been more enthusiastic ! "

" The lecturer scribbled a few diagrams on the board with inadequate explanation.
Too little was explained in an understandable way.
The OHP's were too difficult to understand as they had far too much detail to comprehend anything at all.
Overall, I learned absolutely nothing from this series of lectures and I left at the end feeling that I had worked (for) an hour. "

" (This lecturer) says ' right ' and ' OK ' too many times.
(Lecturer's) writing on the blackboard becomes (illegible) because (lecturer) writes on top of notes which are already there. "

" There was too much repetition of inadequate points and less emphasis on the important points. Almost no notes were given, and those (notes) given were too little, and (were) quickly rubbed off before I had a chance to note them. I learned almost nothing. "

" Slow it down, expand on things, cool it and the topic could be fun.
Give out some information before the first lecture so (that) people can listen rather than frantically trying to write all these structures down. "

" What is (this lecturer) going on about ?
These are about the most boring lectures so far. "

" Incoherent ramblings. "

" I was disappointed to find out that there has been no past exam questions on this section. "

" It was boring just copying off the board. Why not put more on a handout and use lecture to make interesting explanatory comments ? "

" Macromolecules 1 — the most boring topic ever — more so than Organic Chemistry. "

Lecturer I

" Lecturer did not explain fully. "

" Lecturer did not specifically explain what certain words (like anthropogenic) meant. "

" The lecturer did not give any explanation of notes (written) on board and did not emphasise significance of ion - exchange. Most notes (written by the lecturer) were percentages or reactions which were very memorable. (I found that my own) notes did not make any sense at all. I am not taking chemistry next year if (the) lectures continue as they are. "

" (The lecturer did not spend) enough time explaining the important bits. "

" (The lecturer) did not give much indication of what (the lecturer) was talking about. I still do not know what adsorption is ! (The lecturer) misses out important working leaving me baffled. "

" Additional notes on the board would be helpful. "

" The (blackboard) notes were a bit abstract and random. (The) headings were not too clear. "

" The written notes were crap, and the lecturer did not write enough on the board. (The lecturer) wrote nothing but headings and talked the rest. This may to some be interesting but at (the) exam time I'm not going to be able to remember any of it ! "

" (The lecturer) didn't write any titles on the board — just fragmented information and (then the lecturer) moved on too quickly. "

" (The lecturer displayed a) poor board presentation (which) jumped quickly from topic to topic without any new titles. "

" (The) lecture(s) seemed a bit disjointed. "

" (The lecture) notes were not carefully prepared, with many explanations omitted. The explanations were very good but (the) rate at which they were given were too fast to be taken down. (I found that there were) too many empty spaces. "

" I was lost from start to finish and could not see the relevance of the topic. (The lecturer) just wrote words on the board. When I got home they made very little sense. This is mainly due to (the lecturer's) single words and no explanations. Please excuse the total objectionality which is all down to frustration. "

" Some titles or explanations of what the topic being talked about is, may help ! "

" The lectures dragged past very slowly. "

" (These lectures were) almost as boring as Organic Chemistry and Macromolecules. '

" (The lectures dealt with an) interesting topic (which) could have been made more stimulating by more use of slides. "

" (You should) try putting this on later in the course, as a bit of light relief. "

" (I) could not see (the) relevance of Chemistry in the environment. (The lecturer) went too fast (and I) could not get down everything (the lecturer) said. (It was) just a mass of figures and calculations, with no explanation of what they mean or imply. "

Lecturer J

" Please write more on board !! "

" (The lecturer) should write more on board. "

" I found that the lecturer did not emphasise enough what points of the lecture should have been noted. It would have been helpful if (the lecturer) had written more notes on board. (The) lectures were too unorganised — the lecturer jumped around from subject to subject. "

" Far too little notes were written on the board. "

" The lecturer did not give suitable notes. "

" (The lecturer) could have written more on the board to make the important points and definitions and reactions clearer. "

" Not enough (was written) on blackboard. "

" More notes on board would have helped. "

" The only problem was (that) the notes were insufficient and (I) couldn't read some of the overhead (transparencies). Also (the lecturer) needed to speak up a bit. Also (I found it was a) strain on the eyesight as we were writing in half-light. "

[Unfortunately, no record was kept of the *written-in* comments for lecturer K.]

Lecturer L

" Why can't we have this lecturer all the time ? "

" Such interest and dedication — gives a whole new dimension and meaning to Chemistry. "

" (This was the) best lecturer this year. (The lecturer) made the course seem general knowledge i.e. giving everyday examples to put across the Chemistry. "

" One of the best lecturers we have had. "

" (This was the) best lecturer we've had yet. "

" (This was an) excellent topic and lecturer. (The course was) well explained and very interesting.
(The) last lecture in this course was interesting from the point of view of showing applications of the topic in man. "

" Very well done ! "

" Well done — no changes needed ! "

" (The lecturer gave) no references to inorganic textbooks. "

" (The lecturer's) explanations were laborious to the point of being patronising. "

APPENDIX 8 Analysis Schedule of Student Notes

Mat.No: Name: Course: Date :

	no. of info. unit / items				noted words	%	Elaboration	Others
	B.Board	VERB.	AV- OHP'S Slides Models Film Demons.	%				
1. any mathematical relationship (equation)								
2. any chemical equation								
3. any name or formule of a chemical not given with equation.								
4. any name or definition of a scientific term								
5. any heading, comment or explanation of an equ., relationship or data								
6. any item of data								
7. commission								
8. abbreviation								
9. error								
Total								

ELABORATIONS :

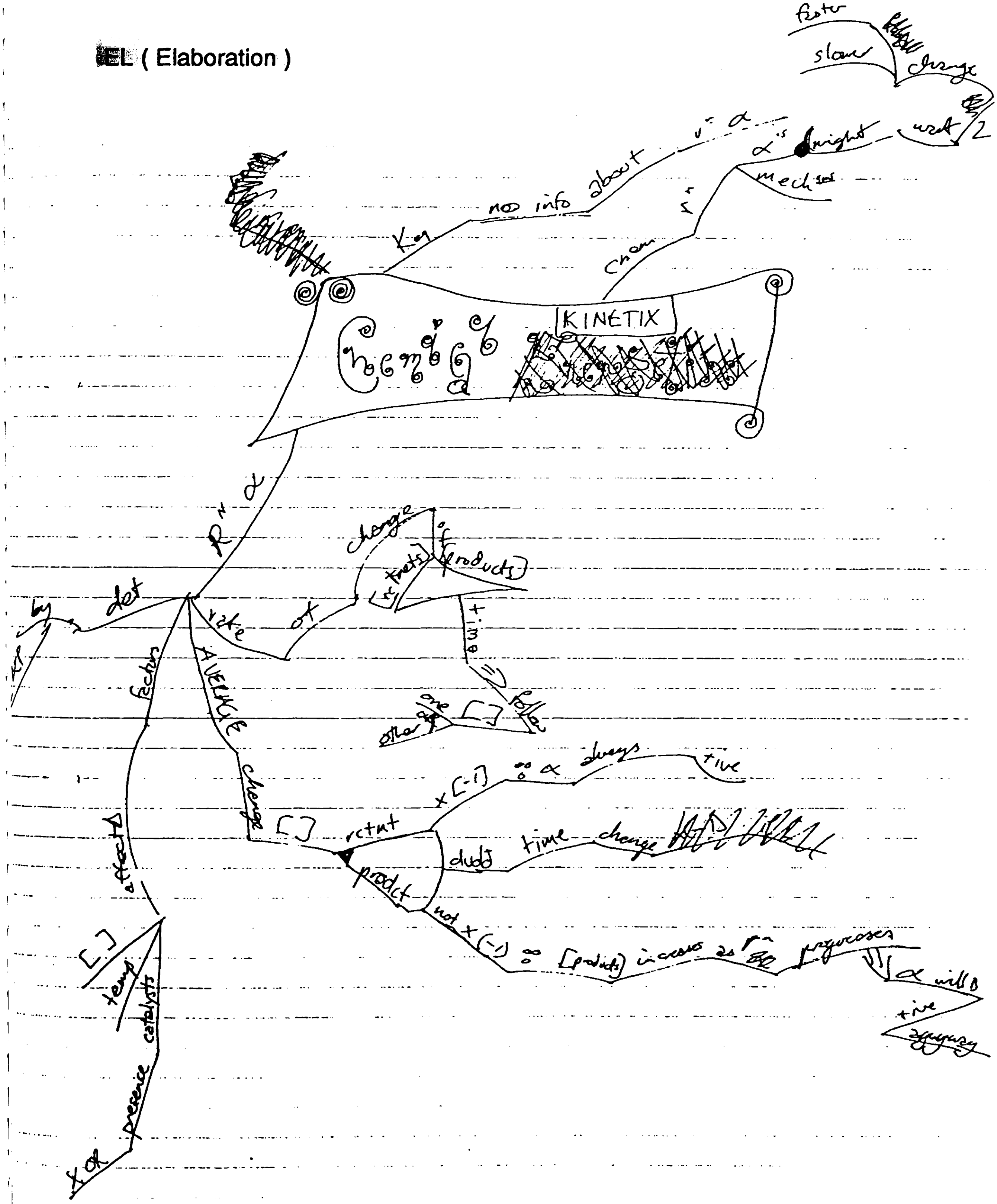
OTHERS:

Physical appearance :

neatness	1	2	3
layout	1	2	3
margin	1	2	3
writing	1	2	3
	Good		poor

APPENDIX 9 Examples of Different Types of Note-taking

EL (Elaboration)



Chemical Kinetics

BSO (Blackboard Signal Only)

$\Delta H^\circ, \Delta S^\circ \Rightarrow \Delta G^\circ (= -RT \ln K) \Rightarrow K$

For $3C_2H_2(g) \rightarrow C_6H_6(l)$

$\Delta G^\circ = -503$ kJ at room temperature (298K)

$K = 1.45 \times 10^{88}\ M^{-2}$

$= \frac{[C_6H_6]}{[C_2H_2]^3}$

Chemical kinetics is concerned with reaction rate and reaction mechanism

$\Delta H^\circ, \Delta S^\circ \longrightarrow \Delta G^\circ (= -RT \ln K) \rightarrow K$

For $3C_2H_2(g) \longrightarrow C_6H_6(l)$

$\Delta G^\circ = -503$ kJ, at $T = 298$ K

$K = (1.45 \times 10^{88})\ M^{-2} = \frac{[C_6H_6]}{[C_2H_2]^3}$ {occurs slowly/not at all at room te

The study of Chemical Kinetics is concerned with the reaction rate and the reaction mechanism

$\Delta H^\circ; \Delta S^\circ \longrightarrow \Delta G^\circ (= -RT \ln K) \Rightarrow K$

For $3C_2H_2(g) \rightarrow C_6H_6(l)$

$\Delta G^\circ = -503$ kJ, at $T = 298$ K

$K = 1.45 \times 10^{88}\ M^{-2} = \frac{[C_6H_6]}{[C_2H_2]^3}$

Chemical kinetics:

- is concerned with reaction rate and reaction mechanism

For $3\,C_2H_2(g) \rightarrow C_6H_6(l)$

$\Delta G^\circ = -503$ kJ, at $T = 298$K.

$K = 1{\cdot}45 \times 10^{88}\ M^{-2} = \dfrac{[C_6H_6]}{[C_2H_2]^3}$.

BS - (Blackboard Signal Minus)

Chemical kinetics:

- reaction rate
- reaction mechanism.

For $3C_2H_{2(g)} \rightarrow C_6H_{6(l)}$, $\Delta G^\circ = -503$ kJ at $T = 298$K.
$K = 1.45 \times 10^{88}\ M^{-2} = [C_6H_6]/[C_2H_2]^3$
Thermodynamics tells us nothing about the rate or mechanism of this reaction. Chemical Kinetics is concerned with reaction and reaction mechanism.

Chemical Energetics

Brown & Le May, CH. 15

~~Reaction~~ Chemical Kinetics

- reaction rates of great importance
- reaction mechanism

Reactions rates are very closely related to reaction mechanisms

Chemical Kinetics:

- reaction rates.
- reaction mechanism

$\Delta H^\circ,\ \Delta S^\circ \longrightarrow \Delta G^\circ\ (= -RT \ln K_{eq}) \rightarrow K_{eq}$

~~From ΔG°~~

ethyne — benzene

$3\,C_2H_2(g) \longrightarrow \cancel{Q}\ C_6H_6(g)$, at $T = 298$ K.

BS + (Blackboard Signal Plus)

From ΔH° and ΔS° we can calculate ΔG°

$\Delta G^\circ = -RT\ln K$

$\Longrightarrow$ we can calculate K.

For $3C_2H_2(g) \longrightarrow C_6H_6(l)$

$\Delta G^\circ = -503\ kJ$ at $T = 298\,K$

$K = 1.45 \times 10^{88}\ M^{-2}$

$= \frac{[C_6H_6]}{[C_2H_2]^3}$

This will occur spontaneously at room temperature.
Almost all of the C_2H_2 will be converted to C_6H_6.
but this reaction occurs so slowly that we can say that it doesn't occur at all.

K doesn't tell us how fast a reaction is or what the processes involved are.

Chemical Kinetics is concerned with Reaction Rate and Reaction Mechanism. Reaction Rate is closely related to Reaction Mechanism.

$\Delta H^\circ, \Delta S \rightarrow \Delta G^\circ (= -RT\ln K) \rightarrow K$

For *$C_2H_2(g) \rightarrow C_6H_6(l)$ [Problem!!! this reaction doesn't occur at rm temp. it's very, very slow]

$\Delta G^\circ = -503\ kJ$ at $T = 298\,K$

$K = 1.45 \times 10^{88}\ m^{-2} = \frac{[C_6H_6]}{[C_2H_2]^3}$

*Tells us nothing about speed, way; sequence of conversion into benzene, state when reaction occurs etc.

Chemical kinetics – reaction rate
– reaction mechanism

reactions

strong acid + strong base – very fast

Oxygen + organic compounds – very fast

(de)composition of wood or stone – very slow

$\Delta H^\circ, \Delta S^\circ \rightarrow \underset{\text{(Free energy)}}{\Delta G^\circ} (= -RT\ln K_{eq}) \rightarrow K_{eq}$ (equi constant)

$3\,C_2H_2(g) \rightarrow C_6H_6(g)$ at $T = 25^\circ C$ (298K)

$\Delta G^\circ = -503\ kJ$

[From this free energy, we can calculate K_{eq}.]

$K_{eq} = \frac{[C_6H_6]}{[C_2H_2]^3} = 1.45 \times 10^{88}\ M^{-2}$

For all practical purposes, this reaction goes too slow! at 298

Thermodynamics only is concerned with final and end states. Reaction rates + mechanisms constitute Chemical Kinetics

[Importance in e.g. Ageing process, decay of food. Great Importance in Industry]

Rate is closely associated to reaction Mechanism

Study of small / molecular changes.

To study kinetics of a reaction,

1) Experimental determination

351

DEPARTMENT OF PHYSICS
LECTURE COURSE QUESTIONNAIRE

This questionnaire requests your point of view on the course so far. Feel free to give specific reasons where relevant why you answered the way you did; thus if you disagree with the statement "Previous knowledge assumed is about right", explain why, eg. "Assumes knowledge about ....".

Tick the box which most closely matches your view. (NA/NC - Not Applicable or No Comment)

	Good	Satis.	Poor	NA/NC	Reason for choice
Audibility of lecturer					
Quality of blackboard presentation					
Quality of OHP's					
Quality of demonstrations					
Quality of handouts					

	Too much	Bit high	About Right	Bit Low	Too Low	NA/NC	Reason for choice
Speed of lectures							
Level of presentation							
Previous knowledge assumed							
Level of problem sheets							
Amount of material on OHP's							

[SA-Strongly Agree, A-Agree, OK-OK or Neutral, D-Disagree, SD-Strongly Disagree]

	SA	A	OK	D	SD	NA/NC	Reason for choice
The lecturer is enthusiastic about the subject							
The course is interesting							
The course is understandable							
You can get a good set of notes							
Demonstrations are good							
Handouts are clear and useful							
Recommended book is useful							

PLEASE TURN OVER

Please answer the following questions in the space provided:

Which points (if any) on the course have you found particularly difficult?

Which text books (including the recommended text) have you read for this course?

Any other comments?

Signature..

(More notice will be taken of signed responses)

Course...

Lecturer...

APPENDIX 11 The Response Grid for Motivational Style Test

UNIVERSITY OF GLASGOW

CENTRE FOR SCIENCE EDUCATION

NAME________________

Instructions : (1) Please read carefully ALL the statements in the following grid.

(2) Select up to FIVE descriptions which you think MOST CLOSELY fit your own feelings about studying.

(3) Fill the numbers you have selected into the bracket on the right : (   )

1 I enjoy studying with my friends and discussing our problems together.	2 It is very important to me to be in the top few of the class.	3 When exam times come round I cut out other activities to concentrate on study.	4 I hate being held back by the teacher having to deal with slow students.
5 The support of my friends is very important to me during exam times.	6 My social and recreational interests are very important to me.	7 I am keen to learn about the latest discoveries and inventions rather than sticking to set materials.	8 I am normally so busy enjoying life that I tend to put off my study till the last minute.
9 In class I enjoy hearing about the applications to everyday life whether they are examined or not.	10 Class discussions are boring if you have to listen to a lot of obviously wrong answers from others.	11 Practicals with very rigid instructions bore me. I prefer to follow my own ideas such as in a project.	12 I like practical work when the instructions are clear and you know just where you are and what is expected.
13 I enjoy the challenge of competing with others for top marks.	14 I may not do brilliantly but I feel a duty to do as well as I can.	15 Exams seldom give me a chance to explore the questions properly and show that I can think for myself.	16 I prefer not to offer suggestions in class discussions unless I am sure I am right.

APPENDIX 12

"Student Evaluation of Teaching" - -- New Version (1989)

University of Glasgow
Centre for Science Education

STUDENT EVALUATION OF TEACHING

This questionnaire is seeking information about your experience of ***this*** course and ***this*** lecturer.

Please answer each question accurately. If you feel you cannot answer a particular question, leave it and go on to the next question. Your responses are anonymous.

Circle the number which most closely corresponds to your view about each statement.

Thank you for your assistance with this evaluation

PART A

1. Relative to other courses I have done, this course was

very easy	easy	reasonable	difficult	very difficult
1	2	3	4	5

2. Relative to other courses, the workload for this course was

very heavy	heavy	reasonable	light	very light
1	2	3	4	5

3. For me, the pace at which this course was presented was

too fast	fast	about right	slow	too slow
1	2	3	4	5

4. Overall, I would rate this course as

very good	good	satisfactory	poor	very poor
1	2	3	4	5

5. Overall, I would rate the lecturer as

very poor	poor	satisfactory	good	very good
1	2	3	4	5

PART B

Please indicate the extent to which you ***agree*** or ***disagree*** with each of the following statements by circling the appropriate number.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
COURSE CONTENT					
6. I understood the subject matter	1	2	3	4	5
7. Course co-ordination was poor	1	2	3	4	5
8. I found the course was challenging	1	2	3	4	5
9. Course content was well prepared	1	2	3	4	5
10. I learned something valuable	1	2	3	4	5
11. Recommended readings contributed to my understanding of the course.	1	2	3	4	5
LECTURER CHARACTERISTICS					
12. Effective communicator	1	2	3	4	5
13. Enthusiastic about teaching the course	1	2	3	4	5
14. Teaching style held my interest	1	2	3	4	5
15. Gave clear, lucid explanations	1	2	3	4	5
16. Made note-taking difficult	1	2	3	4	5
17. Stimulated my interest in the subject	1	2	3	4	5
18. Used OHP (and/or blackboard) well	1	2	3	4	5
19. Friendly and approachable	1	2	3	4	5
20. Well organised	1	2	3	4	5
21. Confident and self assured	1	2	3	4	5
22. I would not go to this lecturer for help	1	2	3	4	5

PART C (Optional)

23. What improvements to the course, or to the teaching, could you suggest ?

Write your comments below :

Thank you for answering this questionnaire.

Please return it as directed.

APPENDIX 13

Computerised Response Questionnaire for

"Student Evaluation of Teaching"

Printed in two colors

UNIVERSITY OF GLASGOW
Centre for Science Education

STUDENT EVALUATION OF TEACHING

is questionnaire is seeking information about your experience of ***this*** course and ***this*** lecturer.

ase answer each question accurately. If you feel you cannot answer a particular question, ve it and go on to the next question. Your responses are anonymous.

ase use an HB pencil. Mark the boxes like this ▬ . Rub out errors thoroughly.

RT A

elative to other courses I have done, this course was

very easy [1] easy [2] reasonable [3] difficult [4] very difficult [5]

elative to other courses, the workload for this course was

very heavy [1] heavy [2] reasonable [3] light [4] very light [5]

or me, the pace at which this course was presented was

too fast [1] fast [2] about right [3] slow [4] too slow [5]

verall, I would rate this course as

very good [1] good [2] satisfactory [3] poor [4] very poor [5]

verall, I would rate the lecturer as

very poor [1] poor [2] satisfactory [3] good [4] very good [5]

RT B

Please indicate the extent to which you ***agree*** or ***disagree*** with each of the following statements by filling in the appropriate box.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
URSE CONTENT					
I understood the subject matter	[1]	[2]	[3]	[4]	[5]
Course co-ordination was very poor	[1]	[2]	[3]	[4]	[5]
I found the course was challenging	[1]	[2]	[3]	[4]	[5]
Course content was well prepared	[1]	[2]	[3]	[4]	[5]
I learned something valuable	[1]	[2]	[3]	[4]	[5]
Recommended readings contributed to my understanding of the course.	[1]	[2]	[3]	[4]	[5]
CTURER CHARACTERISTICS					
Effective communicator	[1]	[2]	[3]	[4]	[5]
Enthusiastic about teaching the course	[1]	[2]	[3]	[4]	[5]
14. Teaching style held my interest	[1]	[2]	[3]	[4]	[5]
15. Gave clear, lucid explanations	[1]	[2]	[3]	[4]	[5]
16. Made note-taking difficult	[1]	[2]	[3]	[4]	[5]
17. Stimulated my interest in the subject	[1]	[2]	[3]	[4]	[5]
18. Used OHP (and/or blackboard) well	[1]	[2]	[3]	[4]	[5]
19. Friendly and approachable	[1]	[2]	[3]	[4]	[5]
20. Well organised	[1]	[2]	[3]	[4]	[5]
21. Confident and self assured	[1]	[2]	[3]	[4]	[5]
22. I would not go to this lecturer for help	[1]	[2]	[3]	[4]	[5]

RT C
tional)

What improvements to the course, or to the teaching, could you suggest? Write your comments below:

nk you for answering this questionnaire. Please return it as directed.

Glasgow University
Science Education
Research Group

(H F T)

NAME:
(Capital letters)

SEX:

Matriculation No: | | | | | | |

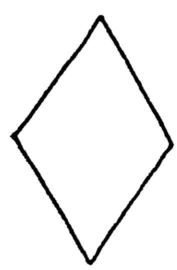
This is a test of your ability to find a simple shape when it is hidden within a complex pattern.

The results will not affect your university work in any way.

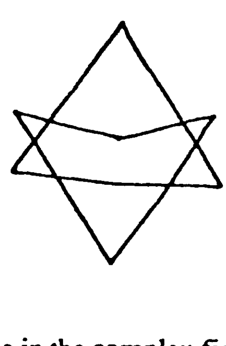
Example (1)

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

(X)



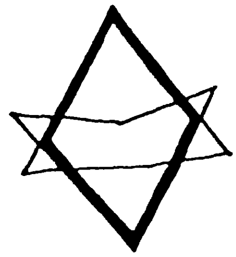
This simple shape is hidden within the more complex figure below:



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

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

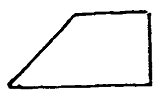
The answer is:

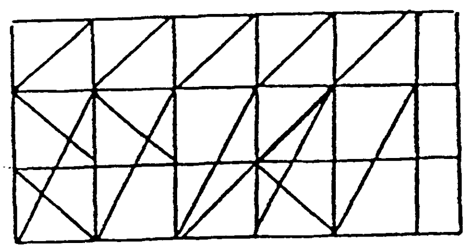


Example (2)

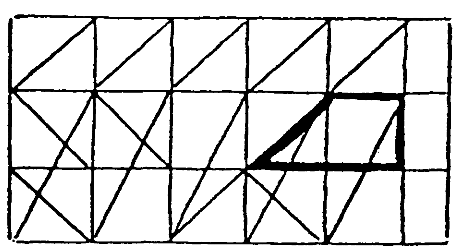
Find and trace the simple shape (Y) in the complex figure beside it.

(Y)





The answer is:



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

Note these points:

(1) Rub out all mistakes.

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

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

(4) The simple shape is always present in the complex figure in the

same size,

same proportions,

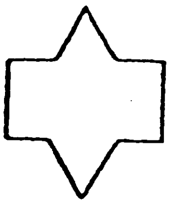
and facing in the same direction;

as it appears alone.

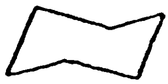
(5) LOOK BACK AT THE SIMPLE FORMS AS OFTEN AS NECESSARY.

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

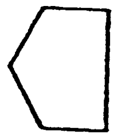
SIMPLE FORMS



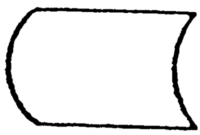
A



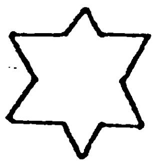
B



C



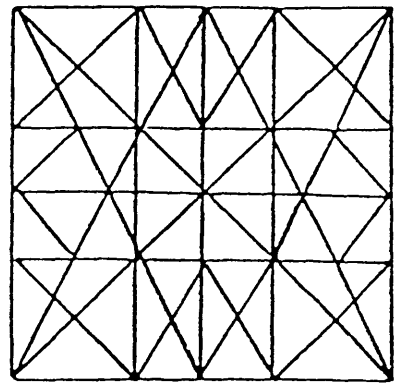
D



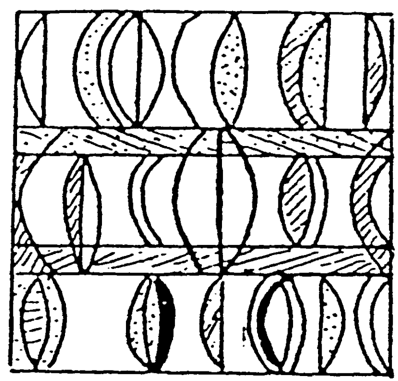
E

G

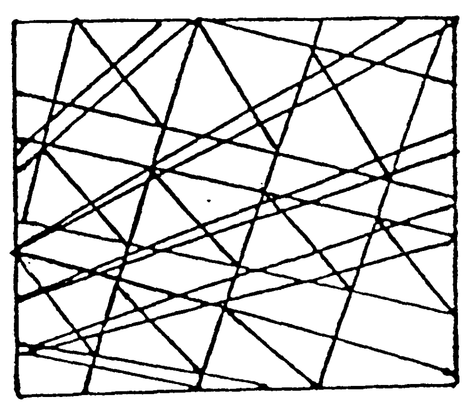
FIND SIMPLE FORM 'C'



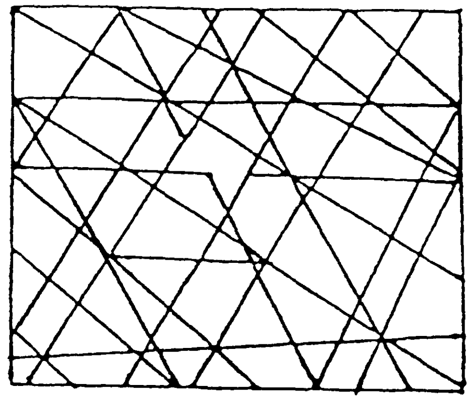
FIND SIMPLE FORM 'D'



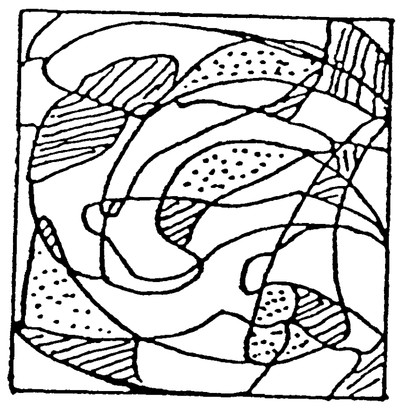
FIND SIMPLE FORM 'B'



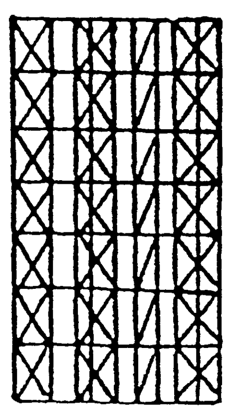
FIND SIMPLE FORM 'E'



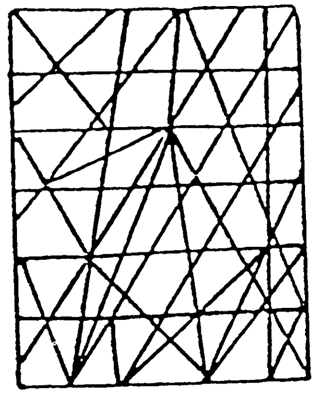
FIND SIMPLE FORM 'G'



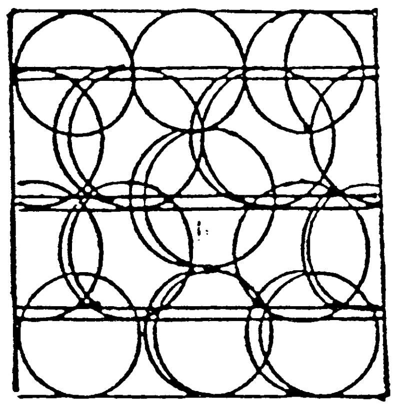
FIND SIMPLE FORM 'C'



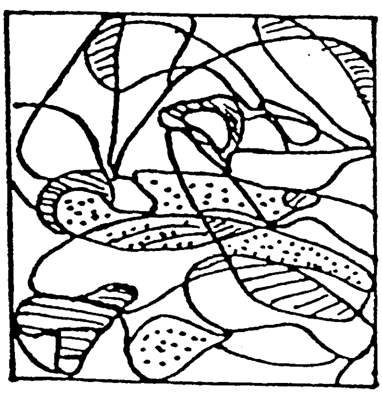
FIND SIMPLE FORM 'C'



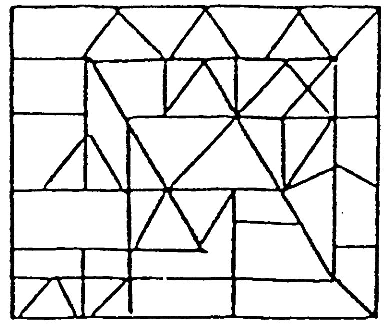
FIND SIMPLE FORM 'D'



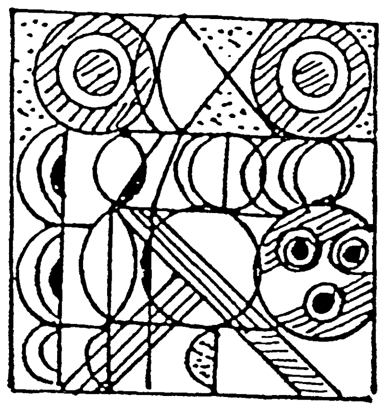
FIND SIMPLE FORM 'G'



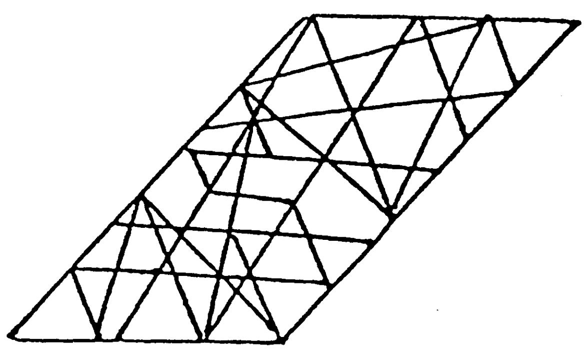
FIND SIMPLE FORM 'A'



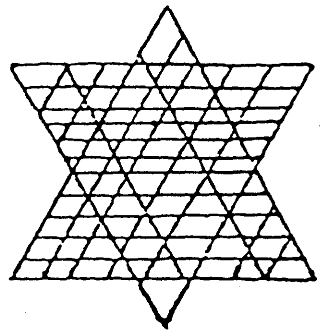
FIND SIMPLE FORM 'D'



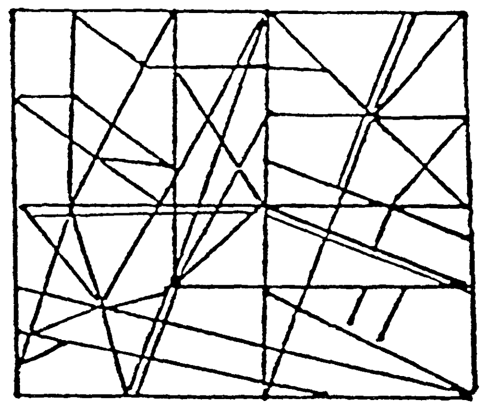
FIND SIMPLE FORM 'E'



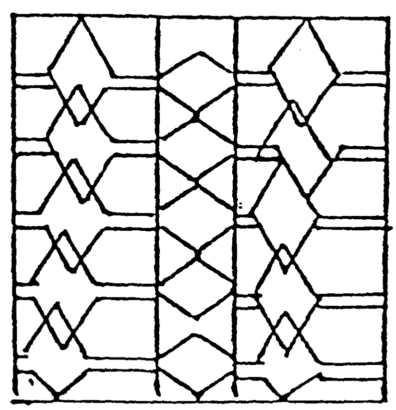
FIND SIMPLE FORM 'E'



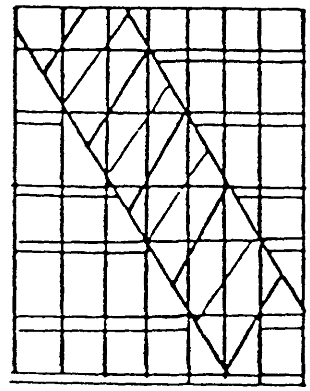
FIND SIMPLE FORM 'B'



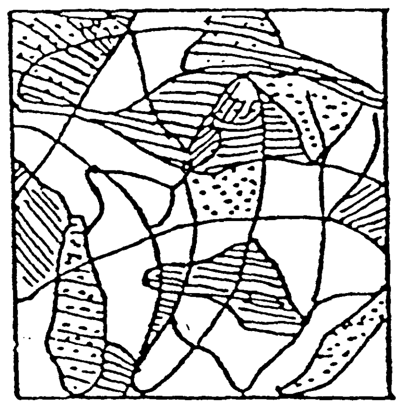
FIND SIMPLE FORM 'A'



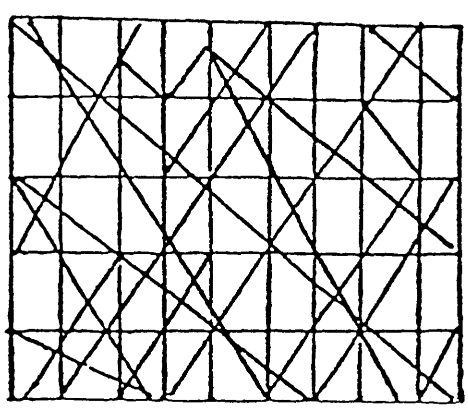
FIND SIMPLE FORM 'A'



FIND SIMPLE FORM 'G'



FIND SIMPLE FORM 'A'



APPENDIX 15 (FIT)

*FIGURE INTERSECTION TEST

NAME : SEX :

SCHOOL : DATE OF BIRTH :

CLASS :

This a test of your ability to find the overlap of a number of simple shapes.

There are two sets of simple geometric shapes, one on the right and the other on the left. The set on the right contains a number of shapes separated from each other.

The set on the left contains the same shapes (as on the right) but overlapping, so that there exists a common area which is inside all of the shapes.

Look for and shade in the common area of overlap.

Note these points:-

(1) The shapes on the left may differ in size or position from those on the right, but, they match in shape and proportions.

(2) In some items on the left some extra shapes appear which are not present in the right hand set, and which do not form a common area of intersection with all of the other shapes. These are present to mislead you but try to ignore them.

(3) The overlap should be shaded clearly by using a pen.

(4) The results of this test will not affect your schoolwork (university work) in any way.

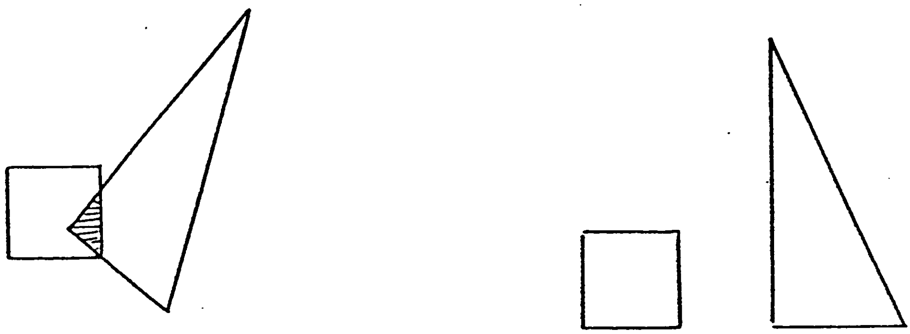
---

* This test may not be used without permission from:
Professor J. Pascual-Leone, Room 246 B. S. B., York University, 4700 Keele Street, Downsview, Ontario, M3J 1P3.

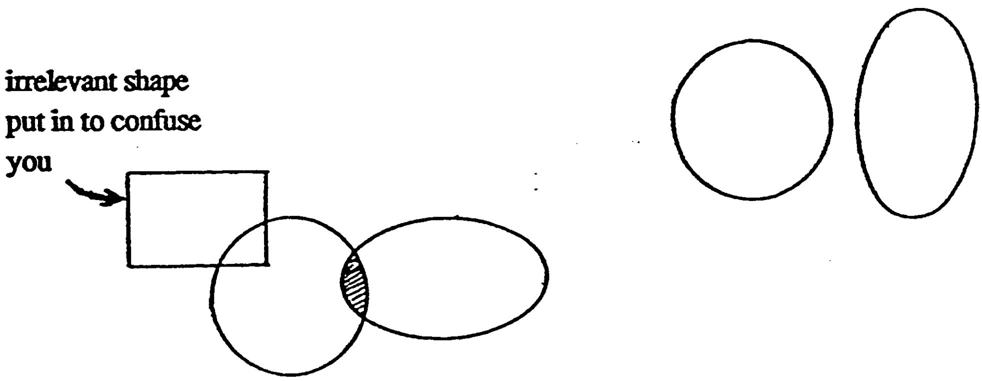
* This test is photo-reduced to fit the pages of this thesis.

Here are some examples to get you started.

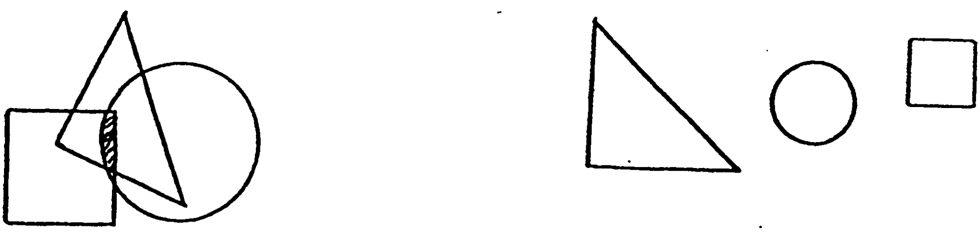
Example (1)



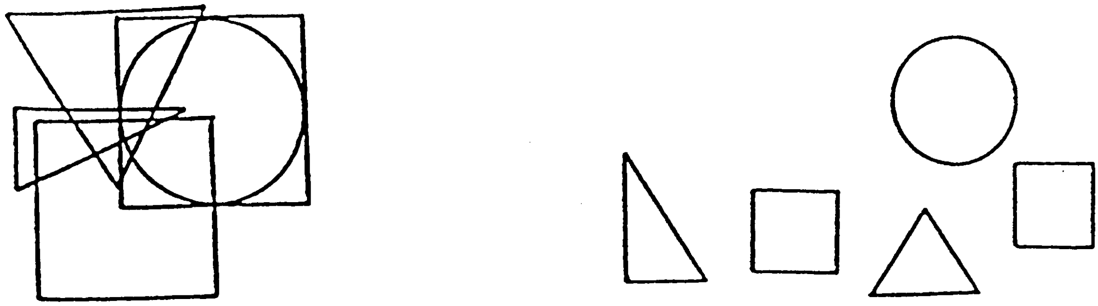
Example (2)

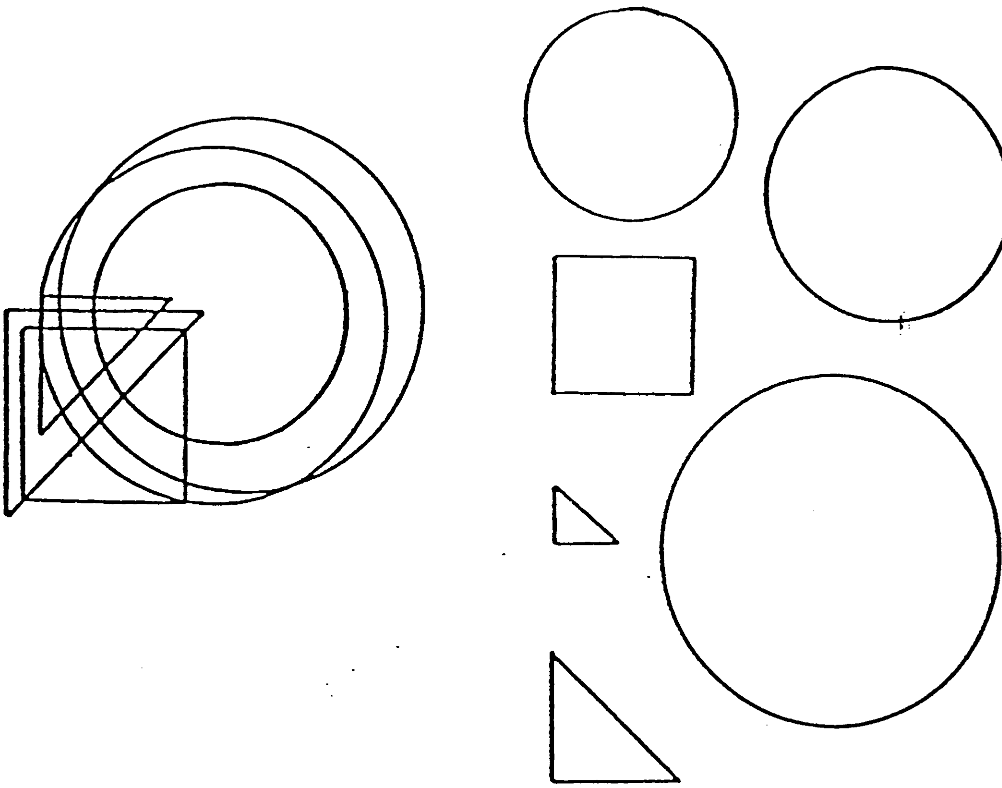


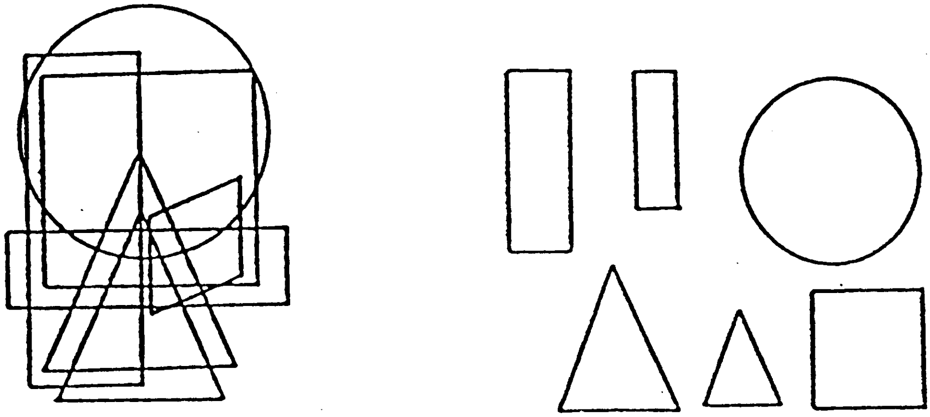
Example (3)

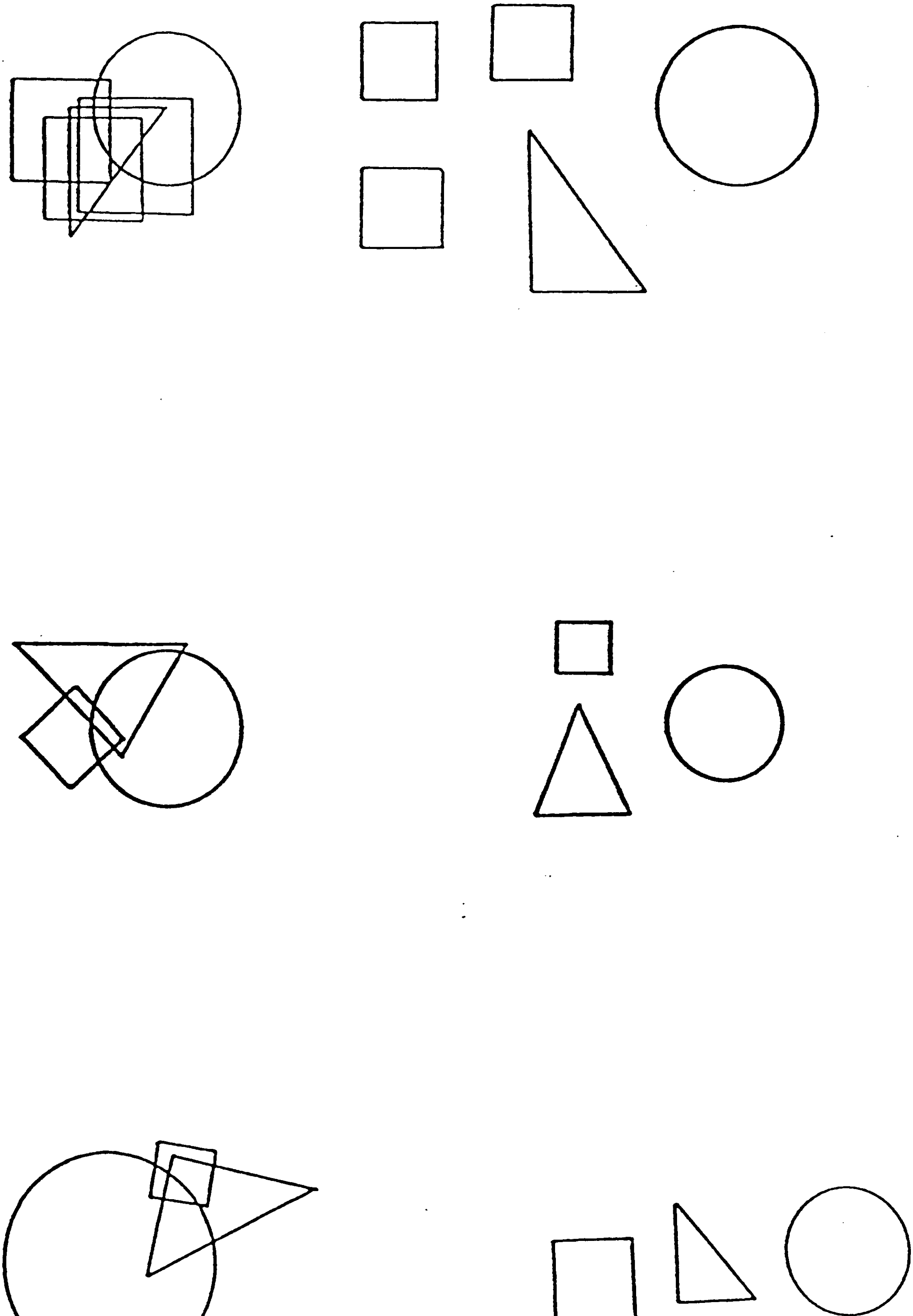


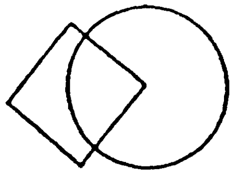
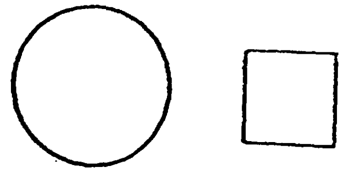
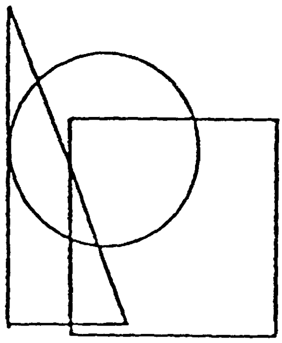
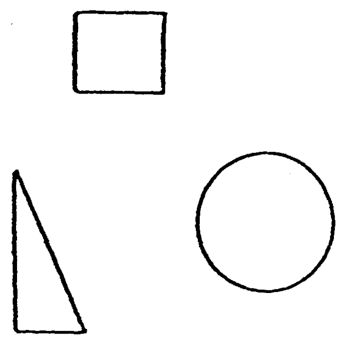
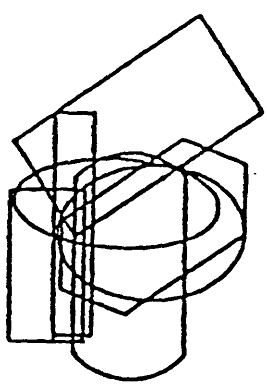
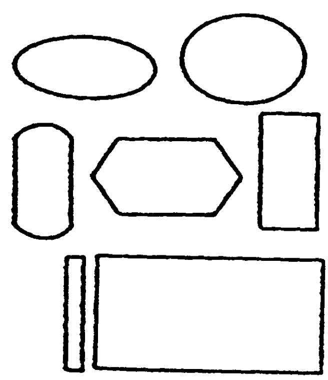
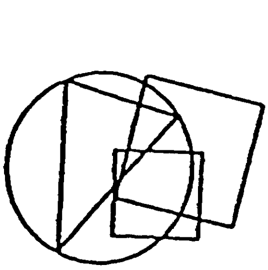
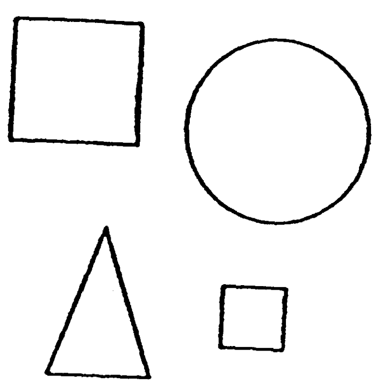
Now attempt each of the items on the following sheets.

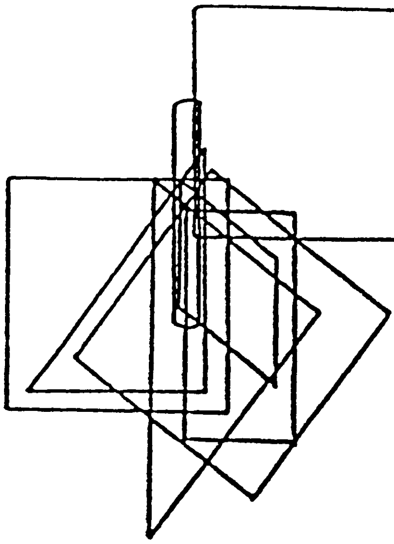


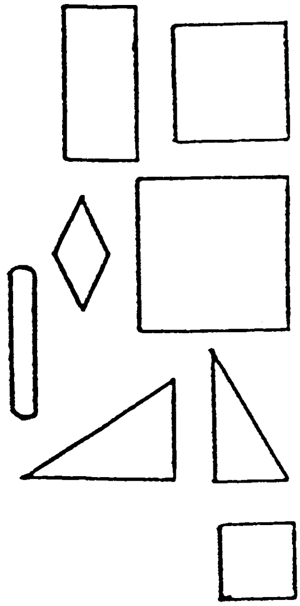


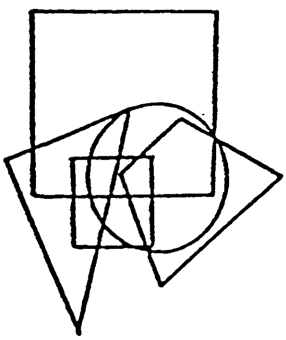


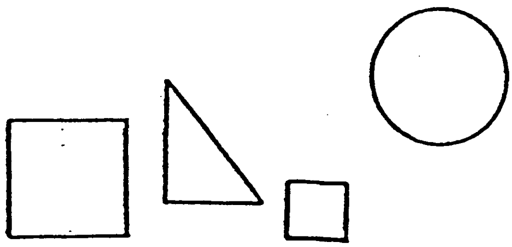


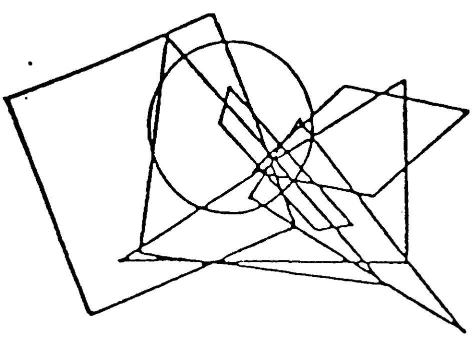









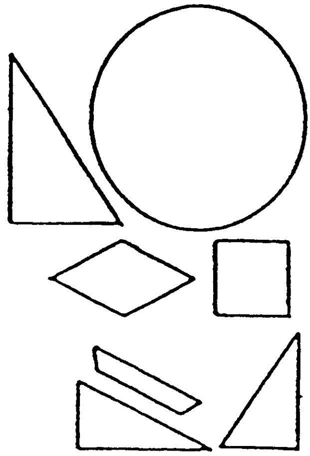


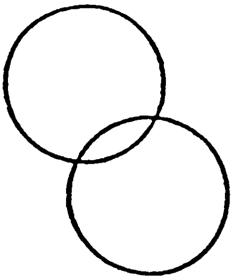


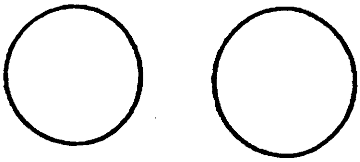


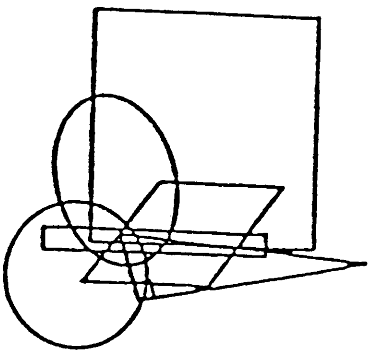


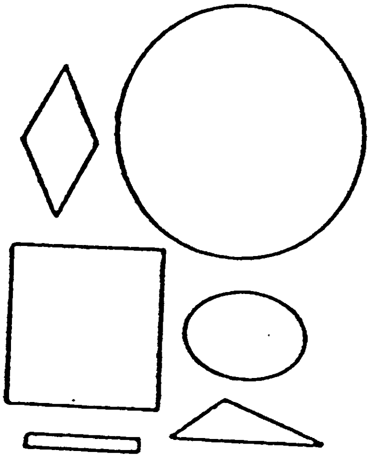


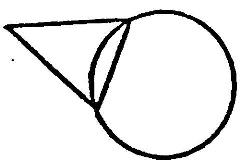


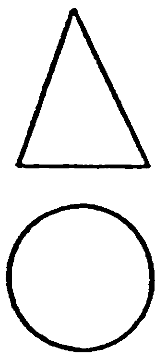


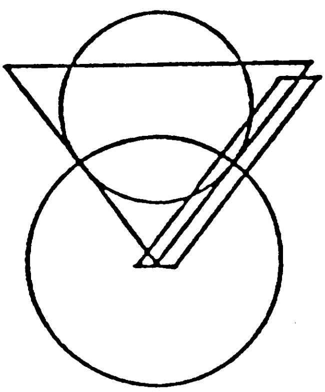


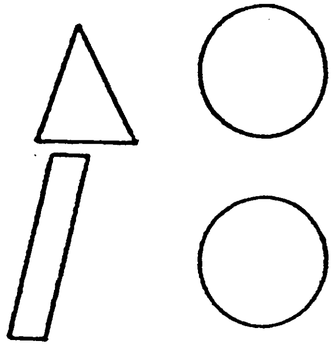


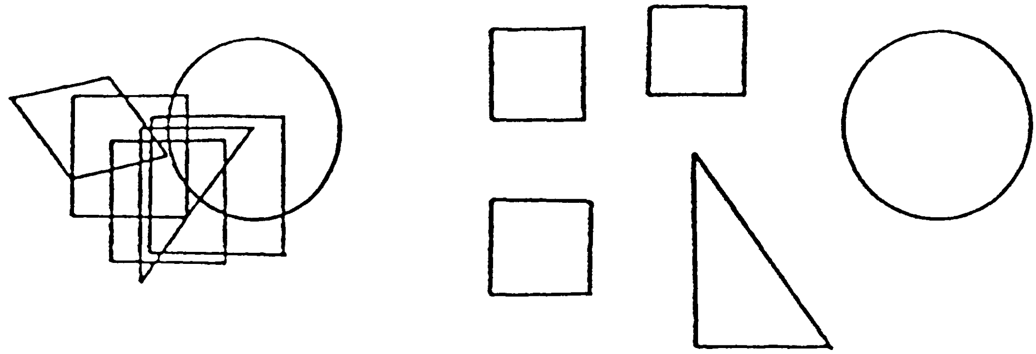


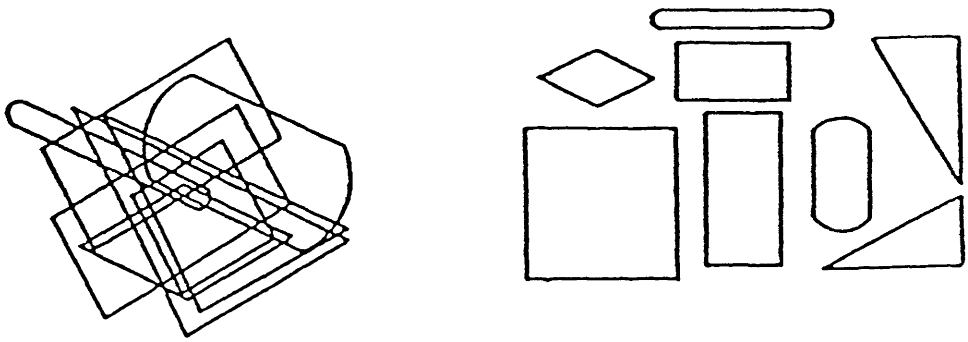


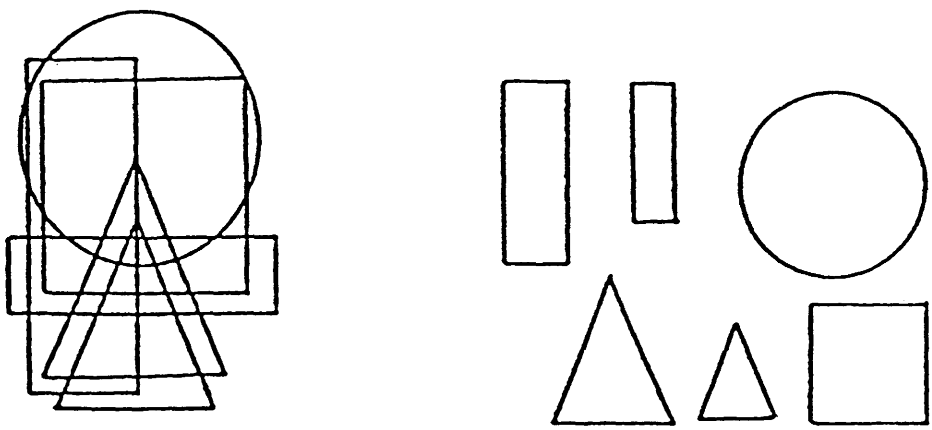


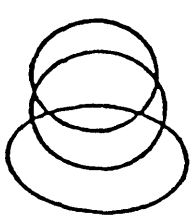


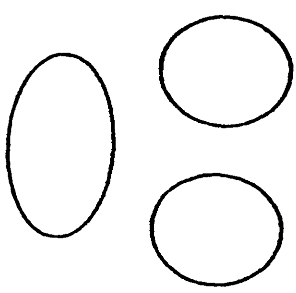


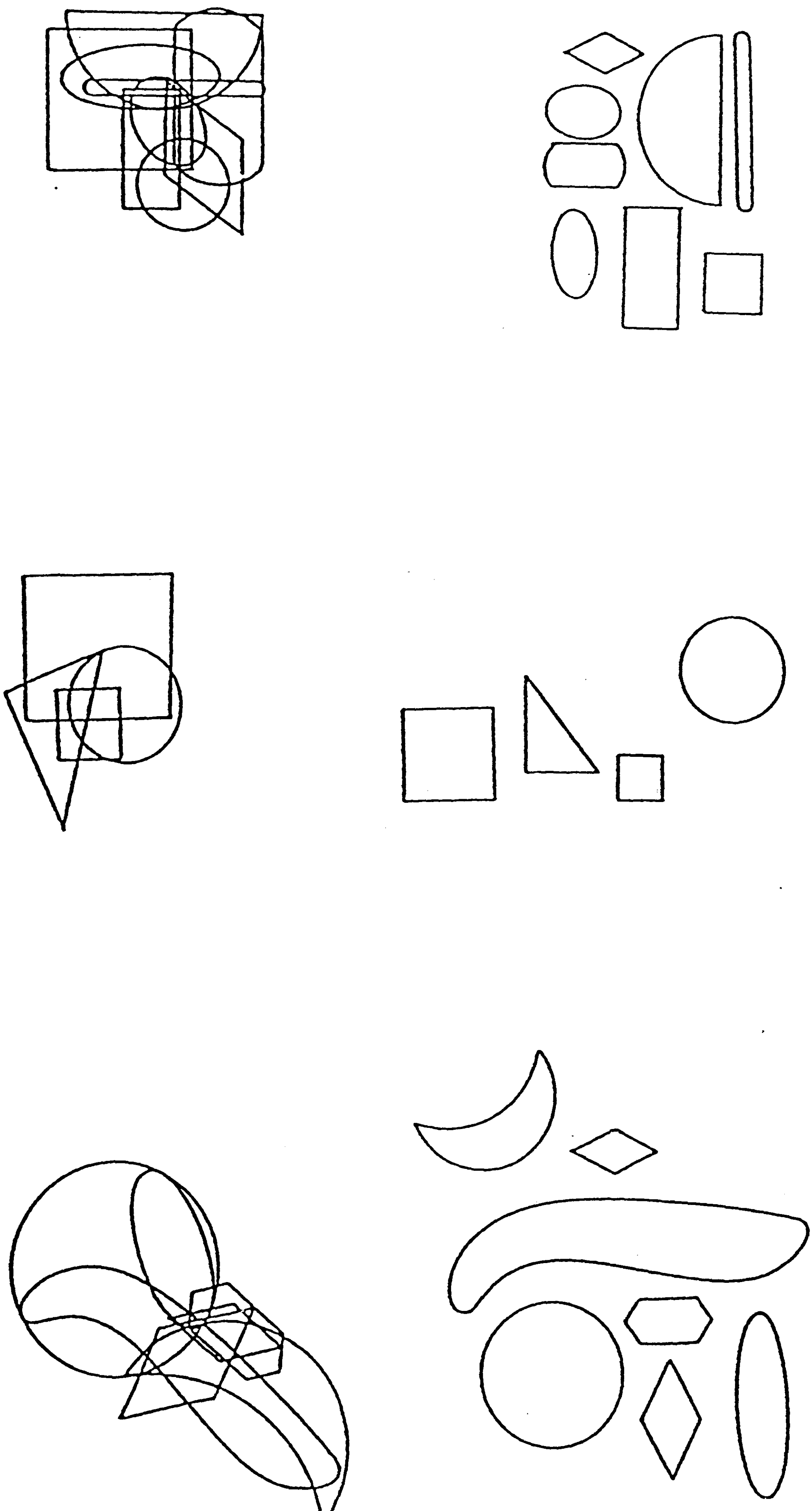


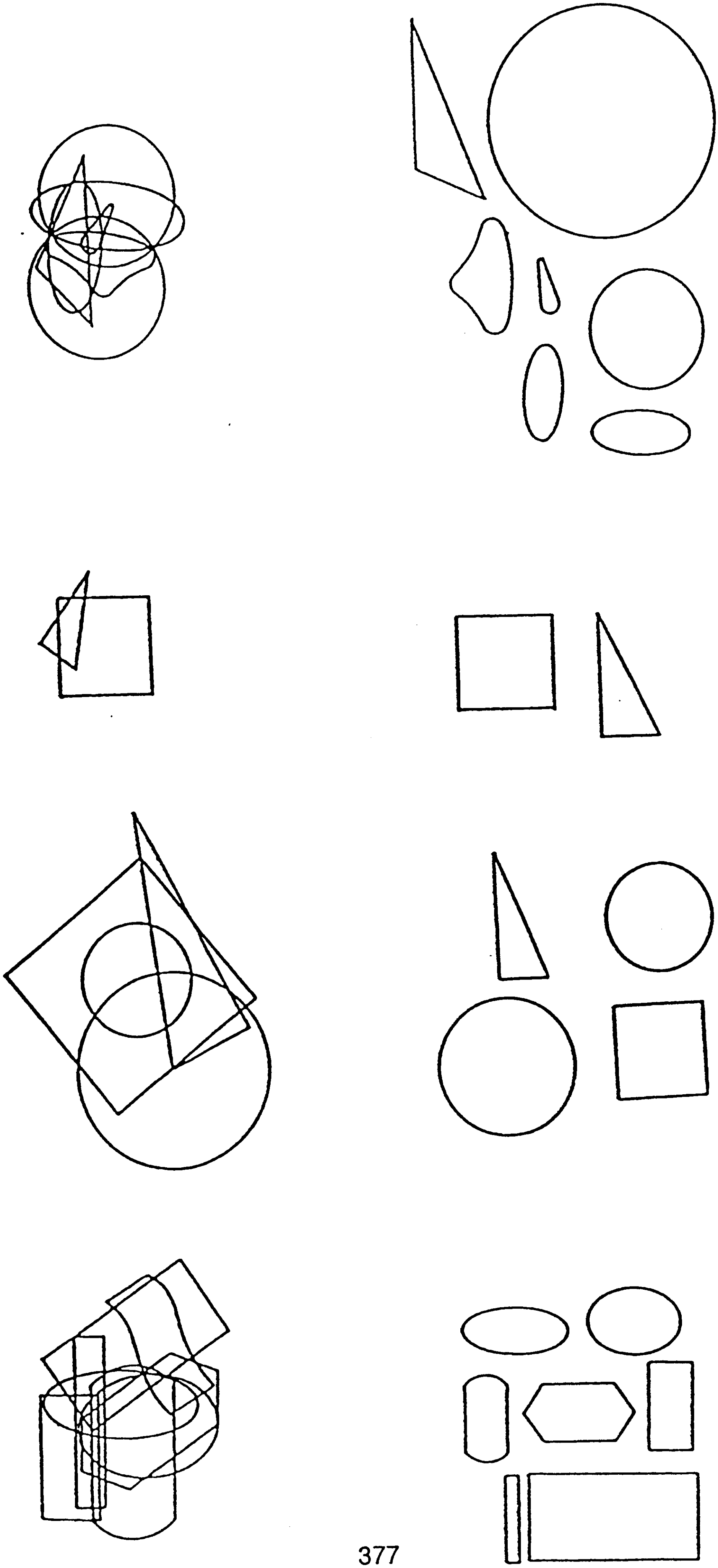


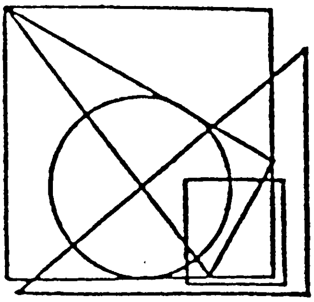


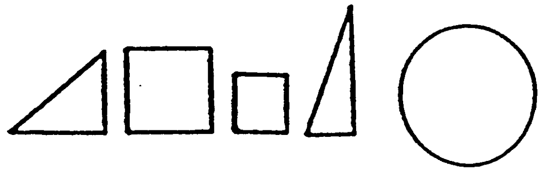


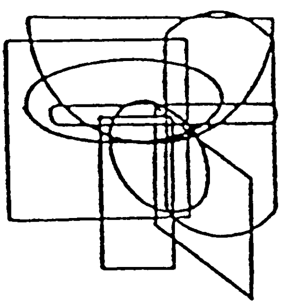


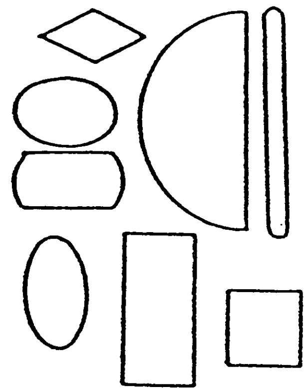


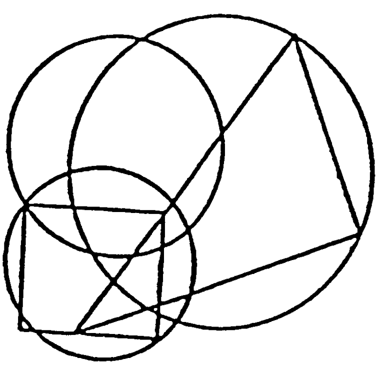


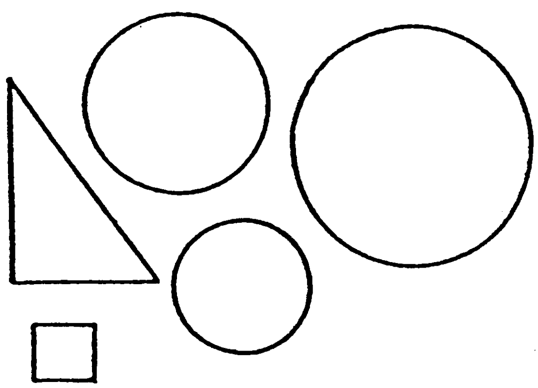


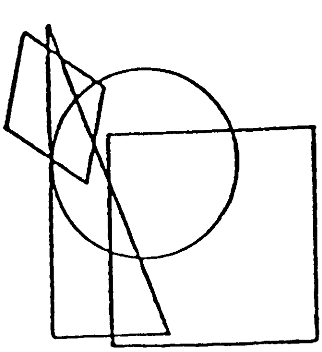


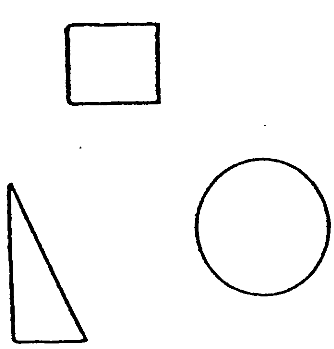


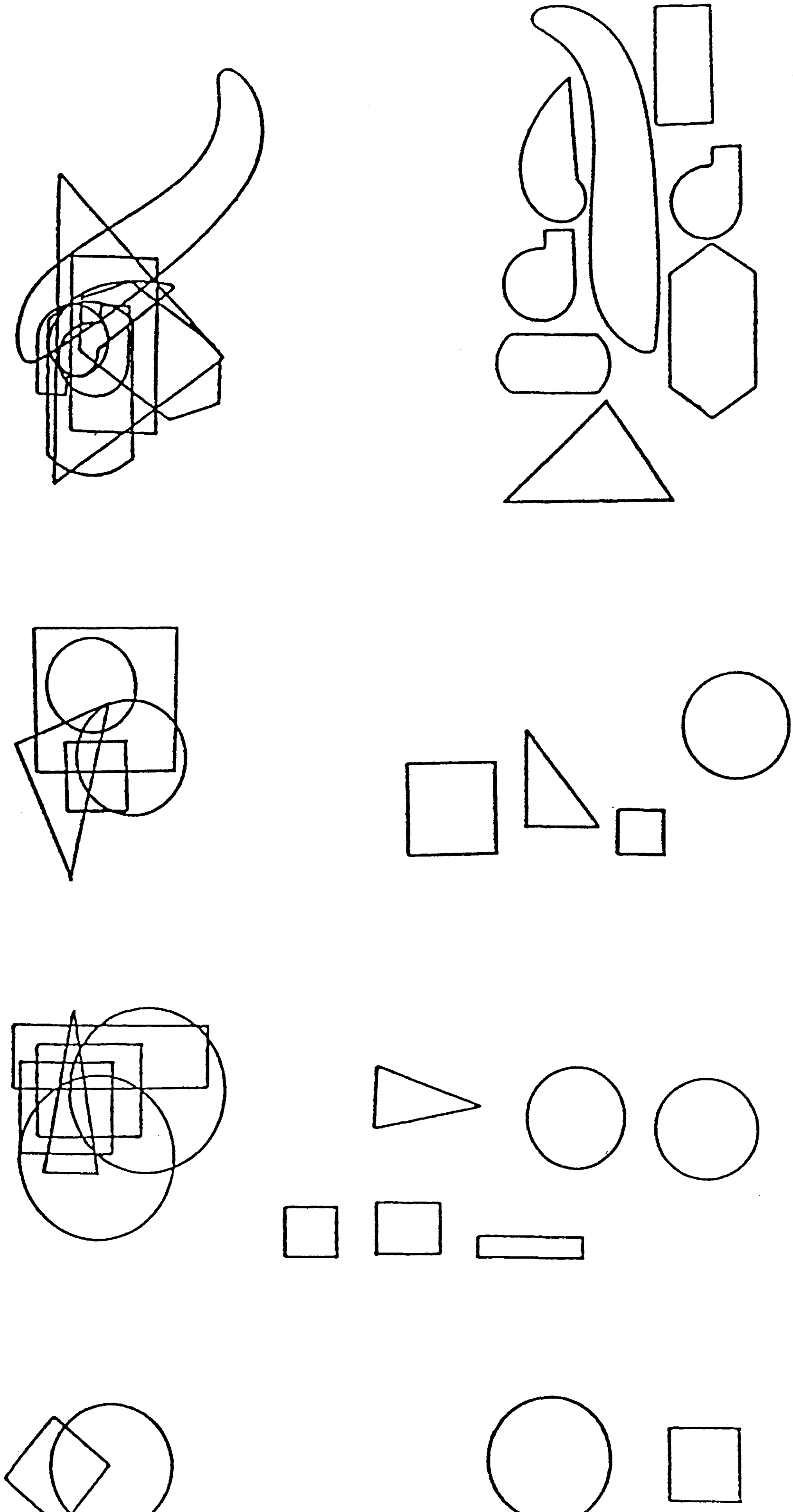












APPENDIX 16 (DST)

DIGIT SPAN TEST

The following tests, Digits Forward and Digits Backward, are administered separately. For both, say the digits at the rate of one per second, not grouped. Let the pitch of voice drop with the last digit of each series. The series denotes the number of digits in an item.

DIGITS FORWARD

Directions - Start by saying -

"In a fairly simple game, I'm going to say some numbers. Listen carefully to them, and when I stop speaking you write them down in the space provided in the sheet that you have been given."

Are you ready then? Let us begin."

Series:

3	5	8	2						
	6	9	4						
4	6	4	3	9					
	7	2	8	6					
5	4	2	7	3	1				
	7	5	8	3	6				
6	6	1	9	4	7	3			
	3	9	2	4	8	7			
7	5	9	1	7	4	2	8		
	4	1	7	9	3	8	6		
8	5	8	1	9	2	6	4	7	
	3	8	2	9	5	1	7	4	
9	2	7	5	8	6	2	5	8	4
	7	1	3	9	4	2	5	6	8

DIGITS BACKWARD

Directions - Start by saying -

"Now I'm going to give another set of numbers, but this time there's a complication. When I've finished saying each set of numbers, I want you to write them down in reverse order. For example, if I say, "719", you would write down 917. Now, no cheating. Do not write from right to left. You listen carefully, turn the number over in your mind and write from left to right. Have you got that? Then let's begin."

Series:

2	2	4						
	5	8						
3	6	2	9					
	4	1	5					
4	3	2	7	9				
	4	9	6	8				
5	1	5	2	8	6			
	6	1	8	4	3			
6	5	3	9	4	1	8		
	7	2	4	8	5	6		
7	8	1	2	9	3	6	5	
	4	7	3	9	1	2	8	
8	9	4	3	7	6	2	5	8
	7	2	8	1	9	6	5	3

APPENDIX 17

The Immediate Recall Test on Lecture Content

1. Explain the meaning of ligand DENTICITY.

2. Draw and name the isomers of $Pt(NH_3)_2Cl_2$.

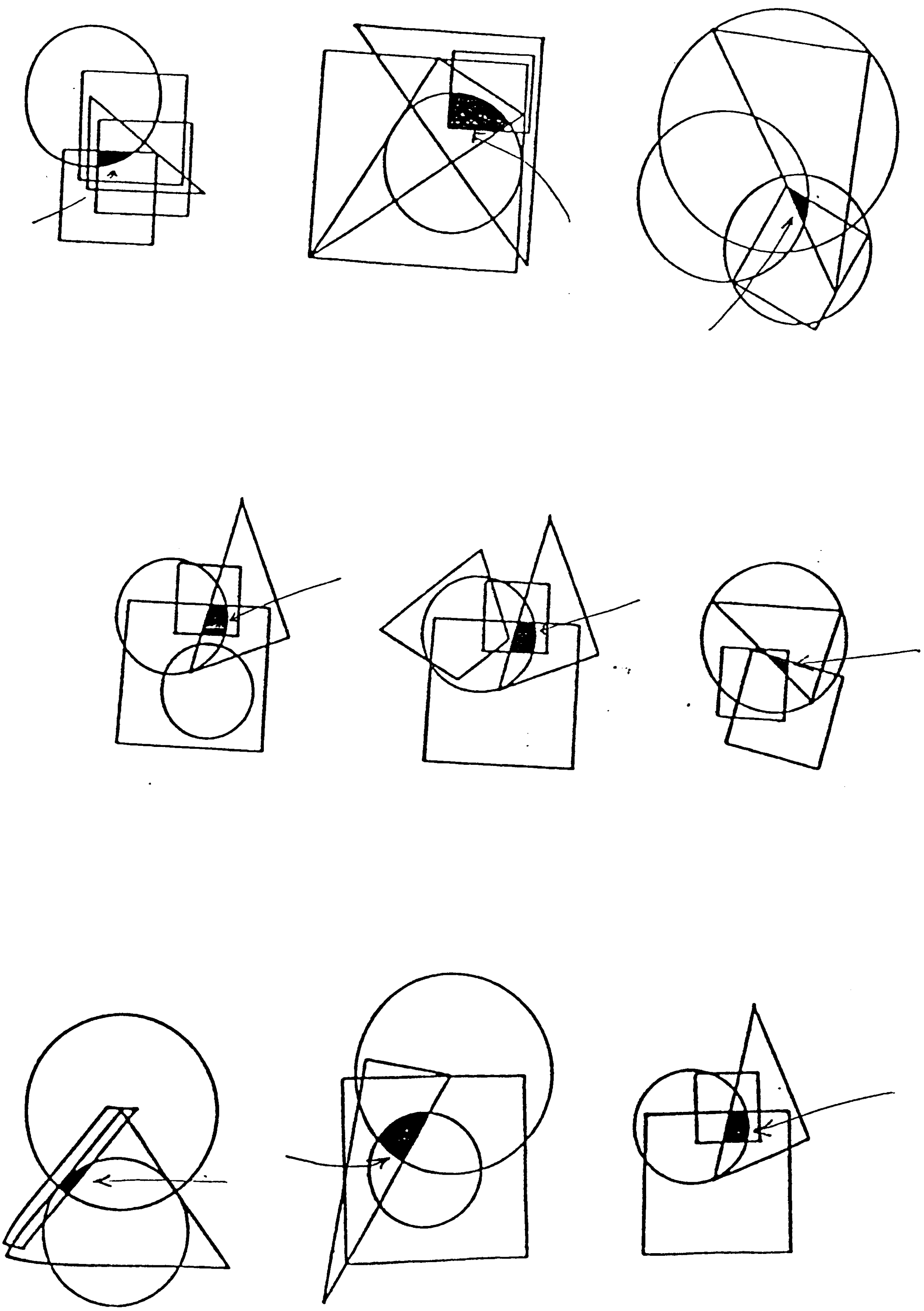
3. Draw all isomeric forms of :

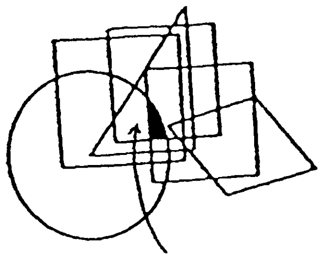
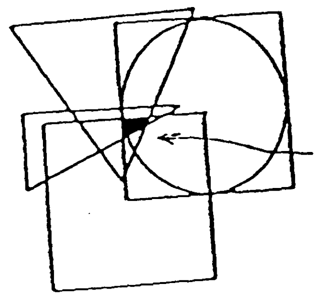
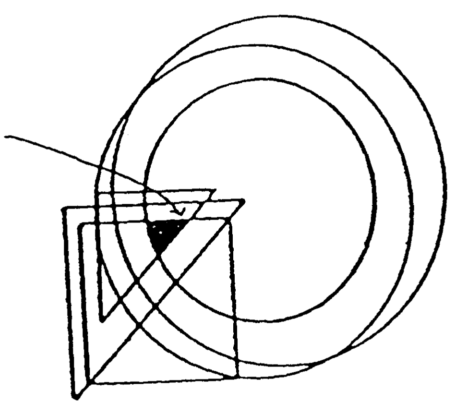
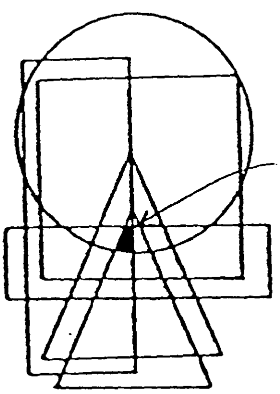
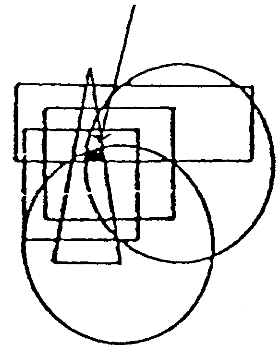
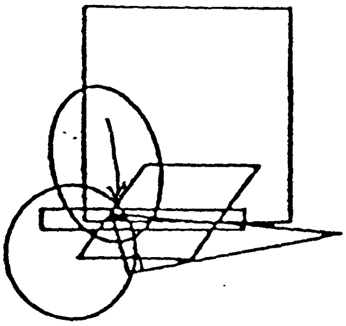
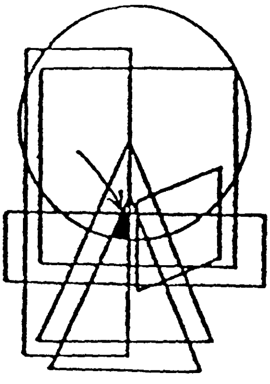
   (a) $[Co(NH_3)_4ClBr]Cl$

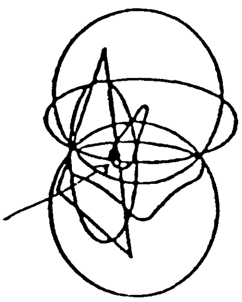
   (b) $[Cr(en)_2Cl_2]Cl$

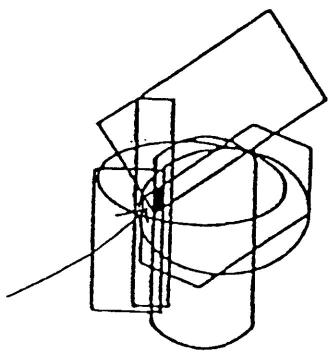
APPENDIX 18

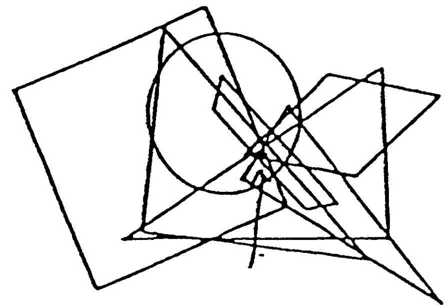
F.I.T. SCORING KEY

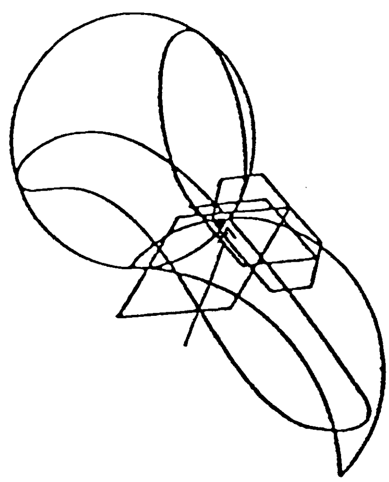


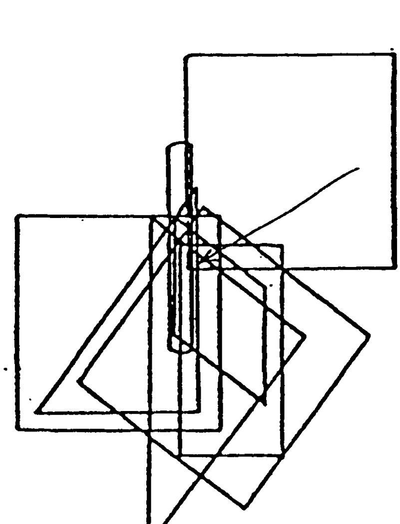








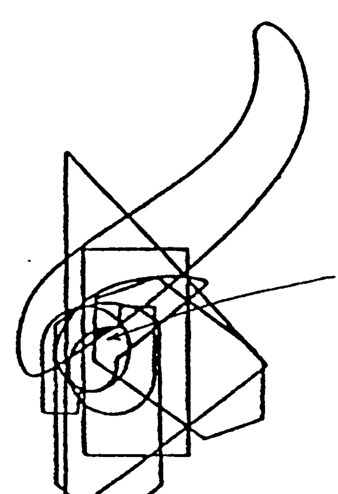


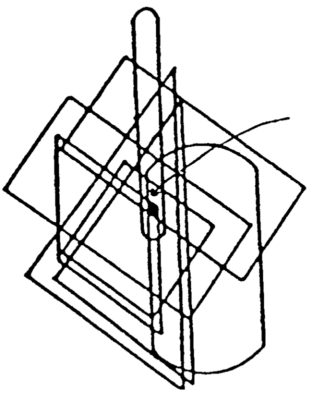
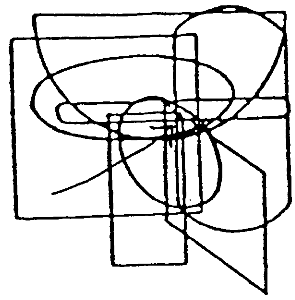
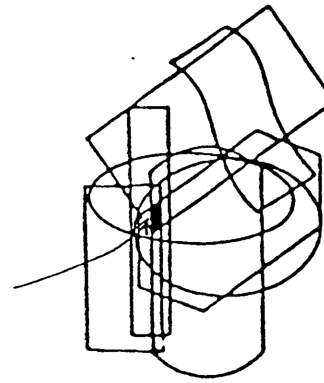
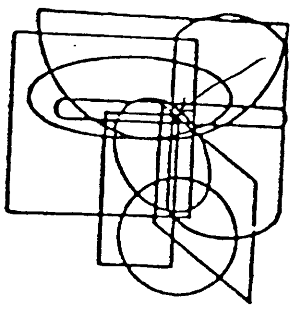
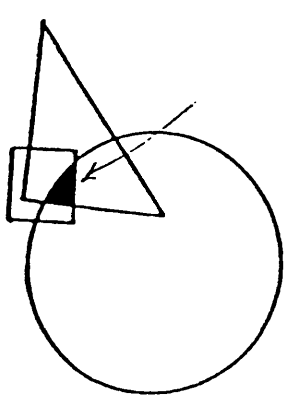
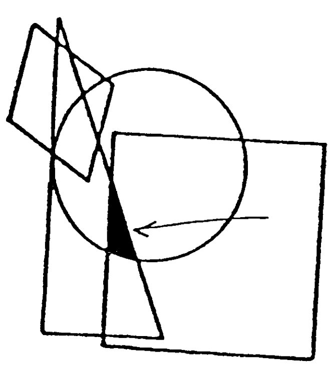
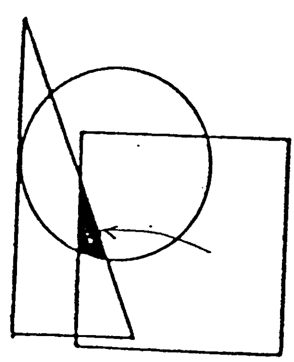
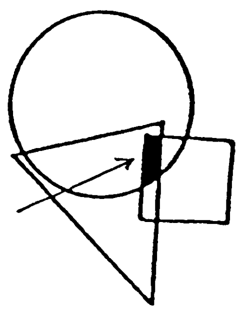
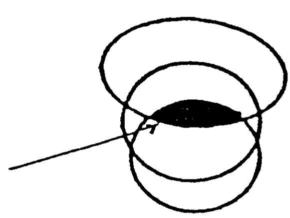










APPENDIX 19

The Questionnaire on Students' Note-taking Behaviour in General

U N I V E R S I T Y O F G L A S G O W

CENTRE FOR SCIENCE EDUCATION

During this session we have been concentrating on first year lectures with a view to helping students to get the best out of them. To round off our study we should value your help by answering five questions. Use as many options as you need to express your views.

1. What do you see as the purpose of note-taking during lectures?

   (a) To make you concentrate.

   (b) To give you something as a record.

   (c) Your own ideas ....

   ....

   ....

2. What do you think about note-taking as opposed to having complete printed handouts?

   (a) Can't understand lecture and takes notes at the same time.

   (b) Handouts are not in my own language or style.

   (c) Your own ideas ....

   ....

   ....

3. When you are taking lecture notes, how do you know that you have got down "the essentials"?

   (a) I take down what is on the board only.

   (b) I get "signals" from the lecturer about what is important.

   (c) Your own views ....

   ....

   ....

4. When you have a set of notes, <u>how</u> do you use them and <u>for what purpose</u>?

   (a) I supplement them from the textbook.

   (b) I don't look at them till exam time.

   (c) They are the main source of my revision material.

   (d) Your own views ....

   ....

   ....

5. What features of lectures would you like to see changed to enable you to take satisfactory notes?

Your views: ....

....

....

....

....

Thank you very much. Please return as directed.

APPENDIX 20

Examples of Handout, Course Objectives and Printed Materials

(1)

MACROMOLECULES 1

Lecturer: Dr. I.C. McNeill, Room 363

This is the first of four courses on Macromolecular Chemistry given in the Chemistry Department. Macromolecules 2 is part of the Higher Ordinary Chemistry course and Macromolecules 3 and 4 are parts of the Honours Chemistry course.

Textbooks

Polymer chemistry is not adequately dealt with in most chemistry textbooks which cover a wide field. To clarify and amplify your lecture notes, you need to consult specialist polymer textbooks. These are available in the Chemistry Department Library for consultation. If you intend to continue to Honours in Chemistry, you may wish to consider purchase of one of these. The following are the most useful and contain material relevant to all four Macromolecules courses:

BILLMEYER:	*Textbook of Polymer Science, 3rd Edition (Wiley)*
ALLCOCK & LAMPE:	*Contemporary Polymer Chemistry (Prentice Hall)*
COWIE:	*Polymers - Chemistry & Physics of Modern Materials (Intertext)*

This handout pack contains some material intended to offset the lack of polymer topics in your class textbooks. You should also feel free to consult the lecturer over any difficulties with aspects of this course.

Objectives

As a useful means of testing your recollection and understanding of the course, you should use the following list, particularly for revision purposes.

After this course, you are expected to

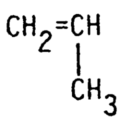
1. Be able to define a MACROMOLECULE or POLYMER.
2. Know what is meant by a MONOMER.
3. Understand the meaning of MONOMER UNIT, REPEAT UNIT or MONOMER RESIDUE, when applied to a polymer chain structure.
4. Be able to list the three aspects of molecular size which distinguish polymers from non-polymeric materials.
5. Recognise why the molecular weight of a polymeric material must normally be expressed as an average value.
6. Understand what is meant by OSMOTIC PRESSURE of a solution.

7. Know how to calculate the molecular weight of a polymer from osmotic pressure data at several solution concentrations.
8. Understand why polymer solutions are viscous and be able to define the SPECIFIC VISCOSITY of a polymer solution.
9. Know how to calculate the molecular weight of a polymer from specific viscosity data (or viscometer flow times) at several solution concentrations.
10. Be able to write the equations used in the procedures of items 7 and 9, explain all the terms and specify the units of each quantity.
11. Have some idea of the relation between length and diameter for a typical, fully extended linear macromolecule.
12. Understand what is meant by the RANDOM COIL state for a linear macromolecule and why this is preferred to the fully extended state.
13. Appreciate what is meant by each of the following descriptions when applied to a polymer: AMORPHOUS, CRYSTALLINE, ISOTROPIC, ANISOTROPIC.
14. Be able to define the RELAXATION MODULUS for a polymer.
15. Appreciate why this is high for a rigid polymer but lower for a flexible polymer.
16. Be able to explain clearly the change in physical properties of a polymer which occurs at its GLASS TRANSITION TEMPERATURE (T_g) and account for this in terms of what is happening to the macromolecules as heat is supplied (or removed) to bring the sample through its T_g.
17. Know what is meant by FREE VOLUME in a solid amorphous polymer and why this is present.
18. Appreciate the difference between the type of molecular motion which occurs at T_g and that at the approximate melting temperature, T_m.
19. Be able to list and discuss the structural features in a polymer which influence the value of T_g.
20. Understand the difference between a THERMOPLASTIC and a THERMOSETTING polymer.
21. Be able to give examples of several ways in which the thermoplastic behaviour of suitable polymers is utilised in processing.
22. Be able to explain the classification of polymers as ELASTOMERS, RESINS and FIBRES and discuss the properties of each class.
23. Know which types of molecule may be polymerised by addition polymerisation, be able to illustrate the chain mechanism by an example and to discuss the initiation process.
24. Be able to explain why macromolecules are soon present in an addition polymerisation and why a distribution of molecular sizes results.
25. Be able to discuss the formation, structure and properties of the following addition polymers and relate the properties to their common commercial applications: POLYETHYLENE, POLYPROPYLENE, POLYSTYRENE, POLY(VINYL CHLORIDE), POLY(METHYL METHACRYLATE), POLYACRYLONITRILE.
26. Be able to name the most important elastomers used commercially, give their structures and discuss their properties.
27. Understand what is meant by VULCANISATION and how this is commonly carried out for natural rubber.

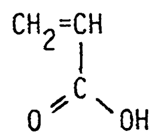
NOMENCLATURE IN POLYMER CHEMISTRY

The systematic nomenclature of organic chemistry is not used. Traditional names for monomers and polymers have been retained in the polymer industry, in polymer textbooks and will be used in the lectures. It is therefore important to learn the names of monomers and polymers and be able to relate these to the chemical structures.

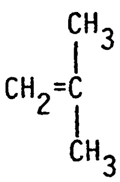
The following are examples of some of the monomers which are used in making commercially important addition polymers:



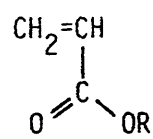
propylene



acrylic acid

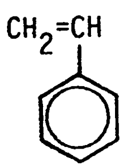


isobutylene

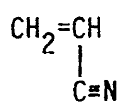


acrylic esters

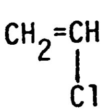
(e.g. methyl acrylate, R = CH_3)



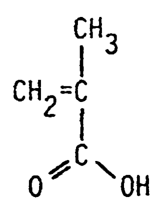
styrene



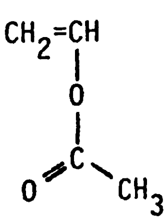
acrylonitrile



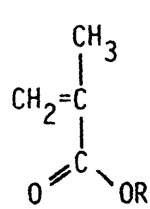
vinyl chloride



methacrylic acid

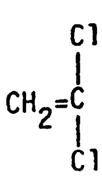


vinyl acetate

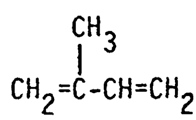


methacrylic esters

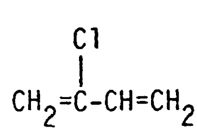
(e.g. methyl methacrylate, R = CH_3)



vinylidene chloride



isoprene



chloroprene

Practice Problem in Molecular Weight Calculation from Osmotic Pressure Data

This problem is taken from the September 1989 Chemistry-1 degree examination.

Write the relationship which provides the basis for the determination of the molecular weight of a polymer by *osmometry*, explaining clearly all the symbols used.

The osmotic pressures of several solutions of a polymer were measured at 27°C. Data are presented below in which the measured osmotic pressures have been converted to atmosphere units:

Solution concentration, g l^{-1}	2.00	4.00	7.00	9.00
Osmotic pressure, atm	0.00176	0.00388	0.00756	0.01053

Explain in outline how these data may be used to determine the number-average molecular weight of the polymer and then carry out the calculation.

[The Gas Constant, R = 0.08204 l atm deg^{-1} mol^{-1}.]

DETERMINATION OF AVERAGE MOLECULAR WEIGHT OF A POLYMER BY VISCOMETRY

Resistance of a liquid to flow is measured by its VISCOSITY. If a polymer is dissolved in a solvent, the viscosity of the solution is much higher than that of the pure solvent, because the presence of large, tangled molecules makes the flow of the liquid much more difficult.

Viscosity may be measured in an instrument called a VISCOMETER, in which the time for a fixed volume of liquid to flow through a vertical capillary tube under gravity is measured. The technique is called viscometry.

Let t_s be the flow time (s) for the pure solvent

and t_p be the flow time (s) for a polymer solution

in a viscometer under similar conditions. Then t_p will be greater than t_s.

The SPECIFIC VISCOSITY (η_{sp}) for a particular solution concentration, is defined as

$$\eta_{sp} = \frac{t_p - t_s}{t_s}$$

The greater the concentration of the polymer solute, the longer the flow time, t_p, so η_{sp} increases with concentration. It also increases with polymer MW.

No theoretical relationship can be derived between viscosity and molecular weight, but a useful empirical relationship has been found when data for several different solution concentrations are collected.

An analogous approach is used to that applied in osmometry. The flow time, t_p, and hence η_{sp}, are obtained for a series of solutions of the polymer of different concentration. The convention in viscometry is to express these solution concentrations in the unusual unit of GRAMS PER DECILITRE (grams per 100 ml). η_{sp}/c is evaluated at each value of c, and a graph is constructed of η_{sp}/c versus c.

See diagram showing $\eta/_{sp}$ versus c graph.

We extrapolate this graph to c = 0. The value of η_{sp}/c at c = 0 is written $(\eta_{sp}/c)_\circ$ and called the INTRINSIC VISCOSITY. It has been found from many experiments that the results fit a relationship between intrinsic viscosity and polymer molecular weight called the MARK-HOUWINK equation:

$$\boxed{(\eta_{sp}/c)_\circ = K\,M^{\alpha}} \quad \text{(where c is in g/dl)}$$

where K and α are constants for a particular polymer/solvent system. It leads to an AVERAGE MOLECULAR WEIGHT for the polymer which lies somewhere between $\overline{M}_n$ and $\overline{M}_w$.

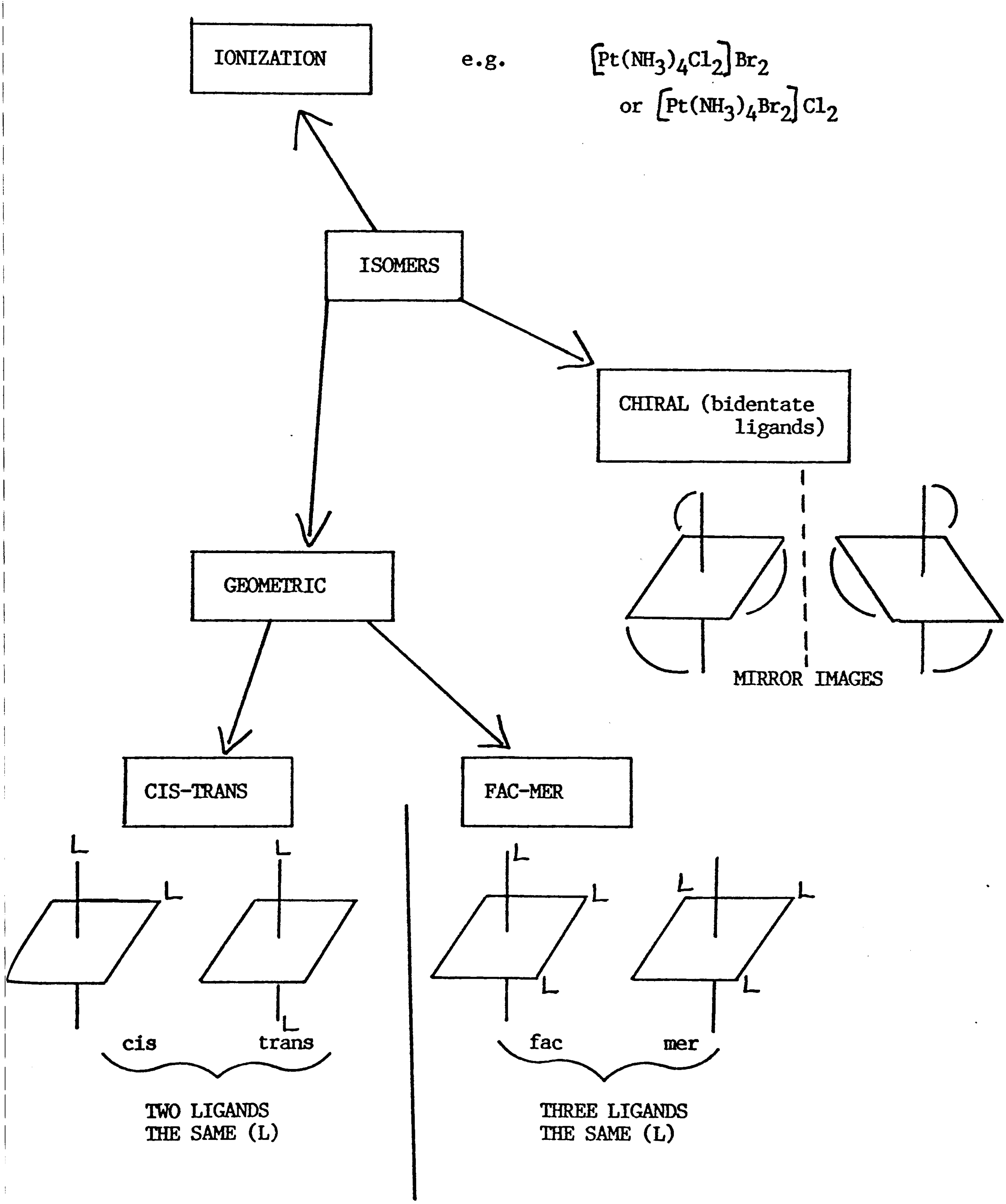
(2)

TRANSITION METALS AND THEIR BIOLOGICAL SIGNIFICANCE

At the end of this unit you should be able to:

1. Locate the Transition Metals in the Periodic Table
2. write the electronic configuration of First Row d-block elements and the ions derived from them
3. derive the oxidation state of a T.M. in a given ion
4. define the term LIGAND and give examples
5. relate the term LIGAND to LEWIS BASE
6. distinguish between the inner and outer coordination spheres in a complex
7. describe methods for finding the structure of complexes in terms of freezing point depression, AgCl precipitation and ion exchange
8. write the name of a complex given its structure
9. draw the structure of a complex given its name
10. explain the meaning of ligand DENTICITY
11. draw and name the isomers of complexes
12. list the factors which affect the stability of a complex
13. write the spectrochemical series
14. express the stability of a complex in terms of K, the stepwise stability constant, and β the overall formation constant
15. use given values of K to obtain a value for β
16. relate β to ΔG^{o} for a reaction in which a complex is formed
17. explain what is meant by the terms HARD and SOFT ACID and HARD and SOFT BASE
18. predict the relative stability of a complex given information about the hardness of its acid and base components
19. predict if a complex is likely to be paramagnetic given information about its electronic configuration
20. explain the change in colour of a complex as its ligands change in terms of $d \rightarrow d$ transitions
21. describe the function of some ligands in removing unwanted metal ions from living systems
22. relate the abundance of elements in living systems to their abundance in the sea, the air and the earth's crust
23. describe the function of ligands capable of transporting metal ions in biological situations.

SUMMARY OF ISOMERISM



UNIVERSITY OF GLASGOW

DEPARTMENT OF CHEMISTRY

IONIZATION ENERGIES OF SOME METALS

I.E. kj mol^{-1} / METAL	1	2	3	4	5	6	7
Li	519	7300	11800				
Na	494	4560	6940	9540	13400	16600	20100
Mg	736	1450	7740	10500	13600	18000	21700
Ti	661	1310	2720	4170	9620	11600	13600
Mn	715	1510	3250	5190	7360	9750	11500
Fe	762	1560	2960	5400	7620	10100	12800
Cu	745	1960	3550	5690	7990	10500	14300

OXIDATION STATES OF TRANSITION METALS

O.S.	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
+1			(✓)	(✓)	(✓)		(✓)	(✓)	✓	(✓)
+2		(✓)	(✓)	✓	✓	✓	✓	✓	✓	✓
+3	✓	✓	✓	✓	(✓)	✓	✓	(✓)	(✓)	
+4		✓	✓	(✓)	✓	(✓)	(✓)	(✓)		
+5			✓	(✓)	(✓)	(✓)				
+6				✓	(✓)	(✓)				
+7				✓						

(less common oxidation states are shown in brackets)

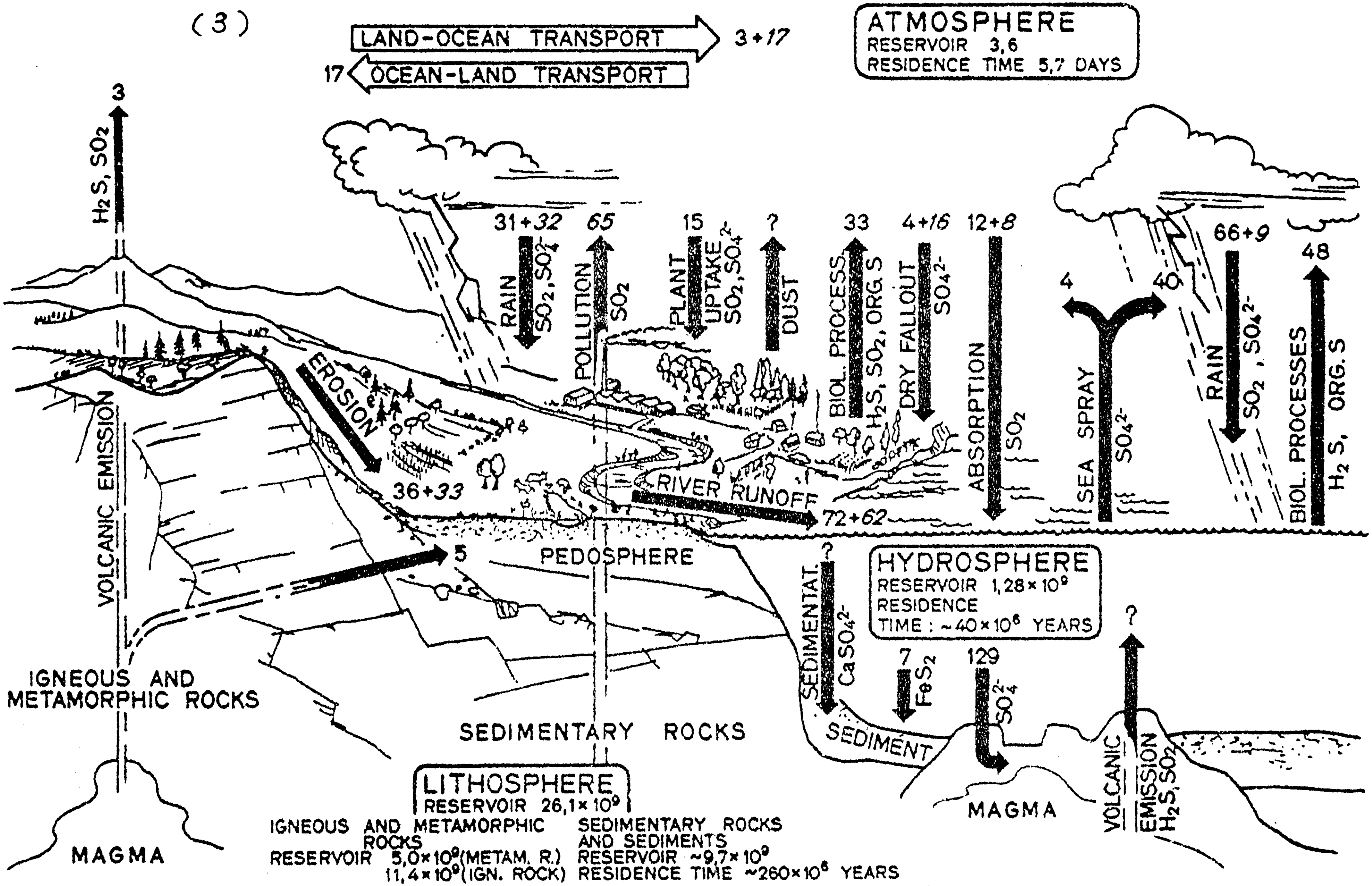
PERIODIC TABLE OF THE ELEMENTS

s^1	s^2	d^1	d^2	d^3	d^4	d^5	d^6	d^7	d^8	d^9	d^{10}	p^1	p^2	p^3	p^4	p^5	p^6
1·008 H 1																	4·003 He 2
6·939 Li 3	9·012 Be 4											10·811 B 5	12·011 C 6	14·007 N 7	15·999 O 8	18·998 F 9	20·183 Ne 10
22·990 Na 11	24·312 Mg 12											26·982 Al 13	28·086 Si 14	30·974 P 15	32·064 S 16	35·453 Cl 17	39·948 Ar 18
39·102 K 19	40·080 Ca 20	44·956 Sc 21	47·900 Ti 22	50·942 V 23	51·996 Cr 24	54·938 Mn 25	55·847 Fe 26	58·933 Co 27	58·710 Ni 28	63·540 Cu 29	65·370 Zn 30	69·720 Ga 31	72·590 Ge 32	74·922 As 33	78·960 Se 34	79·909 Br 35	83·800 Kr 36
85·470 Rb 37	87·620 Sr 38	88·905 Y 39	91·220 Zr 40	92·906 Nb 41	95·940 Mo 42	[99] Tc 43	101·070 Ru 44	102·905 Rh 45	106·400 Pd 46	107·870 Ag 47	112·400 Cd 48	114·820 In 49	118·690 Sn 50	121·750 Sb 51	127·600 Te 52	126·904 I 53	131·300 Xe 54
132·905 Cs 55	137·340 Ba 56	138·910 La– 57	178·490 Hf 72	180·948 Ta 73	183·850 W 74	186·200 Re 75	190·200 Os 76	192·200 Ir 77	195·090 Pt 78	196·967 Au 79	200·590 Hg 80	204·370 Tl 81	207·190 Pb 82	208·980 Bi 83	[210] Po 84	[210] At 85	[222] Rn 86
[223] Fr 87	[226] Ra 88	227* Ac– 89	104														

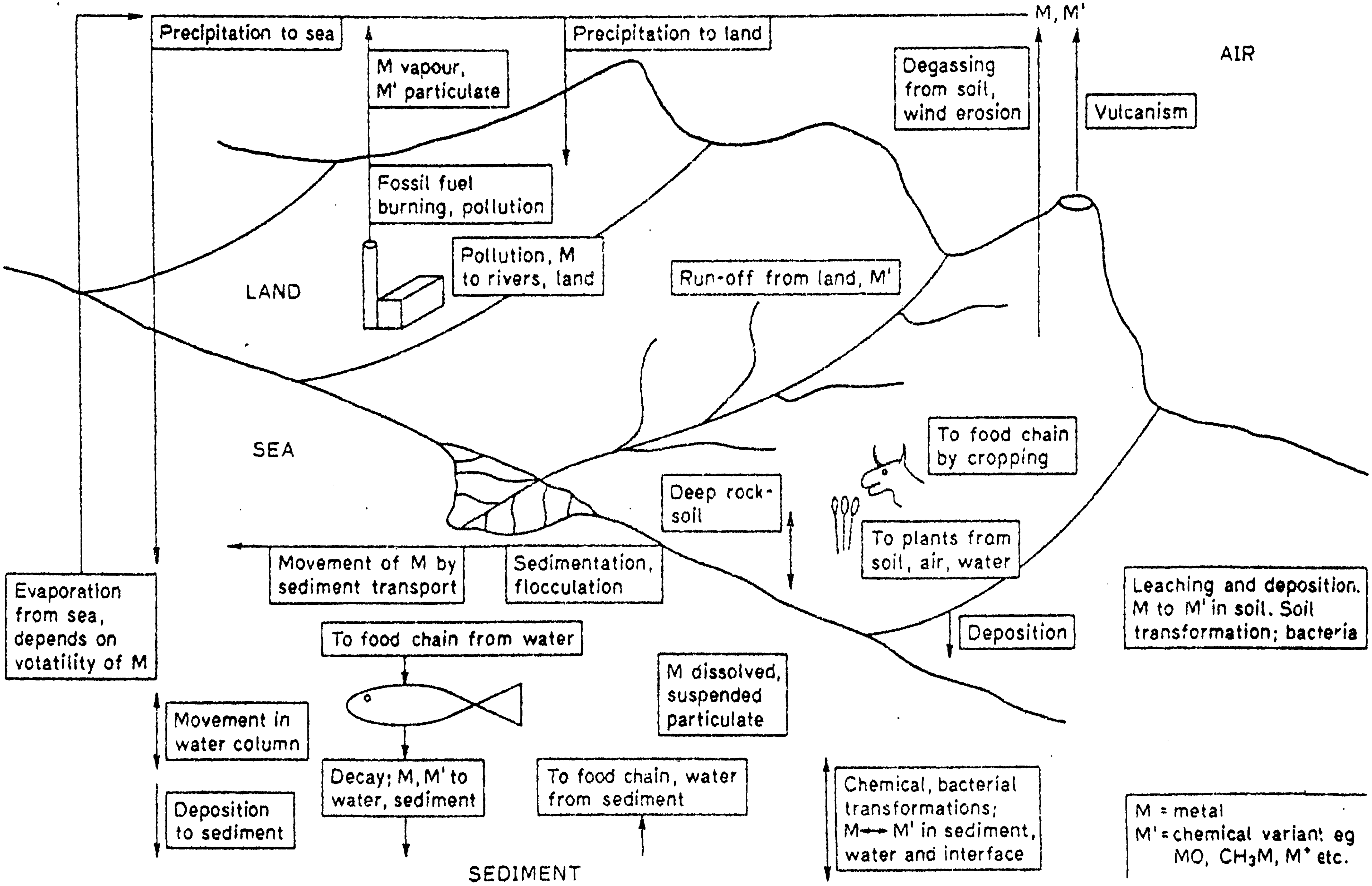
d^1	f^1	f^2	f^3	f^4	f^5	f^6	f^7	f^8	f^9	f^{10}	f^{11}	f^{12}	f^{13}	f^{14}
138·910 La 57	140·120 Ce 58	140·907 Pr 59	144·240 Nd 60	[147] Pm 61	150·350 Sm 62	151·960 Eu 63	157·250 Gd 64	158·924 Tb 65	162·500 Dy 66	164·930 Ho 67	167·260 Er 68	168·934 Tm 69	173·040 Yb 70	174·970 Lu 71
227* Ac 89	232·083 Th 90	[231] Pa 91	238·030 U 92	[237] Np 93	[242] Pu 94	[243] Am 95	[247] Cm 96	[249] Bk 97	[251] Cf 98	[254] Es 99	[253] Fm 100	[256] Md 101	254* No 102	[257] Lw 103

[ ] Mass number of Isotope of longest half-life. * Best known or most stable Isotope.

(3)



The global sulfur cycle. The fluxes shown are given in millions of tonnes sulfur per year of Tg S yr^{-1}. Roman typed numbers denote the transfers as estimated to have prevailed before civilization had a significant influence on the sulfur cycle. The italic numbers give the amounts of what man had added



Biogeochemical cycle for metal M

(1) *Solid State Chemistry 1*

We will continue from where we were left yesterday, yesterday when we were considering the "unit cells", and I think I would like to start you, uhm, with this very simple stereo-slides, which is conceived as to be able to cope with the optical problem. So, if you put on, put on your spectacles, that the, the red spec over the left eye, take time, it takes a few minutes to, to, ah, to get your eyes to click into this place, to see them properly. So that is just the slide to set in there, O.K? So, take next slide, please. That is just the simple cubic one, can you see that wavering? I just make a typical one for you. If you have difficulty in seeing this image, because that of that, the alignment of projection, it is difficult to get each of the alignment of angle properly. And it is important that we have to align that, in the, in the horizontal plane, the vertical doesn't matter. Sorry! The vertical plane! The horizontal doesn't matter. You may find that if you shoulder your head just slightly into one side or the other, that they will come in place. That one, that one should be a fairly easy one.

That is a simple cube, and now let's have something more complicated. As we mentioned earlier, a particular face-cubic unit cell, and finally, with time being left, we just look at the "diamond structure". We've got certain carbons on the six faces, and carbons at the corners, some of them at the centres of the faces, and some are acting "inside" the centre actually, not on the surface. See that, there are a four of them, which are actually inside the cells, they are not on the surface. They are arranged in such a way that two of them, are like that, and the other two are like that.

Well, we come back to the slides later, if this, this is what I'm saying that's, just gives you a preview, of, of how the systems are going to work. And if you wish, we like your comments on whether this is helpful to visualise in three dimensions or this finds more bothered in this work. Right! Have the slides off now, please.

Now, we change the concept of the unit cell, which we established yesterday.

These are two things that you want to develop, because there are two uses we want to make of this idea of unit cell. First of all, we want to count the number of units and the number of atoms, the molecules, and depending on what sort of solid we are talking. We want to be able to determine how many of these there are in the unit cell. And secondly, we want to be able to measure the unit cell dimension. So, in the simplest case for the unit cell, the cube, we want to know what is the length of the side of that cube. Let's take an example of this, the face-centred-cubic structure. Can I have the next slide! Ah1 You see that is the face-centred-cubic. You've got an atom on each of the corners and an atom at the centre of each of these faces, and nothing in the middle.

Let's just, in case you don't find it easy to see the stereo-diagram, let me give you the face-centred-cube in the formal ordinary slide as well. Let that red projector off, please! Switch it off, please! Red! There is the face-centred-cubic structure in a space-filling model, with the atoms cut off head, to suit in the boundary of the cube. And the same thing in, in the ball-sticked model, you have that only two sticks. Probably easier to see all in it rather than the cut-off in space-filling model, to see that, there are two atoms in each of the corner, and there are atoms at the centre of each of these faces. So that is called the face-centred-cubic structure because it has atoms at the corners and atoms at the centres of the faces.

Now, the question is that "How many atoms are there in that unit cell?" If you look at the diagram, and count them up, you will find that there are fourteen, but, be quite clear about this: that there has not been such things that there are fourteen atoms in a unit cell because that would allow the fact that similar atoms, we've got all of the atoms in this particular structure, are shared with each edge of each other unit cell, they do not belong entirely to that unit cell. And so, we need to allow for this. And on the next slide, you see, we, two occasions of cells, and on it, we have one of the atoms which are located at the centre of this face, and you see, it equally well belongs to this unit cell, as it equally well belongs to this unit cell. IT is the component of each of those two unit cells. Because the two unit cells, at that face, in contact with each other. So, whenever we are counting atoms in the unit cell, we have to allow for the factor, an atom like that is only counted as a "half" of an atom to any one of the unit cells. That's the easiest way to do.

Ask the question, how many unit cells that they happen to belong to, and then you count the proper fractions to any whole of the unit cell. So, an atom which is in the centre of the face, will be counted as a half atom to either one of those unit cells. In the same way, if we have an atom which is at the corner of a unit cell, see, we draw a shadowed unit cell here, and see, that there are eight unit cells which are in contact with the central atom at this corner. We've got four of them arranged in the square, and another four of them arranged in the second separate square. And that corner is common to all those eight cells, so we therefore have to count the atom as contributing only one "eighth" of an atom to one particular unit cell.

So, we go back to the previous slide, the one we call, that, this the ring up here, we can now look at those four of the atoms, and besides, now we can count them up. First of all, now the corner atoms, there are eight atoms at the corners, but since we have said that it is common to eight unit cells, we have to count them as one eighth, so we take one eighth for each atom, and multiplied by eight, we get one corner atom. Similarly, the other six atoms of the fourteen, are in the centre, they are face-centres. There are all six of them, and each is counted as a half because they are shared between two. It is this unit cell, and the other unit cell. And so, when we are talking about the number of atoms in a unit cell, in that particular unit cell, there are four atoms.

Let's have another example to look at, this is the caesium chloride. Please switch on the green projector, No! Could you please slide away the green projector, a bit further. No! Switch off the red one, but take the green and turn away from the left. No! on the other hand, green! That's right! Yes! Right! There, we have caesium chloride structure. The arrangement is, that caesium ion is at the centre, surrounded by a cluster of four chloride atoms, chloride ions, if we are correct. And the same thing, from another diagram for the ball-stick model, can you see that the caesium is at the centre, and there are eight chloride ions surrounding the caesium. And then we count the number. The centre atom, is within the unit cell itself, it is not shared with any other unit cells, so we have to count it as a whole atom. In this case, so that we count as one atom, that is the caesium ion. So far as chloride ions, there are eight of them. Each of them is at the corner, and counted as one-eighth. There is totally one chloride atom. So, we give the formula of CsCl. That is one, that each of them has one in the unit cell.

Let's have a look at one more example, which is, a bit more complicated. That is the sodium chloride, the just one slide after the caesium chloride. Put the green one, and switch on the red projector. And change the slides. And that, I don't think that one is really well aligned, but, yes, the wrong slide. Yes, No! That's caesium chloride. Yes, this is sodium ion, but this one, here, in the sense of a cube, it is not on any of the cubic faces. Right, change to the next slide, please! This is the sodium chloride structure. Yes, the sodium chloride structure. Let's define, the, getting the right one circle, let's call the shaded circles the chloride ions, and the open circles, the sodium ions. And we can see that, that, at the, the centre of the diagram, all the circles are shaded ones, and all of the rest are open circles of the unit cell.

Let's just see the same thing in the form of another diagram, another red come up, please! And the red, switch it off, please! That is the space-filling model diagram of the sodium chloride structure. That is the cut-off way version, showing the fraction of the atoms. And that is the modern ball-stick model which we'll stick with all the remaining session that I want to say that, I'd better give you the references to your textbooks, that we need. Now, let's try on that, the diagram I showed you, where two of occasions of unit cells, or instead with eight unit cells, showing that how theions are shaped. You'll find that in your textbook, in the second edition of Brown and LeMay, on the pages three one eight, and three six two, or the sodium chloride structure, you'll find that on page three one eight again, in the second edition, and two two six in the old version.

Let's look at the sodium chloride unit cell and let's work out how many of each type of atoms we've got in the unit cell. Let's look at the open circles which we write as Na plus mark. Ah, now, in that diagram, we have eight of them at the corners, and that is eight times one-eighth, because they are shared among eight unit cells. We have another six on the face-centres, times one half because they are shared by two unit cells. So, there is totally four of Na plus. Here, we have four at the corners, first of all, we have one in the very centre, where there is no sharing with others. We thus count as one chloride ion, and remember, which there are twelve, of all at the centre of the edges of the cube. There are twelve, because there are twelve edges. But, what fractions do they contribute to any one particular unit cell? Well, quite naturally, how many unit cells share in it? If we look down at the unit cell, we consider looking into the blackboard vertically, ah, we get four unit cells. We have eight edges in total, so obviously, for the edge-centred atom in the unit cell, we count as one-fourth, and times twelve, and the total is four, we might expect from the chloride ions. So it is very important to be able to take an unit cell and, to decide how many units there are in.

Before I pass on forward, there is only one thing I want to point to, in the sodium chloride structure, or in the caesium chloride structure, I define the open circles, for example, as the sodium ions, and the shaped ones as the chloride ions. But it is equally well to define the other way around, all you have to do is to change the origin of the cube. And so now, this is now the corner, and it continues to cover the unit cell along this way. This unit cell itself is drawn as either the Na plus ions, the other ones in the edge of faces, which is the one in the above diagram.

Right, the second thing that we want to do, is to be able to measure the unit cell dimensions. And this is, something that can be done experimentally, by diffraction or electromagnetic radiation. Now, let's keep open-minded about this for a moment. We will consider the electromagnetic radiation in general, uhm, never mind whether it is the visible light, whether it is radiowave, whether it is ultraviolet,or whether it is X-ray. Consider the electromagnetic radiation in general. Now, if we have a crystal, which has an arrangement of planes of ions, or atoms. Take this model for instance, if you look at the side of its own, we can see we can have an array of sodium and chloride ions, but these are only related at arrays of equal distance. That is how this sort of ordinary arrangement that we have in simple crystals.

(2) Chemical kinetics 1

We considered yesterday, excuse me,please. Maybe before the talk begins, let me just pass the message from Dr. Hill, he wanted you to be reminded that next week is your tutorial. Right, we talked yesterday about the temperature dependence of the reaction rate, and we saw that that is expressed by the "Arrhenius equation". We then considered, considered one that Arrhenius equation arises, and saw that if the critical point of the minimum kinetic energy of molecular collisions, denoted by E naught, then plot the rate constant, it is the activation energy. Therefore, out of this kinetics of collision of reaction rate, the minimum activation energy of reaction has the minimum kinetic energy of molecular collisions per mole, at which the reaction can occur.

For, as we talked yesterday, about some length the reactions occur only when the molecules of reactants collide, and when they collide the energy climbs up, and in orientation suitable for formation of new bonds of molecules of products, that's the reaction could occur. Yesterday, I didn't mention the collision, I thought that we will speak of it all today. And it is in the handout, which is just one sheet. I want to illustrate in that handout why the activation energy promotes the transformation of the molecules of the reactants into molecules of products.

You have it, so don't take any notes, don't copy the diagram. And I want you just follow my argument. So, to see how the activation energy promotes the reaction, I just copy here from the textbook I show you in the diagram. It shows the reaction profile for a exothermic gas reaction which is described there in the box. The formation of NO two, the reaction of NO two plus carbon monoxide, to produce NO and CO two. What we are looking at here, is the change in the internal energy or the potential energy of the atomic arrangements in the molecules of the reactants and the arrangements from there are the molecules of the products.

So, here along the reaction coordinate, we see that we have the state of the internal energy of the reactant molecules on the left to the diagram, to transform into the molecules of the products. Imagine that one molecule of NO two has, is travelling through or moving to the gas reactor and collides at some moment to the molecule of CO. Now, each of these two molecules possesses some kinetic energy and also some potential or internal energy, that internal energy is the energy of ah, vibrations of bonds, and rotational energy and so on.

Now, when these molecules collide, then just for a very brief moment, their kinetic energy drop to zero. And of course, that energy is not destroyed, it is transformed into additional amount of potential energy and it is stored within these two molecules as the internal energy. Consequently, the ah, vibrational energy of some bonds in this molecules is increased. What ah, after a very brief molecules collisions, most ohm, molecules is separated again, and at that moment, that additional amount of the internal energy is released again as a kinetic energy as they fly apart as the reaction will not occur.

Only if the colliding molecules invited to collide have sufficient amount of kinetic energy to produce as sufficiently large increase in the internal energy, in the reactant molecules. And that additional internal energy is put in the right chemical bond in the molecules of the reactants, then the reaction can occur. Only then, the molecules become this "activated complex". Now, as we see here, the activated complex is an atomic arrangement from particular atomic arrangement of the reactants, from the molecules of the reactants, which is characterised by the extra amount of internal energy along the reaction coordinate. Because it has such high amount of internal, or potential energy, this activated complex is unstable, is, is very short-lived, and it can decompose into the molecules of the products.

When that happens, the ah, internal energy drops to the lower internal energy of the molecules of the products. So, you can see that this activated complex is actually the transition state in this reaction, something which the molecules of the reactants must pass if the reaction will occur.So, we see now that what ah Arrhenius has called the energy barrier, and the reaction must pass that barrier. And for the activation energy, actually, this, the amount of energy which the molecules of the reactants must acquire, in order to increase the internal energy sufficiently to climb up to the higher energy state of the activated complex.

This reaction is exothermic, therefore when the molecules, when it goes from the reactant, the initial state to the final state, the amount of energy equals to the enthalpy change of the reaction is released as the heat of the reaction. But although as you see it here, the internal energy of reactants is higher than the internal energy of the products, that is to say, reactants are at the higher level of the potential energy than products. They cannot, the reaction can not occur by this molecule, they collide and then fall down directly into the molecules of the products.

If that is actually the case, then every molecular collision will result in the reaction but it isn't so. The molecules ah, can react only if they collide with sufficient amount of energy, kinetic energy greater than, sufficiently large increase in the internal energy, an amount which is required to climb up to the activated complex. Now, obviously, the reaction reverses to that which we've shown here, with that as the products. Now, in this reaction, the endothermic reaction, the activation energy barrier is much higher, and it was to the sum of the activation energy of the overall reaction and the enthalpy change of the product reaction.

So, now we know, we are the same quantity of the activation energy of the reaction is, and we also know one ah, the that the rate constant increases with the temperature, and therefore y is empirical, equation of Arrhenius. For x we said yesterday, looking at the bottom of the board, and you can see the reaction. What we have in the "Arrhenius equation", which is the fraction in terms of valid collisions which can have sufficient amount of energy which is high enough for the reactants, increase the internal energy to the transition state, therefore the reaction can occur.

Now, if we have here rearranged the Arrhenius' equation, then we can see how we are able to determine the activation energy of the reaction. Oh! Sorry! I forgot taking the paper away. Right! Let us then consider the determination of the activation energy of the reaction. Let us consider the Arrhenius' equation, k is rate constant, and A is

Arrhenius' pre-exponential factor of the molecules. If we take logarithm of each side of this equation, we obtain ln k equals to, here we a product, and the product of logarithm of two numbers, is, equal to ah, Sorry! The logarithm of the product of two numbers is equal to sum of the logarithms of each number. Therefore we have ln A minus E a , activation energy over RT, and that's because ln e x equals x.

If we employ the logarithm in base ten, then this equation becomes log k equals log A minus Ea over two point three o three times RT. And now, if we compare these two equations, these equations are straight lines, then we can see that if we consider ln k or log k as y, log A or ln A as C, minus Ea over RT in the ln, or minus Ea over two point three o three RT in the log as m, and one over T as x, then we are noting here that both two are straight lines.

But, let us suppose that if we measure the rate constant for a particular reaction at several temperatures, by measuring concentrations-time data. Then if we plot ln k against the reciprocal of temperature, this as I said yesterday, temperature must be always in absolute temperatures in all the calculations of chemical kinetics, therefore one of the requirement is that you have to convert the temperature into Kelvin. We obtained a line, and the slope of this line is equal to minus Ea over R. If however, we plot log k against the reciprocal of the temperature, we obtain a straight line again, but the slope now is equal to minus Ea over two point three o three R.

So, to obtain the activation energy for a particular reaction, we must determine the rate constant of that reaction at several temperatures by measuring the concentration-time data, we then plot either ln or the log of the rate constant against the reciprocal of the temperature, and obtain the straight line. We determine the slope of this line and then from the slope we determine the value of the activation energy.

Ah, in your textbook, on page four nine seven, you can find the exercise fifteen point seven, this considers the determination of the activation energy of the reaction in which methyl acetonitrile converts into ethyl acetonitrile. Now, what we will find there, are the columns of data, we find the temperature at which each rate constant has been measured, then we find the values of rate constants from the temperatures. Then we do want to get the information of the reciprocal of the temperature, so leave a space over there.

So, our first step starts with the need to convert the temperature in Celsius to Kelvin scale, for each temperature listed in the tabular form there. We have then to find the reciprocal values of the temperatures in Kelvin, and finally we have the log values of the rate constants or the ln k values of the rate constants. And then we make a plot, Arrhenius' plot of the, of the log k against the reciprocal of the temperature. And now, let me just get the textbook and the plot which you will get for this reaction.

Ah, Sorry! I'd better take this away. Fine, this will look. So what I have done here, I just take the values from the textbook, and work out the log k for every temperature at which these values are measured and then plot, I have plotted the graph. From this graph, I have selected then two points which are far from each other, and calculate the gradient.

Now, just one point which I want to make here, and that is something which often occurs with the Arrhenius' plot. You see if we then to take the quantity which are shown in this graph, from zero up to the right of the x-axis, and the same for the logarithm. We will have to have a much larger graph, let's say when we use the A four paper, or the grid paper, we have only one small graph on which we are plotting. And of course, there is line then, would intercept, intercept thus is collapsing if the line starts from zero. That is belong of the Arrhenius' pre-exponential factor.

But, it is not necessary always expected to have a large line, to have the points on the line well separated from each other, because in that case we obtain more accurate than the slope, and it is not necessary to start from zero, zero. We start, I started here from point zero zero one nine, which is then close to the first temperature measurement, and then log at minus two, I adopted that as the first value of rate constant. I simply used the whole ah, width and the length of the graph paper to stretch, these, the portion of the ah, of the line which I have measured rate.

APPENDIX 22

University of Glasgow

Centre for Science Education

Director : Professor A. H. Johnstone

Student evaluation of teaching — the staff view

A *Student Evaluation of Teaching* form designed by the Centre for Science Education is already used by a number of Departments. It is likely that other Departments may wish to use this form to sample students' views on the courses they offer.

Student evaluation forms have been regularly used, within the Chemistry Department, for some time now. Our colleagues in other Departments could benefit from our experience. We could tell them, for example, what we think of student ratings in general or the present mark-sense form in particular. We could also let them know of any drawbacks to the present system or what use we make of the information we get from the students. The attached questionnaire has been designed to collect such information.

The rating of statements on a '1 ... 5' scale, as used on the mark-sense forms, had proved to be a very reliable technique, and we decided to use the same technique for sampling staff opinion.

To ensure that our chosen statements would be reasonably unbiased, we did not write them ourselves. Instead, we selected the statements from a variety of sources — books, official documents, articles in journals and, in a few cases, actual comments from staff members. To maintain their authenticity, we have retained the original wording for the statements.

Recently published material in some higher education journals has dealt with evaluation of university teaching, indicators of performance and staff appraisal techniques. Because of this current interest, we have included some general statements on staff appraisal. In all such statements, the term '*appraisal*' is to be clearly understood as meaning the existing mechanism for staff self-evaluation and career development. *It does not include student ratings of lectures.*

We produced a list of 60 statements, sub-divided into eight categories. Since the task of rating all 60 statements would take too long, we then created three separate questionnaire forms, each having 30 statements, randomly arranged.

These different questionnaire forms (see specimen attached) have been issued randomly to all academic staff in the Chemistry Department.

You are asked to rate the 30 statements on a '1 ... 5' scale. You may assume that

a rating of '1' indicates strong agreement,
a rating of '5' indicates strong disagreement.

Please circle only one response for each statement.

If you wish to make any comments about the questionnaire, or about the student ratings in general, please use the reverse side of this page for that purpose.

If you wish to remain anonymous, you may do so. It would be helpful, however, if you identified yourself.

If you have any problem with the completion of this questionnaire, please contact :

Dr. Peter MacGUIRE (Ext. 6565) or Prof. Alex JOHNSTONE (Ext. 5172).

Please return your completed questionnaire, in the envelope provided, to the Centre for Science Education, Room 157, Chemistry Building, by the end of March.

A summary report of the staff views on student evaluation will be circulated in due course.

Thank you for your cooperation.

Student evaluation of teaching — List A

1. I welcome this regular feedback of information from students.	1 2 3 4 5
2. The time spent filling in the mark-sense forms could have been used for other, more important, purposes.	1 2 3 4 5
3. Little active learning occurs during most lectures.	1 2 3 4 5
4. Constructive criticism by students can be most helpful	1 2 3 4 5
5. The last section of the summary report dealing with the 'Lecturer Characteristics' was particularly helpful.	1 2 3 4 5
6. Staff appraisal involves the recognition that an individual is doing an important and worthwhile job.	1 2 3 4 5
7. Student ratings are a good measure of overall teaching performance.	1 2 3 4 5
8. Students are not competent to make value judgments about the quality of the course and/or the lecturer	1 2 3 4 5
9. Student ratings are greatly influenced by the personal 'charisma' of the lecturer.	1 2 3 4 5
10. Students expect a lecturer to be able to lecture well.	1 2 3 4 5
11. Within the university system, teaching is generally viewed as a poor relation to research.	1 2 3 4 5
12. Science students tend to attach considerable importance to the "systematic organisation of the subject matter".	1 2 3 4 5
13. Students' comments often highlighted basic problems of communication of information from lecturer to student.	1 2 3 4 5
14. Not all the statements on the mark-sense form applied to my course of lectures.	1 2 3 4 5
15. The lecture method is an efficient way of transmitting factual information.	1 2 3 4 5

16. Student ratings are more suited to younger, less-experienced members of staff. 1 2 3 4 5

17. Student ratings are a good measure of overall teaching performance. 1 2 3 4 5

18. As a form of consumer control, student ratings have a useful place. 1 2 3 4 5

19. Any system of appraisal should be designed to monitor research performance as well as teaching performance. 1 2 3 4 5

20. The summary report identified some problem areas. 1 2 3 4 5

21. There are important aspects of teaching which cannot be assessed by simply rating statements on a '1 . . . 5' scale. 1 2 3 4 5

22. Student ratings can provide useful feedback to lecturers about their teaching. 1 2 3 4 5

23. Evaluation of teaching must be broadened to include measurements other than student ratings of lectures. 1 2 3 4 5

24. The lecturer should make the course interesting and one the students enjoy attending. 1 2 3 4 5

25. Using student ratings as a measure of teaching effectiveness can be as misleading as using the 'best-seller' lists as a measure of literary excellence. 1 2 3 4 5

26. The 'written-in' comments from students were unhelpful. 1 2 3 4 5

27. Student ratings are greatly influenced by the personal 'charisma' of the lecturer. 1 2 3 4 5

28. The pattern of student responses is often inconsistent. 1 2 3 4 5

29. Over frequent use of these mark-sense forms is counter-productive. 1 2 3 4 5

30. Lectures encourage students to think for themselves. 1 2 3 4 5

Student evaluation of teaching — List B

1. The primary aim of any system of staff appraisal must be the *improvement of performance.*	1	2	3	4	5
2. Students have a right to make judgments about the quality of teaching they encounter.	1	2	3	4	5
3. The summary report confirmed my own impressions.	1	2	3	4	5
4. Highly qualified academic staff members should not be judged by possibly capricious or even antagonistic students.	1	2	3	4	5
5. The processing of the completed mark-sense forms took too long.	1	2	3	4	5
6. Student opinion can be unfairly biased by a few 'extremists'.	1	2	3	4	5
7. Only the *adverse* 'written-in' comments were returned to the lecturer.	1	2	3	4	5
8. Good teaching is central to the maintenance of academic standards.	1	2	3	4	5
9. Students think the lecturer should provide "all you need to know for passing the exams."	1	2	3	4	5
10. I am basically satisfied with the mark-sense form used for student evaluation.	1	2	3	4	5
11. In general, the feedback from students has helped me to improve my teaching.	1	2	3	4	5
12. Students make very constructive suggestions as to how the teaching can be improved.	1	2	3	4	5
13. Little active learning occurs during most lectures.	1	2	3	4	5
14. The fact that students were able to respond anonymously encouraged frivolous responses.	1	2	3	4	5
15. Within the university system, teaching is generally viewed as a poor relation to research.	1	2	3	4	5

16. The 'feedback' of information in the summary report was insufficient.	1 2 3 4 5
17. I am in favour of student evaluation of teaching, provided it is offered as a service which I can use if I wish.	1 2 3 4 5
18. Students learn more from *reviewing* their lecture notes than from making them.	1 2 3 4 5
19. Student ratings can provide useful feedback to lecturers about their teaching.	1 2 3 4 5
20. The 'written-in' comments from students were, for me, the best source of information.	1 2 3 4 5
21. Over frequent use of these mark-sense forms is counter-productive.	1 2 3 4 5
22. The 'written-in' comments from students were unhelpful.	1 2 3 4 5
23. The first section of the summary report, dealing with relative difficulty, workload, pace and overall rating of the course and lecturer, was the most useful part.	1 2 3 4 5
24. I am basically satisfied with the mark-sense form used for student evaluation.	1 2 3 4 5
25. An appraisal system which focused on monitoring individual and departmental performance with the aim of improving efficiency would be welcomed.	1 2 3 4 5
26. Student ratings are greatly influenced by the personal 'charisma' of the lecturer.	1 2 3 4 5
27. Consultation and training resources should be provided for lecturers seeking to improve their teaching.	1 2 3 4 5
28. Lecturers need to pay attention to student opinion.	1 2 3 4 5
29. The issue and collection of the mark-sense forms caused a major upheaval.	1 2 3 4 5
30. Students make very constructive suggestions as to how the teaching can be improved.	1 2 3 4 5

Student evaluation of teaching — List C

1. The fact that students were able to respond anonymously encouraged frivolous responses.	1 2 3 4 5
2. Students are most impressed by the lecturer who can 'package' the main points in ways which are easy to grasp.	1 2 3 4 5
3. The lecture *content* has little effect on the student ratings.	1 2 3 4 5
4. The lecturer should make the course interesting and one the students enjoy attending.	1 2 3 4 5
5. It is unrealistic to make value judgments based on such small samples of student opinion.	1 2 3 4 5
6. Little active learning occurs during most lectures.	1 2 3 4 5
7. The students' perception of a lecturer's performance is, in most cases, surprisingly accurate.	1 2 3 4 5
8. Within the university system, teaching is generally viewed as a poor relation to research.	1 2 3 4 5
9. Students are unimpressed by the lecturer who merely reads from notes.	1 2 3 4 5
10. Some items on the mark-sense form need to be revised.	1 2 3 4 5
11. The summary report confirmed my own impressions.	1 2 3 4 5
12. Using student ratings as a measure of teaching effectiveness can be as misleading as using the 'best-seller' lists as a measure of literary excellence.	1 2 3 4 5
13. Student ratings are a good measure of overall teaching performance.	1 2 3 4 5
14. Students have a right to make judgments about the quality of teaching they encounter.	1 2 3 4 5
15. Good teaching is central to the maintenance of academic standards.	1 2 3 4 5

16. The lecturer should make the course interesting and one the students enjoy attending. 1 2 3 4 5

17. Student ratings can provide useful feedback to lecturers about their teaching. 1 2 3 4 5

18. Students make very constructive suggestions as to how the teaching can be improved. 1 2 3 4 5

19. Using student ratings as a measure of teaching effectiveness can be as misleading as using the 'best-seller' lists as a measure of literary excellence. 1 2 3 4 5

20. I am basically satisfied with the mark-sense form used for student evaluation. 1 2 3 4 5

21. Students have a right to make judgments about the quality of teaching they encounter. 1 2 3 4 5

22. The summary report was difficult to understand. 1 2 3 4 5

23. Student ratings can provide information on only the most trivial aspects of teaching. 1 2 3 4 5

24. Good teaching is central to the maintenance of academic standards. 1 2 3 4 5

25. Student ratings are conditioned more by the lecturer than by the course. 1 2 3 4 5

26. The summary report confirmed my own impressions. 1 2 3 4 5

27. The 'written-in' comments from students were unhelpful. 1 2 3 4 5

28. Over frequent use of these mark-sense forms is counter-productive. 1 2 3 4 5

29. The fact that students were able to respond anonymously encouraged frivolous responses. 1 2 3 4 5

30. The performance of academic staff and departments should be appraised in a more regular and systematic way. 1 2 3 4 5

APPENDIX 23 The Results of "Student Evaluation of Teaching - - -

Staff's View

The full list of 60 statements used in staff questionnaire, divided into 8 categories

(The statements in italics appeared in all three lists)

		1	2	3	4	5
(a)	**Staff appraisal in general**					
1.	The performance of academic staff and departments should be appraised in a more regular and systematic way.	13	33	27	7	13
2.	Any system of appraisal should be designed to monitor research performance as well as teaching performance.	60	20	10	0	0
3.	*Within the university system, teaching is generally viewed as a poor relation to research.*	24	39	21	8	8
4.	An appraisal system which focused on monitoring individual and departmental performance with the aim of improving efficiency would be welcomed.	15	15	23	0	38
5.	Staff appraisal involves the recognition that an individual is doing an important and worthwhile job.	27	13	27	6	27
6.	The primary aim of any system of staff appraisal must be the *improvement of performance.*	30	40	0	20	10
7.	Consultation and training resources should be provided for lecturers seeking to improve their teaching.	15	54	23	0	8
8.	*Good teaching is central to the maintenance of academic standards.*	74	13	5	3	3
9.	Evaluation of teaching must be broadened to include measurements other than student ratings of lectures.	20	30	50	0	0
(b)	**The lecture method**					
10.	The lecture method is an efficient way of transmitting factual information.	20	27	33	20	0
11.	Lectures encourage students to think for themselves.	0	40	20	40	0
12.	*Little active learning occurs during most lectures.*	11	31	24	29	5
13.	Students learn more from *reviewing* their lecture notes than from making them.	46	38	8	8	0
14.	*Students expect a lecturer to be able to lecture well.*	33	33	13	7	7

(c)	**What students expect of a lecture or lecturer**					
15.	Students think the lecturer should provide "all you need to know for passing the exams."	40	60	0	0	0
16.	*The lecturer should make the course interesting and one the students enjoy attending.*	55	34	8	0	3
17.	Students are most impressed by the lecturer who can 'package' the main points in ways which are easy to grasp.	54	38	8	0	0
18.	Science students tend to attach considerable importance to the "systematic organisation of the subject matter".	47	33	13	0	0
19.	Students are unimpressed by the lecturer who merely reads from notes.	84	8	8	0	0
(d)	**Student ratings in general**					
20.	*Students have a right to make judgements about the quality of teaching they encounter.*	47	39	11	0	3
21.	As a form of consumer control, student ratings have a useful place.	10	50	0	20	10
22.	Student ratings are conditioned more by the lecturer than by the course.	13	53	13	13	0
23.	The lecture *content* has little effect on the student ratings.	0	15	8	54	23
24.	*Student ratings are greatly influenced by the personal 'charisma' of the lecturer.*	20	50	24	3	3
25.	Student ratings are more suited to younger, less-experienced members of staff.	0	0	30	50	20
26.	Student ratings can provide information on only the most trivial aspects of teaching.	6	27	20	20	27
27.	I am in favour of student evaluation of teaching, provided it is offered as a service which I can use if I wish.	31	15	31	23	0
28.	*Student ratings can provide useful feedback to lecturers about their teaching.*	34	47	16	3	0
29.	Highly qualified academic staff members should not be judged by possibly capricious or even antagonistic students.	20	20	10	20	30
30.	Students are not competent to make value judgments about the quality of the course and/or the lecturer	7	7	20	46	20
31.	There are important aspects of teaching which cannot be assessed by simply rating statements on a '1 . . . 5' scale.	50	20	20	10	0

32.	*Using student ratings as a measure of teaching effectiveness can be as misleading as using the 'best-seller' lists as a measure of literary excellence.*	26	26	18	24	5
(e)	**Negative aspects of present format**					
33.	*The fact that students were able to respond anonymously encouraged frivolous responses.*	18	29	18	13	21
34.	The time spent filling in the mark-sense forms could have been used for other, more important, purposes.	0	13	27	33	27
35.	It is unrealistic to make value judgments based on such small samples of student opinion.	15	23	15	23	15
36.	Student opinion can be unfairly biased by a few 'extremists'.	10	40	0	50	0
37.	*Over frequent use of these mark-sense forms is counter-productive.*	39	29	18	5	3
38.	The processing of the completed mark-sense forms took too long.	0	10	20	20	50
39.	The issue and collection of the mark-sense forms caused a major upheaval.	0	38	23	15	23
40.	Not all the statements on the mark-sense form applied to my course of lectures.	7	33	33	20	7
(f)	**The summary report**					
41.	The summary report identified some problem areas.	10	40	0	20	10
42.	The summary report was difficult to understand.	13	7	27	33	20
43.	The 'feedback' of information in the summary report was insufficient.	0	8	23	46	8
44.	*The summary report confirmed my own impressions.*	11	47	24	8	0
45.	The pattern of student responses is often inconsistent.	30	30	10	20	0
46.	Some items on the mark-sense form need to be revised.	23	15	54	0	0
47.	The last section of the summary report dealing with the 'Lecturer Characteristics' was particularly helpful.	7	53	40	0	0
48.	The first section of the summary report, dealing with relative difficulty, workload, pace and overall rating of the course and lecturer, was the most useful part.	8	54	30	8	0
(g)	**The 'written-in' comments**					
49.	*The 'written-in' comments from students were unhelpful.*	16	8	32	26	16

50.	Students' comments often highlighted basic problems of communication of information from lecturer to student.	**0**	**40**	**47**	**13**	**0**
51.	The 'written-in' comments from students were, for me, the best source of information.	**8**	**23**	**38**	**8**	**15**
52.	Only the *adverse* 'written-in' comments were returned to the lecturer.	**0**	**10**	**60**	**10**	**20**
53.	*Students make very constructive suggestions as to how the teaching can be improved.*	**5**	**24**	**26**	**34**	**11**
54.	Lecturers need to pay attention to student opinion.	**54**	**46**	**0**	**0**	**0**
(h)	**Positive aspects of present format**					
55.	*I am basically satisfied with the mark-sense form used for student evaluation.*	**11**	**39**	**21**	**21**	**8**
56.	I welcome this regular feedback of information from students.	**47**	**27**	**20**	**6**	**0**
57.	In general, the feedback from students has helped me to improve my teaching.	**0**	**30**	**20**	**30**	**20**
58.	Constructive criticism by students can be most helpful.	**46**	**40**	**7**	**0**	**7**
59.	The students' perception of a lecturer's performance is, in most cases, surprisingly accurate.	**15**	**23**	**38**	**8**	**8**
60.	*Student ratings are a good measure of overall teaching performance.*	**0**	**45**	**13**	**24**	**16**

(All the figures shown are percentages, based on a sample of 38 completed questionnaires)

APPENDIX 24 Test of significance for some tables

(1) **TABLE 2-12** (Page 48)

$t = -2.3$ & -2.7, $p < .05$ significant difference between **BS+** and **BS- & BSO.**

(2) **TABLE 2-15** (Page 57)

$t = -2.8$, $p < .05$ Male students scored significantly better than female ones.

(3) **TABLE 5-13** (Page 151)

$t = -4.1$, $p < .05$ and there is significant difference between Low W.M. and High W.M. students.

(4) **TABLE 5-16** (Page 161)

$t = -6.6$, $p < .01$ and there is significant difference between Field-dependent and Field-independent students.

(5) **TABLE 5-19** (Page 171)

$t = 2.1$, $\underline{p < .10}$ difference between Achiever and Sociable.
No significant difference found between other groups.

(6) **TABLE 5-22** (Page 181)

$t = 2$, $\underline{p > .10}$ No significant difference between Male and Female students, i.e., Females didn't have higher performance than male ones.

(7) **TABLE 7-13** (Page 244)

$t = -3.1$, $p < .01$ and there is significant difference between Low W.M. and High W.M. students.

(8) **TABLE 7-16** (Page 256)

$t = -3.4$, $p < .01$ and there is significant difference between Field-dependent and Field-independent students.

(9) **TABLE 7-19** (Page 266)

$t = 2.4$, $p < .05$ significant difference between Achiever and Sociable.
$t = 2.1$, $p < .05$ significant difference between Curious and Sociable.

(10) **TABLE 7-22** (Page 271)

$t = 1.5$, $\underline{p > .05}$ No significant difference found between Female and Male students, i.e., Female students didn't have higher performance than Male students.

(1) The Relationship between Working Memory Space and Exam Performance

A. **TABLE 5-13** (28 students)

Low W.M. (10 students)
High W.M. (6 students)

$t = -4.1$, $p < .05$

B. **TABLE 7-13** (32 students)

Low W.M. (11 students)
High W.M. (7 students)

$t = -3.1$, $p < .01$

C. **Conclusion :**

The students with higher working memory capacity (who are in general more complete note-takers) had higher performance in exams than the students with lower working memory capacity.

(2) The Relationship between Cognitive Styles and Exam Performance

A. **TABLE 5-16** (28 students)

Field-dependent (7 students)
Field-independent (10 students)

$t = -6.6$, $p < .01$

B. **TABLE 7-16** (32 students)

Field-dependent (6 students)
Field-independent (10 students)

$t = -3.4$, $p < .01$

C. **Conclusion :**

Field-independent students (who were found to be more complete in note-taking) have higher mean scores than Field-dependent students in the exams.

(3) The Relationship between Motivational Styles and Exam Performance

A. TABLE 5-19 (28 students)

Achiever (6 students)
Conscientious (11 students)
Curious (6 students)
Sociable (5 students)

$t_1 = 2.1, \quad p < .10$

B. TABLE 7-19 (32 students)

Achiever (5 students)
Conscientious (16 students)
Curious (7 students)
Sociable (4 students)

$t_1 = 2.3, \; p < .05$

$t_2 = 2.1, \; p < .05$

C. Conclusion :

(1) There are no simple patterns in this analysis.

(2) Sociable students have worst performance.

(3) The Achiever and the Curious students have higher exam scores than the Sociable ones.

(4) Tabulating of Note-taking Types versus Outcomes of Performance

A. **TABLE 2-12** (Page 48)

The results from 1988-1989 session showed that :

BS + > BSO > BS -	$t_1 = -2.3, \ p < .05$
(4) (4) (6)	$t_2 = -2.7, \ p < .05$
	$t_3 = -2.2, \ p < .05$

EL (only 1 student) --- impressively good performance.

B. But there are some factors which may affect students' exam performances :

[1] Revision and review
[2] Effort
[3] Exam skills
[4] Motivations or moods
[5] Others

The relationship between note-taking types and performance might mediated or affected by these complicated factors.

C. **Conclusion :**

[1] The results seemed to suggest a tendency that :

BS + > BSO > BS -

but this might not necessarily be so.

[2] Note-taking types in this study were used as indicators of note-taking completeness only, rather than as variables of predicting students' exam performance.

APPENDIX 25 The Raw data of the samples in this study

(1) The sample in 1988-1989 session

Subject number	Sex	Note-taking type	Performance	
			1st Exam	2nd Exam
S 1	M	BS -	24	50
S 2	M	EL	75	79
S 3	M	BSO	31	42
S 4	F	BS +	27	34
S 5	F	BS +	71	67
S 6	F	BS +	24	33
S 7	F	BS +	63	66
S 8	M	BS O	71	58
S 9	M	BS +	73	78
S10	M	BS -	27	44
S11	F	BS O	20	30
S12	M	BS +	29	26
S13	F	BSO	37	44
S14	M	BS -	69	63
S15	F	BS -	21	35

The data of student sample in session 1989 – 1990

Subject	Sex	W.M. capacity	FD / FI	M.S.T.	Performance	
					1st Exam	2nd Exam
S 1	M	5	FI	S	24	55
S 2	F	6	FN	S	64	79
S 3	F	4	FD	S	38	34
S 4	M	6	FI	S	40	54
S 5	F	5	FI	S	52	62
S 6	F	6	FN	A	63	60
S 7	M	5	FI	A	17	61
S 8	F	7	FI	A	100	100
S 9	F	4	FN	A	43	61
S 10	F	4	FN	A	46	34
S 11	M	7	FI	A	56	74
S 12	M	4	FD	Cu	22	43
S 13	F	5	FI	Cu	34	54
S 14	M	7	FN	Cu	77	76
S 15	M	7	FI	Cu	52	80
S 16	M	6	FI	Cu	60	65
S 17	F	5	FI	Cu	47	72
S 18	F	4	FD	Con	32	47
S 19	M	6	FI	Con	62	78
S 20	F	4	FD	Con	25	35
S 21	M	6	FI	Con	55	82
S 22	F	6	FD	Con	33	35
S 23	F	6	FN	Con	44	65
S 24	F	5	FI	Con	66	64
S 25	F	4	FD	Con	31	41
S 26	M	7	FI	Con	69	86
S 27	M	7	FI	Con	96	95
S 28	M	5	FD	Con	49	60

The data of student sample in session 1990 - 1991

Subject	Sex	W.M. capacity	FD / FI	M.S.T.	Performance (1st class exam)
S 1	M	5	FN	Con	47
S 2	M	4	FD	Con	34
S 3	M	5	FN	Cu	74
S 4	F	6	FI	Con	62
S 5	M	6	FI	A	88
S 6	M	5	FN	Con	45
S 7	M	4	FN	S	41
S 8	F	6	FN	Con	53
S 9	M	5	FN	Con	46
S 10	M	4	FD	Con	36
S 11	M	6	FN	Con	85
S 12	F	6	FI	Cu	64
S 13	F	8	FI	Con	80
S 14	M	7	FD	A	58
S 15	M	6	FI	Con	46
S 16	M	6	FI	Cu	76
S 17	M	7	FN	Cu	89
S 18	M	5	FI	A	70
S 19	M	6	FD	Cu	65
S 20	F	7	FI	Con	89
S 21	F	6	FD	A	40
S 22	F	6	FD	Con	43
S 23	F	6	FN	Cu	25
S 24	F	7	FN	Con	58
S 25	F	4	FN	S	42
S 26	F	4	FN	Con	31
S 27	F	6	FN	S	48
S 28	F	6	FN	Con	28
S 29	F	6	FN	Con	32
S 30	F	5	FN	S	52
S 31	F	6	FN	Cu	48
S 32	F	8	FI	A	70