UNIVERSITY
of
GLASGOW

A Study of Assessment Formats and Cognitive Styles Related to School Chemistry

By

Eleni Danili
B.Sc. (Chemistry)
M.Sc. (Science Education)

A thesis submitted for the degree of Doctor of Philosophy (Ph.D.)
Centre for Science Education, Faculty of Education
University of Glasgow

"Εν οίδα ότι ουδέν οίδα"
(Σωκράτης Σωφρονίσκου Αθηναίος, 469-399 π.Χ.)

The only true wisdom is in knowing you know nothing
(Socrates, 469-399 BCE)

Rafael, The School of Athens
Raffaello Sanzio (1483-1520) The School of Athens
(1509-1510) (Vaticano).

Abstract

This study has two principal aims. It explores the relationships between the results of various formats of paper-and-pencil classroom assessments of Chemistry. It also investigates the performance of pupils in different formats of assessment in relation to their cognitive style, personal preferences, and intellectual development. The study was conducted mainly in Greece with the participation of first year upper secondary public school pupils (Lykeio, Grade 10, age 15-16) in two stages.

In a pilot study correlations between different formats of assessment were explored. The correlations between the different formats of assessment tended to be between 0.25 and 0.65. This is a wide range but even the highest value is well short of 1.0. This suggests that the best student found by one method is not necessarily the best student by another method. This also raises questions about the validity of the formats of the assessment and what different formats of assessment are testing.

To address these questions, a larger scale study was designed which engaged 12 public upper secondary schools and 476 pupils in Greece during the school year September 2002 - May 2003. In this study, the two cognitive styles 'field dependent/field independent' and 'convergent/divergent' were explored as well as the pupils' intellectual development following to the Perry scheme in relation to three formats of assessment (multiple choice, short answer and structural communication grid) in five classroom chemistry tests.

The convergent/divergent characteristic correlated with pupils' performance in assessment where language was an important factor. However, in algorithmic type of questions or in questions where there is more use of symbols and less use of words, the convergent/divergent characteristic did not relate to pupils' performance. The short answer or open ended questions favour divergent pupils more than objective questions because in short answer questions pupils need to articulate their thoughts, and divergent pupils were the ones more able to do it. In objective testing, if a question needs reading skill in order to elaborate and interpret a text given, then again the convergent/divergent style is a very important factor for success. It seems that, in

relation to the convergent/divergent characteristic, the chemistry content is a factor affecting the type of questions being asked.

Field independent pupils surpassed field dependent pupils in all the tests, and in almost all the formats of assessment. It seems that the field dependent/independent characteristic is a very important factor for pupils in order to perform well in almost all types of assessments, irrespective of the content of the question. The short answer questions favour more field independent pupils than the objective questions in some of the chemistry tests.

It is a matter of concern that performance in a chemistry test is so strongly related to these particular psychological parameters, control over which is outside the individual pupil. This raises an important ethical issue about assessment. Are we testing chemical knowledge and understanding or cognition?

In relation to the Perry scheme, the study showed evidence that the pupils who have developed an autonomous, more confident attitude towards learning and who believed that deep learning and not rote learning are the key points for success in science performed better in the majority of the chemistry tests. Pupils who have developed the aptitude to work with open problems, which do not necessarily demand a clear-cut answer, performed better in open ended chemistry questions and in more difficult questions.

This study suggests that some of the factors which affect pupils performance might be: (a) the content and presentation of the test, (b) the format of the test, (c) the psychology of the individual.

Acknowledgments

Studying for five years (MSc and PhD) in the Centre for Science Education, has been one of the great gifts that life has reserved for me at a mature age. Apart from the fact that the centre has a multicultural environment, something which I have experienced for the first time in my life that has giving me the opportunity to learn how to respect other cultures, it also has a very pleasant atmosphere full of life, discourse, debate and jokes. At the same time during my studies in Glasgow I have had the privilege to make very good friends who helped and supported me during all these years. Now, on completion of my studies I wish to thank all of them with the hope that they will stay in contact with me in the future.

First of all I wish to express my deep respect and gratitude to Dr. Norman Reid and Professor Alex Johnstone who were my first tutors and who had a significant effect on my ideas and practice about the education. Dr. Norman Reid supervised me with patience and wisdom and was a benevolent and tolerant supervisor to my Mediterranean temperament and recalcitrant character. Professor Alex Johnstone gave the idea for this study, supported and advised me with his immense experience.

I would like to express my admiration to Professor Rex Whitehead with whom I had very pleasant and educated discourse about science, literature, social issues, philosophy and particular ancient Greek history and mythology. Indeed his knowledge about Greek mythology and history is extraordinarily admirable.

I am very grateful to my Greek colleagues and their pupils who participated in this project and without their help this study could not have been done.

My thanks are also due to my statisticians friends Dr. Ursula Berger, Dr. Ersnst Wit, Dr. Nial Friel, and Dr. John McClure for their valuable suggestions in statistical analysis of the results of this study and to my friend Dr. Esther Daborn for her constant contribution to the improvement of my English and her generous support and friendship.

I also wish to thank all my colleagues of the Centre for their support and friendship. Particular Wen-Chao Chen who help me in the final editing of this thesis.

Finally I reserve my great acknowledgement for my family and friends, for their constant support and encouragement.

Contents

List of Figures

Chapter Nine

Chapter Eleven

List of Tables

Chapter Eight

Chapter Nine

Chapter Ten

Chapter Eleven

Chapter One

Introduction

In Greece, in 1998, reform in education included changes in assessment practices. Thus, it was decided to make changes in the examination system which affected the form of assessment used in upper secondary education which runs from age 15 to 18. For the first time in the Greek education system, there were introduced into the national examinations different formats of assessment. Until then, short answer open-ended questions assessing knowledge and facts and solving problems mainly of algorithmic type were the only formats of assessment used in science. The new assessment styles which were introduced during the reformation were objective questions such as multiple-choice, true-false, matching questions, identifying reasons to support assertions, and filling in blanks to complete statements.

The changes in the formats of assessment did not have teachers' approval and their general criticisms of objective tests related to the limited information that they give about the thought processes used by the student, because they were focussing on recall skills rather than higher-order thinking skills, penalising the highly able student while rewarding the less able student, fostering guessing, and enabling cheating since students can easily interact in neighbouring seats. However, of the greatest importance was the teachers' concern about the belief that the establishment of fixed response assessment in the future would discourage pupil's language skills and diversity in their thinking processes.

A further difficulty is the lack of provision of organised training and educational studies for Greek science teachers and, therefore, teachers lack the theoretical background that is needed for evaluating and assessing their pupils. In addition, the very small amount of teaching time spent on chemistry makes teachers mainly concerned to finish the teaching units that they have to teach according to the curriculum programme and to neglect regular formative assessment. At the same time assessment is one of the most difficult issues in the educational community and can profoundly affect life opportunities. As Boud (1995) stated

> *"the effects of bad practice are far more potent than they are for any aspect of teaching. Students can, with difficulty, escape from the effects of poor teaching, they cannot (by definition, if they want to graduate) escape the effects of poor assessment. Assessment acts as a mechanism to control students that is far more pervasive and insidious than most staff would be prepared to acknowledge".*

There is, therefore, a pressing need to explore the field of the assessment under every day classroom conditions in Greece.

1.1 Assessment

Assessment plays an important part in the learning process having both formative and summative aspects. Formative assessments have the purpose to evaluate students' performance on tasks or assignments that are primarily planned as an integral part of a learning experience. They function as a diagnostic tool for both teachers and students. Thus, teachers may appropriately understand the individual needs of their students and students can determine their areas of strengths and weakness. Summative assessments report progress for certification, for monitoring and accountability.

Assessment can take many forms, and ideally it would seem that test performance is unrelated to the mode in which a test is administered. However, can this statement be true in a real situation? Moreover evidence from research shows the effects of assessment task format on student achievement (e.g. Caygill and Eley, 2001). Research into different assessment formats showed that, if the same area of learning is assessed by two different methods of assessment, the correlations between methods range from 0.4 to 0.8 (Johnstone and Ambusaidi, 2001; Friel and Johnstone, 1978a; Badger, 1990; Yuh-Yin, 2000). The correlations between the two types of formats often are only moderately high. This suggests that the best student found by one method is not necessarily the best student identified by another method (Johnstone and Ambusaidi, 2001). The reasons why the good students do not come first in all the different formats of assessment is something that needs to be explored. Hence, the question which arises is: does a particular assessment method seem to favour and fit particular individuals better?

As Johnstone (2003) articulated *"in recent years there is a temptation to adopt objective testing to cope with the rise in student population"*. However, there is a problem, because *"to conduct all assessment by this method is not advisable. The* *most intellectually mature students generally hate objective testing because they need room to expand and show their independence of thought"* (Johnstone, 2003). It is certain that no one method of assessment is adequate for testing a course. A battery of test methods is required to allow for a fair measure of our students' attainments (Balla and Boyle, 1994) and *"to cater for the range of student abilities, of testable objectives and student maturity"* (Johnstone, 2003). Indeed, Race (2003) argue *"that the greater the diversity in the methods of assessment, the fairer assessment is to students"*. Each one of the formats of assessment can be claimed to disadvantage those students who do not give of their best in the particular circumstances in which it is used. Therefore, diversifying assessment so that students experience a range of assessment methods balances out the situation, and increases the chance that they will be able to demonstrate their best performance in at least some of the formats. It is time for taking a careful look at the strengths and weaknesses of all kinds of assessment and trying to match them to the different kinds of objectives of a course (Gibbs, 1995) as well as to individuals. A sound starting point is learning theories.

1.2 Learning Theories and their importance for Assessment Practice

Educational psychology's conception of learning has progressed during the 20th century from objective theory of learning to constructivism, and to cognitive approaches. Objective theory supports the notion that knowledge exists independently of the knower and understanding is coming to know that which already exists (Biggs, 1996). An *objective* theory of learning is very much opposite to a *constructivism* theory of learning. In this theory, emphasis is placed on the learners' personal construction of knowledge and the conceptions they develop about natural phenomena. According to constructivism every person constructs the world by different ways and tests out this construction against experience (Bodner, 1986). Cognitive approaches look at how we derive information from the environment. They investigate how we perceive, organise, store, retrieve, and use information. They ask which are the criteria which drive us to select and influence our attention and what cognitive processes make us different.

Much of the teaching, learning and assessment practice of chemistry in Greece is based on the objective theory of learning. The objective assessment policy is to *"use* *of assessment data to name, to compare and to judge"* (Broadfoot and Black, 2004). However,

> *"the worldwide tendency for more young people to stay on longer in formal education that now increasingly includes higher education, coupled with a growing discourse of 'lifelong learning', has helped to shift attention towards how best to support students' learning, rather than to judge"* (Broadfoot and Black, 2004).

This new assessment policy requires the acceptance of a new *'paradigm'* to be extended by the practices of the main prevailing objective assessment policy (Kuhn, 1962).

In shifting to a new paradigm of assessment, cognitive factors should be brought into assessment practice. Such factors are students' cognitive characteristics and student's intellectual development which Perry (1970) refers to as 'positions'. While cognitive approaches are concerned with how information is processed in human beings, Perry examines changes in students' perceptions as they progress through a series of nine developmental stages in their academic years.

Individuals have different ways of collecting and organising information depending upon what they already know, what their expectations are, and what their cognitive structure is. Cognitive styles of individuals have a significant effect on their performance (see chapter 3) and there is some evidence in the literature that the type of assessment techniques used may favour a particular kind of cognitive style (Bahar and Hansell, 2000)

Perry's (1970) work was developed through interviews with students at Harvard and Radcliffe. Perry worked on students' perceptions of the nature of knowledge, their preferences towards assessment, the role of learners and teachers, and how their perceptions change as they go from one year to another. He created a scheme

> *"which represents a continuum that describes the steps by which students move from a simplistic, categorical view of the world to a realization of the contingent nature of knowledge and values to the formation and affirmation of their own commitments"* (Brooks, 1998).

Students/pupils performances in different format exams are highly correlated, not only to cognitive factors, but also to students' perceptions and attitudes towards learning (e.g. Struyven *et al.*, 2002). Different types of assessment seem to encourage different approaches to learning and vice versa. Thus, in effective teaching and learning, all aspects of a course must convey the same message to pupils regarding what will be rewarded through assignments and examinations (Entwistle and Tait, 1995).

1.3 Greek Education System

Because this study is mainly conducted in Greece, it was thought that it might be useful for the reader, in order to understand better the design of the study and pupils' responses, to have some information about how the Greek education system functions.

In the Greek education system, there are 9 years of compulsory education: six years primary education (age 6-12), and three years lower secondary education (Gymnasio age 12-15). After that there are three years of upper secondary education (Lykeio age 15-18). There is no national examination for entering the upper secondary education and the majority of the pupils attend upper secondary education irrespective of their ability and acquired knowledge. The upper secondary school year has two terms which are four months in length. At the end of each term the students is assessed in formal exams in the school and the grades are provided to the parents. In the second and third year of Lykeio the pupils participate in national examinations in 9 subjects. These 9 subjects consist of main core educational subjects, and 3 subjects of interest known as 'direction subjects'. There are three directions of studies in the second and third year of Lykeio: 'science direction', 'theoretical direction' (e.g. history, classical Greek language, Latin, law), and 'technological direction'. Entering higher education depends on the marks in the 9 subjects. The national examinations are very difficult and there is very strong competition since there is a tradition in every Greek family for their child to attend higher education (irrespective if he/she is capable of that). According to European Union research on the educational level of European countries, Greece has the third place in percentage terms of students attending higher education (Christou, 2001).

Because of the very strong competition in the national examinations, most of the students take support classes in preparatory private institutes (frontistirio) or private lessons at home. Pupils take these afternoon classes very seriously because they prepare them to pass the national examinations. They teach them to the tests and the way to succeed in examinations. Thus, the last three years of high school are no longer functioning as an autonomous higher level of general education. The actual knowledge and the intellectual development of the teenagers are of minor importance. What counts the most is a standardised and unfinished knowledge, a preserved education which aims only to the pursuit of the grades at the final examinations (Mpampiniotis, 2000).

The curriculum and the teaching materials are introduced by the Greek Pedagogic Institute and the Ministry of Education and Religious Affairs, and they are the same for all the schools in the country. It is a teacher centred system and learning is based on verbatim recall of facts and knowledge. There is no active learning approach and no group work. Pupils try to learn by heart from the textbook as many things as possible, so they can write them down as accurately as they can. There is no tradition of solving problems and there are always exercises and problems of algorithmic types. Only in the last five years has the ministry of education tried to create a modern classroom environment by introducing computer laboratories and science laboratories. However, teachers lack teacher training when they enter the classroom, and the majority of them make little or no effective use of science laboratories. Schools most of the time do not have reading rooms and libraries. The average number of pupils in the class is thirty, and this causes many problems in the teaching activity.

1.4 Study Overview

In considering the problems related to different formats of assessment, cognitive styles of the pupils, and pupils intellectual development, this study seeks to explore first what are the relationships between the results of various formats of classroom assessment, and second to find out if there are links between (a) pupils' cognitive characteristics and (b) intellectual position according to Perry's scheme and pupils performance in different formats of question in classroom conditions. In other words, the aim of this study is to investigate if different formats of assessment suit pupils better according to their cognitive style, personal preferences, and intellectual development.

The study mainly was conducted in Greece in two stages. In the first stage, a pilot study was conducted with the intention to measure the correlation of different formats of assessment (mainly multiple-choice, structural communication grid and short answer). In the second stage, a larger scale study was designed with the purpose of engaging a number of pupils of different schools and to measure: (a) pupils' cognitive characteristics in two cognitive tests, (b) pupils' perceptions according to Perry scheme and (c) pupils' performance in different paper-and-pencil formats of assessment in every day classroom conditions. Each chemistry test consisted of various formats of paper-and-pencil assessment covering five different topics.

Because teaching, learning and assessment are inseparable in the educational practice, when educators make decisions about the assessment practice, they should have in mind the learning models which underpin and support their assessment practice. Thus, this study seeks to look closely at the following areas:

- Chapter two reviews learning models and their importance for educational assessment.
- Chapter three explores what is cognitive style and puts a special emphasis on field dependent vs. field independent and convergent vs. divergent styles.
- Chapter four looks systematically at some forms of assessment, listing some advantages and drawbacks.
- Chapter five examines different approaches affecting learning derived from Perry's work.
- Chapter six shows the result of a pilot study that was designed to test the correlation of different formats of assessment.
- Chapter seven describes the methodology of the main project; the measuring instruments that have been used in this study and the findings of the two cognitive tests applied to the Greek pupils.
- Chapters eight and nine explore the connection of pupils' cognitive characteristics and pupils' achievement on different task formats.
- Chapter ten seeks to find out if pupils' perceptions identified in the Perry questionnaire are related to their performance in different formats of assessment.
- Finally chapter eleven draws attention to the conclusions and implications to be drawn from the whole study.

Chapter Two

Learning Theories

The development of a human being from a highly dependent, relatively non-capable, newborn infant into a marvellously adaptable, competently functioning person within a complex society is one of the most intriguing things to ponder. One part of the answer to this question lies in an understanding of the processes of growth and development, characteristic properties shared by all living things, and the other part lies in learning. Learning is a change in human disposition or capability, which can be retained, and which is not simply ascribable to the process of growth (Gagné, 1970). Thus, learning may be defined as a relatively permanent change in behaviour that results from practice; behaviour changes that are due to maturation (rather than practice), or to temporary conditions of the organism (such as fatigue or drug-induced states) are not included (Atkinson *et al.*, 1993).

There have been many attempts to describe the human learning process. Among the most important for teachers are those that look at the growth of the human mind and provide clear and explicit instructions, recommendations and models. Educational psychology's conception of learning has progressed during the 20th century from learning-as-response-strengthening in the first half of the century to learning-as-knowledge-acquisition during the information processing revolution of the 1960s and 1970s to learning-as-knowledge-construction during the constructivist revolution of the 1980s and 1990s (Atkinson *et al.*, 1993). Revolution in scientific theories happens in the society when '*anomalies*' and '*crises*' in the established research tradition necessitate the acceptance of a new '*paradigm*' to be extended by the practices of the prevailing normal science (Kuhn, 1962).

In the following pages is a brief look at some of those theories which are considered to be the prominent theories in understanding learning during the 20th century: the behaviourism theory; cognitive developmental theory; constructivism theory; and information processing. A special emphasis is put on the last one, as it is the main basis underpinning this project.

2.1 Behaviourist Approach

Behaviourism concentrates on observable behaviour and behaviourism-learning theory deals with the relationship between stimuli (events in the environment) and subsequent responses made by an individual. Behaviourists, led by Watson, Pavlov and Skinner, started to study the human learning process based on the study how lower organisms learn an association between stimuli or an association between a stimulus and a response (Atkinson *et al.*, 1993). Thus, human learning was first seen as response acquisition (Smith *et al.*, 1998).

Behaviourism is associated today with the name of B.F. Skinner. Skinner (1938) was influenced by Pavlov's Russian neuroscience tradition and Darwin's evolutionary theory. Russian neuroscience materialised the mind into the brain and offered a reflex-based account of the latter. From Darwin's evolutionary account of the continuity of species and proposed natural selection as the explanatory process emerged comparative psychology and the psychology of adaptation. The former inquired into the evolutionary basis of mind and behaviour with increasingly objective methods, while the latter sought mental and behavioural processes (e.g. association) by studying nonhuman species in laboratory settings (e.g. rats in mazes). In this view, mind and behaviour were acts-in-context, historically dependent, and so too was science (Morris, 2003).

During the same period, Watson (1913) challenged the concept of mind and coined the term behaviourism. Watson's work was based on the experiments of Ivan Pavlov (1849-1936), who had studied animals' responses to conditioning. In Pavlov's best-known experiment, he rang a bell as he fed some dogs several meals. Each time the dogs heard the bell they knew that a meal was coming, and they would begin to salivate. Pavlov then rang the bell without bringing food, but the dogs still salivated. They had been 'conditioned' to salivate at the sound of a bell. Pavlov believed, as Watson was later to emphasize, that humans react to stimuli in the same way. To use Morris (2003) words

> *"Watson founded the system: Psychology as the behaviourist views it is a purely objective experimental branch of natural science".*

Watson first claimed that psychology was not concerned with the mind or with human consciousness. Instead, psychology would be concerned only with behaviour. In this way, men could be studied objectively, like rats and apes. Skinner was one of his followers (*ibid*).

Skinner (1938) studied *operant conditioning* in learning. *Operant conditioning* states that environmental contingencies or the environment's 'reaction' to an individual's behaviour controls that individual's behaviour. The study of *operant conditioning* began at the turn of the 20th century with a series of experiments by E. L. Thorndike (1898), who tried to show that learning in animals is similar to learning in humans. He supported the idea that, when an animal is engaged in *trial-and-error* behaviour as a reward immediately follows on of this behaviour, the learning of the action is strengthened. Thorndike referred to this strengthening as the *law of effect* (Atkinson *et al.*, 1993). Skinner study of *operant conditioning* was simpler than Thorndike's and has been widely accepted. He stated that actions that are followed by reinforcing consequences are more likely to re-occur, and that actions that are followed by unpleasant or punishing consequences are less likely to re-occur (Bentham, 2002). In Skinner's *operant conditioning* the child operates on the environment but is only rewarded by the adult if he makes the response the adult desires. The child then goes on to step two and passes this only when he has given 'the right answer'. This process goes on until the child has achieved the final goal the teacher/psychologist has decided in advance. This constitutes a linear programme for material devised by expert teachers and curriculum planners.

Skinner, influenced by Pavlov's dictum, *"control the environment and you will see order in behaviour"* (Morris, 2003), invented and refined methods for controlling his independent and dependent variables (the 'Skinner box'), measuring behaviour in real time and experimentally analysing the behaviour of individual organisms. He used behaviour analysis to built teaching machines that were devices for delivering programmed instruction methods (Morris, 2003). He sought to introduce information in smaller units, ensure mastery of each unit, and reinforce success more effectively than teachers did.

Skinner made a strong impact on both psychology and education. The principles behaviourists outlined can be applied to learn emotional reactions and learned emotional reactions are central to the educational process. A key point is that learning any skill involves many cognitive processes. It is essential that learning be a positive experience, as unpleasant emotional associations will interfere with the learning process (Bentham, 2002).

However, Skinner's behaviourism had limits since he failed to give any explanation of mental processes. He believed that the learner's mind was a '*black box*' and that it was impossible to see what happens inside. He believed that it was unnecessary and unscientific to invoke inner mechanisms to explain behaviour and he preferred to keep explanatory concepts to a minimum and simply report data and relationships (Asher, 2003). Skinner's ideas are most suitable for linear subjects, such as computing, where tackling one topic depends on the successful achievement of the previous one. Behaviourist ideas remain influential in the methods of assessment called multiple-choice testing.

The Behaviourist approach is the underpinning basis of objective testing. They assess students' observable behaviours that can be reliably recorded as either present or absent (Kyoko, 1997). Objective testing *"policy 'objectively' seeks to identify relative levels of student performance as the basis for educational selection"* (Broadfoot and Black, 2004). It has *"elevated quantitative data as the principal mechanism for delivering transparency, accountability and predictability"* (Broadfoot and Black, 2004). The Behaviourist approach and its implications for objective testing will be discussed in Chapter four.

In contrast to the emphasis of American psychologists on learning as an overt stimuli-responses (S-R) process, European researchers tended to emphasise covert processes such as perception, cognition, and language. Gestalt psychologists viewed learning as a perceptual reaction to a complex pattern or organisation. Their name stemmed from an interest in learners' holistic perceptions of meaning or 'Gestalts'. Among the most prominent of these German theorists were Kohler (1925), Wertheimer (1923), and Koffka (1924). Gestalt psychologists not only attempted to explain how humans perceived the world but also how humans discovered new things in problem solving situations (Asher, 2003). Gestalt researchers sought to identify the principles by which humans perceive simple patterns in complex, changing, or ambiguous stimuli. For these psychologists, learning was a matter of seeing underlying relationships in a problem to be solved. When a pattern is recognised, they believed that learning occurred suddenly rather than gradually as most American S-R psychologists had envisioned. Gestalt theorists were also called 'field theorists' because of their emphasis on the importance of perceptual field in making figure-group recognitions (Asher, 2003). Gestalt theory had an impact on cognitive theories, which in contrast to behaviourism, involve the study of mental processes rather than actual behaviour (Miller, 1993). Cognitive theories try to understand basic learning processes and become more concerned with what is unobservable - what is going on inside the brain and the factors which affect them and why individuals are different in their capability to learn.

Cognitive psychologists developed models to describe the cognitive activities. The complexity of human thinking, memory, problem solving, decision making, and creativity are all cognitive activities. They saw learners as active processors of information, a metaphor borrowed from the computer world. The cognitive theories became broader in the 1970s and 1980s, when many educational psychologists began to do research on how learning occurs in an actual classroom setting. Another factor involved in the accelerated rise of cognitive psychology was the technological advance of computer science. Among the cognitive theories the most significant ones are cognitive developmental theory, constructivism theories, and information processing theories.

2.2 Piaget and Cognitive Developmental Psychology

Jean Piaget (1896-1980) is considered to be one of the most influential thinkers in twentieth century developmental psychology. His approach was based on an evolutionary epistemology. Piaget recognised that any decent learning theory involves epistemological considerations and he called his own research program '*Genetic Epistemology*' (Piaget, 1972). At an early age, he studied zoology and he developed a strong interest in biology, and his ontological studies of various creatures had a lasting influence on his thinking. During his adolescent years he was interested in philosophy, in particular the problems of epistemology: how do we acquire knowledge. His ideas came from case studies of his own children (Sutherland, 1992). Piaget's life was devoted to the search for the mechanism of biological adaptation on the one hand, and the analysis of logical thought on the other. Adaptation is the change that happens to an organism in response to the environment. Adaptation plays a central role in Piaget's theory. Perhaps the most basic of all Piaget's ideas, as von Glasersfeld (1989) noted, is that knowledge does not attempt to produce a copy of reality but, instead, serves the purposes of adaptation.

He was asking children for their ideas about natural events and listening to what they answered with great attention. He believed that the highest form of human adaptation is cognition.

Piaget's question was:

- how do children manage to adapt to their environment? and
- how can we classify and order child development?

For Piaget (Piaget, 1952; Piaget and Inhelder 1969), the development of human intellect proceeds through adaptation and organization. In order to explain children's adaptation to the environment, he used features of biological adaptation and created his own distinctive terminology as explained below:

- **Schemas**, according to Piaget, are the simplest organised patterns or units of action or thought that we construct to make sense of our interactions with the world. Schemas can be likened to files in which we store information. Piaget believed that thought is internalised action. Individuals interact with and explore the environment around them, and it is this physical interaction that becomes internalised to create thought.

- **Adaptation** comprises **assimilation** and **accommodation**. Assimilation, put simply, is taking in new information and trying to fit this information into existing schemas, or responding to the environment in terms of previously learned patterns of behaviour or schemas. Accommodation is changing or modifying existing schemas to fit the new information, or responding to the environment in a new manner, as previously learned patterns of behaviour or schemas are not sufficient.

- When the individual's perception of the world fits into existing schemas then there is **equilibrium** or balance. When existing schemas cannot deal with new experience there is **dis-equilibrium.**

As Piaget identified knowledge with action, he considered that mental development organises these schemes in more complex and integrated ways to produce the adult mind. In his attempt to answer the question how to classify and order child development, he created the stages development theory. It is a description of the series of stages through which children progress and develop. He claimed that children passed through a series of stages of thinking that were qualitatively different from each other. In the first quarter of this century the prevailing view of children's cognitive activity was the same as adult's cognitive activity, only less efficient. Piaget's notion that a baby thought and learnt in a radically different way from an adult was a revolutionary one.

Piaget (1961) supported the principle that development takes place gradually and everyone passes through an invariant sequence of four qualitatively distinct stages. Atkinson *et al.* (1993) listed these cognitive stages as shown below in table 2.1.

Table 2.1: Piaget's cognitive stages

Stages of intellectual development	Description
Sensorimotor (birth to 2 years)	• Differentiates self from objects. • Recognises self as agent of action and begins to act intentionally. • Achieves object performance, realising that things exist even when no longer present to the senses.
Pre-operational (2-7 years)	• Learns to use language and to represent objects by images and words. • Thinking is still egocentric with difficulty in seeing the viewpoint of others. • Classifies objects by a single feature e.g. colour.
Concrete operational (7-11 years)	• Can think logically about objects and events. • Achieves conservation of number (age 6), mass (age 7) and weight (age 9). • Can classify objects according to several features and can order them in series along a single dimension.
Formal operational (11 years on)	• Can think logically about abstract proportions. • Can test hypothesis systematically. • Becomes concerned with the hypothetical, the future, and ideological problems.

Source: (Atkinson *et al.*, 1993)

2.2.1 Evaluation of Piagetian Theory

There are several criticisms that can be made of Piaget's theory. Among the standard criticisms of Piaget's work are as follows:

- He did not use sufficiently large samples and he did not pay enough attention to statistical significance (Ausubel *et al.*, 1978).
- The boundaries of his stage development theory are too rigid. Sutherland (1992) summarised criticisms of aspects of Piaget's stage theory on sensorimotor period, on concrete operation period and Piaget's clinical interview for its lack of scientific rigour by different scholars. Donaldson (1978) was strongly critical of the way in which Piaget asked children questions in experimental situations. She did not accept stage theory and refuted the deterministic nature of the implications of Piaget's findings for teachers.
- He underestimated the significant role of social interaction and language in child development. He believed that development precedes learning. In contrast, Vygotsky (1986) believed the opposite. In particular, on the development of speech, Piaget argued that the egocentric speech of children goes away with maturity, when it is transformed into social speech. On the contrary, for Vygotsky the child's mind is inherently social in nature and so speech moves from communicative social to inner egocentric. Therefore, since the development of thought follows that of speech, Vygotsky claimed that thought develops from society to the individual and not the other way. Vygotsky emphasised the importance of the socio-cultural context of learning and as Bruner (1996) said "The child's experience and environment are far more powerful influence on his cognitive development than Piaget allowed".
- For teachers, one of Piaget's greatest weaknesses was a failure to take individual differences into account. By this is meant individual differences in personality, gender, intelligence and other factors that affect the ability to progress cognitively (Sutherland, 1992).

In summary, Piaget was a psychologist who established the basis for modern educational thought and he had a profound impact on educational practice and research (Miller, 1993; Donaldson, 1978). Perhaps the greatest tribute to Piaget's work is the amount of research it has generated. It is this research that has led not only to criticisms of Piaget's original theory but also to a greater understanding of cognitive development (Bentham, 2002). He is important to the current work because his ideas are used by constructivists and educators to create specific principles for teaching.

2.3 Constructivism

Constructivism constitutes a very important, although often contested, practical and theoretical perspective in current education research. It had considerable influence in science education research through the 1980s and 1990s and it was inspired by Piaget and Ausubel's work (Novak, 1978). It also was related to epistemonological constructivism whereas epistemonological constructivism believes that knowledge and discovery is a logical process where the observer looks for something with a definite expectation of what to find. The observers put properties to phenomena when they describe their observations.

> *"In the question whether we are discoverers (in which case, we are looking as through a peephole upon an unfolding universe) or inventors (in which case we see ourselves as participants in a conspiracy for which we are continually inventing the customs rules and regulations) constructivism opts for the latter position"* (Larochelle *et al.*, 1998).

Philosophical constructivism tradition argues that our beliefs and perceptions of the world are purely human constructs and fall into the camp of philosophical anti-realism (Boudourides, 1998). The roots of philosophical constructivism, going back to Aristotle and the ancient Greek instrumental philosophy, could be found in Kant's philosophy and Berkeley's philosophy of science (Boudourides, 1998).

Various streams of constructivism have been identified in the literature in studies of education, society, science and technology (Boudourides, 1998). In education, there are different schools of constructivism each with different implications for educational practice (Biggs, 1996). Biggs brought some order by suggesting that

> *"cognitive constructivism refers to what goes on in individual minds, with socio-cultural and linguistic versions of constructivism referring more to the contexts and ways in which minds construct knowledge".*

The following two varieties of constructivism in education, which emerged during the early 1980s, will be discussed: personal constructivism, and social constructivism theory.

The theory of personal constructivism: A first 'mild' version of constructivism originating in the work of Piaget. Piaget held that knowledge was actively constructed by the learner and not passively transmitted by the educator. According to constructivism knowledge cannot be transmitted; it cannot be neutral either. *"Instead, it is constructed in the mind of the learner"* (Bodner, 1986). Children's everyday knowledge of natural phenomena is viewed as a coherent framework of ideas based on a common sense interpretation of their experience of living in the world. In this theory, emphasis is placed on the learners' personal construction of knowledge and the conceptions they develop about natural phenomena. Every person constructs the world by different ways and tests out this construction against experience. The interaction of learners' cognitive structures with physical events and phenomena is important to this approach (Bodner, 1986).

'Naïve' constructivism very often confuses a theory of learning with a way of classifying teaching methods (group work leads to constructive learning, but lecturing only involves transmission). Therefore Ernst von Glaserfeld, (1992) created the idea of a 'radical' version of constructivism, both as a theory of knowledge and as a guide for science education. Asked about the differences in the various versions of constructivism he said:

> *"A few years ago when the term constructivism became fashionable and was adopted by people who had no intention of changing their epistemological orientation, I introduced the term trivial constructivism. My intent was to distinguish this fashion from the 'radical' movement that broke with the tradition of cognitive representation"* (von Glaserfeld, 1992).

Von Glasersfeld (1989) stated:

> *"Verbally explaining a problem does not lead to understanding, unless the concepts the listener has associated with the linguistic components of the explanation are compatible with those the explainer has in mind. Hence it is essential that the teacher have an adequate model of the conceptual network within which the student assimilates what he or she is being told. Without such a model as basis, teaching is likely to remain a hit-or-miss affair".*

The social construction of knowledge: The social constructivist version of Vygotsky is an effort to challenge Piaget's ideas (Vygotsky, 1986, 1978). He developed a fully cultural psychology stressing the primary role of communication and social life in meaning formation and cognition. In this theory, emphasis is given to the interaction of the language, society, and the learner. Learning is viewed as more a cognitive structure used to interpret nature rather than physical events and phenomena themselves. In this approach the social context in which learning takes places is crucial.

> *"Cross-linguistic research showed that different meanings in different languages accounted for many of the common school misconceptions in those countries"* (Solomon, 1994).

Stressing the role of social interaction, Vygotsky asserted the significance of dialogue as a tool through which individuals collectively, or individually, could negotiate conceptual change (Boudourides, 1998). In his experiments Vygotsky studied the difference between the child's reasoning when working independently contrasted with when working with an adult. He believed that the teacher's role is to extend and challenge the child to go beyond where he would otherwise have been. He devised the notion of the '*Zone of Proximal Development*' to reflect on the potential of this deference. As illustrated in figure 2.1 a child is at present at level X. However she/he has the potential (innately/environmentally derived) to reach level X+1. The area in between is the zone of proximal development. It is the teacher's duty to try to achieve X+1 for each pupil in his/her class (Sutherland, 1992).

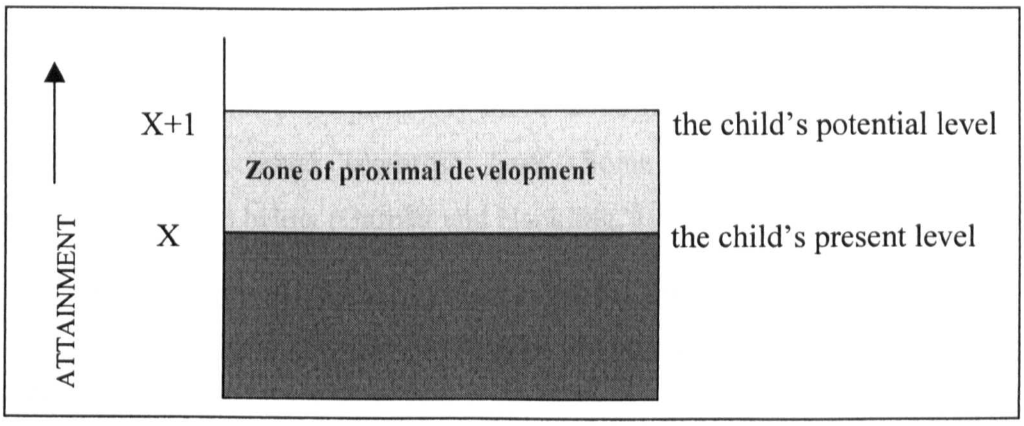


Figure 2.1: Vygotsky's zone of proximal development

Source: (Sutherland, 1992)

Children of approximately the same ability may differ in the areas of their zones (or sizes) of proximal development. A child with a large zone will have a much greater capacity to be helped by teachers than a child with a narrow zone. However, the teacher still has a duty to help the latter child (Sutherland, 1992).

Through this notion, Vygotsky reached to the concept of a learning environment consisting not only of children and learning material and processes, but children, learning material and interactive communication. Vygotsky's findings suggest learning environments should involve guided interaction, permitting children to reflect on inconsistency and to change their conceptions not only through Piaget's intelligent action but also through speech and communication. The children's verbal and conceptual maturation can be achieved by exposure to increasingly more expert vocabularies through social interaction (Boudourides, 1998).

But whatever particular constructivist theories may variously emphasize, a consensus would be that learners arrive at meaning by actively selecting, and cumulatively constructing, their knowledge, through both individual and social activity (Biggs, 1996).

During 1978, considerable research was carried out within the paradigm of constructivism. In this research there was much new terminology and no universal agreement on their meanings. There are numerous examples of common misconceptions (Lefrançois, 2000; Nakhleh, 1992). Of course, as Solomon (1994) stated, phenomena like children's misconceptions that constructivist researchers have described, were familiar and well known to educators, although unremarkable. Thus, the vocabulary was picked up by educators and it helped constructivism grow. Children's ideas were not considered any more to be necessarily wrong but merely different from the accepted scientific ones. Some of the major effects of constructivism are listed below (Garnett and Hackling, 1995; Solomon, 1994).

- ✓ It has accelerated the elicitation of pupils' points of view.
- ✓ It has created a new language to describe the association between metaphors of alternative ideas and meaning of pupils' concepts.
- ✓ It has helped educators to recognise that alternative conceptions can influence subsequent learning and these conceptions might be very difficult to change. Alternative conceptions are extensive and tenacious.
- ✓ It has revealed that some of these conceptions might result from pedagogical practices and we might reduce them with carefully constructed instruction.

However, it was argued by Millar (1989) and Jenkins (2000) that constructivism-learning theory requires a particular model of instruction or demands a progressive pedagogy. Of course, several writers have proposed instructional strategies based on constructivism ideas, namely: greater emphasis on discourse relating to students concepts; discussion in the classroom; exchange of ideas; demonstration or experience with conflict situation; increasing the active involvement of students. Some suggested the use of modern audiovisual technologies and computer graphics can overcome difficulties with abstract, unobservable concepts (Garnett and Hackling, 1995).

Nevertheless, Jenkins (2000) argued that none of those strategies and techniques are 'unique' to constructivism and stated that

> *"selecting a strategy that is more, rather than less, likely to interest students and promote their learning is central to a teacher's professional competence".*

In addition, Solomon (1994) very poetically said:

> *"what constructivism has not described is the process of learning as arrival on a foreign shore, or as struggling with conversation in an unknown language".*

Therefore, the question that arises is: 'is the evidence which we have from the constructivism framework of pupils ideas powerful enough to affect directly the teaching process?' Of course, it might be always a debate of how and to what extent the outcomes of research can affect the classroom science. However, to describe the problem offers few solutions and does not generate a testable hypothesis.

Overall, constructivism has succeeded to have only a peripheral impact on the theory and practice of scientific education, although undoubtedly it has given a challenge to reflect on a relativist approach to the teaching and learning processes. Some of these reflections were rather critical against it (Suchting, 1992; Matthews, 1993; Phillips, 1995; Osborne, 1996) and some have urged caution in its adoption (Millar, 1989; Solomon, 1994). Although many would disagree with the constructivist approach, few would silence the psychological influence on education brought about by the constructivist view of learning. In fact it is as *"a psychological theory about how beliefs are developed"* (Matthews, 1998), where the original core of constructivism might be found.

The importance of constructivism ideas in assessment practice has been stressed by many educators in recent years (e.g. Biggs, 1996; Boud, 2004, Osborne, 2004 Gipps, 1994). According to constructivism, emphasis is placed upon the learner' mind and assessment should enhance learner ability in understanding, comparing interconnecting concepts instead of memorizing facts. Thus, constructivism policy in assessment leads to collaborative, dynamic performance-based assessment and open-ended problem solving assessment.

2.4 Cognitive Theories and Information Processing Models

Information Processing models develop elements of cognitive development theory (sequences, activity) and social constructivist theory (experience) but emphasise cognitive strategies rather than structures. They are related to cognitive theories which emphasise how information is processed. Cognitive approaches are concerned with the things that happen inside humans' heads as they learn. They take the perspective that students actively process information and learning takes place through the efforts of the student as they organise, store and then find relationships between information, linking new to old knowledge, schema and scripts. Sutherland (1992) stated that

> *"The Information Processing approach differs from the Piagetian one in focusing on a single act of learning, taking place at one particular time. Information Processing puts its emphasis on giving a precise, comprehensive, quantitative account of a single learning experience".*

It is concerned with the process of learning rather than with the nature of the learner. However, it does provide an explanation of why young children are poorer than adults at single-focus tasks and complex multifocus tasks. According to the Information Processing approach, the young child has a limited capacity for memorising, and this capacity is smaller than the average adult capacity (Sutherland, 1992).

Ausubel, Bruner and Gagné were among the most influential in the discussion on how people learn and their ideas have contributed to the cognitive theories although they take different perspectives (NSW HSC ONLINE, 2004). Ausubel's advanced organiser is a concept that considers the impact of prior learning. This differs from the behaviourists who do not consider the importance of this factor. Bruner's work on categorisation or the forming of concepts provides a possible set of answers to how the learner derives information from the environment. Gagné looks at the events of learning and instruction as a series of phases, using the cognitive steps of coding, storing, retrieving and transferring information. The three researchers Ausubel, Bruner and Gagné, although they have adopted quite different theoretical positions, share the following features in common (NSW HSC ONLINE, 2004).

- they all put forward their ideas initially in the 1960s. At that time all three were established in their careers and recognised as authorities in their own right.
- all three attempted to define cognitive theories of instruction.

In the follow paragraphs, the key concepts in Ausubel's and Gagné's theory of learning are briefly discussed because of their importance implications for the assessment practice.

2.6 Ausubel

One of the main researchers who made use of the constructivist movement was David Ausubel. Ausubel (1968) advocated the case that the most important thing for teachers to know at the outset of the teaching is what each pupil knows already. However, he held a different approach of how the teaching material should be presented in the classroom or the self-study than Bruner. He argued that pupils need guidance if they are to learn effectively and he advocated the direct instruction learning approach.

Ausubel (1968) focussed on both the presentational methods of teaching and the acquisition of knowledge. He made a major contribution to learning and he studied and described the conditions that lead to the 'meaningful learning'. In some way he tried to find 'the laws of meaningful classroom learning'.

Meaningful learning, according to Ausubel, happens when the new concept can be related to the pre existing concept in the learners' cognitive structure (for example, already existing relevant aspect of knowledge of an image, an already meaningful symbol, a known concept or a proposition). The new concept interacts on a nonarbitrary (in the sense of plausibly, sensibly and nonrandomly), and substantive (nonverbatimly) basis with established ideas in cognitive structure. Thus, meaning derives directly from associations that exist among ideas, events, or objects. According to Ausubel, meaningful learning presupposes:

1. *That the learning material itself can be nonarbitrarily (plausibly, sensibly, and nonrandomly) and substantively (nonverbatimly) related to any appropriate cognitive structure (possesses "logical meaning").*
2. *That the particular learner's cognitive structure contains relevant anchoring idea(s) to which the new material can be related.*
3. *The interaction between potentially new meanings and relevant ideas in the learner's cognitive structure gives rise to actual or psychological meanings. Because each learner's cognitive structure is unique, all acquired new meanings are perforce themselves unique.*

Source: (Ausubel *et al.*, 1978)

In contrast, rote learning results in arbitrary verbatim incorporation of new knowledge into cognitive structure. It occurs when no relevant concepts are accessible in the learner's cognitive structure. The distinction is not a simple dichotomy. 'Rote-meaningful' learning is a continuum, which depends on the learner and varies from learner to learner. The idiosyncrasy of the cognitive structure of the learner interacts in a different degree from topic to topic in the 'rote-meaningful' continuum. The nature of the learner's existing knowledge and the way that new knowledge is associated and linked to existing knowledge involves subsumption.

As the new knowledge is subsumed into the existing knowledge, it interacts and modifies it and the new whole matrix now becomes more elaborate and new linkages form between concepts. Ausubel called this process 'progressive differentiation'. In adult cognitive structures, the differentiation of concepts takes place in a more radical way than in children. In addition, these qualitative differences are not due to different stages of cognitive structure but rather due to the amount of knowledge an adult holds. Most adults' cognitive frameworks subsume much more elaborated and relevant concepts than most children's. Hence, Ausubel disagreed with Piaget's ideas. He did not relate learning to cognitive development over the age but saw

> *"rather the cognitive development manifested as a broadening array and elaboration of specific concepts"* (Novak, 1978).

The effectiveness of the Ausubel model may lie in one sentence:

> *The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly.*
>
> *Source: (Ausubel, 1968)*

Thus, meaning is never taught directly but constructed by the learners. As (Johnstone, 1987) suggested learners are not empty pots to be filled

> *"and information is not transmitted, but is reconstructed idiosyncratically by each student".*

2.7 Gagné

Robert Gagné built upon behaviourist and cognitive theories to recommend approaches to instruction. Much of Gagné's early experience as an instructional psychologist was spent tackling practical problems of training air force personnel. Gagné's research on simulators and other training devices in the Air Force Laboratories during the war led him to

> *"form an early information processing conception of human performance and influenced the later development of his (a) taxonomy of learning outcomes, (b) concept of learning hierarchies, and (c) related concepts of instructional events and conditions of learning"* (Ertmer *et al.*, 2003).

He emphasized the importance of articulating learning outcomes for instructional design as a basis for planning instruction, assessing performance, and conducting formative evaluation (Ertmer *et al.*, 2003).

In 1968, Gagné proposed the theory of cumulative learning. This theory was based on the premise that new learning depends primarily on combining previously acquired and recalled learned entities, as well as on their potentialities for transfer of learning. This theory was consistent with the notion of an intellectual skills hierarchy. The hierarchy indicated which types of skills were prerequisites for which other types of skills. This theory was in contrast to developmental theories of the time and particularly Piaget's theory of cognitive adaptation. Gagné's (1968) intellectual skills hierarchy were:

Perceptual discrimination:	A recognition that classes of things differ.
Concrete concepts learning:	An ability to classify things by their physical features alone.
Defined concepts learning:	An ability to classify things by their abstract features (perhaps also including physical features).
Rule using:	The ability to apply a simple procedure to solve a problem or to accomplish some task.
Higher-order rule:	In this, there is the ability to use complex procedures in order to solve a problem or accomplish some task.

During the 1970s and 1980s, Gagné's work increasingly reflected cognitive information processing theory as it was developing in psychology. He dealt particularly with problems in determining just what skills and knowledge are required for someone to be an effective performer at a given job (Gagné, 1977). He also identified five major categories of learning:

Verbal information:	The knowledge we store about all matters around us (essentially factual information);
Intellectual skills:	Enabling a human to understand his environment;
Cognitive strategies:	Referring to the strategy a person adopts to learn;
Motor skills:	The physical skills that are necessary to be learnt in life (like bicycle riding and computer skills);
Attitudes:	The kind of knowledge concerning individual reaction toward external items.

His notions of task analysis and the importance of the correct sequencing of instruction are followed by most mathematics teachers when designing their programmes. Gagné's approach is really that of an instructional designer. Gagné's theory of learning hierarchies could be said to be a teaching theory, which is easy to apply in some circumstances, but is not easily applied in other circumstances.

2.8 The Hypothetical Model of Human Memory

Cognitive psychology uses a metaphor borrowed from the branch of computer science concerned with artificial intelligence. Thus, according to cognitive models, the brain operates somewhat like a computer and it has input and output devices (the sensori-motor systems), various classes of storage, or memories. Information processing models tend to use computer analogues in describing learning. A variety of models have been proposed, with slight variations on the functions and the relationships between the different components of the human memory system. Bruning *et al.* (1995) presented a model that contains common features of the various models mentioned. This is referred to as the 'modal model' (see figure 2.2). According to Ashcraft (1994) the modal model of human mind memory is divided into three types of information storage:

1. *The sensory memory (or sensory registrar or perception filter).*
2. *The short-term memory (or working memory or working space memory.*
3. *The long-term memory.*

Source: (Ashcraft, 1994)

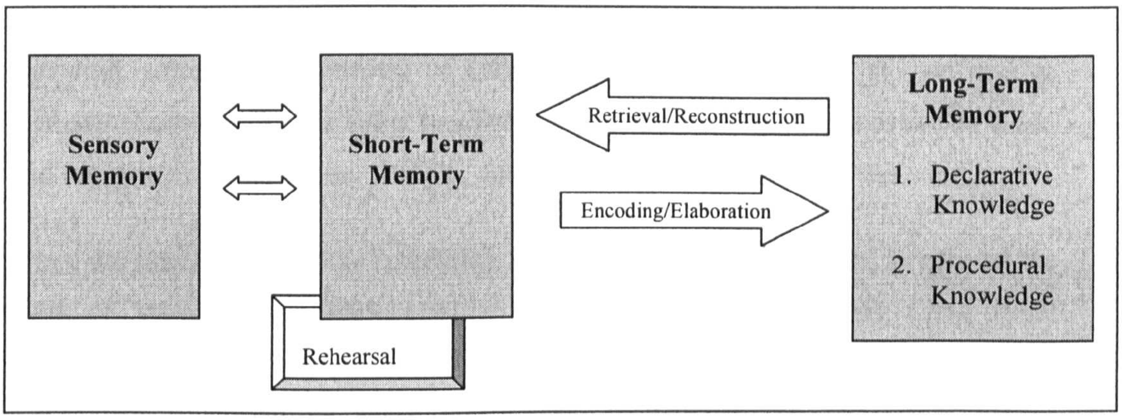


Figure 2.2: The Modal Model
Source: (Bruning *et al.*, 1995)

The differences between the three types of memory lie in the nature and extent of the processing that the information undergoes and in their capacity. It can be broken into three processing stages namely:

- Encoding stage,
- Storage stage, and
- Retrieval stage.

The encoding stage is when a physical input that corresponds to new information is transformed into the kind of code or representation that memory accepts, and then it is placed in memory. The storage stage is when the new information is maintained for some period of time and the retrieval stage is when the new information is recovered from storage. Theories of memory attribute forgetting to a failure at one or more of these stages (Atkinson *et al.*, 1993).

The following sections discusses mainly the information processing model developed by Johnstone (1993)

2.9 The Information Processing Model - A Model of Learning

The human mind is a meaning maker. From the first microsecond we see, hear, taste, or feel something, we start a process of deciding what it is, how it relates to what we already know, and whether it is important to keep in your mind or should be discarded (Slavin, 2003). One major emphasis of the cognitive approach deals with the process of knowing. It describes the process by which information is absorbed, and how teachers can take advantage of this process to help students retain critical information and skills. It is the cognitive theory of learning that describes the processing of encoding, storage, and retrieval of knowledge in the mind. After all, we owe to memory almost all that we either have or are. Our ideas and conceptions are its work, and our everyday perception, thought, and movement is derived from this source.

There are many Information Processing models in the literature based largely on the work of Atkinson and Siffrin (1971), for example, Ashcraft (1994); Child 1993; Johnstone, 1993. The model (figure 2.3) proposed by Johnstone (1993) is based on a mechanism suggested by many researchers. It includes the key characteristics emphasised by Ashcraft (1994) and it entails ideas of others theories such as Piaget's stage theory, Ausubel's importance of prior knowledge in meaningful learning, Gagné's learning hierarchy, Pascual-Leone's idea of limited space related to age.

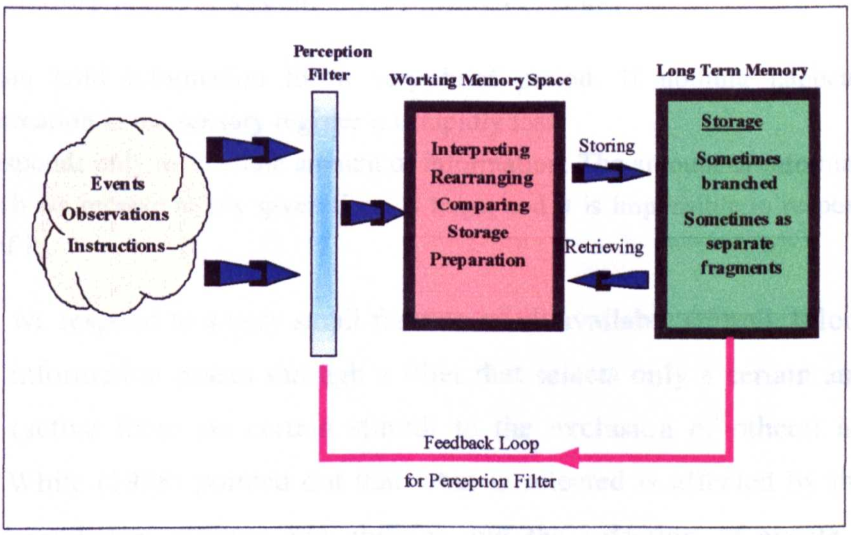


Figure 2.3: A Model of the Information Processing

Source: (Johnstone, 1993)

This model focuses on learning and the learner. It suggests a simplified mechanism of the learning process and enables us to understand the limitations of learning.

2.9.1 Sensory Memory-Perception Filter

The process by which we select information is referred to as perception. In figure 2.3 the sensory memory is called the perception filter. Our sensory memory consists of our sensory registers. Our sensory registers are linked to the five senses: sight, hearing, taste, touch, smell. They help us to contact the environment and to receive information from it. Research has focussed on the vision and hearing sensory registers. In the literature (Brunning *et al.*, 1995; Kellong, 1995; Bourne *et al.*, 1986), two types of sensory memory are described:

- The visual sensory memory; and
- The auditory sensory memory.

The visual sensory memory deals with information which can be seen and which stimulates the visual registers. The length of time information can be held in the visual registers is about one second after the stimulus is not longer physically available. The auditory sensory memory deals with auditory information which stimulates our auditory registers and can be held for about four seconds after the stimuli disappear. Thus, the sensory memory system is very limited because:

- ❖ It can hold information for a very brief period. If nothing happens to information in the sensory register it is rapidly lost.
- ❖ It responds only to a certain amount of information. The amount of information, which we receive at any given time, is huge, and it is impossible to respond to all of it.

However, we respond to a very small fraction of all available stimuli. It looks like the incoming information passes through a filter that selects only a certain amount of it. *Attention* (active focus on certain stimuli to the exclusion of others) is a limited resource. White (1998) pointed out that what is selected is affected by the learner's previous knowledge, attitude and abilities and the selection of events is vital in learning. The perception filter is controlled by information which lies in the long-term memory. Our previous knowledge, our preferences, experiences and our prejudices control the perception filter and we respond and pay attention to certain stimuli (Johnstone, 1993). For example, the smell of a fragrance makes us pay attention to a stimulus because it evokes the memory of a person we love. Moreover, sensory images are not exactly what we saw, heard or felt; they are what our senses perceived. We perceive different stimuli according to rules that have nothing to do with the inherent characteristics of the stimuli. We do not perceive stimuli as we see or sense them, but as we know (or assume) they are (Slavin, 2003).

2.9.2 Working Memory's Function

Sensory memory precedes attention. It controls whether or not we pay attention to a stimulus. However, the information that a person perceives and pays attention to is transferred to short-term memory (Atkinson and Siffrin, 1971; White, 1998) or working space memory (Baddeley, 1986; Johnstone, 1988). Hence, short-term memory is the part of the memory in which information that is currently being thought about is stored. It is the place where the mind operates on information, organizes it for storage or discarding, and connects it to other information. When we try to memorise a set of numbers and then we try to recall them within seconds, this process occurs in our short-term memory. The short-term memory is easily disrupted and has certain features:

- ❖ It has a limited space for storage.
- ❖ It has a limited duration.

For the first feature, Miller (1956), after various memory experiments found that the average capacity is about seven plus or minus two (7 ± 2) separate *chunks*. *Chunks* are parcels of information, the size of which is in the control of the learners. It might be a single number or a single letter or many pieces of information grouped together. Chunking is the process of grouping information into parcels, which are easy to handle. By the process of *chunking*, working memory space can be used more efficiently because the learner can arrange items in groups of data. It is like to having a purse which can hold only seven coins. If the coins are seven pennies its capacity is only seven pennies. However if the coins are seven pounds its capacity increases to 700 pennies. The second feature of short-term memory is the limited time that it can hold items. Without continued rehearsal the items can be held in it for about 20 seconds (Brunning *et al.*, 1995).

Working memory has two functions: to hold information, and to process it into a form which can be used or stored. In recent years, the concept of short - term memory has been broadened into the idea of working memory space. It reflects better the notion that it is not only a space for storing information for a certain time, but it is a space for processing and transforming information. It permits us to keep information long enough to make sense of sequences of words and directions, to solve problems, and to make decisions (Brunning *et al.*, 1995). According to Johnstone (1984) working memory is

> *"that part of the brain where we hold information, work on it, organise it, and shape it, before storing it in the long-term memory for further use".*

2.9.3 Long-term Memory

Sensory memory and short-term memory involve information recently experienced while long-term memory is a permanent repository of information that we accumulate over periods of days, week, months and years (Brunning *et al.*, 1995). This is the part of the memory where information is kept for long periods of time. After we learn a fact (like the capital of Greece) we are likely to know it tomorrow, next month and even for the rest of our life. Unlike sensory and short-term memory, it is unlimited, not easily disrupted, and indefinite. Thus, it seems to be remarkably stable and long lasting and to have a very large capacity. Some theorists call it permanent memory; i.e. we never lose the information, just the ability to find it. Although forgetting occurs, there is a debate whether it happens because metabolic changes cause gradual decay in long-term memory or because of the inability to retrieve from it.

The long-term memory is divided into two types:

- *Declarative memory*
- *Procedural memory*

Declarative memory holds *knowing of what.* It is the knowledge we have of things that we can put into words such as our names, the meaning of words, the description of facts, the recalling the name of the capital of a country and generally what we have in our consciousness. Many researchers like Tulving (1983) and Squire (1987) have differentiated declarative memory into two types: memory of personal experience and memory of general knowledge. The former, which might be abstract and hold general knowledge, is called *semantic,* and the later might hold personal (autobiographical) knowledge and it is called *episodic.*

Procedural memory, in contrast, is unconscious memory. It deals with *knowing how* to perform certain activities. It includes knowledge that we cannot put into words such as information related to how to walk, how to drive, how to swim.

Information is transferred from sensory memory to short - term memory through the process of attending, and the information remains in short-term memory mainly through rehearsal. However, the transfer of material from short-term memory to long - term memory requires concentration. It is not a simple rehearsal but it requires encoding which means transforming the information and representing it in another way. Encoding is a process through which meaning is derived from experience. Information is encoded into:

(1) the verbal coding system which is linguistically adapted information e.g. words, stories, discourse, or
(2) the imaginably coding system which is adapted for non-verbal information such as pictures, sensations, sound.

According to the aphorism 'a picture is worth a thousand words', it is believed that we recall visual information better than linguistic information. Paivio's dual coding theory suggests that information can be coded within one or both of the systems (Paivo, *et al.*, 1988). He indicated that if information were coded into both systems, memory would be enhanced, whereas if information were coded only into one coding system, it would be less well recalled.

2.9.4 Processes in Long-term Memory: Storage and Recall

The important function of the long-term memory is to receive the information and store it for recall.

> *"We store information which is potentially important, or interesting, or useful. We ignore or discard information which is more trivial or unimportant. This is a personal process and for that purpose memory uses a variety of functions such as: pattern recognition, rehearsal, elaborating, organisation. We seek for patterns as we try to connect the new information with existing information in order to make sense. We discard the new information when it does not make sense to us"* (Johnstone, 1997).

In general, memory has a constructive nature. It generates rather than reproduces the facts. Johnstone (1997) compared the process of storage and recall of long-term memory to the process of a filing system in a computer.

> *"If an incoming letter does not fit the system, a new file is created and cross-referenced or indexed in some way to facilitate its retrieval"* Johnstone (1997).

The difficulty of this filing process may rise when we try to retrieve the file. We do not know how someone organises his/her filing system and it may not be the same way as the others do.

Johnstone (1997) indicated four ways for storing:

a. *The new knowledge finds a good fit to existing knowledge and is merged to enrich the existing knowledge and understanding (correctly filed)*
b. *The new knowledge seems to find a good fit (or at least a reasonable fit) with existing knowledge and is attached and stored, but this may, in fact, be a misfit (a misfiling).*
c. *Storage can often have a linear sequence built into it, and that may be the sequence in which things were taught.*
d. *The last type of memorisation is that which occurs when the learner can find no connection on which to attach the new knowledge.*

Source: (Johnstone, 1997)

Looking at Johnstone's suggestions, the first way of storing knowledge is what is called meaningful learning, whereas the last type is what is called rote learning. Meaningful memorisation is very easy to retrieve and almost never lost. Conversely, rote memorisation is more easily lost and more difficult to retrieve. The second way of storage leads to misconceptions, which are very persistent and very difficult to change. The linear memorisation is the way we memorise something like the alphabet and can be accessed in only one way. This type of memorisation is useful in some cases although it is often slow and needs a lot of effort.

2.10 Neo-Piagetians

Pascual-Leone (1976) and Case (1985) have moved from pure Piagetian theory to a synthesis of Piagetian and Information Processing models (Sutherland, 1992). They used the main ideas of Information Processing theories in terms of its emphasis on cognitive processing or short-term memory capacity to explain how meaningful learning occurs particularly during the formal operations stage.

First Pascual-Leone (1970) conceptualised Piaget's cognitive-development variable as quantitative construct, the central processor M. Pascual-Leone (1970) proposed the concept of M power: the ability of a child to store instructions and to scan his perceptual scene for relevant elements to focus on. He said that human performance on cognitive tasks involves three major demands:

1. The mental strategies used to work out solutions to the task which he calls the 'repertoire H'.
2. The demands that the mental strategies places on the mental span which he refers to as the 'M-demand' and
3. The actual available capacity of the individual which he calls the central computing space or ' M-space'.

He then developed a hypothesis that the mental capacity or the M-space of individual is a function of Piaget's stages of cognitive development and therefore grows with age as well as the range of strategies available to the student would grow with experience and with education.

Pascual-Leone's revision of Piaget's stages involved a synthesis of Piaget's stages with his own M value, as illustrated in Table 2.2 (Sutherland, 1992). He argued that his M power successfully explains what Piaget model of cognitive development has failed to address: *"the asynchronous appearances of variations of the same cognitive structure (horizontal decalage)"* (Serumola, 2003). A child achieves different stages in different areas. For example, if a child requires M power to reach a higher stage in, say, history, the child requires the same M power to reach a lower stage in, say, mathematics.

Table 2.2: Pascual-Leone's revision of Piaget's stages

Piagetian substage	Age (years)	Value of M-power (a+ k)
Early pre-operational	3-4	a + 1
Late pre-operational	5-6	a + 2
Early concrete	7-8	a + 3
Late formal	9-10	a + 4
Early formal	11-12	a + 5
Middle formal	13-14	a + 6
Late formal	15-16	a + 7

M-power:	the maximum number of schemata available to the individual at any given mental strategy operations.
The letter (a):	denotes the space taken up by the mental strategy (executive schemata) that applied to the task or problem solving.
The letter (k):	denotes the number of units that can be manipulated by the individual simultaneously without causing any confusion.

Sources: (Sutherland, 1992; Serumola, 2003)

Case (1985) built on both Piaget's original ideas and Pascual-Leone. He suggested that the Pascual-Leone's idea of mental strategies (*repertoire-H*) were parallel to Piagetian idea of *schemata*. However, he has been much influenced by the Information Processing movement and its crucial concept of working memory capacity. He called this short-term storage space (Sutherland, 1992). He thought that this short-term storage space is developed chronological. However, he argued that growth in short-term storage space could be achieved by greater operational efficiency. Thus, teachers' responsibility is to help children to use their capacities more efficiently.

The studies conducted by Pascual-Leone and Case formed a basis for a number of studies on the information processing capacity and mental demand for many psychologists. In the next paragraph some of these studies will be explored in more detail

2.11 Information Processing - Learning and Assessment

Since working memory is limited (Miller, 1956) and has to be shared for holding and operating processes, if we try to do too much at once we simply overload. According to Johnstone (1999) *"if there is too much to hold there is no room for processing"* and vice versa. If much processing is required, little information can be held. Much research has developed on the basis of working memory limitation. Baddeley (1986), particular, has contributed enormously to the understanding of working memory and how it works.

Johnstone and Wham (1982) showed that, during laboratories, students' working space memory overloads easily because too many functions are required to be manipulated simultaneously and learning in the laboratory situation may fail. Students have to deal with many tasks at the same time such as: to recall theory, names of apparatus, old skills; to recognise materials; to deal with new written instructions, new skills, and new verbal instructions. They eventually lose concentration and they reach a *state of unstable overload.* They proposed that overload in working memory appears when the learner cannot distinguish the *noise* from the *signal.* The term *noise* was used to describe the non-essential and irrelevant information that the teacher is transmitting to learners, whilst the term *signal* was used to describe the essential and useful information that the teacher is transmitting. Johnstone (1999), found that overload happens also very often during lectures, when all the student's working space is devoted to write notes from the spoken words and little space is left for elaborating them and thus understanding them (Johnstone, 1999).

Research in the field of science education suggested that language is one of the barriers in understanding some topics (Selepeng, 1995; Cassels and Johnstone, 1983). Cassels and Johnstone (1984) stated that

> *"what goes on in working memory occurs in visual or verbal forms. An unfamiliar word or known word in an unfamiliar context takes up valuable working space. For a second language learner the problem is even more serious because the working space is used not only for holding and processing but also for translating. The same problem might occur in multiple-choice questions, which are posed in a negative form. In this case, this needs more processing and may go beyond the capacity of the working memory space needed to hold, organise, sequence, process and solve it".*

Pollitt *et al.* (2000) also in their study addressed the problems related to language barrier that students face when they study in a language which is not their mother tongue. They concluded that the problems are linguistic, contextual and cultural.

Many studies have been carried out looking at the relationship between working memory capacity and solving problem success. Niaz (1987) showed that a relationship existed between the mental capacity of students and the information demands of the questions, in terms of student's performance. Johnstone and El-Banna (1986) investigated the overload of working memory by assessing students in both secondary and tertiary education with a number of chemistry problems with increasing complexity (number of thought steps) and facility values (facility value is the faction of problem solvers who were able to solve a given problem correctly, and is measured on a scale from 0-1). They demonstrated that if the number of things students had to keep in mind at one time in order to solve the problem exceeded their working memory capacity, then they would find the problem very difficult or even impossible. Thus, students of a given working memory capacity would successfully answer questions of demand (Z) until their working memory capacity was exceeded, at which point their performance would fall dramatically Figure 2.4 idealises their result.

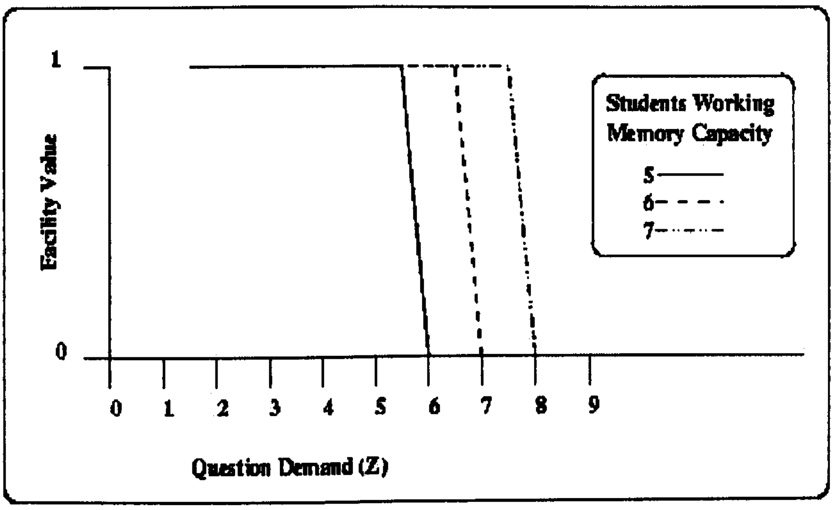


Figure 2.4: Predicted performance in students with different working memory capacity.

Source: (Palmer, 2002)

Bahar (1999) summarised research studies in the field of science and mathematics education that have suggested the following:

I. *Working memory can be easily overloaded, because of its limited capacity (e.g. with unnecessary information, unfamiliar vocabularies, negative questions),*

II. *Overloading the working memory can be an obstacle to acquiring the information,*

III. *If working memory is overloaded by too many pieces of information, the processing of this information cannot take place unless such information can be effectively chunked,*

IV. *There is a relationship between the working memory capacities of students and their performances in problem solving and in exams.*

Source: (Bahar, 1999)

These results do not imply that a student with a small working memory capacity is not able to solve problems and is incapable of learning. Working space has limited capacity and this cannot be changed. However, learning demand can be kept below the working memory capacity of the learner and strategies can be developed in order to help a student to operate beyond his capacity. Attention should be given by teachers, especially in primary and secondary level, to provide well-organised teaching materials by scrutinising the information density of the text and worksheets and by separate the important information for the unimportant one.

Psychological processes for learning provide a useful tool for many researchers to create models which explain the psychological processes involved in answering questions (Sanderson, 1998). Oakhill's (1988), cited in Sutherland (1992), explanation why the use of negative comparisons such as *"Ann is not as bad as Betty. Betty is not as bad as Carol. Who is the best?"* can make it difficult for children to reason soundly was based on the information processing model:

- *Perceiving and encoding the premises.*
- *Transferring them into the working memory.*
- *Combining the premises representations in the memory to form an integrated representation.*
- *Encoding the question*
- *Scanning the representation of the premises to answer the question or to formulate o conclusion.*

Source: Sutherland (1992)

Bell (1999) created a model for a retrieval question, which is a simplification of the actual processes involved. According to this model the candidate will be unable to answer the question if something goes wrong with at least one of the six processes:

❖ *Exposure/observation*	*The exposure of the information to the candidate*
❖ *Encoding*	*The formation of a long-term memory and the creation of a network.*
❖ *Query*	*Interpreting the question*
❖ *Interrogation*	*Sent a query into long-term memory*
❖ *Retrieval*	*Recovering the answer from long term memory*
❖ *Expression*	*The conversion of the information into a suitable response for the examiner*

Source: Bell (1999)

The language and the format of questions can influence students' performance. Psychological processes for learning provide useful information for avoid constructing questions which may be beyond any reasonable expectation of student's abilities. Thus, attention should be given to scrutinising fixed-response questions by the process of shredding (Johnstone 2003). Johnstone has drawn attention to the following common faults which can easily occur in the fixed response questions: superficial clues, options of uneven length, negative and double negative expressions, grammatical construction, self-cancelling responses, instructions to students, question length, test editing. Crisp and Sweiry (2003) emphasised the importance of how a question is understood by subtle changes of certain aspects of a question such as diagrams or images which are particularly salient and hence can come to dominate the mental representation that is formed.

Moreover, differences in cognitive processes which occur when an examiner marks an essay may cause problems for the inter-rater reliability.

> *"The essay is recognised as one area where inter-rater reliability is likely to be at its weakest and where the judgement is most likely to be regarded in common sense terms, as 'subjective'"* (Sanderson, 1998)

Possible causes of halo effect can be explained by models based on information processing such us: observation encoding, aggregation and storage in short-term memory, short-term decay, long-term memory decay, presentation of categories to be rated, observation and impression retrieval from long-term store, recognition of observations and impressions relevant to rating categories, recognition comparison of observations and impressions to rater's standards, incorporation of extraneous considerations.

Conclusions

Learning theories investigate and emphasise the importance of the structure of knowledge; the hierarchical ordering of concepts; and the difficulties that children face due to their developmental stages and cognition. Constructivism emphasises the importance of prior knowledge in proving the basis for further learning and the need for the learner to be actively involved in the learning process.

To some extent, it is true that students begin to forget much of the knowledge that they have learned very soon after they finish their examinations. Teachers can experience that many times in the classroom when pupils are asked to recall concepts that they had been taught the previous school year. It seems that they have never been taught these concepts before. It is also known from personal experience, when, in vain, someone tries to recall things that he/she has learned in the past. However, the most important function of schools should be to impart skills and knowledge to the pupils that will be available for the rest of their life.

Teaching and assessment are inseparable in the learning process. Assessment does not stand outside teaching and learning but stands in a dynamic interaction with them.

Shepard (1992) emphasised the importance for educators to understand the conception of teaching and learning when they make decisions about testing practice and to examine the implicit theories which guide their practice. In the traditional model of teaching (objectivism approach) learning is seen as a distinct body of information, specified in detail, that can be transmitted to the learner. Assessment, in this context, consists of checking whether the information has been received (Entwistle and Entwistle, 1992). However isolated facts, if learnt, quickly disappear from the memory because they have no meaning and do not fit into the learner's conceptual map. Students can succeed in objective tests without necessarily understanding the material they have learned. This particularly may be true in science where much research has shown that students carry widespread misconceptions and misunderstanding of both natural and scientific phenomena (e.g. Anderson, 1990; Bodner, 1991; Osborne and Cosgrove, 1983; Nurrenber and Pickering, 1987; Sawrey, 1990; Gabel, 1999). The behaviourist learning theory requires practice, repetition and testing of discrete basic skills prior to any teaching of higher-order thinking skills (Shepard, 1992).

On the contrary, in the constructivism and information processing models, learning is seen as a process of personal knowledge construction and meaning making. In this approach, learning is a complex and diverse process and therefore requires assessment to be more diverse and to assess in more depth the structure and quality of students' learning and understanding (Gipps, 1994). In the Information processing models the structure of effective learning is seen in such a way that it can be stored usefully in the long-term memory. Knowledge is seen as something cohesive and holistic which provides scaffolding for later learning (Atkins *et al.*, 1992). In fact, cognitive processes indicate that there is an intimate connection between skills and the contexts in which they are used. This means assessment should reduce the emphasis on the ability to memorise and increase the emphasis on thinking and problem solving. Information processing approaches to learning require a new assessment methodology and tests ought not to ask for demonstration of small, discrete skills practised in isolation (Gipps, 1994).

Learning theories are the bases which help teachers and educators to understand diverse factors of individual differentiation in: perceiving information; encoding information; transferring information; scanning the representation of the information; and working memory capacity. Differences in the above factors make individuals to have different cognitive styles and to be different in intelligence, ability, personality, and achievement. The next chapter throws some light in to what are cognitive styles and how they influence our: intellectual abilities; skills; personalities; teaching and learning; and performance.

Chapter Three

Cognitive Styles

Psychologists who are working at the interface between cognition and personality emphasise the importance of cognition. There are individual differences in styles of perceiving, remembering, thinking, and judging, and these individual variations, if not directly part of the personality, are at the very least intimately associated with various non-cognitive dimensions of personality (Kogan, 1976). Nevertheless, it has been demonstrated by the massive volume of cognitive style research that cognitive styles can have an impact on intellectual and academic achievements.

Individuals have different ways of collecting and organising information depending upon their cognitive structure and what they already know. Differences that exist in someone's cognitive structure and in psychological functioning enable individuals to have different cognitive styles. A number of different labels has been given to cognitive styles and it has been argued that many of them are just different conceptions of the same dimensions. This chapter represents an effort to summarise some of the different cognitive styles that appear in the literature and a review of research in this field and their serious implications for academic achievement. Attention is focussed on field dependent/independent and convergent/divergent cognitive styles, as they are the main cognitive styles used for this research for the following reasons:

- They are dominant over the other cognitive styles in the literature.
- Previous work suggests that they are related to assessment.

3.1 What Cognitive Styles Are

Cognitive style was defined by Tennant (1988) as

> *"an individual's characteristic and consistent approach to organising and processing information".*

Sternberg and Grigorenko (1997) hold that cognitive styles are a subset of the general construct of style, that of thinking styles. According to them

> *"thinking styles are not themselves abilities but rather preferred ways of using the abilities one has. Thinking styles are but one manifestation of a broader program of research in which psychologists have been engaged for many decades, that on cognitive styles or people's characteristic and typically preferred modes of processing information".*

Thus, Sternberg and Grigorenko (1997) characterized cognitive style as

> *"a distinctive or characteristic manner or method of acting or performing"* .

Witkin, *et al.* (1971) defined cognitive styles as

> *"the characteristic, self-consistent modes of functioning, which individuals show in their perceptual and intellectual activities".*

Messick's (1993) definition was

> *"cognitive styles are characteristic modes of perceiving, remembering, thinking, problem solving, decision making that are reflective of information processing regularities that develop in congenial ways".*

Hartley (1998) listed different kinds of individual differences related to learning and studying under four headings. These are:

1.	*Fundamental difference:*	fundamental in the sense that these are very hard to alter.
2.	*Cognitive styles:*	these are ways in which different individuals. characteristically approach different cognitive tasks.
3.	*Learning strategies:*	these are ways in which individuals more consciously select methods of approach, and
4.	*Preferences:*	these are less serious ways in which individuals differ.

Information Processing theory sees considerable individual differences in learning arising due to differences in a number of factors such as:

- *The component processes.*
- *The strategies into which these processes combine.*
- *The mental representations on which the processes and strategies act.*
- *The ways in which individuals allocate their attentional resources.*

Source: (Sutherland, 1992)

Sutherland (1992) stated Sternberg's (1977) notion that the various factors involved in Information Process make up intelligence. By definition, therefore, to be intelligent is to be able to process information efficiently. Steinberg's six factors are as follows:

Spatial ability:	The ability to visualize a problem spatially in all its details.
Perceptual speed:	The ability to grasp a new visual field (or view) quickly.
Inductive reasoning:	The ability to generalize from evidence presented.
Verbal comprehension ability:	The ability to understand new words quickly.
Memory:	The ability to store visual material in the brain
Number ability:	The ability to manipulate numbers according to certain rules.

There have been a number of attempts to de-construct intelligence such as Gardner's (1993) theory of 'multiple intelligences'. Instead of concentrating purely on correlations and factor analyses of tests such as usually represented by the notorious single IQ measure, Gardner drew on disciplines such as neuroscience to examine abilities that appear to be largely independent of each other. Thus, he discussed ways in which they may be impaired by brain injury, while other faculties are left intact; or occasionally appears in isolation, as in the case of idiots savants. On this basis, he suggested that the following cognitive abilities are substantially independent of each other at a neuropsychological level:

- Linguistic intelligence,
- Musical intelligence,
- Logical mathematical intelligence,
- Spatial intelligence,
- Bodily-kinesthetic intelligence,
- Intra-personal intelligence,
- Inter-personal intelligence,
- Naturalist intelligence (the ability to recognise fine distinctions and patterns in the natural world).

Gardner was not dogmatic about this list. He thought that might be more or fewer of the categories. Goleman (1996) has suggested that there is a form called 'emotional intelligence', which he regards as distinct from those already proposed.

Hartley (1998) gave the following examples of individual cognitive styles differences and ways of thinking and related studies:

- Convergent/divergent (Hartley and Greggs, 1997)
- Reflexive/impulsive (Goldman and Flake, 1996)

- Field dependent/independent (Liu and Reed, 1994)
- Visualisers/ verbalisers (Kirby, 1993)
- Abstract/concrete/active/reflective (Willcoxson and Prosser, 1996)
- Locus of control (Millar and Irving, 1995)

Sternberg and Grigorenko (1997) epitomised different cognitive styles under the follow labels:

1. **The cognition-centred approach**: Differences between individuals caused of the way they function in their perceptual and intellectual activities and the styles produced by this approach seem quite close to abilities.
2. **The personality-centred approach**: The styles produced by this approach seem closer to personality traits.
3. **The activity-centred approach:** This approach is centred on the notion of style as mediator of various forms of activities that may arise from aspects of cognition and personality.

For the cognition-centred approach they concluded that the two styles that have generated the most theory and research, as well as interest are: reflection-impulsivity and field dependence-independence. Kogan (1976) held the same opinion as Sternberg and Grigorenko.

Riding and Caine (1993) quoted the survey of Riding and Cheema (1991). This was about the various labels of cognitive styles. After reviewing the descriptions, correlations, methods of assessment and effects on behaviour, they concluded that cognitive characteristic might be grouped into two principal cognitive style dimensions: the Wholist-Analytic and the Verbal-Imagery. Riding and Caine (1993) summarised them as follows:

The Wholist-Analytic style: of whether an individual tends to process information in wholes or parts.
The Verbal-Imagery style: of whether an individual is inclined to represent information during thinking verbally or in mental images.

These two styles are independent of one another in that the position of an individual on one dimension of cognitive style does not affect their position on the other.

There have been various arguments relating to the overlap between style and ability. Some researchers support the idea that '*ability*' describes performance in a given task whereas '*style*' describes the way the task is approached (Messick, 1994). Whilst, intellectual abilities are primarily concerned with the ability to learn, cognitive styles are primarily concerned with differences in the ways of learning. Hartley (1998) stated that cognitive styles are important variables in two key areas:

1. How students make academic and career choices; and
2. How students learn, how teachers teach, and how these interact.

According to Riding and Cheema (1991), cognitive style is considered to be a fairly fixed characteristic of an individual. While cognitive strategies are the ways that may be used to cope with particular situations and tasks. Strategies may be learned and developed. Styles, by contrast, are static and are relatively in-built features of the individual.

The following sections concentrate in the field dependent/independent and convergent/ divergent cognitive style.

3.2 Field-Dependent /Independent Cognitive Style

Hundreds, if not thousands, of articles pertaining to the field dependence-independence (FDI) construct have been published. This polar construct originated in Witkin's work (Witkin *et al.*,1962; Witkin *et al.*,1974; Witkin and Goodenough, 1981). Witkin (Witkin and Goodenough, 1981) investigated for many years the idea, suggested by Gestalt psychology, that some people are dominated by any strong frame of reference or pattern in a stimulus field, to such an extent that they have trouble in perceiving elements that cut across the pattern. He investigated the personality in relation to the integrative process of making contact with the environment through perception.

Early studies of Witkin and Asch (1948a, 1948b) found that some individuals consistently tended to attend to different type of cues. Subjects who used visual cues were designated 'field-dependent', while those who used postural cues (such as tactile, vestibular and kinesthetic cues) were designated 'field-independent'. Further probes of the subject's ability to perceive individual elements within an organised perceptual field have followed. It was thought that might be a relationship between the individuals '*disebedding ability*' and their '*cognitive restructuring*'.

Within this framework Witkin and Goodenough (1981) defined the main characteristic of the field-dependent and field-independent cognitive styles as:

- **Field - Dependent (FD)** individual who can insufficiently separate an item from its context and who readily accepts the dominating field or context.
- **Field-Independent (FID)** individual who can easily 'break up' an organised perceptual field and separate readily an item from its context.

In order to determine an individual's level of field dependency, one of the tests that Witkin *et al.* (1971) used was the paper-and-pencil Embedded Figure Test (EFT) or Group Embedded Figure Test (GEFT). In this test, the individual was required to recognise and identify a simple geometric shape within a complex pattern. The more shapes correctly found the better the individual is at this process of separation and is said to be field-independent, and vice versa for field-dependent. The designation of field-dependent\independent did not imply two distinct categories. There is a continuum between these two classes and those of intermediate ability are classed as field-intermediate.

Witkin *et al.* (1962), in seeking to find out the sources of these different constructing patterns between FD and FI, explored the idea of segregation of self from the outside world, where boundaries are set up between the person and their immediate environment i.e. people, places, things. In the light of the new data, a theoretical model '*the theory of psychological differentiation*' was developed (Witkin *et al.*, 1962). The greater the level of psychological differentiation that the individual possesses the greater the degree of 'self-nonself' segregation. According to this theory are two ways of perceiving elements of the environment, the analytical and the global. An analytical, in contrast to a global, way of perceiving entails a tendency to experience items as discrete from their backgrounds, and reflects ability to overcome the influence of an embedding context. People differ in the extent to which their perception is analytical.

Witkin *et al.* (1974) demonstrated evidence that, in addition to the relation between characteristics present in infancy and patterns found in later development, the nature of mother-child interaction is important for a child's progress toward greater differentiation. As expected, the mothers of children with a more global field approach have had the kinds of relations with their children which tended to inhibit the children's progress toward differentiation; mothers of children with a more analytical field approach have interacted with their children in a way which tended to foster the development of differentiation in their children.

In the new theory, the Field-Dependence-Independence (FDI) dimension of individual differences was connected with the analytical-global dimension of individual. These patterns of behaviour suggested consistency in psychological functioning, which pervades the individual's perceptual, intellectual, emotional, motivational, defensive, and social operations (Witkin *et al.*, 1974).

In the following sections is discussed the association between (a) FDI and structuring ability; (b) FDI and intelligence; (c) FDI and personality; (d) FDI and academic achievement; (e) FDI and information processing approach.

3.2.1 FDI and Structuring Ability

Studies have confirmed the relationship between disembedding and structural ability (Goodenough and Karp, 1961; Witkin, *et al.,* 1962). Field-dependent individuals tend to rely on task structure and are less able to deal with ill-structured tasks than are field-independent individuals. Witkin *et al.* (1977) commented on results of several studies suggesting

> *"that the field-dependence-independence dimension is very similar to dimensions of perceptual functioning (flexibility of closure and spatial decontextualization) identified by other investigators. It may be that these refer to the same dimension, called by different names."*

In general field independent learners show evidence of greater skills in their cognitive analysis and restructuring than field dependents (Witkin and Goodenough, 1981).

3.2.2 FDI and Intelligence

The concept of psychological differentiation was originated to overcome the inadequacy of conventional intelligence tests as bases for explaining individual differences in cognition (Stenberg and Grigorenko, 1997). As was expected, it triggered a huge amount of research that attempted to find the relation between conventional measures of intelligence and FDI. Much research pushed aside Witkin's suggestion that EFT measures a 'style of field independence' requiring a theory of its own, separate from ability theory. FDI has frequently been associated with higher spatial and overall intelligence (Richardson, 2000). Richardson declared that

> *"a key problem for the theory has been its inability to display discriminant validity with conventional intelligence tests".*

Stenberg and Grigorenko (1997) reviewed that the evidence from the literature suggested a close connection and perhaps an identity between FDI and aspects of intelligence.

Tinajero and Paramo (1998), with regard to FDI related to intelligence, presented different researchers who came out with different results. However, they stated that subjects with different cognitive styles show consistently different tendencies in their cognitive function, these tendencies being more or less adaptive for specific intellectual tasks. Their view was supported by the fact that the result was maintained when between-subject differences in intelligence were taken into account. Thus, it can be concluded that individuals' field dependent/independent cognitive characteristic is different from their intelligence ability.

3.2.3 FDI and Personality

Witkin *et al.* (1974) realised at a certain point in their investigations that the way in which each person orients himself in space is an expression of a more general preferred mode of perceiving which, in turn, is linked to a broad and varied array of personal characteristics involving many areas of psychological functioning. Thus, they searched the relationships between field approach and some behavioural characteristics of individuals. The sense of separate identity, the sense of their body concept, and the defensive structure of individuals were among others characteristics that they investigated.

The Study of Sense of Separate Identity: A sense of separate identity is the result of development of awareness of one's own needs and characteristics as distinct from those of others. Evidence from Witkin *et al.*'s (1974) studies in fact showed that people with a relatively field-dependent way of perceiving have a less developed sense of their identity and of their separateness from others than do more field-independent people. Individuals with an analytical field approach, in contrast to people with a global approach, tend to be less dependent on the examiner in test situations for definition both of the task and their role in it; they are regarded by others as socially more independent; they show less interest in and need for people and a relatively intellectual and impersonal approach to problems; they are usually less influenced by authority, tending to be guided by values standards, needs of their own; they are apt to have a stable self view; and they are less attentive to subtle social cues given by others. Individuals with a global approach impression of people are usually based on the physical characteristics these people show and the actions they engage in. On the whole, they favour occupations that involve contact with people and that are popular within a group.

The Study of Nature of Controls and Defences: The study of nature of controls and defences is the relation between field approach and defensive structure (the capacity to control of impulsive behaviour). A number of studies of Witkin *et al.*'s (1974) tended to confirm the view that people with a global field approach had less capacity for the management of impulsive behaviour than people with an analytical field approach. Children and adults with an analytical field approach tended to have a relatively developed defensive structure and to use relatively specialized complex defences (as isolation and intellectualisation, rather than primitive denial and massive regression). Children with an analytical approach were shown to be better able to modulate and mediate the ideas and feelings of aggression because of their more developed differentiation. For adult subjects, who were engaged in their research, was confirmed that people with an analytical field approach would use intellectualisation and isolation as modes of defence (Witkin *et al.*, 1974).

Many characteristics of the personality that Witkin and his co-workers have explored are similar to personality characteristics that Jung (1923) proposed in his theory of psychological types. Jung believed that individuals could be characterised in terms of:

- **Attitudes:** as introversion or extroversion.
- **Perceptual:** functions sensing or intuition.
- **Judgment functions:** thinking or feeling.

The attitudes of introversion or extroversion describe the way individuals relating to others. Extraversion characterises those who are outgoing, with an interest in people and the environment, while introversion describes people whose interests are more inwardly focused. Intuition and sensing are used in Jung's types to describe preferences in perceiving stimuli. An intuitive person tends to perceive stimuli holistically and to concentrate on meaning rather than details, whereas a sensing individual perceives information realistically and precisely. Thinking and feeling represent two distinct ways of judging or understanding perceived stimuli. Judgments made in the thinking mode tend to be logical, analytical, and impersonal; those made in the feeling mode are usually based on values rather than logic.

Because of the similarities between Witkin's theory of psychological differentiation and Jung's theory of psychological types much research has been stimulated trying to find relationships between FDI theory and personality theory as well as Sternberg's Triarchic Theory of Intelligence (e.g. Farr and Moon, 2003; Richardson, 2000; Didkovskaya, 2003). They believe that FDI theory's resulting typology was heralded for its simplicity of measurement and became the focus of more researchers than any other cognitive style who neglected a range of topics of key interest for education and psychology (Richardson, 1999).

3.2.4 FDI and Academic Achievement

Witkin's initially contention was that field-dependent and field-independent subjects are equally well-adapted to meet the demands of their environment. Tinajero and Paramo (1998) referred to early data from Witkin and co-workers suggested that there was no link between FDI and overall achievement, supporting the 'neutrality' hypothesis.

It was suggested by Cohen (1969) and Kogan (1976) that the greater restructuring ability of field-independent subjects favoured achievement in the school environment, particularly in those areas that requiring analytical skills and the use of processing strategies based on the organisation and restructuring of information. Dubois and Cohen's (1970) research provided support for this hypothesis since they found significant correlations between the overall mark in a university admission examination and scores in field dependence-independence test. A number of studies have followed in examining the correlation between FDI and academic performance in disciplines such as language, mathematics, natural sciences, social sciences, art, music and computer science at secondary school level as well as at university level. Tinajero and Paramo's (1998) review concluded that

> *"in general field-independent subjects perform better than field-dependent subjects, whether assessment is of specific disciplines or across the board".*

Research results in the Centre for Science Education in Glasgow University (El - Banna, 1987; Al-Naeme, 1988; Gray, 1997; Bahar, 1999; Danili 2001; Christou, 2001) in FDI and students' performances are consistent with Tinajero and Paramo conclusion.

Although there are studies that give no correlated results, yet in no case have field-dependent subjects been shown to perform better than field-independent subjects (Tinajero and Paramo, 1998; Davis, 1991). In particular, in natural sciences, many studies did not provide clear support for the expected superiority of field-independent students. Tinajero and Paramo (1998) gave an explanation for the origin of this inconsistency. They thought that for the learning and reading skills, particularly during the early stages when the goal is to identify elements of the writing system FDI is an important factor. However, the influence of FDI on reading ability gradually lessens as the ability becomes more automatic. For the mathematics computations, they thought that *"as educational level advances, mathematical operations become automatic, causing the role of restructuring ability to be diluted"*. For the natural sciences, they believed that the wide diversity of methods used for evaluating achievement conceals an implicit diversity of the teaching material, the instructional methodology, the degree of structuring of teaching materials, etc. which helps field dependent students to overcome the difficulties.

Overall, the field dependent/independent test is considered by many researchers a very powerful instrument to predict academic performance of individuals. For example, Terrell (2002) used the Group Embedded Figures Test as an instrument to predict membership in middle and high school programs for the academically gifted. He found that the Group Embedded Figures Test performance was a powerful indicator of giftedness.

3.2.5 FDI and Information Processing Approach

Tinajero and Paramo (1998) reported studies of Berger and Golberger, 1979; Goodenough, 1976, who believed that the differences in certain information processing components such as memory and attention between field-dependent and field-independent subjects might be affecting the ways in which children perform in the classroom. Some researchers (Frank and Keene, 1993; Farr and Moon, 2003) supported the idea that FDI is related to the Wholist-Analytic style in processing information. Some studies that threw some light on the relationships between working memory, attention and field dependent-independent style are now discussed.

Tinajero and Paramo (1998) quoted the work of Davey (1990) who presented sixth to eighth grade students with a series of questions about texts, which they had previously read under four conditions which varied with regard to the demand for memory and restructuring:

a. Condition A: questions with alternative answers and the subjects were allowed to have the text in front of them in order to be able to answer them;
b. Condition B: questions with alternative answers but without the text being present;
c. Condition C: questions with open answers with the text being present, and
d. Condition D: questions with open answers without the text being present.

The assumption was that the open questions would put a greater demand on restructuring as the subject would have to recover the information from the text and adjust its structure so that it was adapted to a suitable format in order to be able to answer the question. In turn, this type of question needed less demand on memory. Having the text while answering the question also called for a lesser demand on memory. No differences were obtained between field dependent and field independent subjects with regard to the number of correct answers in the first three conditions. However, they obtained differences in the fourth condition of maximum memory and structuring demand, when open questions were asked without the text being present. The author concluded that differences were not produced by cognitive style differences. The differences, which appeared in his study, were more due to external factors such as memory efficiency and restructuring ability.

Several other researchers (e.g. Pascual-Leone, 1970; Case, 1974; Case and Globerson, 1974) have attempted studies concerned with field-dependence/independence in relation to other cognitive factors such as intelligence, learning and memory. The result of these studies support the hypothesis that some intellectual and perceptual tests had a common requirement for overcoming embedding contexts. Moreover, they believed that the field independent individuals might use their working space memory more efficiently than their field dependents counterparts and they suggested that field-independent students performed more efficiently in testing hypotheses than field-dependent counterparts. The researchers believed that, in problem solving tasks when the solution depends on using an object in an unfamiliar way, the field independent students are more likely to give a good performance than field-dependent students. The field independent students might use a more effective encoding strategy when solving problems.

In particular, several studies (e.g. Pascual Leone, 1970; El-Banna, 1987; Al-Naeme, 1988; Christou, 2001) examined the relationship between working memory capacity and the field-dependence/independence ability. Their results suggested that field - independent ability is a developmental characteristic and learners with this ability possess at the same time a high working space capacity. They may be described as high processors. Burton and Sinatra (1984) used audiovisual techniques to investigate vocabulary acquisition by preschool children. Their result was consistent with the above results: field-dependent subjects recalled fewer words than field-independent subjects in both modes of presentation.

El-Banna (1987) found a relationship between field-dependency and performance in chemistry students. He found that among students with the same working memory capacity, their performance declined when the student is more field dependent. Several other studies (Al-Naeme, 1988; Danili, 2001; Christou, 2001) found that there is little difference in performance between low working memory capacity field-independent students and high working memory capacity field-dependent students.

Johnstone *et al.* (1993) gave a possible explanation for this, suggesting that students' working space with high capacity and field dependency is occupied with noise as well as *'signal'* because of their field dependency characteristic. While low capacity and field independent student will take only the *'signal'* and ignore the *'noise'*, they can use all their limited low working space for useful processing. Therefore, high capacity-field dependent students cannot benefit from their larger working memory because it is reduced by the presence of useless information (see figure 3.1).

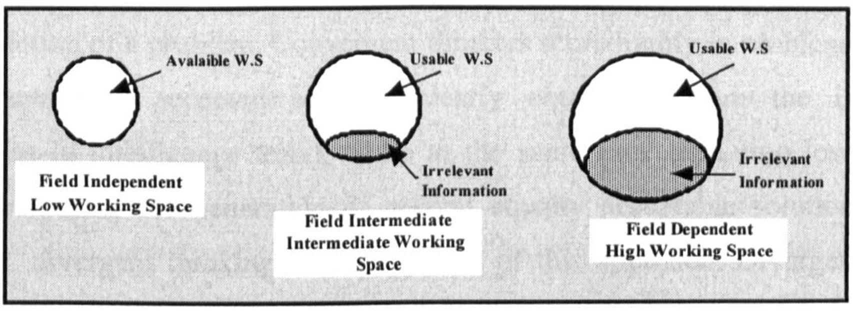


Figure 3.1: Usable working space capacity

In line with Johnstone's consideration, Tinajero and Paramo (1998) quoted many authors who start out with the assumption that disembedding and restructuring abilities facilitate the discovery of relevant information. They concluded that

> *"some evidence from studies show that field dependent subjects centre their attention preferably upon the global aspects of the information in hand, while field independent subjects pay attention to partial. Thus the analytical approximation of the latter is more adequate for dealing with certain perceptive and symbolic configurations where the relevant information is embedded in irrelevant information: for this reason it is not unusual that field independent subjects get better results in tasks which use these configurations, and whose clearest example are embedded figure tests".*

Because field-dependent students have difficulty in separating information from less important details, Armstrong (2000) suggested that students need more practice with learning words in context rather than in isolation. The teacher should help the student in reading a section by encouraging them to make prediction before reading and asking them to explain their answers.

3.3 Convergent / Divergent Cognitive Style.

Research on Convergence-Divergence cognitive styles has not received as much attention as the FDI cognitive style from educators and researchers. The idea of convergent - divergent cognitive style has its origin in Hudson (1966) who, as an undergraduate, had found himself better at some parts of intelligence tests than others:

good at the diagrammatic questions, and relatively poor at the verbal and numerical ones. At that period there was a growing feeling that typical intelligence tests did not measure all aspects of intelligence. It was argued that such tests only measured what was termed 'convergent thinking' and not 'divergent thinking'. Convergent thinking means that someone has to focus down-converge-on the one right answer in order to find the solution of a problem. Convergent thinkers score highly in problems requiring one conventionally accepted solution clearly obtainable from the information available (as in intelligence tests), while at the same time obtaining low scores in problems requiring the generation of several equally acceptable solutions. On the other hand, divergent thinking is the opposite of this approach. Divergent thinking deals with the capacity to generate responses, to invent new ones, to explore and expand ideas, and in a word, to diverge. Convergent thinking thus demands close reasoning; divergent thinking demands fluency and flexibility (Child and Smithers, 1973).

Hudson made an attempt to look into the question of verbal, numerical, and diagrammatic biases in intelligence. After investigating a large store of undergraduates' scores on an intelligence test, he made a momentous discovery that arts specialists usually had verbal biases in ability while scientists had numerical or diagrammatic ones. He gave the same test to clever 15-year-old and to 13 and 14-year-old schoolboys whose academic specialization had not begun and he found that the difference in scores still held good. He came to the conclusion that biases of intelligence existed prior to academic specialization and were not merely by-products of it.

Hudson has based his research on Getzels and Jackson (1962) work. They made a distinction between two types of child: the 'High IQ' and the 'High Creative'. The 'High Creative' children can be good at the creativity tests but relatively low in IQ test. And this because in IQ test the pupils have to choose the right answer from a list of alternatives. They know that there is one solution which is correct, and their task is to find it out. His reasoning is said to converge on the right answer. In the creativity test the individual has to formulate his own answers and to think for himself. This equates creativity with the ability to write. He proposed to name the 'High IQ' convergent and the 'High Creative' divergent.

Hudson (1966, 1968) thought that he may be able to measure arts/science aptitude and made an attempt to devise tests of aptitude for arts and science respectively in order to measure their ability. In the traditional IQ test the individual is required to find the one right answer for a problem after he is invited to choose this right answer from a list of alternatives. The new tests do not require the respondent to produce one right answer and like intelligence tests can take different forms. In order to look for labelling, for fantastic, imaginative themes he asked questions on different topics such as:

> How many uses can you think of for each of the following objects?
>
> How many meanings can you think of for each of the following words?
>
> Draw a picture in the space below to illustrate the title 'Zebra Crossing'.

According to Hudson

> *"the converger is the boy who is substantially better at the intelligence test than he is at the open-ended tests; the diverger is the reverse"* (Hudson, 1966).

In additions, there are the all-rounders, the boys who are more or less equally good (or bad) on both types of test. He defined 30 per cent of his sample as convergers, 30 per cent as divergers, and left the remaining 40 per cent in the middle as all-rounders. His results were expressed in terms of comparison between the two extreme groups, convergent- divergent and he neglected the all-rounders because comparison between contrasting groups are convenient way of describing complex results. He referred also to extreme divergers (10 per cent); moderate divergers (20 per cent); all-rounders (40 per cent); moderate convergers (20 per cent); and extreme convergers (10 per cent).

Hudson (1966) pointed out that

> *"the convergence/ divergence dimension is a measure of bias, not a level of ability".*

Thus, it is logically possible for a converger actually to have a higher open-ended score than a diverger, either because of having a quite exceptionally high IQ scores, or because of the diverger's IQ being exceptionally low.

The general characteristics of convergent and divergent thinkers can be outlined as in table 3.1.

Table 3.1: General characteristics of convergent and divergent thinkers	
Converger Characteristics	**Divergers Characteristics**
• Higher performance in intelligence tests • Good at the practical application of ideas • Specialised in physical science and classics • Prefer formal materials and logical arguments • Ability to focus hypothetical-deductive reasoning on specific problems • Better in abstract conceptualisation • Hold conventional attitudes • Like unambiguity • Emotionally inhibited	• Higher performance in open-ended tests • Fine at generating ideas and seeing things from different perspectives • Specialised in the arts • Better in concrete experience • Interested in people • Hold unconventional attitudes • Strong in imaginative ability • More likely to be witty

Source: (Bahar, 1999)

Many researchers tended to equate divergent thinking with creativity and convergent thinking with intelligence. This has caused a great deal of controversy, with different research supporting different results (e.g. Nuttall, 1972; Bennett, 1973; Runco, 1986; Fryer, 1996).

3.3.1 Convergence-Divergence Dimension and Subject Choice

The main result of Hudson's research was a surprise for him. His comments on his result were:

> *"Far from cutting across the arts/science distinction, the open-ended tests provided one of my best correlates of it. Most arts specialists weak at the IQ test were much better at the open-ended ones; most scientists were the reverse. Arts specialists are on the whole divergers, physical scientists convergers. Between three and four divergers go into arts subjects like history, English literature and modern languages for every one that goes into physical science. And, vice versa, between three and four convergers do mathematics, physics and chemistry for every one that goes into arts. As far as one can tell from the samples available, classics belong with physical science, while biology, geography, economics and general arts courses attract convergers and divergers in roughly equal proportions"* (Hudson, 1966).

Bahar (1999) and Lloyd-Bostock (1979) referred to several research studies in the literature that would seem to support these findings of Hudson.

Hudson's finding has generated a debate whether convergence and divergence is a cause or an effect of subject choices. He saw convergence and divergence as a cause of subject choices and he suggests that its origin may be found in early childhood

(Hudson, 1968). Butcher (1968) indicated that this study of Hudson in the upper forms of English schools should be replicated in other types of schools and at other ability levels. None the less, there were some studies that attempted to see how far Hudson's findings about arts and science specialists could be replicated with university students. Hartley and Greggs (1997) results showed that arts students do not differ significantly from science students regarding the score they gained in divergent thinking tests. Field and Poole's (1970) results showed that, even though the majority of science specialists entering university were convergent thinkers, it is mainly the divergent thinkers among them who finally achieved the better results. Runco (1986) indicated that there were particular domains of performance, for example art and writing, that were more strongly related to divergent thinking than other areas such as music and science.

However most of the debate concentrated on the implications of the findings for teaching and learning, and particularly on enhancing creativity at primary and secondary level. Teachers may play a part in shaping the thinking style of students. Lloyd-Bostock (1979) mentioned evidence of other studies (Mackay and Cameron, 1968; Povery, 1970) to support that educational experience is a reinforcing factor in the development of cognitive style, though not the prime cause. Hartley (1998) held that

> *"In general, it seems that members of staff react more favourably to convergent than to divergent students. To put it bluntly, teachers find divergent students difficult to deal with, and this may be especially true of teachers who are themselves convergent thinkers. Such teachers don't like guessing or playfulness, but prefer a more serious approach. If, however, divergent thinking does enhance creative output then teachers need to be made aware of this and persuaded to encourage divergent thinking rather than to respond to such thinking with hostility".*

Student-Teacher interaction is of a very important issue and raises the question of whether or not a match or a mismatch in cognitive style makes significant differences in learning. The studies of the results by Witkin (1976) indicated that individuals matched in cognitive style were likely to get along better. However, other research in this area has produced mixed results.

3.3.2 Convergent-Divergent Cognitive Styles and Performance in Science

Most of the research related to convergent/divergent styles has concentrated on the relationship between divergent thinking and arts-science orientation. As mentioned earlier, research showed that most of the convergers tend to choose science subjects. Johnstone and Al-Naeme (1995) indicated that much science teaching is convergent and students are rewarded for convergent thinking leading to unique specific answers. However, this may not to be the case for biology because it attracts both groups of students (Hudson, 1966; Orton, 1992; Bahar 1999). Bahar statement was that

> *"biology might be one of the science branches in which students might cope equally well with a convergent or a divergent bias"* (Bahar, 1999).

In the literature, little research is reported related to convergence/divergence cognitive styles and performance in science. The few studies found are discussed below.

Al-Naeme's (1991) research showed that divergent students had higher scores than convergent students in mini projects in chemistry. He pointed that

> *"it seems that the convergent thinking ability may not assist pupils in performing practical problem-solving in chemistry particularly when the practical tasks require a creative and imaginative thinking ability"* (Al-Naeme, 1991).

Field and Poole (1970) noted that, while a convergent bias is associated with high level students' passes in the first year of study, there was no difference in the relative success of convergent students in the second year. Yet their study showed that senior Australian undergraduate students who were divergent were outstanding at the end of the science course.

Bahar (1999), in an attempt to investigate the reason why divergent students had higher scores than convergent students in science, looked whether there are relationships between student's performances with the assessment techniques. He came out with the following conclusions:

- *Although it was expected the overall performance of convergent first year Biology students, would be better than divergent students in the multiple choice questions, he found no significant correlation appeared between the MC question scores and convergent/divergent tests scores.*
- *Statistically significant correlation (at the 5% and 0.5% level) appeared between first year Biology students' total exam scores in four different modules and convergent/divergent tests scores, indicating students who were divergent had higher*

scores in the exams. However no significant correlation appeared between convergent/divergent thinking style scores and study project scores as well as scores in four different modules for the volunteer sample.

- *No significant correlation between convergent/divergent test scores and Higher Grade Biology exam scores of the secondary school pupils was found.*
- *Pupils/students who had a divergent style had higher scores than pupils/ student who had a convergent thinking style on structural grid questions*
- *Convergence and divergence dimension cognitive styles showed a significant relationship with the word association tests and mind maps of the students.*

From the above studies, it seems that in many cases divergent students perform better that convergent. Johnstone and Al-Naeme (1991) commented

"when divergent thinkers took science, they did better than convergers thinkers".

However, the way that the convergent/ divergent ability is defined and the kind of tests which have been used to define it are of great importance and, of course, have an impact on the results of the study. Marjoribanks (1978) defined convergent ability in terms of scores on two conventional intelligence tests, a verbal reasoning test, and a nonverbal reasoning measure; while divergent ability was assessed in terms of a combination of scores from tests of fluency, flexibility, and originality. Marjoribanks (1978) investigated the academic performance and school-related affective characteristics of 12-year-old English children who were classified as convergers, divergers, or all-rounders by using the above two methods. Tests of English, French, biological science, mathematics, and physical science were used to test academic achievement. He found that convergers performed better than divergers in English and French as well as in mathematic and physical science tests. For most subjects, high all-rounders performed as well as or better than convergers and generally much better than divergers. In biological science, high all-rounders performed better than convergers, who in turn had higher biology scores than divergers. However, these results might merely reflect the nature of the tests used in the various subjects.

3.4 Cognitive Styles and Assessment Format

Some studies, as was mentioned earlier, have looked at the correlation between one cognitive factor (e.g. FDI or CND) and student performance. While other studies have looked at the correlation between cognitive styles and the interaction between the styles and performance in different subjects. For example, Al-Naeme (1991) and Bahar (1999), studied the convergence-divergence dimension along with the field dependence-independence dimension of cognitive styles and pupils/students performance. Both studies emphasised that field dependent-field independent learning styles were better predictors of success than convergent-divergent learning styles. Riding and Caine (1993) conducted a preliminary study of cognitive style and performance in General Certificate of Secondary Education (GCSE) for pupils at 16 years in England. Comparison of cognitive style and GCSE performance indicated that,

> *"for overall performance across the subjects the pattern was a modified dome shape with the candidates who were intermediate on both dimensions of cognitive style doing best. There was a significant interaction between the styles of the candidates and the GCSE subjects in their effect on performance"* (Riding and Caine, 1993)

However, not many studies have looked at the relationship between cognitive style and pupils' performance in different formats of assessment (Lu and Suen, 1995). Bahar (1999), in an attempt to explain why not in all cases divergent pupils/students performed better than convergent pupils/students, suggested that the answer might be related with assessment techniques. He said

> *"when one is looking at the relationship between students' performance in any topic and their cognitive styles, the type of assessment techniques used, such as multiple choice type of questions, essay questions, projects and so forth should be reported because a particular type of assessment technique may favour a particular kind of cognitive style"* (Bahar, 1999).

Conclusion

From the above, it can be concluded that cognitive styles influence the personality of the individuals and affect the psychological behaviours that indicate how learners perceive, interact with and respond to the learning environment (Fatt, 2000). Nevertheless, cognitive styles have an impact on pupils' performance and achievement. Therefore, the concern of educators should be to understand, from the heterogeneous mix of pupils' learning styles, the group learning style so that teachers can best adapt their teaching style and assessment materials to suit the pupils' group learning style and help them to overcome their difficulties and exert their abilities. This is a daunting prospect for the teacher!

The intention of this research is to focus on the relationships between pupils' cognitive styles and pupils' performance in different formats of assessment in the secondary school chemistry and in classroom practice. This research is striving to throw some light in Bahar's (1999) suggestion whether particular type of assessment favours a particular kind of cognitive style or not.

Furthermore, if evaluation is to be part of teaching, then first it has to be seen that way. Most areas of learning have both mental and physical aspect: a mental activity, in the case of the academic subjects, or a physical activity in the case of practical subjects (Gipps, 1994). Moreover, all learning has an emotional aspect and numerous research studies emphasise the importance of learner confidence, motivation and self-esteem, which are prerequisites for successful learning and need to be encouraged. Therefore, the negative or positive impact of different forms of assessment on motivation and self-esteem need to be considered seriously. Thus, there is a need to reinforce pupils' motivation by assessing them with appropriate format questions and therefore to reveal from them the best performance (Gipps, 1994). Assessment must be humane (Johnstone, 2003). Humanity takes into account factors that affecting pupils/students' performance such us cognitive and psychological traits of individual personality. The next chapter discusses the role of assessment in education and their importance for the educational practice as well as the implications of learning theories for assessment.

Chapter Four

Educational Assessment

Assessments play an important role in the teaching and learning process and for specific uses. For individuals, assessments, particularly public examinations, profoundly affect life chances, not just in the first years after leaving school, but many years later. Indeed, in some ways, teachers may hold the future of their pupils in their hands. Therefore, some authors characterizations for assessment were: *"both time consuming and potentially dangerous"* (Johnstone, undated); *"a serious and often tragic enterprise"* (Ramsden, 2003); *"nightmares"* (Race, 1995). Indeed, how can someone look into the mind of someone else and judge what he or she knows? To evaluate someone and make decision for his/her career and future is not an easy task to do. It is a very difficult one and carries with it awesome responsibility.

It is clear that the development and spread of computer technology has produced dramatic changes in society and has changed traditional values and the way that people live and think. Changes in society always have a profound impact in education. Education has become part of a global shift to a new way of creating and using knowledge. Modern teaching is not the same as it was 50 years ago and

> *"we work in surroundings that our colleagues of thirty years ago would not recognise"* (Ramsden, 2003).

To use Jones and Bray's (1992) words:

- *classes were once treated as homogeneous units; recently there has appeared an increasing recognition of individual differences.*
- *the old emphasis on content is being balanced by a new emphasis on the learning process and on concepts and skills.*
- *the 'two-by-four' dimensions of learning (two covers of a textbook and four walls of a classroom) are giving way to multi-media materials, practical and oral work, links with the community and so on.*
- *there is less emphasis on factual knowledge and academic studies and more on social, emotional, moral and aesthetic development.*
- *the main role of schools was that of the transmitters of past culture; nowadays they are also expected to participate in the transformation of present and future society.*
- *individual competition between pupils is being supplemented by new strategies for collaborative working.*

Source : (Jones and Bray,1992).

Because of the quick changes in our society, educators call for *"sustainable assessment"*. Boud (2004) defined sustainable assessment as:

> *"Assessment that meets the needs of the present without compromising the ability of students to meet their own future learning needs...A vital role is to prepare students for a future that is unknown to us and to them. The unknown future creates great problems for learning and assessment now and will place demands on students for new knowledge and skills beyond anything they learn in their courses. What can we do to equip students for this? The challenges are substantial. Among many things, we will need to shift our focus to consider the ways in which current assessment practices either assist or inhibit students in developing skills for lifelong learning. We need to align assessment not only with short-term learning outcomes, but also with longer-term aspirations".*

The Curriculum should focus on the basics of thinking, reasoning and learning how to learn since these basics have become important in the wake of global changes in technology, communication and economy. There is a need in the global society for workers who can operate and understand technical systems, and be flexible and adaptive learners

> *"since we are educating a generation of pupils who, rather have a trade or career for life as in our parents' and grandparents' day, are likely to have one or more changes of task and conditions of work during their working lives"* (Gipps, 1994).

The importance of aligning teaching methods and assessment tasks is stressed in many publications pertaining to the curriculum (Osborne, 2004). However, over the last decade, the amount of assessment in schools has increased. Consequently, the assessment workload for the teachers grows dramatically and the time available to devote to assessing each student has fallen. Therefore, more often computer assessment techniques are used in order to assess large number of pupils very quickly and from a distance. Yet, the prevailing assessment techniques in computer assessment are objective tests. Objective testing assessment policy is based on objectivistic theories and is greatly concerned with quantitative measurement (Biggs 1996). The quality of such assessment is embodied in notions of reliability and validity (Broadfoot and Black, 2004). Unfortunately, objective assessment practices inadvertently de-skill students in various ways. They focus attention on the immediate tasks of passing examinations or completing tasks and distract students from the more vital task of learning how to assess themselves (Boud, 2004). This tradition is very much opposite to *constructivism* theory of learning, which regards learning rather in qualitative than quantitative terms (Biggs, 1996). According to constructivism theory, assessments policy should be based on performance on open-ended tasks which can reveal a wide variety of insights of thinking processes in students' written responses.

Moreover, teachers have immense responsibility when evaluating their pupils and they should put effort to find out the best ways, conditions and techniques to bring benefit to individuals. In recent years, cognitive psychology and learning theories are seeking to offer an insight into human cognitive processes and trying to understand the unique characteristic of individuals. These theories should help us not only to develop new strategies for teaching but also to adjust assessment according to pupil's individual differences, which might be either from genetic reasons or from different socio-economic background. However this is a desirable wish, almost impossible to achieve. If we want to be fair to our pupils we should treat them differently and respect their weakness and help them to overcome them. However, as McInnis (2004) articulated:

> *"while most academics believe that assessment should provide information about student's strengths and weaknesses, only a minority actually claim to do this. This is due in part to workload pressures that tend to favour cost and time effective forms of assessment for grading purposes at the expense of practices more likely to motivate students to engage closely in the learning process".*

This chapter gives a brief description including only the most important issues of: why test; what to test; how to test; and how to test fairly. It uses a technical language, and

> *"the problem with technical language is that old and familiar words take on a special meaning without informing the reader that this has happened"* (Johnstone, 2003).

Therefore, an effort has been made to make it familiar to the reader by explaining it.

4.1 Why Test: Formative - Summative Assessment

Assessment lies at the heart of the learning process because it may be conducted to serve several different purposes. Some main purposes are concerned with the support of learning, the reporting the achievements of individuals and for public accountability demands (Black, 1998). Race (2003) listed some of the reasons for assessing students as below:

a) To measure attainment,
b) To encourage students to work,
c) To inform students how they doing (diagnose faults and enable students to rectify mistakes)
d) To inform teachers how they doing,
e) To diagnose and to direct advancement,
f) To provide professional certificates,
g) To add variety to student's learning experience, and add direction to our teaching

Thus, assessment's role can be either formative or summative. In the case of support of learning the assessment form is called formative assessment while summative assessment is related to the product of the learning, to certifying achievement. Boud (2004) added a third purpose to assessment role. He called for the need for sustainable assessment, assessment that fosters lifelong learning.

Formative Assessment

Formative assessment entails intervening during the learning process to gather feedback, which is used to guide subsequent teaching and learning (Brooks, 2002). Ideally, according to Shipman (1983), in formative assessment children are assessed as they work, in order that they can be guided through the feedback obtained. However it rarely works out that way: observations of the teacher, or the test, or the essay tend to occur when a sequence of work has been finished. By the time the results have been given back, the children are on the next piece of work. The idea of continuous assessment is to continuously feedback useful information, but it is usually used to look at products when it is too late to be useful. The only genuine continuous assessment is often the running observations by teachers as they move among the children helping and correcting, diagnosing and remedying (Shipman, 1983). The meaning of continuous assessment really implies periodic assessment and not continual assessment. However, feedback enables teachers to modify their teaching plans and adjust the curriculum to learner's need as well as motivating them to do so. Constructivist theorists are keen to remind us that learning must be an active process - that teachers cannot do their pupils' learning for them (*ibid*). This does not mean that pupils need to engage in a never-ending circus of practical activities but it does suggest that teachers should help pupils to make personal sense of new material, to construct their own meaning and to integrate new information into their own mental map. As the same principles apply to assessment, feedback must be for both teachers and learners.

Summative Assessment

Summative assessment, however, is concerned with the final summing up. The judgment it makes is for the benefit of people other than the learner. Usually the concern is to differentiate between pupils so that selection can be made. This type of assessment often comes of the end of a course, or a school career and includes all written, practical and oral examinations. They can be used for allocation of places in training and education as well as for employment opportunities, all of which are economically important to the individual applicant. There is a special type of summative assessment, which is called *ipsative*. Ipsative assessment measures individual improvement by comparing the grade or level at the start and the finish of a learning programme (Cotton, 1995).

4.2 What to Test: Norm-Referenced, Criterion-Referenced Testing

The purpose for which a test is being used is connected with what to test. Thus, a test designed to rank people is called norm-referenced, whereas a test that has as its purpose is to test if someone has achieved basic competence in a topic e.g. can add pairs of two digit numbers, is called criteria referenced test. Here are some definitions for these tests.

Norm-referenced testing: The goal for the norm referenced tests has been to identify those commonly valued educational outcomes in reading, mathematics, science, social science, etc. and then build a test around those common values that allowed the consumer to identify the range of student achievement on those educational outcomes. Their intention is to check what is the rank order of a student in a particular test. In such cases, a student performance is noted against the overall performance of the population. This overall performance thus provides a norm (and that is why the name 'norm-referenced') against which individual's performance is measured.

> *"There now comes the problem of deciding on a number of boundaries. What score (or mark) is to be considered a pass mark? Where is the boundary between pass and merit or between merit and distinction?"* (Johnstone, 2003).

From the distribution table or graph a certain percentage are assigned each grade (e.g. only 10% will be awarded grade A, 20% grade B and so on); or a cut-off point is chosen for passing, allowing a certain percentage to pass and the rest to fail (Gipps and Stobart, 1993). A common example of norm-referenced test is IQ result given by an intelligence test. Similar approaches are used in national examinations in many countries e.g. Scottish Grade Higher examinations (SQA, undated).

Criterion-referenced testing: or content-referenced testing. They show whether children are ready to go on to the next learning because they have mastered its prerequisites (Shipman, 1983) or testing to be a surgeon, a pilot, or a bus driver. Criterion referenced test measures performance against criteria derived from the objectives of the course. Multiple-choice tests taken to get a driver's licence and on-the-road driving tests are examples of criterion-referenced tests. There is no acceptable half-mastery: either passed or failed. Thus, a pupil's performance is described in terms of what she/he can do (e.g. she/he can type 40 words per minute without error) rather in terms of norms or how she/he compares with others (e.g. she/he can type faster than Jane but is slower than Chris) (Black, 1998).

4.3 How to Test: Assessment Techniques

In order to assess pupil's/ student's educational abilities, educators have employed several techniques or methods. At school level, assessment involves a wide range of methods for evaluating pupil performance and attainment constrained by issues such as limitations of time and expense. The wide range of methods, including formal testing and examinations, practical and oral assessment, classroom based assessment carried out by teachers and portfolios, have been designed to test understanding. However, there are many questions about testing and understanding such us:

> *"What is like to really understand something?"* (Unger, 1993).
>
> *"Does the form of understanding depending on the framework of assessment?"* (Entwistle and Entwistle, 1992).
>
> *"How can we assess students' thinking processes and reasoning? How can we infer the levels of students' understanding? What cognitive constructs are measured in different task formats using different scoring criteria"* (Kyoko 1997).

Unger (1993) (quoted in Biggs, 1996), in his research with high school students asking what it was like to 'really' understand something, found a general hierarchy of understanding, ranging from 'understanding by remembering' to 'performing in novel situations'. The hierarchical nature of understanding has been examined first by Bloom (1956). Bloom drew attention to the fact that educational objectives were not all of the same character, but placed different demands upon students (Johnstone, 2003). Thus, Bloom (1956) devised a taxonomy for educational objectives. This taxonomy covers three main domains: cognitive domain, affective domain and psychomotor domain. He divided the cognitive domain into six cognitive skills: knowledge, comprehension, application, analysis, synthesis and evaluation. According to Bloom these are the six skills, which are important for the learner. Bloom arranged these six educational abilities in a hierarchical order as it is shown in figure 4.1

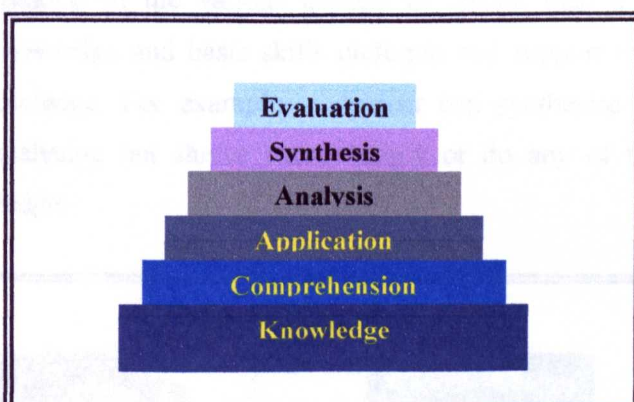


Figure 4.1: Bloom's taxonomy of cognitive goals Source
Source: (Fisher, 1995)

Garratt's (1998) definition from these skills is shown in table 4.1. Knowledge, the lowest of these cognitive skills, demands little but recall; comprehension calls for an understanding and usage of information; application; combines knowledge; and comprehension to solve new situations, whereas the top three skills on Bloom's taxonomy are called 'higher order skills'. These three skills are very important for solving non-algorithmic problems, which are more difficult than problems requiring only comprehension.

Table 4.1: Bloom's cognitive skills	
Skills	**Definitions**
Knowledge	Able to identify and defined the concept.
Comprehension	Able to apply the concept when instructed.
Application	Able to apply concept appropriately without instruction.
Analysis	Able to dissect a problem and apply the appropriate concept.
Synthesis	Able to combine concepts in new and appropriate ways to give new useful knowledge.
Evaluation	Able to analyse a problem in multiple ways and to identify the relative strengths and weaknesses of each approach.

Source: (Garratt, 1998)

There has been a tendency to regard these hierarchical categories with recognition or knowledge at the bottom of the mound. Johnstone (2003) argued that this a rather narrow view since none of the other levels could operate without recall of information or techniques. He proposed an *'umbrella'* diagram (Figure: 4.2) which might be a better representation of the various aspects of testing than a hierarchy implying superiority. Knowledge and basic skills underpin and support the others, which are modes of knowledge. For example, a student can synthesise without necessarily applying or analysing but she/he cannot apply or do any of the other five skills without knowledge.

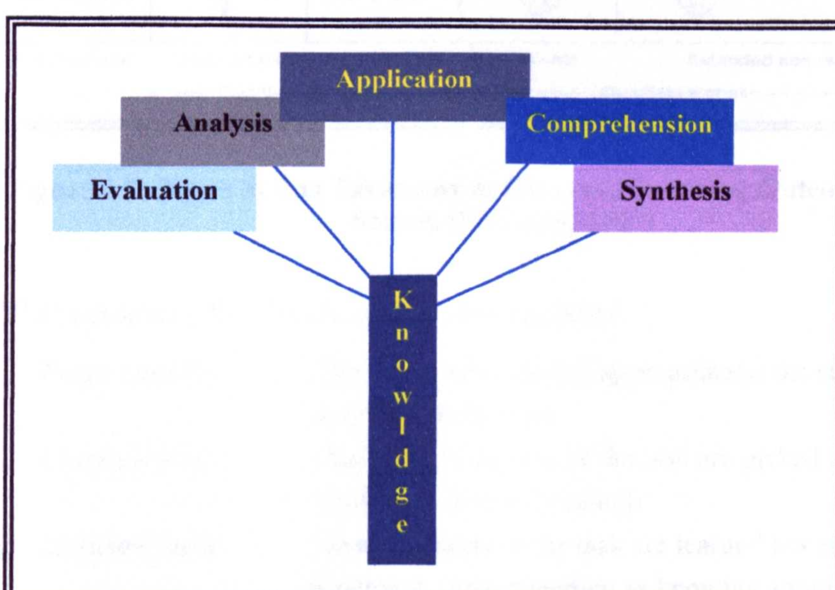


Figure 4.2: Johnstone's umbrella diagram of Bloom's Taxonomy
Source: (Johnstone, 2003)

Yang (2000) supported this modification of the Bloom's taxonomy because she thought it helps us to describe problem solving. The open-ended, real-life problems can be thought of as one or more of analysis, synthesis and evaluation without using application whereas algorithmic problems can be thought of as an application.

Biggs and Collis (1982), aligned with constructivism tradition, have replaced Bloom's taxonomy with the SOLO taxonomy. The SOLO taxonomy stands for the Structure of the Observed Learning Outcomes and it provides a systematic way of describing how a learner's performance grows in complexity when mastering many academic tasks. Biggs and Collis (1982) described the growth of competence in terms of, first, a quantitative accrual of the components of a task, which then become qualitatively restructured (see Figure 4.3).

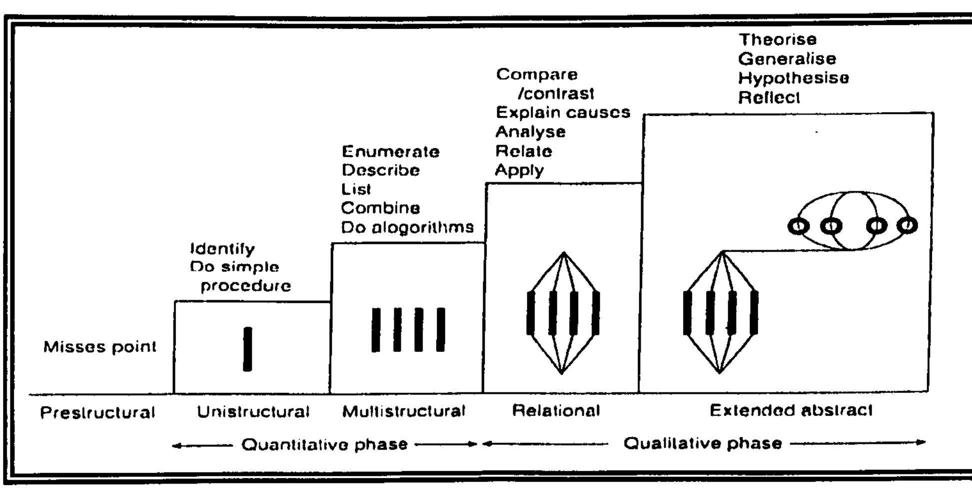


Figure 4.3: Bigg's SOLO Taxonomy of Observed Learning Outcomes
Source: (Hoddinot, 1997)

In SOLO taxonomy five levels may be distinguished:

1. *Prestructural.* The task is not attacked appropriately; the student has not understood the point.
2. *Unistructural.* One or a few aspects of the task are picked up and used (understanding as nominal)
3. *Multistructural.* Several aspects of the task are learned but are treated separately (understanding as knowing about)
4. *Relational.* The components are integrated into a coherent whole, with each part contributing to the overall meaning (understanding as appreciating relationships).
5. *Extended abstract.* The integrated whole at the relational level is reconceptualised

> at a higher level of abstraction, which enables generalisation to a new topic or area, or is turned reflexively on oneself (understanding as far transfer, and as involving metacognition).
>
> Source: (Biggs, 1996)

Below, there are descriptions of some of the assessment forms that are the most common in educational practice. The main formats included in this research were pencil-and-paper activities such us multiple-choice questions, close response question, written open-ended questions requiring short answers and structural communication grids questions. The reason for choosing the first three forms is because they are the most common in educational practice in Greece. As for the structural communication grids, it was thought that it is a useful technique to be introduced in the Greek education system because of the many advantages they have as an evaluative tool. Performance based assessment is also including because there is a movement among educators in recent years and many researchers are referring to them. The following sections cannot serve as a guide to the composition of good questions and other assessment exercise. The account will have to be a rather general of the field, bereft of examples, with the aim of providing a comprehensive overview of the field.

4.3.1 Open-Ended Test

Open-ended tests are an assessment format in which the student is asked to create a written response, where the correct response may vary. There is not simply one correct answer or there is more than one strategy for arriving at the answer. Some common examples of open-ended test are essays and traditional exams in physical sciences with questions measuring decision-making, strategic planning, problem solving, data processing and so on. The score scale of the response depends on the justification, rationale, or explanation that supports the response. A higher score for the question is dependent on answering all parts of the question, rather than only responding to part of the question correctly.

The marking of open-ended questions can be done either using a detailed marking scheme or by impression marking (Black, 1998). Whichever is used, in order to be uniformly fair to all students, it is helpful that the marker has a set of qualitative criteria by writing a 'model answer' for each question based on identification of the mark of a good answer (Race, 2003).

> *"Marking scripts can be boring, exhausting and stressful"* (Race, 2003).

Therefore markers should be realistic about what they can do and avoid to mark large numbers of scripts in short periods of time. In particular

> *"in problems and calculations, credit should be allowed for 'consequential' marks. For example, when a candidate makes an early mistake, but then proceeds correctly thereafter, the marker should allow for some marks to be given for the ensuing correct steps even when the final answer is quite wrong"* (Race, 2003).

Some of the variability of markers' scores may have been caused by the following:

- Halo effect: If the marker has just marked a brilliant answer on a script, it can be easy to go into the same student's next answer seeing only the good points and passing over the weaknesses. Conversely, when he looks at the next student's answer, he may be over-critical if he has just marked a brilliant one.
- Middle-mark bunching syndrome: As the marker gets tired, and his mood changes, it feels safe and easy to give a middle-range mark.
- Prejudices: There will be all sorts of things, which the marker likes and dislikes about the style and layout of scripts, handwriting, and personal idiosyncrasies.

Source: (Race, 2003)

From his review of evidence, Wood (1991) concludes that with only one marker, inter-rater reliability is unlikely to be greater than 0.6, and that multiple marking will help reduce this. He suggested at least two markers for every pupil response, who work independently. The conclusions of a full treatment of marker variability can be summarised as follows (Black, 1998):

- A script should always be marked by two people. It does not have to be more than two.
- The correlation between the marks awarded to the same script by the same examiner on two different occasions is usually greater than that between different markers, although not by much.
- Markers' behaviour on one kind of question is barely predictable from that on another.
- By switching from analytical to impression marking a candidate's result is unlikely to be any more affected than if s/he were to be marked by another examiner.

Source: (Black, 1998)

Some of the advantages and disadvantages of the open-ended assessment are as follows:

Some of the advantages and disadvantages of the open-ended assessment are as follows:

Advantages

- Students are engaged in understanding that there is not only one unique answer to a problem and they can reach the same result by different paths. They are awarded credit if their reasoning is correct, even though their final answer is wrong.
- The questions call for open and extended responses and, therefore, it is required of students to explore complex structures of knowledge and reasoning and to show their ability to select, evaluate, explain and be creative with such material.

Disadvantages

- Question maybe ambiguous and sometimes hide a vagueness in the examiner's own mind. Therefore, they can be interpreted in more than one way. To avoid this, it is very important to set exam questions by elaborating detail to explain what is intended. Examiners should write plain English in short sentences and questions with bullet points or separate parts can be much easier for candidates to interpret correctly than one which is just several lines of continuous prose.
- Pupils can hide uncertainty or ignorance by neglecting to address particular issues. In physical sciences exams lending themselves to problems and calculations, students may miss out on the need to develop other important skills, such as writing effectively and expressing themselves coherently.
- The validity and fairness of the questions. The usual problem is the difficulty of ensuring that the marking is reliable.

4.3.2 Closed Responses or Short Answers Assessment

Closed response questions require answers that are constrained by the form of the question. Short answers questions can be used to assess knowledge, reasoning and skills at various levels of complexity. According to Black (1998), some common examples of short answers questions are items which require pupils:

- to supply a short phrase answers to specific knowledge questions.
- to supply a reason in their own words for a given event or phenomenon.
- to sort a numerical problem which requires only a small numbers of steps.
- to answer a set of short questions designed to test understanding of the text, or skill in responding to and handling new evidence on the basis of a supplied text or set of data.

- to supply other formats where pupils use equipment, investigate, experiment or work in groups.
- to make comparisons between pictorial representations of objects.

Some of their advantages are:

- a fair number of questions can be tackled in a short time, usually by indicating the length of answer expected by providing a set of blank spaces or lines.
- the marking schemes can be fairly tight so that they can be reliable.
- the challenges set to the pupils can be far more authentic than for fixed response questions.
- they allow students to create their own responses, recognising them as active learners.

Black (1998) stated that overall such questions represent the best of both worlds between fixed response and essay questions

4.3.3 Objective Tests or Fixed-Response Questions

Objective tests are based on the psychological theory of behaviourism and they are in alignment with the *objectivist* theory of knowledge. According to the objectivist theory the learner is a vessel to be filled with knowledge and the role of the teacher is to do the filling (Haghanikar, 2003). Objective assessment supports the notion that knowledge exists independently of the knower and understanding is coming to know that which already exists (Biggs, 1996). Objective testing assessment policy greatly concern with quantitative measurement (Biggs, 1996) and objective tests are called so because there is an objective scoring way to mark them. However, as all forms of assessment the objectives of the course are subjectively chosen and the questions are subjectively written to fit these objectives (Johnstone, 2003).

Objective tests are said to measure mainly the ability of the examinee to remember facts and figures. *"However they usually test recognition, which is not the same"* (Johnstone, 2003). In some cases, understanding is assessed. They test knowledge or reasoning which can lead to a single correct answer, and some procedural skills. The most common objective test questions are multiple-choice, true-false, fill-in-the blank and matching items. Doing well on these questions requires that examinees not only master the information but also interpret the test-maker's intentions.

The commonest type of objective questions is the multiple-choice test. It is made up: a statement or question (called the *stem*) followed by a number of options, usually 3 to 5 options, from which the pupil has to choose. Many variations of multiple-choice form have been used. Wesman (1971) defined the following eight types:

> *"the correct answer variety, the best answer variety, the multiple response variety, the incomplete statement variety, the negative variety, the substitution variety, the incomplete alternative variety, and the combined response variety".*

The most commonly used forms are the '*correct*' answer variety, where one of the options is absolutely correct while the others are incorrect, and the '*best*' answer variety, where the options may be appropriate or inappropriate in varying degrees and the examinee has to select the '*best*', namely the most appropriate, option. The '*correct*' answer or the '*best*' answer is called the '*key options*'. The '*incorrect*' options are called '*distracters*'. The stem items should normally relate to concepts or ideas, which are considered important for the pupils to know or to understand. Once the item is roughly formulated, the next step is to find suitable options for distracters. One approach is to set completion items in class and examine the various responses; another is to consider the likely answers arising from the posing of the question in an open-ended manner to a class of pupils and then selecting those nearest to the correct answer.

Although multiple-choice questions are most often used to test memory of details, facts, and relationships, they can also used to test comprehension and ability to solve algorithmic problems. Reasoning ability is a very important skill for doing well on multiple-choice tests.

Advantages and disadvantages of fixed response questions can be summarised as follow (Black, 1998):

Advantages:

- pupils can attempt in a given testing time a large number of items and they can achieve greater coverage and greater overall reliability than is possible with other types of questions.
- pupils' achievements are not dependent on their writing skills
- marking is more reliable

- statistical analysis of the scores is relatively straightforward because the scores are on a simple scale (all 1 or 0)
- by pre-testing a large number of items, discarding those which seem unsuitable and modifying others, the quality can be kept high.

Disadvantages:

- they can give no direct evidence of pupils' reasons for their choices, so their value for formative and diagnostic purpose is limited.
- by guessing pupils can obtain some correct answers. (There is a 20% chance that you will guess the correct choice if there are 5 choices listed.)
- some studies have shown that up to a third of pupils who choose a correct response may do so for a wrong reason.
- the knowledge or reasoning that is tested will be in an isolated or restricted context, so that complex structures of knowledge and reasoning cannot be assessed.
- heavy or exclusive reliance on such questions in high-stakes tests can lead to emphasis, in teaching to the test, on an atomised approach to learning and to a passivity in which one judges other people's ideas but does not propose, formulate or create ideas of one's own.
- a high level of experience and expertise is needed to set good questions of this type.

Friel and Johnstone (1978b), in a general review of multiple-choice testing, discussed the following points: the effect of guessing, the effect of changing the initial response, the effect of item order alteration, the optimum number of choices, the position response set, and the assessment of partial knowledge. The overall pattern of research findings in multiple-choice questions is now discussed.

4.3.3.1 Research on Multiple-Choice Questions

A. Multiple-choice tests as a diagnostic tool

Although multiple-choice tests are often used for identifying students' conceptions, including misconceptions, there can never be certainty about the extent of guessing or the reason for the choice of wrong answers. Hasan *et al.* (1999) used multiple-choice in conjunction with the Certainty of Response Index, (CRI), which provides a measure of the degree of certainty with which a student answers each question, to identify pupils misconceptions. Here the student indicates, on a scale of 0-5, how certain he/she is that his/her answer is correct, using well established knowledge, concepts or laws. They recommend this method to differentiate between students' misconceptions and lack of knowledge. Tamir (1990) noted that for a given multiple-choice question, one third of all students choosing the correct option did so for the wrong reason. He advocates the use of 'best answer' multiple-choice items in conjunction with a requirement that students provide a written justification as to why they chose a particular option. This would enable the identification of 'misconceptions, missing links and inadequate reasoning among students who correctly answered the best answer'.

Friel and Johnstone (1998b) used multiple-choice tests as a tool which can provide important diagnostic information as well as a simple total score. They explored methods which indicate the extent to which an individual's response pattern is unusual. In a conventional multiple-choice test, a point is given for a correct answer and nothing for a wrong answer. There is therefore no guarantee that two students obtaining the same score have the same ability because there are so many ways of obtaining the same score. Of course this is true for all tests. They used modified caution indices, from the work of Sato (1975), and Harnish and Linn (1981), rather than simply using facility and discrimination values to assess student and question performance. Thus, by employing caution indices, it is possible to identify anomalous response patterns to a particular question and of a particular student.

B. Pre-Testing and Modify the Items

It is often answered that one of the advantage of multiple-choice testing is that, by pre-testing, the quality can be kept high. Handy and Johnstone (1973a) provides evidence that statistics from pre-tests sometimes vary widely from those for the actual test and that using common questions, rather than pre-tests, yield a more accurate indicator of performance.

C. Guessing and Scoring System for Guessing

It is generally recognised that multiple-choice items lend themselves to guessing. When a student is provided with a choice of four options, his chance to get the correct answer by purely random selection is 25%. Different evaluators have taken different positions regarding the way this problem should be dealt with. In chemistry examinations Mathews (1967) saw guessing as less of a problem than it is sometimes made out. He asserted that random guessing is rare, and candidates who know any chemistry at all will attempt to assess the merits of alternative answers. He concluded by saying that this latter sort of speculation is not without some merit since, without the intelligent guesser, science would never have made progress. This view was supported by Hudson (1969) who also emphasised the place of inspired guesswork in scientific research.

To prevent, or compensate for, guessing, correction formulae of varying degrees of complexity were developed. Two methods for inhibiting guessing are appeared in literature: a method which penalises for guessing and a method which offers reward for omitting items when uncertain.

Hudson (1969) and Handy and Johnstone (1973a), presented a simple generalised formula to penalise a student's score for guessing by subtracting a correction factor from his/her total score for each incorrect response he/she has made. The formula is:

$$\boxed{S = C - \frac{W}{N-1}}$$

Where S is the corrected score, C is the number of correct responses chosen, W is the number of incorrect responses chosen, and N is the number or possible responses in each question. If all questions have been answered by all students there is no difference between the ranking of corrected and uncorrected scores. The same penalty is exacted irrespective of whether he/she is wrong on the grounds of misinformation, partial guessing or blind guessing.

Hudson (1969) in the same paper suggested another formula, which adds marks to the student's score for omitted items in order to discourage students for guessing and encourage them for the best attitude to the test.

$$\boxed{S = C + \frac{O}{N-1}}$$

Where S is the corrected score, C is the number of correct responses chosen, O is the number of items omitted, and N is the number or possible responses in each question

Little (1966) and Edgington (1965) argued that correction formulae should not be used because they treat mistakes produced through misinformation as though they occurred by chance. In addition, Hudson (1969) and Handy and Johnstone (1973a), although suggesting the above formula, stated that there is little point in adjusting scores in examinations such as the national examinations since the rank order of the candidates is substantially unaltered. They concluded that adjustment of final scores by formulae to correct for guessing does not eliminate or minimise the effect of chance when answers have been guessed. This statement is in agreement with Burton and Millar (2000) who, in a recent study, showed also the futility of this on statistical grounds. If the purpose of the test is to place students in order of merit, there is no need for any deduction, because the rank order correlation between the raw scores and 'doctored' scores is usually in excess of 0.95.

In another study Handy and Johnstone (1973b) concluded that the answers to multiple-choice questions selected validly by students, with minimal blind guessing, along with failure to answer comprehension questions, chiefly arises through deficiencies in knowledge. Wood's (Wood, 1987) comments on Schofield's (1973) article concerning guessing were:

> *"three scoring methods thought to have differing effects on response behaviour in a state of uncertainty were compared for effect on performance using groups undertaking A-level mathematics multiple-choice pre-tests. A method, which induces respondents to omit items when uncertain by offering reward-Schofield's correction (b) -was found to 'under-reward' the better students and 'over-reward' the weak ones. A method, which exacts a so-called penalty for guessing-Schofield's correction (a)-appears to inhibit the better candidates from making full use of their abilities. Only the rubric currently used by the London board- 'attempt all questions'- seems to have this desirable effect while not offering any noticeable gains to weaker candidates who might be expected to take advantage of it".*

D. The effect of initial response changing

Friel (1976) looked at whether it is advantageous for students to change initial answer on multiple-choice test provided time permits a second consideration of some of the items. He used tests given to first and second year pupils in a comprehensive school over a period of two years. There was no time limit put on the tests. Therefore, all the pupils completed every item and there was sufficient time for any response alterations to be made. The results of this investigation concluded that pupils do in fact gain marks by altering their first choice in multiple-choice science examinations and that the number of changes made depended on the degrees of difficulty of the test. The author didn't make any suggestions whether or not we should make instructions at the beginning of a multiple-choice test paper which would encourage pupils to change responses when a second consideration suggests that their initial choice is incorrect.

Smith *et al.* (1979) looked at the results of multiple-choice tests in educational psychology and discovered that eighty-six percent of the students changed one or more answers, and six out of seven students who made changes improved their scores by doing so. The findings of Fabrey and Case (1985) were consistent with the above findings. They studied the effect on test scores of changing answers in multiple-choice question in a nationally administered, speciality examination for medical residents in obstetrics and gynaecology. Their findings are that both low and high scorers improved their scores when they changed answers. Casteel (1991) from a study that he did among good and poor readers in the eighth grade supports the notion that answer-changing responses among young examinees should be encouraged if there is a reasonable doubt about their 'first impression'. His study showed that, for good and poor readers when a single response was changed, there was a two-to-one chance that the new response would raise rather than lower the final score. Gains from answer changing on test items were slightly higher for poor readers as a group than were those for good readers but were not significantly different.

In contrast to this study, Trinkaus (1991) mentioned studies performed primarily with students studying education and psychology, which suggest a generally held belief that more points are to be lost than gained by changing initial answer on multiple-choice tests. In a survey that he did of 442 undergraduate business students tended to confirm that business administration students appear to hold similar beliefs.

E. The effect of item order alteration

The general accepted practice for examiners is to arrange the items in multiple-choice tests in order of increasing difficulty. One obvious reason for this practice is that it increases the probability that an examinee will succeed on the earlier items and thereby gain confidence for the more difficult items later in the test. Another practice for examiners is to arrange the items in multiple-choice tests in a sequence parallel to the order of presentation were studied. However, tests are often not constructed in this way. In order to reduce the likelihood of one examinee copying another's answers on large-scale tests examiners use multiple forms that differ in item ordering. The question that arises is if any changes are made to the test have any impact in the reliability of individual questions in the test.

MacNicol (1966) found that when items were ordered from difficult-to-easy, the mean number of correct responses on the test was significantly lower than the mean numbers of correct responses obtained when the items were ordered in one of two other ways: from easy-to-difficult, and at random. These results were obtained for a test without a time limit. Flaugher *et al.* (1968) found when easy items appeared later in a test they were not reached by some examinees. In other words, if the test is timed, it is clear that the difficult-to-easy item order would disadvantage slow students since they would not have a chance to answer the easier items.

In contrast to these studies, several other researchers failed to observe an item order effect (e.g. Friel and Johnstone, 1978b). Mollenkopf (1950) gave one plausible explanation of the item order effect that the fatigue and pressure to finish could account for the poor performance on easy items when they appeared later in the test. Friel and Johnstone (1978b) think that personality characteristics of individual students such as anxiety and the discouragement of having to omit early difficult items might influence test performance in the difficult-to-easy items. Carstens and McKeag (1982) retested after two weeks the same students giving to alternate rows of students the experimental version of a test, which differed from the original only in item sequence. It was expected that a learning effect would be present, resulting in higher scores and smaller standard deviations on the re-test. Results of their study only partially aligned with expected results. While mean performance was higher on the re-test results, standard deviation did not follow expected results. They conclude that the sequencing of items in a test is a complex factor and needs carefully study and consideration by teachers and test makers.

F. The optimum number of choice

Examiners commonly prefer in constructing multiple-choice tests items with as many as possible choices in the expectation that by doing so their tests will be more discriminating and guessing will be reduced. Thus, converting four option questions to five option questions statistically reduces guessing from 25% to 20%. However, the effort required to produce a fifth plausible distracter is so great that it hardly warrants the effort to reduce blind guessing by such a small amount. So many fifth distracters attract few, if any, students and so tend to reduce the questions to four options. Johnstone and Ambusaidi (2000) stated that:

> *"research showed that students tackle fixed response questions in two ways; by recognition of an answer or by elimination of distracters. If guessing has to take place, it is between the options that have not yet been eliminated, (often two) making the guessing factor 50%! Some writers see this latter technique as a multiple true-false situation".*

Tversky (1964) presented a mathematical basis that, given a fixed number of choices on a multiple-choice test, the use of three choices at each choice point will maximise the discrimination and power of the test. Delgado and Prieto (1998) applied a study of two versions of 90 items comprising three computerised examinations in successive years with four and three options items in multiple-choice tests. Their study showed that three options are more suitable for most ability and achievement test items and three-options items compared with their four-option versions tend to be slightly easier without showing any decrease in discrimination. In addition, they didn't found any systematic changes in reliability for the tests, which adds to the evidence favouring the use of the three-option test item. This view was supported by Haladyna and Dowing (1993) and Bruno and Dirkzwager (1995). They revealed that, in general, three choices in a multiple-choice item seem optimal. The former also emphasised that test items seldom contain more than three useful options and suggests that testing program personnel and classroom teachers may be better served by using two or three options items instead of the typically recommended four or five options.

Arce-Ferrer *et al.* (2001) came out with results favourable to four options when they applied a fifth math test of five versus four response options. Their conclusion was that four-option items are better than five items because they save space and student time, allowing increasing the number of test items, thereby augmenting test reliability.

H. The position response set

Most test constructors agree that proper sequencing of multiple-choice test items, with respect to keyed response position, is a desirable test characteristic. It is usually recommended that the correct answer appear in each position about an equal number of times and that the items be arranged randomly. It is also recommended as a rule for developing equated examination results that the items common to the two examinations being equated should be identical.

Several investigators of position response sets in multiple-choice tests have yielded contradictory results (Friel and Johnstone, 1978b). Marcus (1963) suggested that it is the position of the most plausible distractor that more logically accounts for any significant response bias than does a positional preference. Friel and Johnstone (1979) offered evidence supporting Marcus suggestion. They found that by placing the most plausible distractor immediately before the key, the degree of difficulty of the item would be altered significantly. The degree of difficulty, in this case, was found to decrease significantly.

Johnstone and Ambusaidi (2000) found that the Facility Value (the fraction of the sample choosing the 'correct' answer) depends upon the chance arrangement of the options in the question. They stated:

> *"If the order of the options of each questions of one test are scrambled for the second test, but keep the questions themselves unchanged there is no guarantee that the two tests are now comparable. The averages of the two tests may be similar, but the performance of specific questions between the tests may well differ significantly".*

They concluded that, if any changes are made to the test, the reliability of individual question is severely reduced, and that fixed response tests are reliable if applied unchanged to two similar groups of students. Changes in items' Facility Value are also reported by Cizek (1994) who when reordering items options has found significant but unpredictable effects on item difficulty.

F. The Effect of Language on Student Performance

It is easy to assume that differences in students' mean performance are due to differences in their ability to the subject matter be tested. Cassels and Johnstone (1984) showed that the language in which the question is expressed may be a very significant factor in the student performance. In this study the same questions used in alternative tests were used to assess the influence of language on multiple-choice outcomes. The following results were reported:

- *key words*: replacement of pompous expressions with simpler words brought about improved performance.

- *terms of quantity*: terms of words such as 'most abundant' appear easier to understand than 'least abundant'.
- *negative forms*: in general, the removal of negative questioning (e.g. 'Which statement is true' rather than 'Which statement is not true'.) appears to improve performance.
- *large numbers of words and arrangement of clauses*: long complex sentences proved to be more difficult than short questions written in short sentences.
- *minor changes in parts of speech*: the choice of active or passive voice has little effect.

G. Assessment of partial knowledge

One of the most serious drawbacks of the fixed-response questions is that they do not give insights into the student's knowledge and reasoning for choosing the correct or the wrong answer of a question. In multiple-choice questions when a student makes a choice, it is not known if this choice is the correct choice being made for a right or for a wrong reason. In scoring the open-ended questions, having an insight into the students knowledge, credit is given for partial knowledge or for wrong conclusions arrived at for good reasons. In the multiple-choice situation, no such credit is given. This is a key different between multiple-choice and open-ended questions. To overcome this problem two methods have been proposed as ways of assessing partial knowledge:

- *Differential weighting of response alternatives*
- *Confidence testing*

These two methods will be discussed in term.

Differential weighting of response alternatives

The effects of assigning different weights to different options on multiple-choice items have been investigated both theoretically and empirically by Davis and Fifer (1959) and Aiken (1967). One result of allowing partial credit for options which are not absolutely correct is an increase in the total score variance and, consequently, test reliability without altering test validity. They claimed the reason for that is from selection by examinees among distracters of unequal merit is obtained and arising in the variance; this variance is excluded from measurement when all incorrect choices are weighted equally.

Willey (1960) proposed a scoring system for a special kind of five-option item, which he labelled as a 'three-decision multiple-choice item'. In this system the examinee is asked to indicate which one of the five options is definitely correct and which two options are definitely incorrect. Thus, effectively the three-decision item requires the examinee to sort five options into three categories. Three (3) marks are given to an answer if the option designated as the correct one is in fact the correct one. Two (2) marks are awarded if the correct answer is not put into the 'definitely correct' or 'definitely wrong' categories. No (0) marks are given if the correct answer is placed in the 'definitely wrong' category. Willey believes that the 'Three-Decision Test' is regarded by examinees as more fair because the influence of chance is reduced and because they can get some credit for partial knowledge. He claimed that this method appeared to favour the conscientious examinee over the one who was superficial and impulsive.

Friel and Johnstone (1978a) in an investigation compared the results obtained from scoring a multiple-choice test using the following four different scoring procedures:

1. The conventional multiple-choice scoring system: one mark for a correct choice of option, no marks for an incorrect choice.
2. The system suggested by Willey: the questions were scored as a 'three-decision multiple-choice test' with a marks allocation 3, 2, 0 as described in the introduction.
3. A modification of Willey's system: the questions were scored as in '2' but with a marks allocation of 2, 1, 0.
4. A second modification of Willey's system: the questions were scored as in '2' but with a marks allocation of 2, 1, -1.

Their finding suggested that the first modification of Willey's scoring system is more desirable as a measure of partial knowledge as any such measure should add to the pupils' marks and not reduce them.

Arnold and Arnold (1970) also produced a scoring procedure for multiple-choice examinations that allows for partial knowledge and also allows the examiner to control the expected gain due to guessing. This procedure is based on elementary games theory and in it the examinees are instructed to choose the smallest set that they are confident contains the correct response. A penalty is given if the correct or 'best' response is marked out as incorrect response. This procedure then allows the examinee to receive credit for partial knowledge, the credit being greater the more 'incorrect' responses that he can eliminate i.e. the smallest set he can chosen is the correct response itself.

Confidence Testing

Dissatisfaction with conventional scoring stems from the feeling that it seems inappropriate to require a student to pick a single response when all his information and intuition tells him that he is really not that sure of himself. The conventional practice of multiple-choice tests does not allow a student to make use of his knowledge's uncertainty, and it might be argued that, at times, knowledge of our uncertainty may have considerable value. Rippey (1970) has suggested a system for responding to and scoring multiple-choice tests that asks students to express their distribution of preference for options as well as their certainty in that distribution. He states that one of the options available to the test constructor when confronted by partial knowledge and uncertainty is to adapt conventional items to confidence scoring procedures or use intrinsic items. Intrinsic items require a distribution of belief over the options on a multiple-choice test and do not have unique correct responses. Intrinsic items reflect, realistically, situations which require choices among a finite number of responses, none of which is uniquely correct. Such situations are common and characterise the boundaries of fields of knowledge, and conditions of incomplete information.

Johnstone and Ambusaidi (2001) suggested other forms of fixed-response questions in an attempt to eliminate problems which arise from fixed-response questions and remedy these problems by:

1. giving credit for partial knowledge,
2. reducing the possibility of guessing,
3. and finding indications of reasoning paths

These methods are not new, but have largely been neglected. They are: Interlinked True/False questions, Venn Diagrams and Structural Communication Grids.

The following sections is devoted to examine only the Structural Communication Grid questions because it was the only method of above-mentioned that was used in this research.

4.3.4 Structural Communication Grids

The Structural Communication Grid is a very powerful and flexible method of fixed-response assessment, which can range in use from the checking of facts and simple relationships to the construction of *"objectively markable essays"* (Johnstone, 2003). The earliest ideas for this kind of assessment are found in the work of Egan (1972). It was an attempt of the Centre for Structural Communication in Kingston-upon Thames to develop a means to combat one of the more persistent problems, which seems inherent in all mass educational systems. The student-teacher ratio has tended to rise as more and more young people have sought the advantages available through the educational system, and it has proved impossible to match this increase in students with an equivalent increase in teachers skilled to evoke self-reliant judgment. Thus the increase in the quantity of students, and the consequent stresses on the system, threaten continually, and have caused often, a decrease in the quality of education generally available.

In a Structural Communication Grid question, an array of information is presented as a set of numbered boxes in the form of a grid and the pupil is asked in response to a question to consider the content of each box and decide which box or combination of boxes constitutes the most appropriate answer to the question. In some circumstances, the order in which boxes are chosen is important. The box may contain pictures, words, ideas, equations, formulae, structures, definitions, numbers and operators. The same item may be selected as a part of a response to a series of questions and if the unit (grid) is well structured, it will play a different role in each question.

Egan (1972) pointed out that:

> *"Implicit in its use the Structural Communication seems to be the belief that any curriculum area has within it a vast variety of possible structures. These depend on a whole menagerie of different interactive elements, to which we give names like facts, concepts, organising principles, assumption, presuppositions, etc., which are rarely if ever made explicit in the act of communication, but are rather the means by which the communication is made intelligible. Each teacher must create a more or less coherent structure in this sense to communicate any set of knowledge claims. Structural Communication demands of its authors a much more explicit and organised structuring of the subject-matter of any Study Unit than is normal of the practising teacher, but it does not demand rigorous obedience to any specific dogma about what structure necessarily must be, beyond the construction of a commonly understandable coherence in the relationships of knowledge elements, and indeed it carries the implication that further dogmatism is necessarily misplaced"*

Guessing does not enter into this type of item because the student does not know how many boxes are required or in which sequence they are required to provide an adequate answer (Johnstone, 2003 and Reid, 2003). This is in sharp distinction to multiple-choice questions where the pupil knows that one out of four (or five) must be correct and a roulette game may be appropriate. Yet the diagnosis allowed in the following section permits the authors to keep complete control over the unit while allowing a great degree of freedom to the student in composing his response. A response cannot be made by simply choosing one from a set of prepared answers. Nor can a response be composed by applying a simple yes/no criterion of relevance to the problem, because when items are combined they modify each other by 'semantic interaction' and the way in which the items are combined modifies the potential significance of the remaining items which have yet to be incorporated into, or rejected from, the emerging structure of meaning. Much learning in schools takes the form of simply passing on to students the products of the research of scholars. Structural Communication was designed to engage the student, in a limited way, in a kind of intellectual activity more similar to that of the scholar since the student has to make a coherent picture of a random set of knowledge elements by organising them according to a specific 'telling question' (Bahar, 1999).

However, there is one drawback, which must be countered. If students are given credit for their correct choices and go unpenalised for wrong choices, they could give all the boxes that the grid contains as the answer to all the questions.

In terms of selecting the boxes, there are four possibilities:

I. The student includes all the relevant information and omits all the irrelevant information. He gives a correct and complete sequence and gets <u>full marks</u>.

II. The student include most but not all the relevant information and includes no irrelevant information. This leads to a <u>lesser score</u>.

III. The student includes some or all relevant information along with some irrelevant information. Then he gets an <u>even smaller score</u>.

IV. The student omits all relevant information and includes irrelevant information only and so gets a <u>negative score or no score</u>. Source: (Bahar, 1999)

Johnstone and Ambusaidi (2001), adopted Egan's correction factor to get round these possibilities. The scoring system is:

$$\text{Score} = \frac{\text{Number of correct boxes chosen}}{\text{Number of correct boxes available}} - \frac{\text{Number of incorrect boxes chosen}}{\text{Number of incorrect boxes available}}$$

Suppose in a grid with nine boxes that the correct answer to a question is 3 boxes.

1	2	3
4	5	6
7	8	9

1. A student who responded with the 3 correct boxes would have score: (3:3)-(0:6) = 1
2. A student who responded with 2 correct boxes and omitted one would have score: (2/3)-(0/6) = 0.7 (Partial knowledge is rewarded).
3. However, if a student's response was 2 correct boxes and one incorrect the score would be given by score: (2/3) - (1/6) = 0.5.
4. The student who chose all the boxes would have a score of score: (3/3) - (6/6) = 0

According to this formula, student's scores range from +1 through 0 to -1. This can then be multiplied by some factor to give the student a recognisable score. For example, add 1 to raw score (to get rid of the negative) and multiply by 5. The score would then range from 10 to 0. Even though that this arithmetical procedure is a little tedious to do by hand, this can be handled easily by computer or manually from a table.

The appropriate size of the grid is related to the ages of the population using it. For first year secondary school pupils (age 12) grids with 12 boxes (4 x 3 or 3 x 4) have successfully been used. For fourth year pupils, (age 16) a 16 boxes grid is quite appropriate. The largest grid that has been used contained 20 boxes and this was used with undergraduates (Bahar, 1999).

Structural communication grids can be used for categorising facts, pattern seeking, put responses in sequence and even as 'objecting essay' (Johnstone, 2003). Structural communication grids have been used successfully in various schools and disciplines as well as in research by several researchers when they used SCG tests as an alternative method of diagnostic and summative testing (Bahar, 1999; Hassan, 2003; Chen, 2004; Danili, 2001).

Some of the advantages and disadvantages in using Structural Communication Grids are (Reid, 2003):

Advantages:

- they are much easier to set than multiple choice questions;
- guessing is eliminated;
- they are very good tools either to gain clear evidence of students' knowledge gap or to gain insights into students' conceptual understanding and misconceptions;
- there are several ways to score;
- you can ask many questions using one grid, gaining useful insights into many aspects of some concept or area of interest.

Disadvantages:

- Marking needs careful thought to gain the most powerful insights.

4.3.5 Performance Based Assessment or Authentic Evaluation.

In recent years there is a movement to design assessment, which moves away from the standardised, multiple-choice type test towards approaches where the assessment task closely matches the desired performance and takes place in an authentic, or classroom, context (Glaser, 1990).

Performance-based assessment, more commonly called performance assessment and also called appropriate assessment, alternative assessment, or direct assessment. Performance assessment typically involves students, either individually or in small teams in the act of solving a problem, or thinking critically about a problem, data or observation. Performance assessments also involve assessing students on their ability to use science skills such as sorting and classifying, observing and formulating hypotheses, interpreting data, designing and conducting an experiment, and creating portfolios (Gipps, 1994).

They can be summarised numerically or put on a scale to make it possible to combine individual's results and to meet national requirements for comparable quantitative data. As they promote the thinking curriculum everyone wants for children, they will provide genuine accountability.

The following are some of the advantages and disadvantages of performance assessments (Hassard, 2003):

Advantages:

- typically involve students in real-world contexts
- involve students in sustained work, sometimes over several days.
- focus on the 'big ideas' and major concepts, rather than isolated facts and definitions.
- are broad in scope, usually involving several principles of science.
- involve the students in using science processes, the use of scientific methods, and manipulation of science tools.
- present students with open-ended problems.
- encourage students to collaborate and brainstorm.
- stimulate students to make connections among important concepts and ideas.
- based on scoring criteria related to content, process, group skills, and communication skills.

Disadvantages:

- it can take a long time to assess a set of questions.
- it is hard to mark objectively and decide on a set of assessment criteria.

4.4 Correlations between different Formats of Assessment

Several studies have looked on the effects of assessment task format on student achievement (e.g. Bridgeman and Rock, 1993; Bridgeman and Morgan, 1994; Becker and Johnston, 1999; Eley *et al.*, 2001; Caygill and Eley, 2001; Greer, 2001; Goldberg and Pedulla, 2002; Chansarkar and Raut-Roy, 1987; Wilson, 1992; Stecher *et al.*, 2000; Friel and Johnstone, 1978a). Many other studies have looked on the effect of gender differences on student performance in different assessment forms (e.g. Ben-Shakar and Sinai, 1991; Freeman, 2003; Penner, 2003; Bridgeman and Morgan, 1994; Xionidou-Moskofoglou, 1996; Karageorgios *et al.*, 2001.)

Friel and Johnstone (1978a) showed that, if the same area of learning is assessed by normal open-ended, methods and also assessed by objective, fixed-response methods, two orders of merit are generated for a given group of students. Since the same knowledge and understanding is being assessed, the two orders of merit should be actually the same for the same sample of students. The best student by one method should be the best by another method and so on down the line. In that case, if rank-order correlation is worked out between the two orders of merit there should be about 1.0, a perfect match in order. A complete reversal of the order would give a value of -1.0 and a completely random pair of orders would give a value of zero. The research found that the rank-order correlation was about 0.6. This suggests that the two orders of merit have some similarity, yet are by no means well matched (Johnstone and Ambusaidi, 2001).

In classroom assessment, the study of Yuh-Yin and I-Fen (2000) with science tests found that the correlation between multiple-choice items and short-answer question was 0.68 in on topic (solution) and 0.77 in another topic (momentum), whereas the correlations between the same formats of assessment but in different content areas were smaller. Thus, for multiple-choice solution and multiple-choice momentum, the correlation was found to be 0.47, and for short-answer solution and short-answer momentum it was found 0.66. Moreover, correlations between multiple-choice items and short-answers questions with performance-based assessment were smaller even in the same area of content (0.48 and 0.46 respectively). It was assumed that, under the same content area, multiple-choice and short-answer tapped similar cognitive components while performance-based assessment emphasized different cognitive dimensions.

Badger (1990) findings were similar to the Yuh-Yin and I-Fen (2000) study. He compared the multiple-choice and the open-ended responses given by the same students in mathematics and science. The research showed that the correlations ranging from 0.44 to 0.60 for mathematics and from 0.49 to 0.44 for science.

All the above studies showed clearly that it is unwise to rely on one format only, particularly if the formats are conventional ones (such as multiple-choice, or essay). Chansarkar and Raut-Roy (1987) found that weaker students perform best when traditional examinations are not used. They suggest that performance is best when a variety of evaluation methods are combined.

4.5 How Fair Is a Test

When it comes to evaluating how tests work and how well they serve the purpose assigned to them, there are some characteristics of the scores that have to be studied mainly: validity and reliability (Wood, 1987) and the fitness for purpose (Sutton, 1992).

4.5.1 Validity

The traditional definition of validity is the degree to which a test measures what is was designed to measure (Gipps, 1994). In the literature, there can be found many categories of validity of which the most common are: *face, content, construct, concurrent, and predictive validity.*

Face validity is concerned with how a measure or procedure appears. Does it seem like a reasonable way to gain the information the researchers are attempting to obtain? Does it seem well designed? Does it seem as though it will work reliably? Unlike content validity, face validity does not depend on established theories for support (Fink, 1995).
Content validity is to test whether a given syllabus has been learnt (Black, 1998). The examiners might check whether the questions matched the contents and learning aims of a syllabus, sampling the areas fairly and not going beyond its boundaries.
Construct validity relates to whether the test is an adequate measure of the construct, that is the underlying skill being assessed (Gipps 1994) and consequently whether someone can draw some inferences from the responses to a set of questions. *"A notorious example is the construction and interpretations of intelligence tests: here, the sum of responses to a specific set of questions is said to measure something which is called 'intelligence', and predictions and actions affecting a pupil's future to clarify conceptually the meaning of 'intelligence' and to explore, empirically or by expert judgment, whether a given set of questions do indeed require and evoke this as a common feature in the pupil's response"* (Black, 1998). Black's view is that checking on construct validity can be a complex matter and the aspect of reliability becomes a necessary condition to ensure validity in cases that a set of questions is said to bear the same well-defined construct.
Concurrent validity is concerned about whether the test correlates with, or gives substantially the same results as, another test of the same skill. For example two intelligence tests should produce similar results with the same group of people (Wood, 1987).

Predictive validity relates to whether the test predicts accurately or well some future performance. For example is Higher Grade performance (Scottish school examinations) a good predictor of performance in higher education? Sirhan and Reid (2001) illustrated this by looking at first year Chemistry class and showed that the performance in university examinations related very closely to entry qualification. Gipps (1994), referring to these kind of examples, argued that it is very difficult to predict validity since *"that in calculating predictive validity only those who pass the exam go on to university and we do not know how well students who did not pass might have done"* Gipps, (1994).

It is a real problem attempting to unify the above validities in a general approach. Messick (1989) operating with a notion of validity that relates to inferences drawn from test scores, said that

> *"validity is an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and attitudes based on test scores or other modes of assessment".*

The test or assessment has to focus on what you want to find out about. The basic idea is to ensure that your assessment tells you what you planned to find out. The general principal is:

> *"How You Test Is What You Get"* (Sutton, 1992).

Validity is a difficult concept to measure quantitatively. Absolute validity is impossible in reality: working teachers, in real classrooms with real children have neither the time, the resources, nor the mind-reading abilities it would take to be certain that our assessment tasks can tap the reality of what is inside the children's heads. It is possible for the same assessment to be valid for one child and less valid, even invalid, for another because children have different ways of receiving and presenting information. Some read well, others do not. Some children can explain orally far more successfully than they can in writing, while others would express themselves by diagrams or drawings, using a minimum of words (Sutton, 1992). Wood (1991) (quoted in Blank, 1998) agreed that

> *"the examining boards have been lucky not to have been engaged in validity argument. Unlike reliability, validity does not lend itself to sensational reporting. Nevertheless, the extent of the boards' neglect of validity is plain to see once attention is focused... The boards know so little about what they are assessing".*

This raises an ethical issue about assessment.

It seems generally accepted today that the essential form of validity is construct validity (Messick, 1989; Pollit and Ahmed, 1999). According to Pollitt and Ahmed (1999)

> *"the construct in question is in reality a psychological process, the combination of mental activities that are required to perform at a certain level of proficiency on the test in question. ...Unlike some views of validity, this is essential intrinsic; given an understanding of the activity the test is meant to assess, validity consists in managing the assessment procedures in such a way that candidates' mental activities during the test will correspond as closely as possible to the mental activities of a person engaged in real life use of the knowledge or subject being assessed".*

When construction of a question using physical aspects such as diagrams, pictures; graphs, tables, and sketches, research suggests that can influence the way that students understand it and what kind of answer they think is required (Crip and Sweiry, 2003). Crip and Sweiry (2003) maintained that

> *"when reading a question, students form a mental representation of the task they are being asked to carry out. Certain aspects such as diagrams or images are particularly salient and hence can come to dominate the mental representation that is formed. Therefore, subtle changes to these salient physical features of a question may affect how the question is understood".*

4.5.2 Reliability

Reliability is concerned with the accuracy with which the test measures the skill or attainment it is designed to measure. It tests whether an assessment produces the same or similar score on two occasions or if given by two assessors. The various ways in which an individual's result might have come out differently may have to do with the examiners' judgments and the variability in the pupils' responses. Reliability relates with the consistency of examinee performance is called replicability and reliability relates with the consistency in assessing that performance is called comparability. The quantification of that consistency is the business of reliability analysis.

There are four general classes of reliability estimates, each of which estimates reliability in a different way (Trochim, 2000 and American Educational Association, 1985). They are:

1. Inter-Rater or Inter-Observer Reliability is used to assess the degree to which different raters or observers give consistent estimates of the same phenomenon.
2. Test-Retest Reliability is used when the same test is given in two different times to the same population and the scores are correlated.
3. Parallel-Form Reliability is used when alternative forms of the 'same' test are given to similar populations and the scores are correlated.
4. Internal Consistency Reliability assesses the consistency of results across items within a scale test by estimating how well the items that reflect the same construct yield similar results. It looks at how consistent the results are for different items for the same construct within the measure. When no pattern is found in the students' responses, probably the test is not well constructed or it is too difficult and students just guess the answers randomly or perhaps the test is just measuring different aspects. The most common internal consistency measures are:
    1. average inter-item correlation;
    2. average item-total correlation;
    3. split-half reliability; and
    4. Cronbach's Alpha (α) internal consistency

(when data have many items Cronbach'sAlpha shows how well a set of items – or variables measures a single unidimensional latent construct).

The standard ways of assessing reliability of marking are mark-remark procedures with different markers scoring the same piece of work (*inter-rater* reliability) or the same marker scoring the same or similar pieces of work on different occasions (*test-retest*, or *parallel-form* reliability). However *test-retest* or *parallel-form* reliability are not very feasible, and therefore, not very common. In the literature, it is very common for the researchers to use internal consistency (either split-half reliability or Cronbach's Alpha). However, this is not desirable for many tests which have many heterogeneous items and thus assess a mix of modes, contexts and dimensional skill or attribute. This is likely to reduce the internal consistency while enhancing fairness (Gipps, 1984). Internal consistency is rarely sought in educational measurement when a range of skills and understanding are being assessed. Cronbach's Alpha is rarely appropriate.

4.5.3 The Fitness for Purpose

Validity and reliability are technical issues that are very important. However, there is a more important issue to testing and assessment than validity and reliability. This issue is the *"fitness for purpose"* principle. Sutton (1992) stated that assessment could be a formal procedure with desks in rows, no books, no talking, limited time, written questions and written responses. It could be by observation of children as they work normally in the classroom, laboratory, workshop or gym. It could be by listening to a child tell the answers to questions s/he has been asked, or by looking at what a pupil has produced. There are as many styles of assessment as there are styles of teaching and learning. Assessment, therefore, is a creative process that can be as varied and interesting as teaching and learning, indeed it can be fun. Sutton (1992) made the telling point that

> *"fitness for purpose principle requires us to be clear about why we are assessing, and then to find the most appropriate techniques or styles to fulfil that purpose".*

Clearly, there is a close connection between the way we plan teaching and the way we plan assessment. Sutton asked:

> *"But which comes first?"*

He quoted the Task Group on Assessment and Testing (TGAT, 1987) report which says:

> *"The assessment process itself should not determine what is to be taught and learned",*

Sutton (1992) commented that

> *"this is easy to say, and vital to remember. However, it is not always easy to act upon, particularly when we are anxious about our accountability for the 'results' our children produce, and when the assessment criteria-statements of attainment, at levels-are 'writ large' in statutory orders. The greater your professional confidence, the more likely you are to put teaching and learning needs first, and let assessment adopt its appropriate place, as the servant of the curriculum. In National Curriculum terms, start you planning from the Programmes of Study, not the attainment targets."*

Therefore, what is most important first to ask is assessment for what and then design the assessment programme to fit.

Conclusion

The main question in education is: what should be the aims of educational measurement? Should the aim be to devise tests, which look at the individual and find out 'how well' or should look of 'how many'? Should the aim be to devise tests to support learning or to devise tests to evaluate teachers according to pupils' performance and achievement? The dangers of 'teaching to the test' are well known and if only a limited range of facts and skills are assessed, and if 'high stakes' are attached to the results in terms of the consequences of the publication of league tables, then we can expect teachers to teach to the test and restrict the curriculum accordingly.

Wood (1986) holds that educational measurement aims should be

> *"to devise tests which look at the individual and find out how well rather than how many".*

His definition of educational measurement was that it:

- deals with the individual's achievement relative to himself rather than to others;
- seeks to test for competence rather than for intelligence;
- takes place in relatively uncontrolled conditions and so does not produce 'well-behaved' data;
- looks for 'best' rather than 'typical' performances;
- is not effective when rules and regulations characteristic of standardised testing are relaxed;
- embodies a constructive outlook on assessment where the aim is to help rather than sentence the individual.

Source: (Wood, 1986)

If the purpose of educational measurement is 'how well' rather than 'how many' then this requires a quite different approach to test construction. Gipps (1994) pointed that we need a more measured, analytical approach to assessment in education. We need to resist the tendency to think in simplistic terms about one particular form of assessment being better than other: consideration of form without consideration of purpose is wasted effort. She called for wider understanding of the effect of assessment on teaching and learning and fostering a system which supports multiple methods of assessment while at the same time making sure that each one is used appropriately.

There is also a need for distinction between competence and performance. Gipps (1994) said that

> *"Competence refers to what a person can do under ideal circumstances, while performance refers to what is actually done under existing circumstances. Competence includes the ability to access and utilise knowledge structures, as well as motivational, affective and cognitive factors that influence the response"* (Gipps, 1994).

Thus, according to Messick (1984)

> *"a student's competence might not be revealed in either classroom performance or test performance because of personal or circumstantial factors that affect behaviour".*

It is a need for educators to think of the impact of motivation and self-esteem if they use the wrong tools to assess their students. It is a need to find the assessment forms that are appropriate to individuals and to elicit the best performance of them. In order to do that educators should be aware of the learning theories which seek to understand why the students so often face difficulties and to align assessment with these theories.

Furthermore, different types of assessment seem to encourage deep or surface approaching to learning (Struyven *et al.*, 2002). Fixed response questions for example, may encourage students to think dualistically even if designed to go beyond recall issues because, at the end of the day, students are asked to select one right answer. Therefore, it is argued that the content and style of a test have an important message to students about the nature of science and their intellectual development (Boud, 1995). Perry's scheme (Perry, 1999) of intellectual development in the college years

> *"has offered a useful language to measure and understand student's perceptions of learning"* (Selepeng, 2000).

Research (Byrne, 2001; Al-Shibli, 2003) using a questionnaire based on Perry's scheme revealed that students' perceptions of learning correlated positively with their academic performance. The next chapter describes students' intellectual development according to the Perry Scheme.

Chapter Five

Perry Scheme for Intellectual Development

Students' preferences in learning can be affected not only by cognitive factors, as has been shown in chapter three, but also by students' perceptions and attitudes towards learning (e.g. Struyven *et al.*; 2002; Richardson, 1995; Bruning *et al.*, 1995). Struyven *et al.*'s (2002) review study on students' perceptions about assessment and their approaches to learning suggested that they are strongly related. The perceived characteristics of assessment seem to have a considerable impact on student's approach to learning and vice versa. Furthermore, it was found that students hold strong views about different formats and methods of assessment.

It is asserted that many pupils/students get through all their academic life, from primary school till university, being only familiar with rote learning and repetition of ideas (Greer, 2001). They lack many of the skills that are required to be successful autonomous learners; to be able to question a hypothesis; to become critical thinkers and lifelong learners. These skills are similar to those described by Perry (1970) as being at the higher levels in his proposed scheme of intellectual development - reflecting a critical, self-directed student, capable of evaluating information and evidence, and wanting scope to demonstrate understanding of the complexities of a field of study (Mackenzie *et al.*, 2003). In addition, Perry's development scheme has been used to describe how students view their own role as learner; their teachers role and their preferences towards assessment. According to Selepeng (2000), the Perry scheme has given a language for students and teachers to understand what they all mean, think and believe about learning.

Different approaches to learning require different assessment (Entwistle and Entwistle, 1991; Tomas and Bain, 1984; Entwistle and Tait, 1995; Nolen and Haladyna, 1990; Zeidner, 1987; Birenbaum and Feldman, 1998). Therefore, it will be very interesting to investigate whether there is any correlation between a pupils' position in the Perry scheme with their performance in different formats of assessment. This chapter focuses on intellectual development of students as described by Perry. It will outline the original scheme and discuss the adaptations of it as well as studies related to assessment and students' approaches to learning.

5.1 Perry's Original Scheme

Perry, after a longitudinal study during the 1960s and 1970s with students, developed a scheme for intellectual and ethical development. He was very sensitive to students' views and his scheme was developed through interviews with students at Harvard and Radcliffe Universities. He was surprised by the variety of ways that students viewed learning. Perry himself expressed the view that:

> *"A fundamental belief in students is more important than anything else. This fundamental belief is not a sentimental matter: it is a very demanding matter of realistically conceiving the student where he or she is, and at the same time, never losing sight of where he or she can be"* Perry (1999).

The outcome of his study was a scheme of intellectual and ethical development. He described a series of nine 'positions' or stages together with their associated transition as the individual's development journey. The nine positions and related transitions are described below by Mackenzie (1999) (after Perry, 1999):

Position 1: Authorities know, and if we work hard, read every word, and learning Right Answers all will be well.
Transition: But what about those Others I hear about? And different opinions? And Uncertainties? Some of our Authorities disagree with each other or don't seem to know, and some give us problems instead of Answers.
Position 2: True Authorities must be Right, the others are frauds. We remain Right. Others must be different and Wrong. Good Authorities give us problems so we can learn to find the Right Answer by our own independent thought.
Dualism Transition: But even Good Authorities admit they don't know all the answers yet!
Modified: Position 3: Then some uncertainties and different opinions are real and legitimate temporarily, even for Authorities. They' re working on them to get to the Truth.
Transition: But there are so many things they don't know the Answers to! And they won't for a long time.
Position 4a: Where Authorities don't know the Right Answers, everyone has a right to his own opinion; no one is wrong!
Transition: But some of my friends ask me to support my opinions with facts and reasons. (and/or) Then what right have They to grade us? About what?

Relativism Position 4b: In certain courses Authorities are not asking for the Right Answer; They want us to think about things in a certain way, supporting opinion with data. That's what they grade us on.
Discovered Transition: But this 'way' seems to work in most courses, and even outside them.
Position 5: Then *all* thinking must be like this, even for Them. Everything is relative but not equally valid. Your have to understand how each context works. Theories are not Truth but metaphors to interpret data with. You have to think about your thinking.
Transition: But if everything is relative, am I relative too? How can I know I'm making the Right Choice?
Commitments Position 6: I see I'm going to have to make my own decisions in an uncertain world with no one to tell me I'm Right.
In Relativism Transition: I'm lost if I don't. When I decide on my career (or marriage or values) everything will straighten out.
Developed Position 7: Well, I've made my first Commitment!
Transition: Why didn't that settle everything?
Position 8: I've made several commitments. I've got to balance them-how may, how deep? How certain, how tentative?
Transition: Things are getting contradictory. I can't make logical sense out of life's dilemmas.
Position 9: This is how life will be. I must be wholehearted while tentative, fight for my values yet respect others, believe my deepest values right yet be ready to learn. I see that I shall be retracing this whole journey over and over- but, I hope, more wisely.

Perry used the word authority to describes sources of information such as teachers, textbooks, lectures and others students. He regarded the transition between each stage as being as important as the stage themselves. Mackenzie (1999) stated:

> *"Each Position reflects the person's way of thinking about knowledge, self and the world, as well as how learning takes play. Perry conceptualised the Positions as representing a hierarchical sequence in which individuals moved from relatively simple ways of thinking to highly complex ways of perceiving and evaluating knowledge and their world".*

Perry (1981) emphasised this point about the hierarchical nature of the scheme as follow:

> *"Notice that each Position both includes and transcends the earlier ones, as the earlier ones cannot do with the later. This fact defines the movement as development rather than mere changes or 'phase'".*

As can be seen his first five positions focus on cognitive stages, while the last four are concerned more with ethical development resulting from making personal commitments.

Perry also described three alternatives to progression in the scheme: temporising, retreat and escape (Mackenzie, 1999). This implies that the learner may regress to a lower level or remain at a given level (Perry, 1981). Mackenzie's (1999) comments about these position were:

> *"Temporising' refers to pausing for some time, possibly more than a year, in one position, usually accompanied by an awareness of the step ahead. 'Retreat', according to Perry, usually represents a regression to extreme Dualism and may occur after the person has had a glimpse of multiplicity. It involves the person actively denying that other people's opinions are legitimate. Examples may be found in the 'dedicated reactionary, a dogmatic rebel, or in passive resistance to authority without espousing a cause (Loevinger, 1978). 'Escape' is a more complex reaction, with the person steadfastly in a middle position, exploiting multiplicity or relativism to avoid Commitment, and may become alienated or cynical as a result."*

5.2 Finster Categorisation of Perry's Positions

The Perry Scheme, as originally developed by Perry and his associates, is clearly very complex but it has to be accepted that it reflected what Perry found from his interviews. Attempts have been made to simplify it by Finster (1989). According to Finster (1989) Perry's nine positions were categorised into four main categories:

1. Duality (positions 1,2),
2. Multiplicity (positions 3 and 4a),
3. Relativism (4b and 5) and finally
4. Commitment to Relativism (positions 6, 7, 8 and 9).

Al-Shibli (2003) described them as follow:

Dualism

Dualism consists of the simplistic right/wrong or black/white view. Correct answers always exist, and learning them is paramount - the more of this knowledge which is ingested, the better the student (Gray, 1997). Knowledge is viewed as an absolute and any uncertainty is temporary (Finster, 1989). They also believe that each question has an answer and the authority's job is to give the answers.

Multiplism

Multiplism represents positions three and four. In this main position, diversity and uncertainty are recognised but the student is not sure which idea he should follow from the conflicting ideas he has seen. He needs the authority to supply the guide. Furthermore, diversity and uncertainty are recognized as legitimate to the point where anyone has a right to his or her own opinion and all opinions are equal, even those of an authority (Finster, 1989)

Relativism

At this category, the student recognises that knowledge is contextual and relative. Even if the right\wrong view applied, it should be applied only within certain contexts and never to make that decision outside the context. Students start to realise that personal commitment is necessary to establish an identity and make sense of all opinions. Unfortunately, in this positions students cannot make that commitment. Even if students start to realise that knowledge depends on context, they have not attempted to structure their knowledge.

Commitment in Relativism

Commitment involves the individual making a choice or decision in the full awareness of relativism. In this category, the student orders his knowledge, recognising that decisions can be made only on a basis of uncertainty. He is prepared to take risks to do so.

5.3 Johnstone's Scheme of Perry Position

Perry's Positions have been used by many educators (e.g. Finster, 1991; Fitch and Culver, 1984; Simpson, *et al.*, 1986) to describe how students view their role as learners and those of their teachers or lectures, and to suggest how students might be appropriately challenged to move forwards within the scheme. Johnstone (1998) adapted the scheme in a more simplified version, in which the original nine Positions have been drawn into three categories, A, B, and C (table 5.1).

Table 5.1: Johnstone's categorisations of the Perry Positions				
Category/ Position	**Dualism**	**Multiplicity**	**Relativism**	**Commitment in Relativism**
A	1 & 2			
B		3 & 4a		
C			4b & 5	6, 7, 8 &9

Source: (Selepeng, 2000)

Johnstone put students in his A position that, according to Perry's scheme, are in position 1 and 2 where dualism is still strong. In position B, Johnstone put the students who start to realise the problems that arise from dualism's point of view but they still have problems dealing with multiplicity. And finally in position C, which is the highest position, he puts all the students from position 4b till position 9 of the original Perry scheme. The reason for this simplification is that Perry himself found that usually in the final college year students are between position four and five, and very rare are between position 6 to 9.

Table 5.2 shows Johnstone's adaptation simplified Perry ideas and all four main areas related to learning environment. These areas are: the student's role; the role of lectures/members of staff; the nature of knowledge; and the student's task in examination/ assessment situations. Johnstone used a language which is accessible to all.

Students in position B start to realise the uncertainties that exists in knowledge and to accept that in some situations the truth or the right answer is out of reach. They are beginning to realise that they have responsibilities toward their learning, but they do not know what to do. They start to view the lecturer as the person who is responsible for teaching them the correct ways of finding the right answer. They start to recognise that peers might be able to help them in finding the way to find the right answer through discussion. However, their lecturers are still having the final say and are still the source of knowledge (Al-Shibli, 2003). Their view of assessment become confused about what is expected from them and they hope to be able to present one argument, which will make the lecturer like their line of thought. They will try their best to make their answer suit the lecturer's way of thinking but this will make them still feel they never know when and why they are going to be either marked down or up. They still believe in rewards for quantity of hard work and not quality of work.

Table 5.2: Illustration of the Johnstone's categorisations of the Perry Positions

Perceptions of:	*Student in Position 'A'*	*Student in Position 'B'*	*Student in Position 'C'*
Student's Role	Passively accepts	Realises that some responsibility rests with the student. But what? And how?	Sees student as source of knowledge or is confident of finding it. Debater making own decisions
Role of lecture/ Member of staff	Authority, giving facts and know-how	Authority where there are controversies, wants guidance as to which answer lecturer favours.	Authority among authorities. Values views of peers. Teacher as facilitator.
Nature of Knowledge	Factual; black and white. Clear objectives, non-controversial exceptions unwelcome	Admits 'black-and – white' approach not always appropriate. Feels insecure in the uncertainties this creates	Wants to explore context; seeks interconnections, enjoys creativity scholarly work.
View of Exams	Regurgitation of 'facts'. Exams are objective. Hard work rewarded.	Quantity is more important than quality. Wants to demonstrate maximum knowledge	Quality is more important than quantity. Wants room to express own idea, views.

Source: (Johnstone, 1998)

Finally students in position C are critical, independent learners and they regard the student's task as demonstrating that they can evaluate possible solutions to a problem on the basis of evidence (Mackenzie, 1999). 'Knowledge' is seen as uncertain - shades of grey, not black and white, are perceived - and the individual copes with this uncertainty by taking into account the contexts in which decisions are made. The lecturer's responsibility is seen as one of providing knowledge within a context and of demonstrating evidence for a decision or opinion. Students see tests and examinations as opportunities to demonstrate their skills in relating between contexts, to seek interconnections, to expand and modify concepts, to weigh up alternative approaches. They enjoy being creative and playing with ideas and quality is seen more important than quantity. They do not like short questions, as they don not give them the chance to explain what they know and understand (Al-Shibli, 2003).

Varying levels of confidence on the part of the student are associated with the different types of perceptions. Students A and C have high confidence unlike student 'B' who has a low confidence (Wood and Sleet, 1993). However, the confidence of A student in the system is for different reasons when compared to C student. Student A confidence is because he/she relies on the system, as represented by the lecturer and familiar methods of teaching (e.g. lecture) and assessment (e.g. exams) whereas student's C confidence is because he/she relies on himself and his/her ability to learn. In contrast with both student A and C, student B is faced with feeling of uncertainty, confusion and low self-esteem (Johnstone, 1998).

5.4 Other Studies related to Perry Intellectual Development Model

The work of Magolda and Porterfield quoted in Al-Shibli (2003) produced a structured instrument, which is called the Measure of Epistemological Reflection. This model contains different domains such as decision-making, the role of the learner, the role of the instructor, the role of peers, evaluation of learning and the nature of knowledge. This model reflects similar core issues to Perry's schemes and has similarities to the Johnstone adaptation of Perry scheme (Al-Shibli, 2003).

Other studies of changes in student thinking as they progress through higher education are quoted in Ramsden (2003). These studies have found similar patterns to Perry. Heath (1964) in his interviews of students at Princeton showed the existence of demonstrable effects on intellectual development. Säljo (1979) carried out an interview study that led to his describing five different understandings of what learning consists of among adults. When students were asked to say what they understood by learning, their replies could be classified into different categories:

1. Learning as a quantitative increase in knowledge. Learning is acquiring information or 'knowing a lot'.
2. Learning as memorising. Learning is storing information that can be reproduced.
3. Learning as acquiring facts, skills and methods that can be retained and used as necessary.
4. Learning as making sense or abstracting meaning. Learning involves relating parts of the subject matter to each other and to the real world.
5. Learning as interpreting and understanding reality in a different way. Learning involves comprehending the world by reinterpreting.

Source: (Ramsden, 2003).

It can be seen that the first three conceptions imply a less complex view of learning. They resemble the early stages of Perry's schemes. Conceptions four and five emphasise the internal or personal aspect of learning: learning is seen as something that you do in order to understand the real world. These conceptions imply a more relativistic, complex and systematic view of knowledge and how it is achieved and used (Ramsden, 2003).

The work of deep and surface learning approaches comes up with similar patterns as Perry. Struyven *et al.*'s (2002) review showed that three approaches to learning occur.

- Surface approaches to learning describe an intention to complete the learning task with little personal engagement, seeing the work as an unwelcome external imposition. These intentions are often associated with routine and unreflective memorisation and procedural problem solving, with restricted conceptual understanding being an inevitable outcome.
- Deep approaches to learning, in contrast, lead from an intention to understand, to active conceptual analysis and, if carried out thoroughly, generally result in a deep level of understanding.
- And finally the strategic or achieving approach to learning. This category was introduced by the authors because of the pervasive evidence of the influence of assessment on learning and studying. In this approach the student's intention was to achieve the highest possible grades by using well-organised and conscientious study methods and effective time-management.

Strategic approaches to learning are sensitive to the assessment procedures used and/or expected. It seems that students seek information and form opinions about 'what the teacher wants' because teachers have the final say on such indicators of academic success as student grades (Struyven *et al.*, 2002). Struyven *et al.* (2002) stated

> *"when students' perceptions and expectations about open-ended formats are compared to those about multiple choice formats of examination, some remarkable results occur".*

The impact of student's perceptions and expectations about different format of examination is discussed further in paragraph 5.6.

5.5 Student's Performance and Perry Intellectual Scheme

Byrne's (2001) study showed that the Perry score of intellectual development is significantly correlated with the overall degree and their examination mark. Furthermore, Al-Shibli's (2003) research using Perry's scheme questionnaire revealed that students' perceptions of learning correlated positively with their academic performance. This might lead to the suggestion that, by encouraging students to think in higher levels of the Perry scheme, the teacher may contribute positively to their academic performance. However, as Al-Shibli (2003) stated:

> *"a very important point, which should be kept in mind, is the nature of the examination. If the exams were designed to assess students at high levels of the Perry scheme, then they will correlate positively with Perry score, but if the exams are designed according at lower levels of the Perry scheme, then they might not correlate so positively with Perry scores. The nature of assessment plays a vital role here".*

Mackenzie (1999) compared medical student's perceptions of their learning experience in the traditional course with medical students' perceptions in the problem based learning course at the University of Glasgow. Her research showed that students who participated in the problem based learning course were better than students who participated in traditional course in term of their intellectual development.

Al-Shibli, (2003) made an attempt to change student's perceptions of learning and assessment. He designed interactive teaching materials based on problem solving and these teaching materials were taught for three weeks to an experimental group of 163 second year student science teachers. These teaching materials aimed mainly to enhance student's perceptions of the nature of scientific knowledge and partially to enhance student's perceptions of assessment. In these teaching units students were encouraged to think about the nature of scientific knowledge and assessment while they are studying science. Pre-and post-Perry questionnaire results were compared between an experimental group and a control group of 155 students. The results showed that a considerable improvement occurred in students' perceptions of the nature of scientific knowledge while, in students' perceptions of assessment, there was a slight improvement.

The results of the Mackenzie (1999) and Al-Shibli (2003) studies showed that the way we teach has an impact of student's intellectual development. It appears possible to enhance intellectual development by means of small changes to the curriculum. Assessment has a powerful influence within the education process. If students are always rewarded for recalling knowledge then they will not be encouraged to use other skills. However, if skills other than memorising are rewarded, students intellectual development may be enhanced (Al-Shibli, 2003). As believed by many educators, assessment is the most significant prompt for learning (e.g. Boud, 1995; Kohn, 1993), the style of tests having a key influence on students' intellectual development. The next paragraph, discusses the implementation of some studies which have prompted to the relationship between assessment modes and students' approaches to learning.

5.6 Assessment Modes and Students' Approaches to Learning

Several studies have looked at relationships between learning patterns and attitudes towards assessment formats or links between students' psychological traits and their expressed preferences for learning approaches and performance (Birenbaum and Feldman, 1998; Richardson, 1995; Marton and Säljö, 1997). The Struyven *et al.* (2002) review showed that different types of assessment seem to encourage deep or surface approaching to learning

Birenbaum and Feldman (1998) found that students with good learning skills, who have high confidence in their academic ability, tend to prefer the constructed response type of assessment over the multiple-choice type and vice versa. And students with low test anxiety have more favourable attitude towards the open-ended format.

The study of Trigwell and Prosser (1991) suggested that

> *"deep approaches to learning are especially encouraged by assessment methods and teaching practices which aim at deep learning and conceptual understanding, rather than by trying to discourage surface approaches to learning. As a consequence, teaching methods and educational policy play an important role in creating this 'deep learning".*

Zeidner (1987) found that students' perceptions about different types of exams are highly correlated with students' dimensions of the inventory (i.e. perceived difficult, anxiety, complexity, success expectancy, feeling at ease). Struyven *et al.* (2002)

reviewed that overall students report that they were influenced by the expectation that a test would be in multiple-choice or free-response format.

Conclusion

From the above studies, it can be concluded that learning must fundamentally be seen as relational (Ramsden, 1987). That is, learning is a function of both teaching and context in which it occurs. Assessment can encourage passive, reproductive forms of learning while simultaneously hiding the inadequate understanding to which forms of learning inevitably lead (Entwistle and Ramsden, 1983; Ramsden, 1987). According to Boud (1995)

> *"this means that in terms of assessment, student approaches to learning are a function of:*
> - *the intrinsic qualities of the form of assessment being used*
> - *the ways in which the assessor translated the material to be assessed into the given format and selects assessment tasks appropriate for the subject and the specific learning goals and most importantly,*
> - *how the student interprets the task at hand and the context of the assessment."*

The latter interpretation is very connected with the perceptions and interactions of a student to learning and are more important than

> *"what staff take for granted as the 'reality' of the assessment"* (Boud, 1995).

As Boud (1995) stated

> *"good assessment is not just a matter of finding the 'appropriate' method and using it sensibly in conjunction with given subject matter. There are always unintended consequences in assessment. Students will learn to adopt surface approaches to study in some circumstances and will adopt deep or strategic approaches in others. In so doing they will be prompted partly by the forms and nature of assessment tasks. They will learn that, in order to maximise their marks, they should use rote learning in many circumstances, even when we might believe that this would distract them from the most important aspects of the course"*

Struyven *et al.* (2002) mentioned Eizenberg (1988) who stressed that any component within the learning environment, which contradicted the direction of influence of the other components, might prevent the intended effect from being achieved. Thus, a clear implication for effective teaching is that all aspects of a course must convey the same message to students regarding what will be rewarded through assignments and examinations (Entwistle and Tait, 1995)

The students' perceived assessments requirements seem to have a strong relation with the approach to learning adopted when tackling a task (Marton and Säljö, 1997). Humans have an intrinsic need to build up competence in dealing with the environment. Positive intrinsic motivation takes place when individuals are placed in a slightly 'difficult' situation involving conflict between what they know already and what they are currently learning. However, intrinsic motivation needs an appropriate affective context in which the right task conditions are placed; students must feel positive about the task, the context and themselves (Biggs and Moore, 1993). Thus, pupils' intellectual development takes place when educators create a teaching-learning environment which on one hand respects individuals difficulties and motivations and on the other hand adopts deep and creative and critical learning approach by all means.

Chapter Six

Pilot Study

Following the findings of Friel and Johnstone (1978a), the aim of this pilot study was to examine what are the relationships between the results of various formats of assessment. This chapter outlines the methodology and the outcomes of the pilot project.

6.1 Design of the Pilot Project

The pilot project aimed to examine the correlation of the results of different formats of assessment. Two project were conducted:

a) The first project was carried out in Greece during March-April 2002. In this project two paper-and-pencil chemistry tests were used with three sections. Each section included different forms of questions assessing the same topics and the same knowledge.

b) The second project used data from different forms of assessment of first year Biology undergraduate Students enrolled in 2001 University of Glasgow. The reason Biology' student data were used, and not Chemistry data, was that the Biology Department employs a variety of techniques to assess students.

6.2 The Pilot Study for the Greek Schools

The first method of the pilot study was carried out in Greece during March-May of the school year 2002. Two chemistry paper-and-pencil tests were designed with three sections:

- Section 1: Multiple-Choice questions
- Section 2: Structural Communication Grid questions and
- Section 3: Short-Answer questions

Weighting of marks was carefully decided to reflect the demand level of questions. In each section, the total raw score were converted to a percentage and they were added to give the total mark of each pupil. This change does not alter the statistical results but makes it easier for the reader to compare means between different tests.

Pupils of the first year of upper public secondary schools (Lykeio, Grade 10) sat the tests. The schools were not chosen at random because of the nature of the research. Thus, the researcher contacted several teachers of different schools and explained to them the purpose of the project. Five teachers agreed to use the first test and only one to use the second test. There was a limited choice of chemistry topics, which could be tested since it was necessary to follow the timetable and the syllabus of the Greek schools.

In the first test, 321 pupils (Grade 10) participated. Details of the number of schools and number of pupils involved in the first test are presented in table 6.1.

Table 6.1: Pilot study: schools and number of pupils

School	Number of Pupils	Number of Classes	Females	Males
1	20	1	14	6
2	49	3	28	21
3	132	5	65	67
4	22	1	10	12
5	22	1	12	10
6	55	3	33	22
7	21	1	16	5
Total	**321**	**15**	**178**	**143**

Only two classes of school 3 were involved in the second test and 56 pupils sat the test. One of the reasons for that was that the test was given to the teachers towards the end of the school year and at that period the pupils usually are very busy with other activities. Thus, many hours of teaching are lost and teachers are mainly concerned to finish the teaching units and they are not willing to spend time to evaluate and assess the results of their teaching.

6.2.1 The Pilot Test 1

The first test was based on the content area of acids; bases; oxides and neutralisation reactions. It had three sections:

- Section 1: 13 Multiple-Choice (MC) questions-13 marks.
- Section 2: 2 Structural Communication Grid (SCG) questions-12 marks.
- Section 3: 3 Short-Answer (SA) questions-14 marks.

Each section tested the same knowledge and understanding of the same content area. Mainly the questions asked students to recall, define, recognise and apply knowledge. The items were selected from the Greek chemistry textbook (Liodakis *et al.*, 1999); the Standard Grade Chemistry book (Renfrew and Conquest, 1995) and the book of Moore *et al.* (1999). An English translation of the test as well the Greek test and the marks for each question is shown in appendix D. Furthermore the test was given in four different versions so as to avoid pupils' interaction in neighbouring seats. The differences between the tests related to the order that the three formats of questions appeared in each test. This gave the opportunity to the researcher to test if there are significant differences in pupils' performance related to the order in which the format question appeared in the test. In addition, the effects of gender differences were explored.

6.2.1.1 Descriptive Statistics of Pilot Test 1

Figure 7.1 shows histograms of the Multiple-Choice score distribution; Structural Communication Grid score distribution; Short-Answer score distribution; and Total score distribution in order to check the normality of the tests and choose appropriate statistics (the total score consists of the sum of the three parts scores). As can be seen from the histograms SCG and SA scores distributions are skewed. Table 6.2 shows the descriptive statistics of each section of the test.

Table 6.2: Descriptive statistics of Pilot Test 1

Test Format	N	Minim.	Maxim.	Mean	S.D.
MC	321	8	100	52.9	19.8
SCG	321	0	100	35.2	23.3
SA	321	0	100	34.5	31.4
Total	321	8	300	122.6	65.9

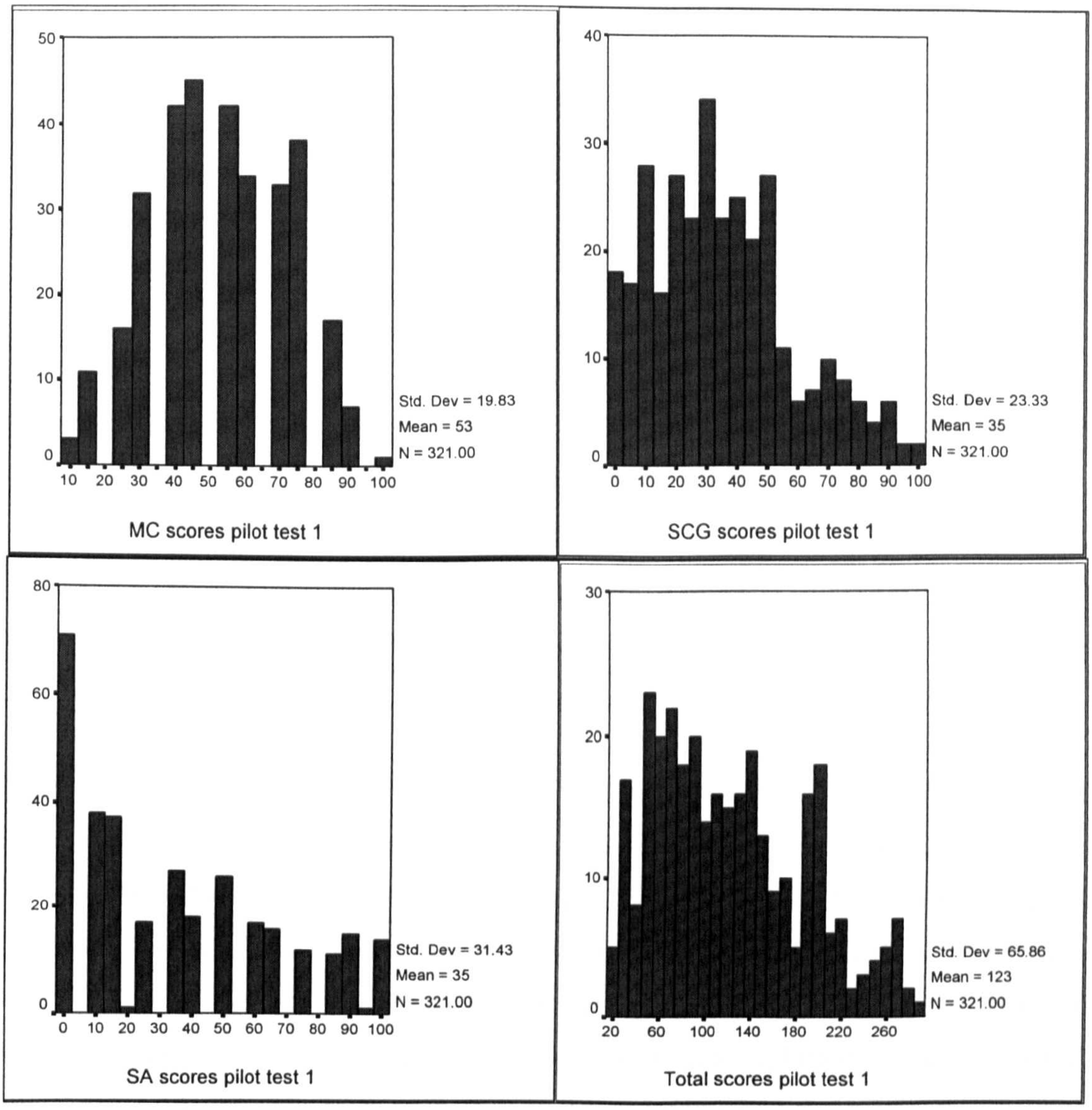


Figure 6.1: Histograms of the different format questions of Pilot Test 1[1]

The skewed to the right distributions indicate that SCG and SA tests were slightly too difficult for the pupils. From the table it is clear that pupils' performances in MC section were higher than SCG items and SA items.

6.2.1.2 Correlations in Pilot Test 1

Both Pearson coefficient and Spearman's rho correlation between the forms of questions were calculated (See appendix F-2). Although both correlations were almost identical it was decided to use Spearman's rho correlations because the distributions

[1] In figure 6.1 (and subsequent tables) the use of inappropriate accuracy is caused by the way SPSS operates

of the pupils' scores in all the formats of the test were not normal. Table 6.3 shows these correlations.

Table 6.3: Spearman's rho correlations of Pilot Test 1		
Test Format	**SA**	**MC**
MC	0.64**	
SCG	0.66**	0.64**

**Correlation is significant at the 0.01 level (1-tailed).

Although all the correlations are highly significant, they are moderate and far from one. A number of questions can be posed from these results such us:

- Which format of the test is more valid?
- Is one format of assessment better than another?
- Does any psychological characteristic of the individual pupil favour him/her to perform well in one format of assessment and poor in another?

These results are similar to the results that Friel and Johnstone, (1978); Yuh-Yin and I-Fen (2000) found in their studies. Perhaps the fact that different formats questions are placing different demands upon students can be one of the reasons. In SA questions students have to recall some knowledge, to define it and in some cases to apply it. In SCG questions students have to recognise some knowledge and in many cases to understand and rearrange it and reveal their ideas and their reasoning. In MC questions, students only have to recognise some knowledge. In both SA and SCG questions the quality of the answer depends upon mental processes, while in MC the quality of the answer mainly depends upon recognition. SA and SCG question are expected to correlate better than SA and MC questions because SCG questions allow credit for partial knowledge.

6.2.1.3 Differences between teams due to effect of cueing

The test was given in four different versions and the four groups of pupils are described here as teams. This also gave the researcher the opportunity to test if there was a follow up effect (or cueing effect) arising from the order of the questions appearing in the test. Each team arrangement of the questions appeared in the test was as follow:

Team A:	Section 1 (MC)	Section 2 (SCG)	Section 3 (SA)
Team B:	Section 1 (SA)	Section 2 (MC)	Section 3 (SCG)
Team C:	Section 1 (SCG)	Section 2 (SA)	Section 3 (MC)
Team D:	Section 1 (SA)	Section 2 (SCG)	Section 3 (MC)

A comparison of the mean scores between each team using One-Way ANOVA procedure with SPSS statistic package was used to test the hypothesis that several means are equal. This technique is an extension of the two-sample *t* test. The statistic analysis is printed in appendix F-3. No significant differences between teams were found. Thus, there was not any effect because of the different order that the questions appeared in the test. Perhaps any effect with one sequence was being balanced by a cueing effect in other sequence.

6.2.1.4 Gender Differences in different Format Questions

Even though the predominant belief is that boys are better than girls in mathematics and science, many studies have displayed contradictory results. For example, in Britain the academic achievements of gifted girls in school surpass those of gifted boys in almost all areas of study and at all ages, whereas this does not appear to be the case in the U.S. (Freeman, 2003). Penner, (2003) used data from the Third International Mathematics and Science Survey to examine whether gender item difficulty interactions like those in American mathematics exist in mathematics and science in 10 countries. For both mathematics and science, the study detected male advantages that were minimal on easy questions and increased as questions grew more difficult. In Greece studies at secondary school level mathematics showed inconsistent results. Xionidou-Moskofoglou (1996) study showed that males' performances in mathematics are better than females' performances, whilst Karageorgos *et al.* (2001) study demonstrated the opposite.

The outcomes of studies which investigate the gender effect on different test format are very interesting. The purpose of the Beller and Gafni (2000) study was to probe into differential performance of boys and girls on Open-Ended (Short-Answer) and Multiple-Choice (IMC) items on the 1988 and 1991 International Assessment of Educational Progress (IAEP) mathematics test. Beller and Gafni (2000) stated:

"These inconsistent results challenge the assertion that girls perform relatively better on OE test items, and suggest that item format alone cannot account for gender differences in mathematics performance. Further investigation of the data revealed that the inconsistent patterns of gender effects with regard to item format were related to the difficulty level of the items, regardless of item format. Correlations between item difficulty and item gender effect size were computed for age 13 in the 1988 assessment and for ages 9 and 13 in the 1991 assessment. The correlations obtained were 0.26, 0.47, and 0.53, respectively, suggesting that the more difficult the items, the better boys perform relative to girls".

The Bridgeman and Morgan (1994) study revealed that males achieved relatively high scores on the Multiple-Choice portion of the Advance Placement United States History Examination while females received higher scores on the essays than the MC questions.

The above studies did not show clear results about gender effect on different test format. In this study, an attempt was made to find if there are differences between genders in different formats of assessment. Table 6.4 shows the mean and standard deviation for each gender group in each section of the test, while table 6.5 shows the mean and standard deviation for each gender group in differences between sections.

Table 6.4: Gender performance in each format assessment

	N	MC		SCG		SA		Total	
Gender		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
F	178	53.5	20.5	35.2	23.9	32.9	29.6	121.7	65.5
M	143	52.1	18.9	35.1	22.7	36.4	33.7	123.7	66.5

MC: Pupils' scores on Multiple-Choice section,
SA: Pupils' scores on Short-Answer section,
SCG: pupils' scores on Structural Communication Grid section
Total: Sum of pupils' MC, SCG, and SA scores.

Table 6.5: Gender in difference between format assessment

	N	MC- SCG		MC-SA		SCG-SA	
Gender		Mean	S.D.	Mean	S.D.	Mean	S.D.
F	178	18.3	18.6	20.6	22.7	2.3	21.5
M	143	17	18.3	15.7	25.9	-1.3	23.9

MC-SCG: Differences between Multiple-Choice scores and Structural Grid scores
MC-OE: Differences between Multiple-Choice scores and Open-Ended scores
SCG-OE: Differences between Structural Grid scores and Short-Answer scores

Although table 6.4 suggests that there are some differences between gender the Independent-Samples *t* Test show no significant differences between different format questions between genders. SPSS statistic results are displayed in appendix F-4.

6.2.2 The Pilot Test 2

The second test was based on the content area of solutions. It tested the understanding of concepts of concentration in solutions. It was a short test (15 minutes test) testing a narrow content area. It had three sections:

- Section 1: 5 Multiple-Choice questions-5 marks
- Section 2: 1 Structural Communication Grid question-5 marks
- Section 3: 3 Short-Answer questions-5 marks

The test was given in two versions. Version two was different than version one only in section 2 (Structural Communication Grid question), where for team A, the question used figures while, for team B, the same question used numerical expressions. This was done in order to test if the way that the grid was constructed had any effect on pupils' performance. This issue will be discussed in the main study. The same test was used in the main study (test 5) therefore an English translation of the test and the marks for each question is shown in section 9.3. The Greek test is shown in appendix E.

6.2.2.1 Descriptive Statistics of Pilot Test 2

Descriptive statistics of each section of the test were computed. Table 6.6 shows the result of the descriptive statistics.

Table 6.6: Descriptive statistics of Pilot Test 2

Test Format	N	Minim.	Maxim.	Mean	S.D.
MC	56	0	100	66.1	29.0
SCG	56	0	100	68.6	30.8
SA	56	0	100	58.4	36.9
Total	56	20	300	193.0	71.7

Figure 6.2 shows histograms of the Multiple-Choice score distribution; Structural Communication Grid score distribution; Short-Answer score distribution; and Total score distribution of test 2.

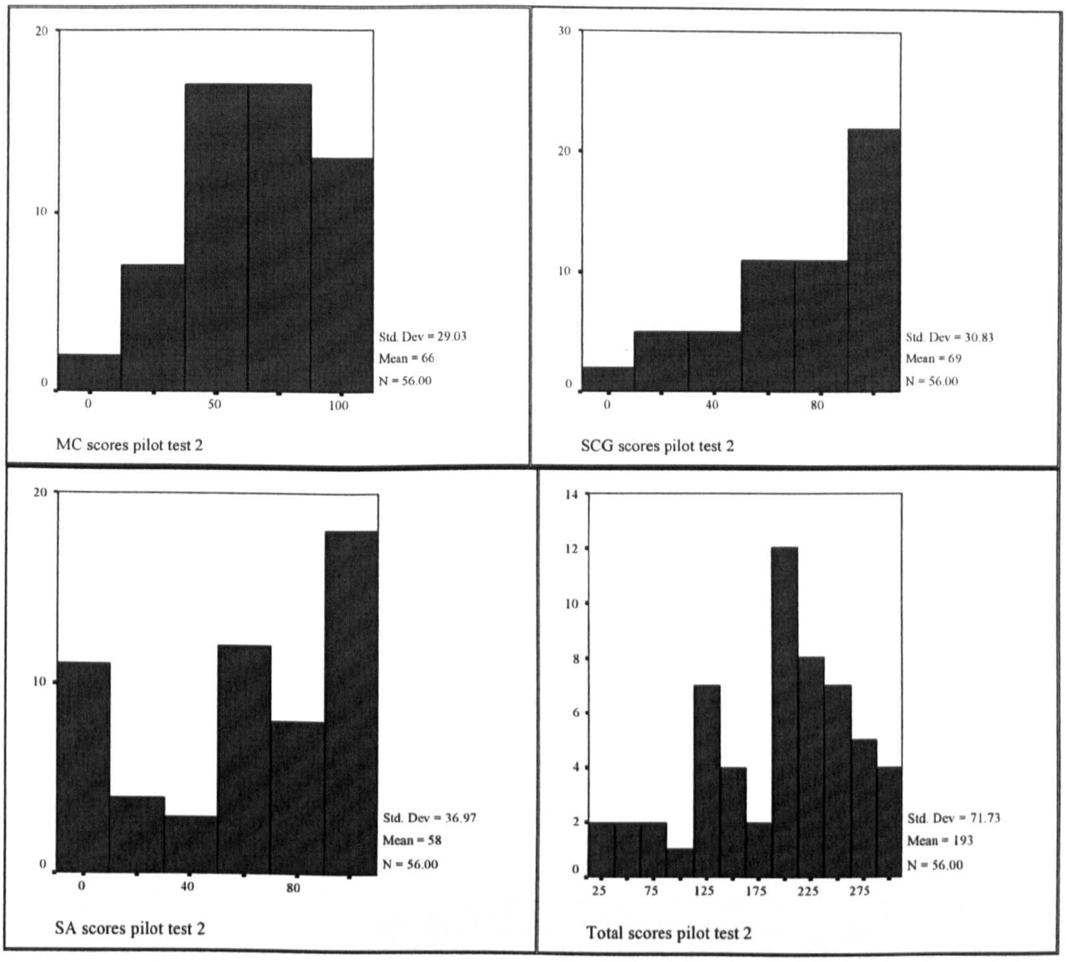


Figure 6. 2: Histograms of the different format questions of Pilot Test 2

From the table 6.6 it is clear that pupils' performances in SCG section were higher than MC items and SA items.

6.2.2.2 Correlations in Pilot Test 2.

Both Pearson coefficient and Spearman's rho correlation between the forms of questions were calculated (See appendix F-5). Table 6.7 shows Spearman's rho correlations.

Table 6.7: Spearman's rho correlations of Pilot Test 2

Test Format	SA	MC
MC	0.33**	
SCG	0.24*	0.40**

**Correlation is significant at the 0.01level (1-tailed).
*Correlation is significant at the 0.05level (1-tailed).

It was expected that very high correlations between different formats of assessment in this test would be found because the test was testing the same narrow area of understanding (concentration of a solution, and how the concentration change by mixing two solutions or diluting a solution). Thus, it is surprising that the correlations are fairly low. Scatter diagrams for SCG versus MC scores; SA versus MC scores; and SA versus SCG scores were plotted and these graphs are shown in appendix F-5.

6.3 Correlations between different Formats of Assessment in Biology

Data from a sample of 631 first year Glasgow University biology students was used and a statistical analysis was carried out. Pearson and Spearman rho correlations between the forms of questions were calculated (See appendix F-6) Spearman rho correlation is shown in table 6.8.

Table 6.8: Spearman's rho correlations in Biology data

	Essay	Plants SA	MC	SA	Triads
Plants SA	0.33**				
MC	0.49**	0.50**			
SA	0.40**	0.28**	0.49**		
Triads	0.44**	0.48**	0.58**	0.40**	
SCG	0.26**	0.25**	0.42**	0.28**	0.34**

** Correlation is significant at the 0.01 level (1-tailed).

SA: Short-Answer questions
MC: Multiple-Choice questions
Triads: Computer based objective testing
SCG : Structured Communication Grid questions

All the above correlations are highly significant, as might be expected. However the correlations are fairly low. Triads and Multiple-Choice give the best correlations in that they are both forms of Multiple-Choice. The MC correlates reasonably with essays and Short-Answer. Multiple-Choice items test by recognition and gives no credit for partial knowledge while essays and Short-Answer do not use recognition in this way and partial knowledge often receives credit. It is difficult to comment too precisely on the grid correlations, in that there are several ways in which the grids might be used and marked. The fairly low correlation values may reflect different content being tested or the use of different formats. However, the lowest values (e.g. 0.25, 0.26) are somewhat surprising.

Conclusion

The findings of the first pilot paper-and-pencil chemistry test are similar to the Friel and Johnstone (1978a); and Yuh-Yin and I-Fen (2000) studies. The findings of the second pilot paper-and-pencil chemistry test are similar to Badger (1990). From the results of the above pilot studies, it can be concluded that the correlations for the first pilot test were larger than the correlations between the different formats of assessment in the second pilot test and between the five formats of the biology programme.

However, all the correlations between the different formats of assessment tended to be between 0.25 and 0.65. This is a large range, and even the maximum of the correlations is less than 1 by a significant margin. If the two formats of assessment were simply testing the same content, then very high correlation would be expected. Of course it can be argued that different formats of assessment test different abilities of the examinees and, therefore, it is fairer to use several formats to assess student skills and knowledge. However, the fundamental issues arising from the pilot study are:

1. Are the different formats of questions testing different abilities or just different themes in a discipline? Probably both?
2. Which format of assessment is more valid?
3. Are the different formats related to differences between students in one or more psychological traits?
4. It might be reasonable to suppose that the use of multiple formats of assessment tests students more fairly than the use of a single format but in what basis can it be justified?

Some of the above questions are examined in the major study which will be discussed in the next chapters.

Chapter Seven

Methodology of the Main Study and Cognitive Tests Results

The purpose of the main study was to engage a number of pupils of different schools with the intention to measure: (a) pupils' cognitive characteristics; (b) pupils' Perry position and (c) at the same time to assess them in five chemistry 15-45 minutes tests during the whole school year, in everyday classroom conditions. Each test consisted of various formats of paper-and-pencil assessment in different topics. From the above measurements the following questions were investigated:

- What were the relationships among the results from various formats of classroom assessment?
- Were the patterns of correlations constant across content areas?
- How did cognitive characteristics correlate with the test results of different classroom assessment formats?
- How did pupils' responses in Perry position questionnaire questions correlate with the test results of different classroom assessment formats, and pupils' cognitive characteristics?

This chapter reviews the measuring instruments that have been used in the study, and the sampling process as well as the statistical methods. Finally, the findings of two cognitive tests are presented: Field Dependent/Field Independent, and Convergent-Divergent. The Perry position questionnaire will be discussed in chapter 10.

7.1 Measuring Instruments of the Main Study

The following measuring instruments were employed to gather information from the pupils:

- Two cognitive tests:
  1. Field Dependent/ Field Independent test
  2. Convergent/ Divergent test
- Perry position questionnaire
- Five chemistry paper-and-pencil tests

7.2 Sampling Method and Administration Procedures

The main part of the study was conducted in Greece during the school year September 2002-May 2003. In this, 12 public upper secondary schools (Lykeio) participated. There was more than one class in some schools and, therefore, the total number of classes was 23 and the total number of teachers was 12 (one teacher in each school). The classes were of different size: the smallest had 11 pupils and the largest had 29 pupils. Table 7.1 outlines the whole plan of the study.

Table 7.1: Schools and classes involved in the main study

Schools	Number of classes in each school	Number of pupils in each class				Total number of pupils		
						F	M	Total
1	1	19				8	11	19
2	3	21	19	14		38	16	54
3	1	21				14	7	21
4	1	14				9	5	14
5	2	18	18			20	16	36
6	4	18	18	17	11	42	22	64
7	3	27	24	23		42	32	74
8	2	29	22			28	28	56
9	1	25				14	11	25
10	2	21	22			25	18	43
11	1	26				15	11	26
12	2	25	19			22	22	44
Total	**23**					**277**	**199**	**476**

It was decided to work with the pupils of the first year of Lykeio (Grade 10) because, at that stage, pupils do not participate in national exams and teachers are more willing to be involved in research. Another very important reason to work with first Lykeio (Grade 10) pupils is that all pupils have to attend chemistry lessons at that stage and pupils are not yet split in directions subjects (e.g. arts, sciences). Thus, classes are heterogeneous with pupils of different abilities and subject orientation.

The schools were not chosen at random because of the nature of the research. The researcher contacted teachers of different schools in advance, before the beginning of the school year, and explained to them the plan of the study. The schools were selected in different geographic areas and of a different socio-economic background as much as possible. After receiving the teachers agreement on the project, the researcher applied to the Greek Pedagogic Institute and Greek Ministry of Education for permission to have access to schools in order to administer the cognitive tests and Perry' position questionnaire.

Initially, eight teachers agreed to use the tests that the researcher had designed as a replacement for the tests which they usually use to assess their pupils at the end of a chemistry topic during the school year. Unfortunately, it was not possible for the eight teachers to use all tests. The researcher engaged more schools in the study and the schools and the number of pupils participated in each test is summarised in table 7.2. As can be seen from this table, in the first test 8 schools participated and the total number of pupils was 288. In the second test, 4 schools participated and the number of pupils was 185. In the third test, three schools participated and the number of pupils was 146. And finally, in the fourth and fifth test only two schools participated and the number of pupils was 75 and 64 respectively.

Table 7.2: Number of schools participated in each test

		Test 1	Test 2	Test 3	Test 4	Test 5
SCHOOLS	1	*				
	2			*		
	3	*				
	4	*				
	5	*				
	6		*	*		
	7	*				
	8	*	*		*	
	9	*	*		*	
	10	*	*			
	11					*
	12			*		*
Number Of pupils		**288**	**185**	**146**	**75**	**64**

It was unfortunate that so many schools opted out but there is no tradition of regular assessment in many schools. The reasons for that were thought to be that the lack of provision of organised training and educational studies for teachers as well as the very small amount of teaching time (just two forty-five minutes period per week through the year) make teachers concerned to finish the teaching units and they are not willing to spend time to evaluate and assess the results of their teaching.

The cognitive tests and the Perry position questionnaire were administered by the researcher after the Greek Pedagogic Institute and the Greek Ministry of Education gave permission for access to schools. Chemistry tests were administered by the class teachers in the various schools.

7.3 Statistics Methods used in the Research

Validation and Reliability of the Instruments

The cognitive tests were based on well-established techniques. Work on Perry questionnaires was explored by Mackenzie *et al.* (2003) while Bahar (1999) had studied test materials for convergent/divergent test. The field dependency test was almost identical to the work of Witkin *et al.* (1971) test.

Mackenzie (1999), Selepeng (2000), and Al-Shibli (2003) used the Perry questionnaires without testing internal consistency. Internal consistency is not relevant to this type of questionnaire in that each of the 18 questions tested a different aspect.

Most statistical tests about reliability (other than test and re-test) merely indicate internal consistency. Thus, internal consistency reliability was not used in any of the chemistry tests. The reason for that was that tests consisted of sections having heterogeneous items assessing mix of modes, degree of difficulty and different understanding. The chemistry tests were discussed with experienced class teachers in Greece to check validity and minor adjustment were made.

Compare Means Statistics

When someone wants to test for differences between two groups, the independent-samples *t* test comes naturally to mind. However, despite its simplicity, power, and robustness, the independent-samples *t* test is invalid when certain critical assumptions are not met. These assumptions centre around the parameters of the test variable (in this case, the mean and variance) and the distribution of the variable itself. *t* test assumes normality of the distribution of the test variable. When the distribution of the test variable may be considerably non-normal, it is better to use nonparametric Mann-Whitney and Wilcoxon tests (Miller, 2002). These tests do not assume normality and can be used to test ordinal variables. For the above reasons, both t test and Mann-Whitney test were computed here.

The One-Way ANOVA procedure was used to test the hypothesis that several means are equal. ANOVA produces a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. This technique is an extension of the two-sample *t* test.

Correlations

There are three different types of correlation in statistics. The Pearson's correlation coefficient (labelled by the letter r) is the most common one and it is used when the data comes from measurements and from a scale. The Pearson correlation coefficient measures the linear association between two scale variables. However, the Pearson correlation coefficient works best when the variables are approximately normally distributed and have no outliers. The Spearman's rho (ρ) and Kendall's tau-b (labelled by the Greek letter τ) correlations measure the rank order association between two scale or ordinal variables. They work regardless of the distributions of the variables. Kendall's tau-b is required when there is a high possibility of 'ties'.

Both Pearson coefficient and Spearman's rho correlation between the formats of questions were calculated and were found to give similar values. However, because the distribution were frequently observed to deviate from normal distribution, it was decided that the Spearman's rho coefficient was more appropriate and this is used in all subsequent discussion. In categorical data, such as the Perry questionnaire, which are records of qualitative category and many 'ties', the Kendall's tau-b correlation formula is more appropriate. Each question in the Perry questionnaire tested different perspective. For this reason each question was analysed on its own. (Reid, 2003)

A Two-tailed test does not assume that the correlation will be positive or negative (2 possibilities, hence 'two-tailed'). With a *one-tailed* test it is assumed beforehand that the correlation is going to be a positive or negative. When correlations were calculated between different formats of assessment in each chemistry test, one-tailed correlation was used. When correlations were calculated between different formats of assessment and cognitive characteristics of individuals, two-tailed correlation was used.

7.4 Chemistry Tests

The upper secondary school year has two terms which are four months in length. At the end of each term the students is assessed in formal exams in the school and the grades are provided to the parents. At the end of the first year of Lykeio, pupils sit leaving exams in their schools and the test materials are designed by their teachers and have different degrees of difficulty, depending on the level of the pupils of each school. Teachers also use informal classroom tests results for assessing and assigning their pupils after finishing a unit. Since the teachers had to replace their classroom tests with the researcher's tests, the tests were designed with the teachers' advice in mind and an attempt was made to keep them short and appropriately demanding. The tests were constructed after going through the study questions with Greek Chemistry textbook (Liodakis *et al.*, 1999) the Standard Grade Chemistry book (Renfrew and Conquest, 1995) and Moore *et al.* (1998) chemical world concepts and applications book.

There was a limited choice of chemistry topics which could be tested since it was necessary to follow the timetable and the syllabus of the Greek schools. Thus, the tests were based on:

- Test 1: Atomic structure, classification of matter, solubility.
- Test 2: The periodic table and chemical bonds
- Test 3: Mole concept.
- Test 4: Acids, alkalis, pH, neutralisation
- Test 5: Solutions.

Each chemistry test was designed to assess pupils by a range of question formats asking about the same knowledge and understanding in the same topics. The range of question formats that have been used in the project is shown in table 7.3.

There were difficulties and restrictions in relations to the format of questions that the researcher wanted to apply. For example, the researcher wanted to try not only Structural Communication Grid questions which allow for patterns seeking but also Grids questions which look for sequencing and even for 'objective essay' (Johnstone, 2003). However, the teachers objected to these questions because they thought pupils are not familiar with them and this might have cause problems.

Table 7.3: Combination of different format questions

	Test 1	Test 2	Test 3	Test 4	Test 5
QUEST FORM	MC	SA	SA	MCPK	MC
	SA	SCG	SCG	SCG	SCG
					SA

MC: Multiple-Choice,
MCPK: Multiple-Choice Partial Knowledge,
SA: Short-Answer (Open-Ended)
SCG: Structural Communication Grid

Pupils were unaware that their chemistry results would be used in an investigation and would be correlated with their two cognitive tests and the Perry questionnaire. There is a potential ethical issue here, but it was important for the purpose of the study that these tests should be seen by the pupils as in no way different from the normal tests. Indeed, the construction of the tests was in no way different from the normal tests and the main use of the tests was unaltered. The only difference was that these tests were designed in such a way that meaningful statistical conclusions could be extracted. Details for each chemistry test will be discussed in chapter 8 and 9.

7.5 Field Dependent/ Field Independent Test

A version of Witkin *et al.* (1977) group embedded figures test was used to determine an individual's degree of field dependency. It is called the Hidden Figure Test (H.F.T.) and comprises twenty complex figures plus 2 additional introductory figures that were used as examples. Simple geometric target shapes are presented on the back of a booklet. Pupils are required to recognise and identify one of the target shapes, which is embedded within each of the complex figures by tracing its outline with a pen or a pencil. The main scoring scheme for the tests is to give one point for a correct simple shape embedded in a complex figure. The overall sum of the scores is the total mark which a student can gain. Thus the possible maximum score that can be obtained is 20. An example of the H.F.T. booklet, along with the correct answers can be seen in appendix A.

The conditions for carrying out the Hidden Figure Test were as follows:

- A total time of 20 minutes was given to complete the test.
- Tasks should be addressed in the order in which they appeared in the H.F.T. booklet.
- The target shapes must be traced in the same size; same proportions; and facing in the same direction as they appeared alone in the last page of the booklet.
- Only the required target shape should be traced, ignoring any of the other shapes in each complex figure.
- Students can refer to the page of simple target shapes as often as necessary.

7.5.1 The Division of the sample into FD/FID Categories

Field dependence/independence is generally considered to describe learners along a bipolar continuum such that individuals at one end are measured as field independent while individuals at the opposite end are considered field dependent, and subjects in the middle of the range are characterized as field mixed or field neutral or field intermediate (Liu and Reed, 1994).

Different studies have used different cut-offs to classify someone as field-dependent or field-independent. In Luk's (1998) study, students obtaining a Group Embedded Figure Test score which was above the median of the overall scores were labelled as field-independent; those was who obtained below the median were labelled as field-dependent. Kepner and Neimark (1984), using GEFT (Group Embedded Figure Test) scores which consist of numerical ranking from 0-18, ranked as field dependent persons as those with scores of 0-9 and the students with scores 10-18 were ranked as field independent.

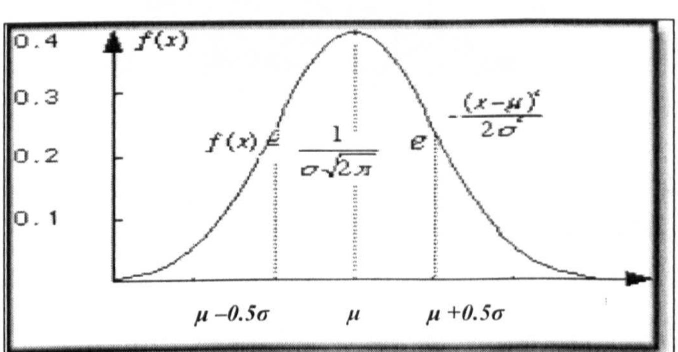


Figure 7.1: Normal distribution

Another method divides the whole cohort into three equal groups (Bahar, 1999). Thus, pupils who scored less than a half standard deviation below the mean (see figure 7.1) were considered to be Field-Dependent (FD). Those scoring more than a half standard deviation above the mean were considered to be Field-Independent (FIND). And finally pupils whose scores were between were labelled as Field-Intermediate (FINT) (El- Banna, 1987; Al-Naeme, 1988; Gray, 1997; Bahar, 1999; Danili 2000; Christou, 2000).

However, many researchers (e.g. Luk, 1998), have omitted the Field-Intermediate category from their studies because they considered that comparisons between contrasting groups (Field-Dependent versus Field-Independent) were a more convenient way of describing complex results.

7.5.2 The H.F.T. result of the Greek sample

The Hidden Figure Test was given to the sample of 487 pupils from the 12 Greek schools. The distribution of the pupils' Hidden Figure Test total scores was plotted. Figure 7.2 shows the histogram of this distribution.

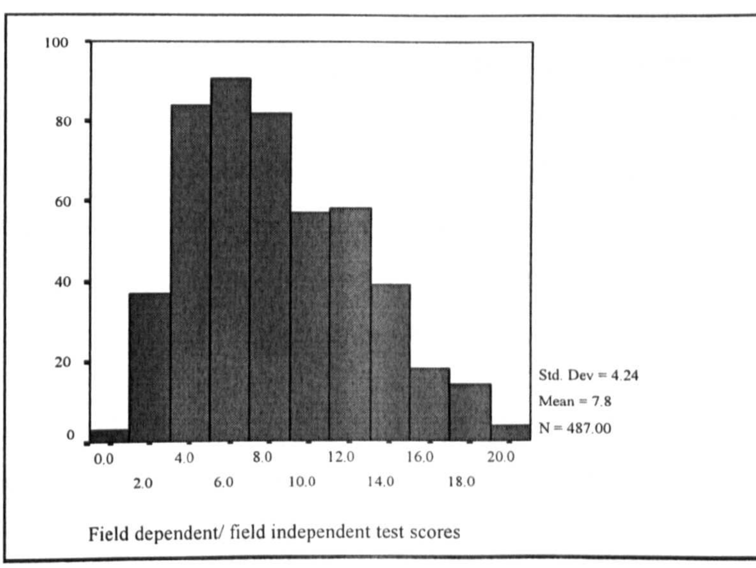


Figure 7.2: The distribution of FD/FIND scores

Descriptive statistics showed that the mean of the score was 7.8 (Minimum = 0, Maximum = 20) and the standard deviation was 4.2 (see appendix F-6). This result divided the sample into three distinct categories: Field-Dependent (FD), Field-Intermediate (FINT), and Field-Independent (FIND).

- FD: those who scored less than 5.7 [5.7 = 7.8 – (0.5 x 4.2)]
- FINT: those who scored between 5.7 and 9.9
- FIND: those who scored more than 9.9 [9.9 =7.8 + (0.5 x 4.2)]

This cut-off divides the whole cohort into three almost equal groups. Table 7.4 presents the number of pupils in each category.

Table 7.4:Number of pupils in FD/FIND category

FD/IND Category	Number of Pupils	Percent
Field Dependent	172	35.3
Field Intermediate	160	32.9
Field Independent	155	31.8
Total	487	100

7.6 Convergent/Divergent Test

The Convergent /Divergent test consisted of 6 mini tests, described below.

Test 1 was designed to find out the subjects' ability to generate words of the same or similar meaning to those given. At the beginning of the test an example was provided to clarify what the pupil was required to do. For example, if the word was '*short*' was given, a set of words such as '*abbreviated, limited, brief, concise, momentary, little, abrupt, petite, crisp, and compact*' might be expected. This test included three questions and the time given for this test was 4 minutes.

Test 2 asked the pupils to construct as many sentences as possible using four given specific words in each sentence, and the words must be used in the form as given. Any sentences which did not make sense, received no credit. An example was provided at the beginning of the test and the time given for the test was 4 minutes.

Test 3 is the only test which is not verbal (i.e. non-word-based). This is because there are some pupils who are pictorial learners and thinkers and, therefore, they perceive ideas more easily by pictures and diagrams. Thus, a pictorial test was included to give an opportunity to this type of student. In this test the student was required to draw up to five different pictures to relate to the idea of the given word. An example was given at the beginning of the test and 5 minutes was allowed.

The purpose of **test 4** was to see how many things the students could think of that are alike in some way. They were asked to write all the things that are round, or that are round more often than any other shape. An example was given at the beginning and 2 minutes was allowed for it.

The objective of **test 5** was to measure the student's ability to think of as many words as they could that begin with one letter and end with another. For example, students were asked about the words, which begin with the letter G, and end with the letter N. Names of people or places were not allowed and the time limit was 2 minutes.

Test 6 aimed to find how many ideas the students could think of about a given topic. They had to list all the ideas they could about a topic whether or not it seemed important to them. An example was given at the beginning of the test and 3 minutes were allowed to complete this test.

The total time allocated for these six mini tests was 20 minutes. The time limit for each test was controlled by the researcher during the session. The test was translated (free translation) into Greek and the clarity of the Greek was checked carefully by two Language teachers. The aim was to detect possible ambiguities and sources of confusion.

In order to measure pupils' performance, one mark was given for every single correct response (Hudson, 1966). Both tests are given in full in appendix B.

7.6.1 The Division of the sample into Convergent/Divergent Thinkers

In his original study, Hudson (1966) divided his sample of school pupils according to their performance in open-ended and IQ tests into 'divergers' (30%), who were predominantly better in the open-ended tests, and the 'convergers' (30%), who were substantially superior at the IQ tests. There were also what can be classified as 'all-rounders' (40%), who were more or less equally good at both kinds of test. Additionally, Hudson (1966) divided his sample again into 'extreme convergers' (10%) and 'moderate convergers' (20%), 'all rounder' (40%), extreme divergers (10%) and moderate divergers (20%). However, Hudson omitted the all-rounder groups from his study because he thought that comparisons between contrasting groups (convergers versus divergers) were a more convenient way of describing complex results.

Al-Naeme (1991) divided his sample according to the mean score of the pupils. He regarded the mean score as a crucial point between moving from convergent thinking into divergent thinking styles or vice versa. Thus, students who had scores below the mean were classified as convergent thinkers and the students who had scores above the mean were classified as divergent thinkers. Bahar, (1999) used the *Mean score ± 0.25SD* as a cut-off to divide his sample in one case and *Mean score ± 0.5SD* in another case.

In this project the sample will be divided in to three groups according to the pupils' mean score and half the standard deviation (see figure 7.3). Thus:

- Convergers (CV): will be those who scored less than a half standard deviation (SD) below the mean (m) [m - 0.5SD].
- All-rounders (AR): will be pupils whose scores were between [m - 0.5SD] and [m + 0.5SD].
- Divergers (DV): will be those scoring more than a half standard deviation above the mean [m + 0.5SD].

7.6.2 The CV/DV Test Applied to the Greek Pupils

The Convergent/divergent test was applied to a sample of 497 pupils from the 12 Greek schools. The distribution of the pupils' CV/DV test total scores was plotted. Figure 7.3 displays the distribution.

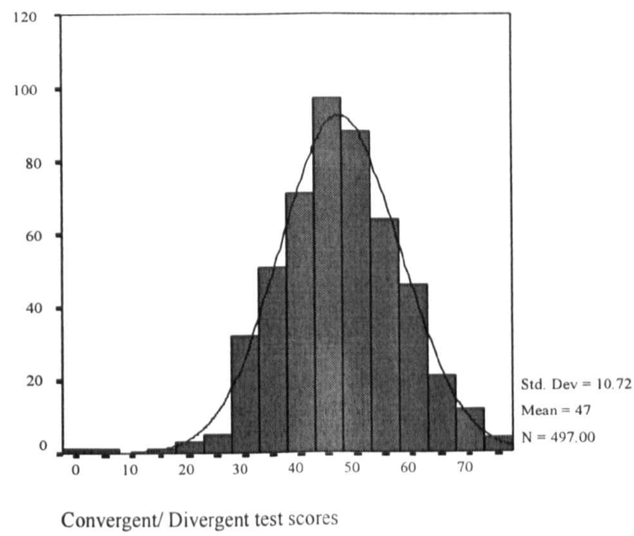


Figure 7.3: The distribution of the CV/DV scores

From the descriptive statistics analysis (see appendix F-6), it was found that the mean of the score was 47 (Minimum = 0, Maximum = 75) and the standard deviation was 10.7. From this result, the sample divided into three distinct categories: Convergers (CV), All-rounders (AR), and Divergers (DV).

- CV: those who scored less than 41.6 [41.5 = 47- (0.5 x 10.7)]
- AR: those who scored between 41.6 and 52.4
- DV: those who scored more than 52.4 [52.4= 47 + (0.5 x 10.7)]

Table 7.5 shows the number of the pupils in each category.

Table 7.5: The division of the pupils in DV/ CV categories

CV/DV Category	Number of Pupils	Percent
CV	144	29.0
AR	206	41.4
DV	147	29.6
Total	497	100

7.7 Gender difference in the cognitive test performance

It is interesting to note that, in the field dependent/independent test, no significant difference was found between females and males while, in the convergent/divergent test a significant difference was found with females outperforming males. Table 7.6 shows the mean of each group and the appendix F-7 shows the statistics.

Table 7.6: Gender differences in the cognitive tests

	SEX	N	Mean	S. D.
FDSC	F	290	7.7	4.1
	M	194	8	4.4
	SEX	N	Mean	S. D.
CVSC	F	298	47.9	10.7
	M	199	45.7	10.6

The above finding for the field dependent/independent test is consistent with the findings of other studies in the literature e.g. Pithers (2002); Morell (1976). As for the convergent/divergent test there is not any evidence in the literature about gender differences. Maybe the differences between the two tests found here can be explained by the nature of the tests. The convergent/divergent test focuses on verbal skills while the field dependent/independent test focuses on non-word-based (visual) ones. One possible reason for this difference is the superiority that girls have exhibited in verbal ability as mentioned by Beller and Gafni (2000).

Conclusion

Having measured pupils' cognitive characteristics and assessed them in five different content areas in Chemistry, in chapters 8 and 9 an attempt will be made to find out:

a) The correlations between the different formats of assessment in each content area.
b) The correlations between pupils' field dependent/field independent test scores and pupils' performance in each format of assessment in each content area.
c) The correlations between pupils' convergent/divergent test scores and pupils' performance in each format of assessment in each content area.
d) The patterns of correlations across content areas.

Chapter 8 discusses test 1, 2 and 3, which are of greater importance for this study, because of the large sample, which makes the data more reliable. Chapter 9 discusses test 4 and 5, which the number of the pupils involved in them was relatively small.

Chapter Eight

The results of Test 1, 2 and 3

This chapter describes the first three paper-and-pencil classroom tests which were used in this study. Furthermore, it explores the correlations between different formats of assessment in each chemistry test as well as the correlations between different formats of assessment and cognitive characteristics of individuals. An English translation of each test with the score for each question is shown reduced in size. The original Greek tests are shown in appendix E. For every section of each test, raw scores were converted to a percentage and these were added to give the total mark of each pupil. Converting the raw scores to a common scale makes easier for the reader to compare means between different tests and see patterns that might emerge from the study, though it does not alter the statistical results.

8.1 Test 1: Multiple-Choice vs. Short-Answer Format

Test one was based on the introductory chapter of the Greek chemistry textbook. The content areas that it tested were atomic structure, classification of matter, and solubility. It consisted of two sections:

- Section 1: 12 Multiple-Choice questions-12 marks,
- Section 2: 5 Short-Answered questions-14 marks.

Section 1 had multiple-choice questions, which mainly require students to recognize or identify knowledge. In section 2 there were short answer questions covering the same thematic area. However, the demands on students were more than simply recognition and memorisation. The short-answer questions vary considerably. For example some require students to recall and define knowledge, other require to solve a numerical problem, which requires only a small numbers of steps but deep understanding of the concept involved, or to interpret a graph. An English translation of the test is shown below.

Test 1: Atomic Structure-Classification of Matter

Section 1. Each question has only ONE correct answer. Tick the answer that you think is correct.

1. What would be the volume in litres of 240g of oil if the density of the oil were 0.8 g/mL? (1)

❒ A. 300L
❒ B. 0.3L
❒ C. 192L
❒ D. 0.19L

2. Which one of the following represents correctly the electrical charges of the three basic particles, which make up atoms? (1)

		proton	neutron	electron
❒	A.	+1	0	+1
❒	B.	+1	0	-1
❒	C.	0	0	+1
❒	D.	+1	+1	-1

3. An atom of element X contains 13 protons and 14 neutrons. Which of the following correctly represents this? (1)

❒ A. $^{14}_{13}X$
❒ B. $^{27}_{14}X$
❒ C. $^{27}_{13}X$
❒ D. $^{13}_{27}X$

4. The two isotopes of carbon, $^{12}_{6}C$ and $^{14}_{6}C$, differ from each other in: (1)

❒ A. mass number
❒ B. atomic number
❒ C. chemical properties
❒ D. number of electrons

5. The atomic number of potassium is 19 and its relative atomic mass is 39. Which one of the following represents correctly the atomic particles found in the K^+ ion: (1)

❒ A. 19 protons 20 neutrons 19 electrons
❒ B. 19 protons 20 neutrons 18 electrons
❒ C. 20 protons 19 neutrons 20 electrons
❒ D. 20 protons 19 neutrons 18 electron

6. When a magnet is passed over a sample of powdered metal, some of the sample is attracted to the magnet and some is not. The powdered metal sample is: (1)

❒ A. a single element
❒ B. pure substance
❒ C. homogeneous mixture
❒ D. heterogeneous mixture

7. Which one of the following is usually described as a 'physical change'? (1)

❒ A. the burning of magnesium in air
❒ B. the rusting of iron
❒ C. the evaporation of the alcohol
❒ D. the rotting of an apple

8. Which of the following involves at least one 'chemical change'? (1)

❒ A. burning of the wood
❒ B. converting water to steam in an electric kettle
❒ C. producing salt from sea water by evaporation
❒ D. sublimation of iodine

9. Which of the following is a pure substance? (1)

❒ A. air
❒ B. milk
❒ C. carbon dioxide
❒ D. rain

10. The solubility of AgCl in water is: (1)

- ❒ A. the minimum mass of water which can dissolve in a given mass of AgCl at fixed temperature
- ❒ B. the maximum mass of AgCl which can be dissolved in water at a fixed temperature
- ❒ C. the mass of AgCl can be dissolved in a given mass of water at a fixed temperature
- ❒ D. the maximum mass of Ag Cl can be dissolved in given mass of water at a fixed temperature

11. The solubility of a gas in a liquid (1)

- ❒ A. increases as the temperature of the solution is increased.
- ❒ B. increases as pressure of the gas at the surface is increased.
- ❒ C. increases as the volume of the solution is increased.
- ❒ D. decreases as pressure of the gas at the surface is increased.

12. What is the percent-by-mass of a solution made by adding 56g of KOH to 944g of water? (1)

- ❒ A. 59%
- ❒ B. 5.6%
- ❒ C. 56%
- ❒ D. 5.9%

Section 2

13. Give the definition of the:

i. atomic number of an element: .... (1)

ii. mass number of an element:.. (1)

Which of the above numbers can be changed without be changed the identity of the element: (1)

14. A coin was dropped into a graduated cylinder containing 20.20mL of water. The volume of the water increased to 20.80mL. The coin has a mass of 1.2g. What is the density of the coin? (3)

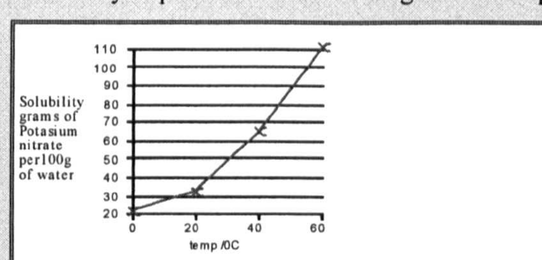
....

15. What is the most important difference between a compound made from iron and sulphur and a mixture of iron and sulphur: .... (1)

16. Give the number of protons, neutrons and electrons in the followings atom or ion: (2)

	neutrons	protons	electrons
$^{23}_{11}Na^{+}$	....	....	....
$^{56}_{26}Fe$	....	....	....

17. A line graph showing the solubility of potassium nitrate changes with temperature is shown below.



Use the curve to estimate:

i. The maximum mass of potassium nitrate that would dissolve in 50 g of water at 30 0C: (2)

....

ii. The temperature the solubility of potassium nitrate is70%: (1)

....

iii. The mass of crystals that would form if a solution containing 60g of potassium nitrate in 100g of water were cooled from 60 0C to 20 0C.. (2)

8.1.2 Descriptive Statistics of Test 1

Eight schools participated in test 1 and the total number of pupils was 288 (see table 7.2, page 127). Figure 8.1 shows histograms of the distribution of the two formats scores, the sum of the two formats scores and the differences of the two formats scores for test 1. Table 8.1 shows the descriptive statistics of test 1.

Table 8.1: Descriptive statistics of Test 1

Test 1	N	Minim.	Maxim.	Mean	S.D.
MC	288	17	100	64.3	20.4
SA	288	0	100	53.5	25.6
MC+SA	288	32	200	117.8	42.5
MC-SA	288	-34.5	66.7	10.8	18.6

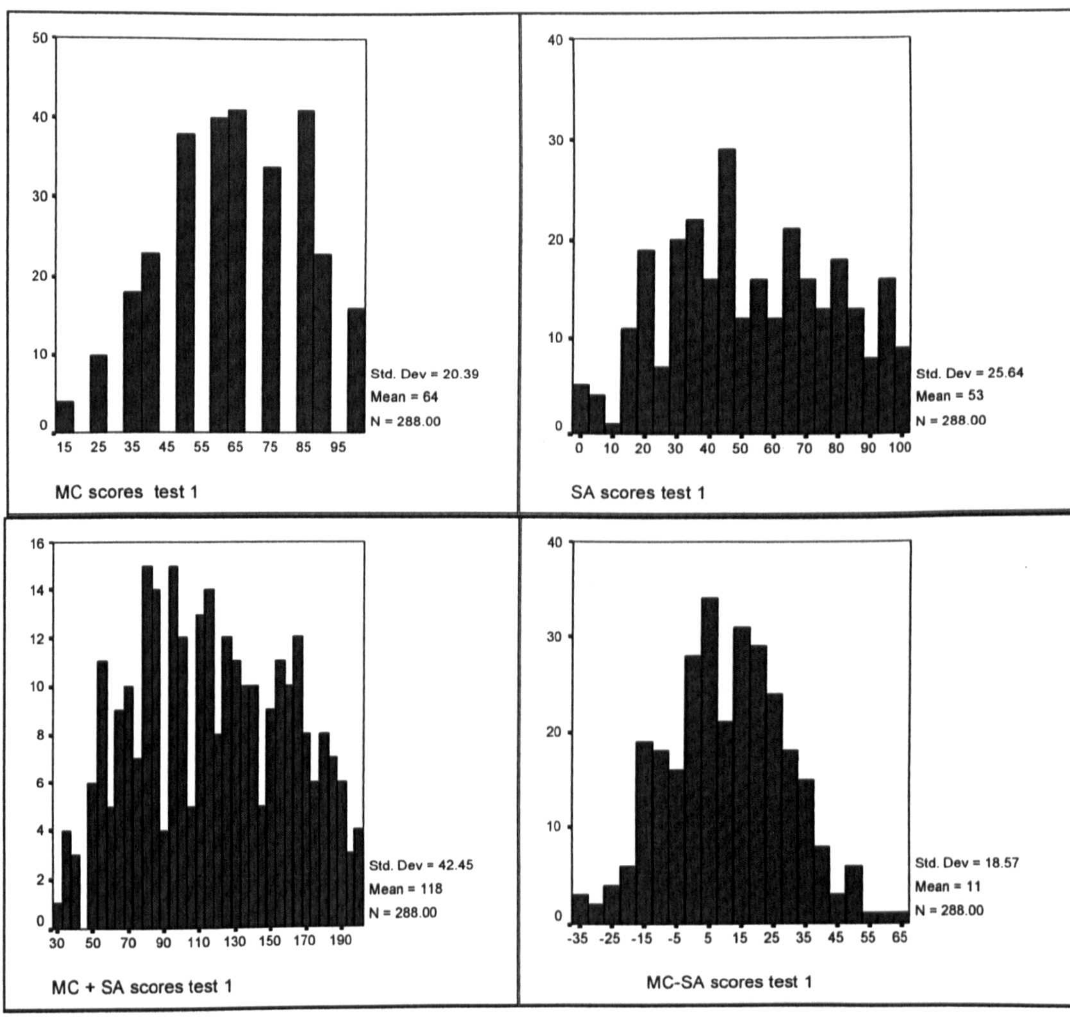


Figure 8.1: The distributions of different format scores of Test 1

The SA test was more difficult than MC test.

8.1.3 Differences between Schools

Initially eight teachers agreed to use the tests designed here in place of the tests that they would have set. However, only three schools continued to take part in the second test and two in the fourth test (table 7.2). In order to check whether only the schools that had achieved high scores in the first test continued to participate in the study a table (8.2) was constructed showing pupils mean performance in test 1 for each school.

Table 8.2: Pupils' mean scores for each school in Test 1

Schools	Number of pupils	Mean
1	19	153
3	21	109
4	14	132
5	36	105
7	74	104
8	56	105
9	25	129
10	43	95
Total	**288**	**118**

Table 8.2 shows that there are some differences in the means score between the schools in some cases. A comparison of the mean scores between each school using One-Way Analysis of Variance (ANOVA) procedure were used to test the hypothesis that several means are equal. As can be seen in appendix F-8 the p-value is 0.000, which is clearly less than 0.05. Thus, from the above analysis it can be concluded that there is significant difference in pupils' performance in test 1 between each school.

Schools 8, 9, and 10 participated in the second test and schools 8 and 9 participated in the fourth test. Table 8.2 shows that the mean score of the school 8 was 105, the mean score of the school 9 was 129 and finally the mean score of the school 10 was 95. From the statistical analysis and from the above mean scores, it can be concluded that it was not only the schools that had achieved high scores in the first test which continued to participate in the study. It was desirable that a variety of schools with differences in pupils' performance continued to take place in the research in order to make generalisation possible. Since the schools have not been chosen at random, the above result was satisfactory for the purpose of this research.

8.1.4 Correlations in Test 1

The Spearman's rho correlation between the MC and SA scores was found to be 0.71 (see table 8.3), which is significant at the 0.01 level (1-tailed). This correlation is the largest found in the whole study. The original statistical results are printed in appendix F-9. A scatter diagram was plotted for the two variables. Figure 8.2 illustrates this diagram.

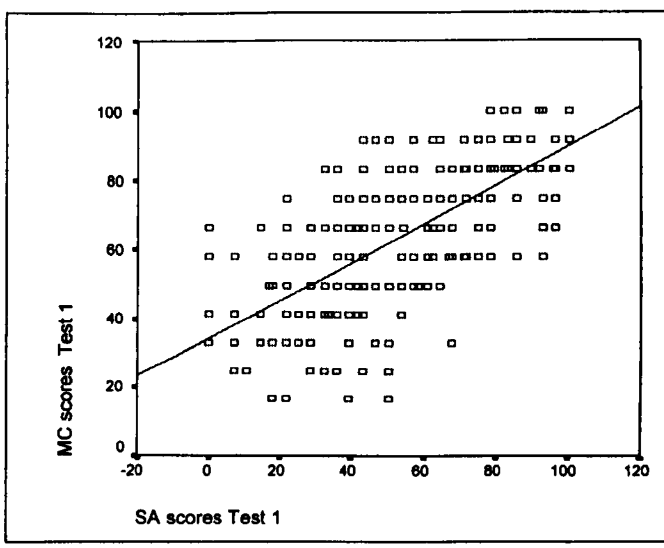


Figure 8.2: Scatter plot for the correlation between MC scores vs. SA scores in Test 1

This result is similar to the result that it was found in the first test of the pilot study. However the correlation is not 1.0. This means that the format of the question with concomitant language differences might have an effect on the rank order of the pupils. In order to examine if the differences in the pupils performance in each format of the assessment are related to pupils cognitive components, Spearman rho correlations were found between different formats of assessment and cognitive tests. Table 8.3 shows these correlations.

Table 8.3: Test 1 Spearman's rho correlations				
Scores	**MC**	**SA**	**MC+SA**	**MC-SA**
SA	0.71**			
CVSC	0.25**	0.29**	0.29**	-0.13*
FDSC	0.34**	0.29**	0.35**	-0.03

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

MC:	Pupils' scores on Multiple-Choice question test.
SA:	Pupils' scores on Short-Answer question test.
CVSC:	Pupils' scores on convergent/divergent test.
FDSC:	Pupils' scores on field dependent/field independent test.
MC+ SA:	Sum of pupils' MC and SA scores.
MC-SA:	Differences between pupils' MC and SA scores.

The following sections discuss in detail the above results.

8.1.5 Convergent/Divergent Characteristic and Test 1

Table 8.3 shows the correlations for convergent/divergent characteristic. In addition to correlations descriptive statistics were found for each convergent/divergent group (see appendix F-10). Table 8.4 shows the means and the standard deviations for each convergent/divergent group.

Table 8.4: Means and standard deviations of CNV/DV groups in Test 1										
CNV/DV groups	**N**	**MC**		**SA**		**MC+SA**		**MC-SA**		
		mean	**s.d**	**mean**	**s.d**	**mean**	**s.d**	**mean**	**s.d**	
CV	82	59.4	13.58	44.8	13.19	104.1	38.31	14.6	19.44	
AR	110	64.0	13.42	54.3	13.93	118.3	40.87	9.7	16.79	
DV	93	68.9	15.21	60.1	15.33	129.1	45.04	8.8	19.72	
Total	285	64.3	14.27	53.5	14.56	117.7	42.57	10.8	18.65	

Table 8.3 shows that the correlations for both the formats of assessment are significant at 0.01 level. This signifies that divergent pupils performed better than convergent pupils in both formats. As seen in table 8.4 divergent pupils' mean scores are better than convergent pupils' mean score in both formats of questions. However, the negative significant correlation (table 8.3) between divergent/convergent scores and the differences between MC and SA scores shows that the more divergent a pupil

is the more the differences between the scores of the two formats decrease. As table 8.4 demonstrates the differences between the scores of the two formats are decreasing as a pupil becomes more divergent (14.6, 9.7, 8.8). This implies that divergent style pupils surpass convergent style pupils at Short-Answer test more than they surpass at Multiple-Choice test. Short-Answer format of assessment favours more divergent style pupils than Multiple-Choice format does.

To examine if there are statistically significant differences in performance between convergent and divergent groups, the Two-Independent-Samples Tests procedure compares two groups of cases on one variable was computed. Both t test and Mann-Whitney test were computed. The analyses show that there are significant difference between convergent and divergent pupils' Multiple-Choice mean scores; Short-Answer mean scores; Total mean scores; and MC-SA scores. This is always in favour divergent pupils. Appendix F-11 shows the result of the above analyses.

8.1.6 FD/ FIND Characteristic and Test 1

Table 8.3 shows the Spearman rho correlations for the field dependent/field independent characteristic. Table 8.5 shows the means and the standard deviations for each group. Descriptive statistics for each Field dependent/Field Independent group are shown in appendix F-12.

Table 8.5: Means and standard deviations of FD/FIND groups in Test 1

FD/FIND groups	N	MC		SA		MC+SA		MC-SA	
		mean	s.d	mean	s.d	mean	s.d	mean	s.d
FD	106	57.4	20.99	46.5	22.49	103.9	39.56	10.9	18.13
FINT	91	65.9	19.63	55.7	28.75	121.6	44.76	10.3	20.48
FIND	86	71.4	18.01	59.9	23.95	131.3	38.67	11.5	17.33
Total	283	64.4	20.47	53.5	25.64	117.9	42.50	10.9	18.63

With both formats, the field dependent/independent significant correlations indicate that the field independent pupil performed better. Table 8.5 demonstrates these results. The insignificant correlation between FD/FIND scores and differences between MC and SA scores denotes that the format of the two assessment does not have preferential effect on field dependent /field independent characteristic. The differences in the average MC-SA scores are almost constant among the groups (10.9, 10.3 and 11.5).

To confirm if there are statistical significant differences in performance between field dependent and field independent groups both t test and Mann-Whitney test were computed. The analyses show that there is significant difference between field dependent and field independent pupils in the mean scores of both formats of assessment. The difference is in favour field independent group. No significant difference between field dependent and field independent MC-SA pupils' scores was found. Appendix F-13 shows the results of the above analyses.

8.2 Test 2 Short-Answer vs. Structure Communication Grid

Test two was based on the periodic table and bonding theory chapters of the Greek chemistry textbook. It included two sections.

- Section 1: 3 Short-Answer questions-10 marks
- Section 2: 1 Structural Communication Grid question-10 marks.

An English translation of the test with the score for each question is shown below. In order to answer the test, pupils were allowed to have the periodic table in front of them. Thus, in both sections the questions require no recalling and memorising of the scientific facts. All questions require an understanding of taught concepts (the periodic table, the properties of the element and the concept of bonding theory); an ability to interpret the presenting information and to apply it. However, Short-Answer questions require pupils to use more their language skills since the questions ask pupils to give explanations e.g. for properties of compounds or for similarities of elements.

Test 2: Periodic Table - Chemical bonds

Section 1

1. You are given the following elements with atomic numbers: 7, 12, 18, 38, 54.

Which of them have similar properties?.. (1)

Explain your answer: .... (1)

2. Two elements, X and Y, each forms a compound with chlorine. The chloride of X is a solid whose solution in water has a high conductivity. The chloride of Y is a liquid, which does not conduct electricity.

a) To which main group of the periodic table is X likely to belong?

.... (1)

b) Explain your answer:

.... (2)

c) To which main group of the periodic table is Y likely to belong?

.... (1)

d) Explain your answer: .... (2)

3. What do the following have in common? $_{10}Ne$, $_{9}F^{-}$, $_{12}Mg^{+2}$

.... (2)

Section 2

4. Each box in the grid below refers to an element.

Look at the boxes and answer the questions that follow.

(Boxes may be used as many times as you wish)

A. The element with electron arrangement 2,8,3	**B.** Sodium	**C.** Ar
D. Magnesium	**E.** The element which is a brown liquid at room temperature	**F.** The element which has 1 electron in each atom
G. The element of atomic number 19	**H.** Chlorine	**I.** Nitrogen

Select the box (es) which contain:

I. Elements in the same group of the periodic table: .... (2)

II. Elements that are gases in room temperature: .... (2)

III. Atoms of which element (or elements) form ions with the same electron arrangement as argon atoms: .... (2)

IV. Two elements that will combine to form an ionic compound with the formula X_3Y_2 :.......... (2)

V. Elements which form a covalent compound with the element which is in the box F:........... (2)

8.2.2 Descriptive Statistics of Test 2

Table 7.2 (page 127) shows that four schools involved in test 2 and the total number of pupils was 185. Descriptive statistics of the score of each part of the test, the sum of the two formats scores (total) and the differences of the two formats scores for test 2 were found (appendix F-14). Table 8.6 shows the outcomes.

Table 8.6: Descriptive statistics of Test 2

Test 2	N	Minim.	Maxim.	Mean	S.D.
SA	185	0	100	52.2	30.7
SCG	185	0	100	36.7	25.4
SCG+SA	185	0	200	88.9	46.9
SCG-SA	185	-100	62.5	-15.5	31

Figure 8.3 shows histograms of the distribution of the scores of Test 2.

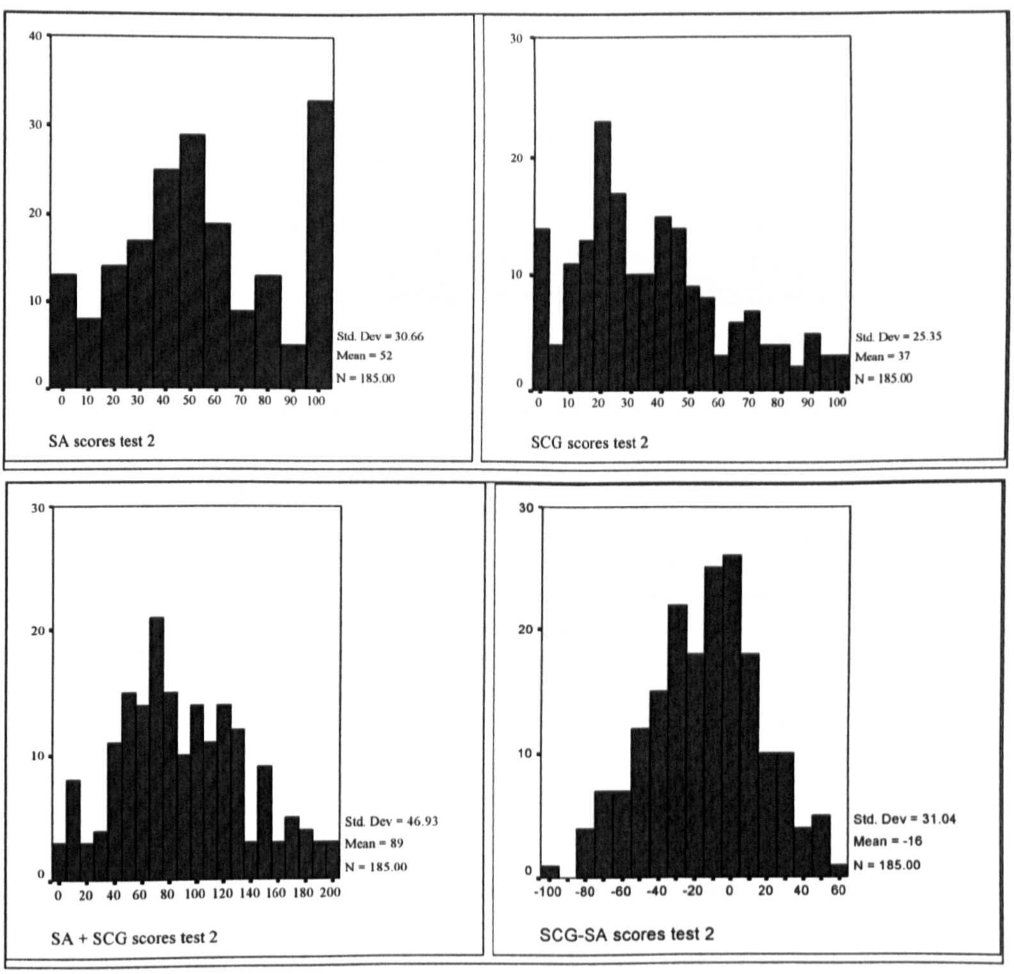


Figure 8.3: The distributions of scores in different format questions of Test 2

The descriptive statistics for each section of the test in table 8.6 as well as the figure 8.5 shows that the SCG test was slightly too difficult for the pupils.

8.2.3 Correlations in Test 2

The Spearman's rho correlation between the SA and SCG scores was found to be 0.38, which is significant at the 0.01level. This result is close to the result that was found in the second test of the pilot study. However, the correlation is small, far from 1.0, and much smaller than the correlation between the two formats of assessment in test 1. A larger correlation was expected since Grids questions allow giving credit for partial knowledge. The original statistical results are printed in appendix F-14.

In order to examine if the differences in the pupils performance in each format of the assessment are related to pupils cognitive characteristics Spearman's rho correlations were found between the different formats of assessment and cognitive tests. Table 8.7 shows these correlations and the following sections discuss in detail these correlations.

Table 8.7: Test 2 Spearman's rho correlations

Scores	SA	SCG	SCG+SA	SCG-SA
SCG	0.38**			
CVSC	0.32**	0.16*	0.30**	-0.16*
FDSC	0.31**	0.12	0.27**	-0.19**

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

SA:	Pupils' scores on Short-Answer (Open-Ended) questions test.
SCG:	Pupils' scores on Structural Grid questions test
CVSC:	Pupils' scores on convergent/divergent test.
FDSC:	Pupils' scores on field dependent/field independent test.
SA+SCG:	Sum of pupils' SA and SCG scores.
SCG-SA:	Differences between pupils' SCG and SA scores

8.2.4 Convergent/Divergent Characteristic and Test 2

Table 8.7 shows the correlations between CNV/DV and SCG scores, and between CNV/DV and SA scores. Descriptive statistics were found of each convergent /divergent group (see appendix F-16). Table 8.8 shows the means and the standard deviations for each group in test 2.

Table 8.8: Means and standard deviations of CNV/DV groups in Test 2										
CNV/DV groups	N	SA		SCG		SCG+SA		SCG-SA		
		mean	s.d	mean	s.d	mean	s.d	mean	s.d	
CV	56	39.0	30.3	30.1	21.5	69.1	43.6	-9.0	29.4	
AR	72	56.0	28.3	38.7	25.5	94.7	41.7	-17.3	34.2	
DV	57	60.5	30.1	40.7	27.7	101.2	50.7	-19.8	27.8	
Total	184	52.2	30.6	36.7	25.4	88.9	46.9	-15.5	31.0	

The correlations between CNV/DV and SCG scores, and between CNV/DV and SA scores are statistically significant. As seen in table 8.8, the divergent pupils performed better than convergent pupils in both formats of assessment. However, the significant negative correlation (-0.16) between CNV/DV and the differences between SCG and SA scores implies that the SA format of assessment favours divergent pupils more than the Grid format of assessment does. As table 8.8 demonstrates the differences between the scores of the two formats are decreasing as a pupil becomes more divergent (-9.0, -17.3, -19.8).

In order to check that there are statistical significant differences in performance between convergent and divergent groups, t test and Mann-Whitney test were computed. From the analyses, it was found that there is significant difference between convergent and divergent pupils mean scores in both the formats of assessment and pupils SCG-SA scores in favour divergent pupils. Appendix F-16 shows all the results from the above statistics.

8.2.5 FD/ FIND Characteristic and Test 2

Table 8.7 shows that the correlation between field dependent/independent scores and Grid scores is not statistically significant while all other correlations are significant. Perhaps one of the reasons for this was the fact that Grid questions was slightly too difficult for the pupils. Descriptive statistics were found for each field dependent / field independent group (see appendix F-17). Table 8.9 shows the means and the standard deviations for each group.

Table 8.9: Means and standard deviations of FD/FIND groups in Test 2									
FD/FIND groups	N	SA		SCG		SCG+SA		SCG-SA	
		mean	s.d	mean	s.d	mean	s.d	mean	s.d
FD	71	45.3	31.5	32.8	24.6	78.1	47.2	-12.5	31.3
FINT	62	53.2	30.7	38.3	26.2	91.4	47.1	-15.0	32.3
FIND	49	61.6	28.1	40.1	25.3	101.6	44.9	-21.5	28.9
Total	182	52.4	30.9	36.6	25.4	89.0	47.3	-15.8	31.1

As seen in the above table field independent pupils perform better than field dependent pupils in both the tests. However, the differences in the average SCG-SA scores are not constant among the groups (-12.5, -15.0, -21.5). The difference is decreasing, as pupils become more field independent. This means that the Short-Answer format of assessment favours more field independent pupils than Grids format of assessment does. To confirm if there are statistical significant differences in performance between field dependent and field independent groups, both *t* test and Mann-Whitney test were computed (see appendix F-18). These analyses show that there is significant difference between field dependent and field independent pupils' Short-Answer mean scores and pupils' Total mean scores. The difference is in favour of field independent pupils. There is no significant difference between field dependent and field independent pupils' Grid mean scores and MC-SA pupils' scores.

8.3 Test 3: Short-Answer vs. Structure Communication Grid in Mole

Test 3, was based on the mole concept and Avogadro's Law. It was only a 15 minutes test and included two sections.

- Section 1: 2 Short-Answer questions-10 marks
- Section 2: 1 Structural Communication Grid question-10 marks

An English translation of the test is shown below. The questions require retrieval of declarative knowledge, and procedural knowledge as well as numerical problem ability (of algorithmic type) in both formats of assessment.

Test 3: Mole

Section 1

1. We have two balloons which when they are empty are identical in weight. The first is filled with 1 mol of oxygen (O_2). The second is filled with 2 mol of methane (CH_4).
(Relative atomic mass: O =16, C = 12, H=1)


A. Work out the formula mass of each substance and find out which balloon now weighs more: (5)

....

B. Which balloon has the bigger volume under STP condition? .... (2)

Explain your answer: .... (3)

Section 2

2. Look at the boxes and answer the following questions. Each question may have more than one answer. (Boxes may be used as many times as you wish). (Ar: N = 14, C = 12, O = 16)

A. $2N_A$ molecules	**B.** 56g	**C.** 22.4l (STP conditions)
D. 44g	**E.** 2mol	**F.** N_A molecules
G. 44.8l (STP conditions)	**H.** 28g	**I.** 22g

A. Pick the box (es) which contain mass of 1mole of CO_2:.. ... (5)

B. Pick the box(es) which contain the same amount of N_2 as the one that is in the box B ....(5)

8.3.2 Descriptive Statistics of Test 3

Three schools were involved in test 3 and the total number of pupils was 146 (table 7.2, page 127). Table 8.10 shows the descriptive statistics of the test 3 and figure 8.4

shows histograms of the distributions of test 3. The mean score of SCG test was higher than the mean score of SA test.

Table 8.10: Descriptive statistics of Test 3					
Test 2	**N**	**Minim.**	**Maxim.**	**Mean**	**S.D.**
SA	146	0	100	60.9	37.3
SCG	146	0	100	67.7	36.7
SCG+SA	146	0	200	128.6	64.6
SCG-SA	146	-100	100	6.8	36.2

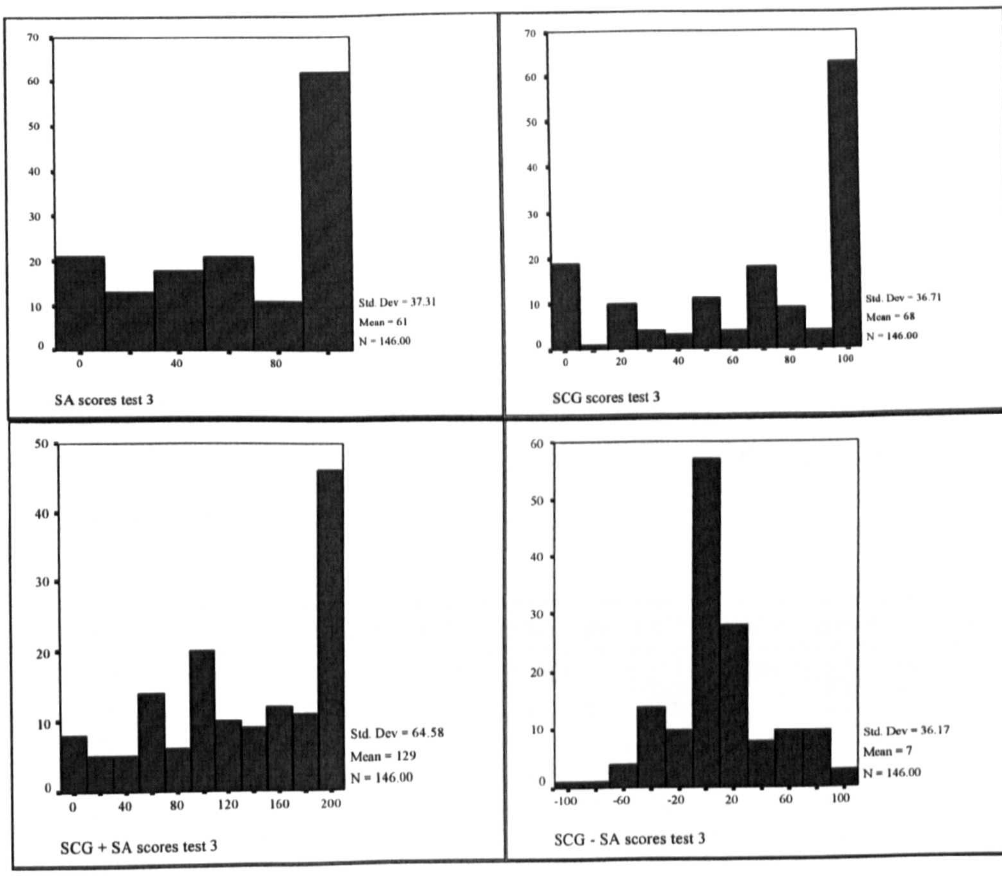


Figure 8.4: The distributions of different format questions of Test 3

8.3.3 Correlations in Test 3

The Spearman's rho correlation between the SA and SCG scores was found to be 0.55, which is significant at the 0.01 level (1-tailed). The original statistical results are printed in appendix F-19. Table 8.11 shows Spearman's rho correlations between different format of assessment and cognitive tests. These will be discussed in the following sections.

Table 8.11: Test 3 Spearman's rho correlations

Scores	SA	SCG	SCG+SA	SCG-SA
SCG	0.55**			
CVSC	0.12	0.04	0.09	-0.04
FDSC	0.32**	0.19*	0.27**	-0.18*

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

SA:	Pupils' scores on Short-Answer questions test.
SCG:	Pupils' scores on Structural Grid questions test
CVSC:	Pupils' scores on convergent/divergent test.
FDSC:	Pupils' scores on field dependent/field independent test.
SA+SCG:	Sum of pupils' SA and SCG scores.
SCG-SA:	Differences between pupils' SCG and SA scores

8.3.4 Convergent/Divergent Characteristic and Test 3

The correlations between convergent/divergent scores and different formats of assessment scores in test 3 were not significant (see table 8.11). This means that the convergent/ divergent characteristic does not relate to pupils' performance for both formats of assessment in this test.

Table 8.12: Means and standard deviations of CNV/DV groups in Test 3

CNV/DV groups	N	SA		SCG		SCG+SA		SCG-SA	
		mean	s.d	mean	s.d	mean	s.d	mean	s.d
CV	46	57.7	37.2	67.9	38.7	125.6	68.3	10.2	33.0
AR	62	61.1	39.1	64.4	39.1	125.5	68.4	3.2	37.9
DV	36	65.1	33.8	71.8	67.9	136.9	53.1	6.6	36.2
Total	144	61.0	37.1	67.4	36.8	128.4	64.6	6.3	35.8

Table 8.12 shows the means and the standard deviations for each group in test 3. As can be seen from this table, divergent students performed better than convergent students. In the grid test, convergent pupils performed better than their all round counterparts. However, there are no significant differences in the performances between the groups (see statistics in appendix F-20).

8.3.5 FD/ FIND Characteristic and Test 3

Significant correlations between field dependent /field independent scores and Short-Answer scores and Grid scores are observed (table 8.11). Table 8.13 shows a summary of the descriptive statistics which were found for each field dependent/ independent group (appendix F-21 shows the original data).

Table 8.13: Means and standard deviations of FD/FIND groups in Test 3

FD/FIND groups	N	SA		SCG		SCG+SA		SCG-SA	
		mean	s.d	mean	s.d	mean	s.d	mean	s.d
FD	40	45.5	39.6	56.2	39.7	101.7	73.5	10.7	29.8
FINT	50	61.5	36.1	70.2	34.3	131.7	60.3	8.7	36.4
FIND	47	72.2	31.6	73.3	34.6	145.5	54.2	1.1	38.1
Total	137	60.5	37.0	67.2	36.5	127.7	64.6	6.7	35.2

From table 8.13, it can concluded that field independent pupils' mean scores are better than field dependent mean scores in both formats of questions. However, the negative significant correlation shows that the more field independent a pupil is the more the differences between the scores of the two formats decrease. As table 8.13 demonstrates, the differences between the scores of the two formats are decreasing, as a pupil becomes more field independent. This means that Short-Answer format of assessment favours field independent pupils more than Grid format of assessment does.

It was found that there is significant difference between field dependent and field independent pupils Short-Answer mean scores, Grid scores and pupils' Total mean scores in favour field independent pupils (see appendix F-21). No significant difference between field dependent and field independent pupils' Grid mean scores and SCG-SA pupils' mean scores was found.

8.4 Interaction of the Cognitive Styles

A significant correlation (0.19 significant at 0.01 level) between convergent/divergent and field dependent/independent cognitive styles was found. Moreover, overall tests 1 and 2 showed that the two cognitive characteristics influenced pupils' performance.

Most of the chemistry tests, which were used in this study, were informal classroom tests. It is reasonable to expect that in formal examinations or in national examinations when pupils are under pressure and usually the tests are more difficult or covering many topics, these cognitive characteristics may become more dominant and pervasive.

Because chemistry test 1 was used by the schools teachers involved in the study as the formal examination for the first term, an attempt was made to see how the two cognitive characteristics interact with the pupils' performance in this test. Thus, the sample of the pupils who participated in test 1 was subdivided according to the pupil's convergent/divergent style and field-dependency cognitive style. Each group with the same convergent style was sub-divided into three groups by field-dependency. It was thought that the field-independent and divergent pupils might achieve better marks in the chemistry test than those who were field-dependent and convergent. A table was constructed for comparison of the three variables: field dependency, convergent/divergent style and scores in the chemistry test 1. Table 8.14 shows the differences between groups in chemistry test 1 and figure 8.5 illustrates this visually.

Table 8.14: Summary of different groups' performance in chemistry Test 1

Groups	FD			FINT			FIND		
	N	Mean	s. d.	N	Mean	s. d.	N	Mean	s. d.
CV	42	47.5	18.5	25	55	19	14	61.5	19
AR	33	51.5	19.5	35	61	21	38	64.5	19.5
DV	30	59	21	31	65	25.5	32	69.0	20

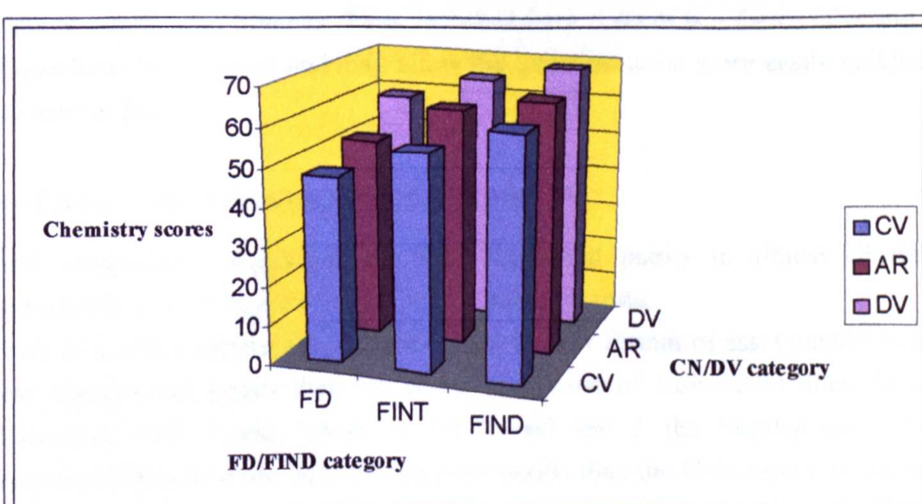


Figure 8.5: Summary performance of the different groups in Test 1

From the above table it is interesting to see that the mean score in the chemistry test 1 of a person who is field dependent and convergent is 21.5% less than a person who is field independent and divergent. It is a matter of concern that performance in a chemistry test is so strongly related to these particular psychological parameters, control over which is largely outside the individual pupil. This raises an ethical issue about assessment. Are we testing chemical knowledge and understanding or cognition?

Conclusion

From test 1, 2 and 3 the following conclusions can be made:

In terms of the correlations between different formats of assessment the correlation between:

- The MC and SA scores in test 1 was found to be 0.71
- The SA and SCG scores in test 2 was found to be 0.38
- The SA and SCG scores in test 3 was found to be 0.55

In terms of the convergent/divergent characteristic (see table 8.14):

- Divergent pupils surpass convergent pupils in all formats of assessment in test 1 and 2.
- Short-Answer format of assessment favours more divergent pupils than objective format of assessment does in test 1 and 2.
- None of the correlations between convergent/divergent scores and test 3 scores was significant. It seems that in algorithmic type questions or in questions that there is more use of symbols and less use of words the convergent/divergent characteristic does not relate to pupils' performance. Thus, the chemistry content is a factor effecting the type of questions being asked and may allow the question to be more easily tackled by, say a divergent pupil.

In terms of field independent/dependent characteristic:

- Field independent pupils surpass field dependent pupils in almost all formats of assessment (in SCG test 2 no significant) and in all tests.
- There is no clear pattern whether the Short-Answer format of assessment favours more field independent pupils than the objective format of assessment does. In test 1 no differences were found, while in test 2 and test 3 the Short-Answer format of assessment favours more field independent pupils than the Grid format of assessment.

Table 8.15 summarises all the above outcomes by showing the correlations between cognitive tests scores and chemistry scores in test 1, test 2 and test 3.

Table 8.15: Spearman's rho correlations between cognitive tests and Test 1, 2, and 3									
	Test 1 (N= 288)			Test 2 (N=185)			Test 3 (N=146)		
	MC	SA	MC-SA	SA	SCG	SCG-SA	SA	SCG	SCG-SA
CVSC	0.34**	0.29**	-0.13*	0.32**	0.16*	-0.16*	NS	NS	NS
FDSC	0.25**	0.29**	NS	0.31**	NS	-0.19**	0.32**	0.19*	-0.18*

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

It seems that the field dependent/independent characteristic is a very dominant and a very important factor for pupils in order to perform well in almost all types of assessments. The convergent/ divergent characteristic seems to be very important when language is an important feature. For example if the question gives students a lot of information, requires good linguistic skills either for reading it or answering it, which makes reasoning more complicated (e.g. test 2), then the convergent/divergent cognitive style of the pupils seems to influence their performance. However if the question requires cognitive processes a straightforward algorithmic type (e.g. test 3 or MC questions 1, 2, 3, 12 of test 1) and good ability to interpret symbols and numbers then the convergent/divergent characteristics is of less importance for pupils in order to perform well in assessment. When the two characteristics interacts then the field dependent and convergent person is in disadvantage in relation to a person who is field independent and divergent. This raises an important ethical issue about assessment. What are we testing? Are we testing chemistry or cognition?

Based on the above outcomes some potential factors which affect pupils performance are:

- ✓ The content and presentation of the test
- ✓ The format of the test
- ✓ The psychological characteristics of the individual

The following chapter discusses the findings of chemistry test 4 and 5.

Chapter Nine

The Results of Test 4 and 5

This chapter describes the findings of the last two paper-and-pencil classroom tests that they have used in this study. For each test an English translation with the score for each question reduced in size is shown. The Greek tests are shown in appendix E.

9.1 Test 4: Multiple-Choice Partial Knowledge vs. Structural Grid

Test four was based on acids and bases and it was part of the first test that it was used in the pilot study. It was only 15 minutes test and it included two sections:

- Section 1: 7 Multiple-Choice partial knowledge questions -21marks.
- Section 2: 1 Structural Communication Grid questions -21marks

The MC items were designed to give credit for partial knowledge by giving the following instructions to the pupils: 'answer each of the Multiple-Choice items marking the box that has the correct answer and put cross in the two boxes that you think have the most wrong answers' (see test below). For marking, the scheme proposed initially by Willey (1960) and later by Friel and Johnstone (1978a) was used.

- 3 marks are given to an answer if the option designated as the correct one is in fact the correct one.
- 2 marks are awarded if the correct answer is not put into the 'definitely correct' or 'definitely wrong' categories.
- 0 marks are given if the correct answer is placed in the 'definitely wrong' category.

Section 1 of the test, which involves multiple–choice questions, were marked in two ways:

- ✓ the conventional way, without giving credit for partial knowledge, and in this case the score is denoted as MC and,
- ✓ the marking scheme which was described above and in this case the score is denoted as MCPK.

Pupils' MCPK mean score, as expected, was higher than Pupils' MC mean score. However, this difference did not alter the statistical results in relation to correlations between the cognitive tests and multiple-choice format question. Perhaps the limited number of multiple-choice questions in the test (only 7) would not allow for statistical comparison. Thus, for the sake of simplicity and making comparisons between the other tests intelligible only the statistics of the conventional way (MC) will be used in the following analyses. When it is necessary the result of the MCPK will be shown in parentheses. Appendix F-22 shows in detail the whole statistics for the MCPK question.

Test 4: Acids-Bases -Salts

<u>Section 1</u>

Answer each of the following questions marking the box that has the correct answer and put cross in the two boxes that you think have the most wrong answers.

1. A solution of NaOH compound in water is alkaline because: (3)
   - ❒A. It has hydroxide ions $OH^-(aq)$ and no hydrogen ions $H^+(aq)$
   - ❒B. It has sodium ions Na^+ (aq) and hydroxide ions $OH^-(aq)$
   - ❒C. It changes the colour of the indicators
   - ❒D. It has more hydroxide ions $OH^-(aq)$ than hydrogen ions $H^+(aq)$
2. A solution of potassium chloride (KCl) has a neutral pH because: (3)
   - ❒A. It has the same amount of potassium ions (K^+) and chloride ions (Cl^-)
   - ❒B. It has the same amount of the hydrogen ions $H^+(aq)$ and hydroxide ions $OH^-(aq)$
   - ❒C. It has no hydrogen ions $H^+(aq)$ and hydroxide ions $OH^-(aq)$
   - ❒D. Potassium chloride is a salt very soluble in water
3. A solution found in a lab has a pH of 10. In order to neutralise the solution what should we add? (3)
   - ❒A. Ammonia solution
   - ❒B. Sodium hydroxide solution
   - ❒C. Sulphuric acid solution
   - ❒D. Distilled water
4. When an acid reacts with a calcium carbonate, the products formed are a: (3)
   - ❒A. Calcium salt and hydrogen
   - ❒B. Calcium, water and carbon dioxide
   - ❒C. Calcium salt, water and carbon dioxide
   - ❒D. Calcium salt, hydrogen, carbon dioxide and water
5. When sodium reacts with water the products made are: (3)
   - ❒A. A salt and hydrogen
   - ❒B. An alkaline solution and hydrogen
   - ❒C. An alkaline oxide and hydrogen
   - ❒D. An acid and hydrogen

6. Which of the follow substances has pH more than 7? (3)

❒A. Sodium hydroxide solution
❒B. Potassium chloride solution
❒C. Hydrochloric acid
❒D. Distilled water

7. Which of the following solutions will turn phenolphthalein solution indicator pink? (3)

❒A. HBr (aq)
❒B. CO_2 (aq)
❒C. LiOH(aq)
❒D. KCl (aq)

Section 2

8. Look at the boxes and answer the following questions.
Each question may have more than one answer.
(You may use each box as many times as you wish)

A Contains same number of hydrogen ions H^+(aq) and hydroxide ions OH^-(aq)	B It reacts with calcium carbonate and gives carbon dioxide gas	C It is formed when sodium reacts with water
D It turns pink solution of phenolphthalein indicator into colorless	E It reacts with hydrochloric acid and gives a salt	F It forms compounds called chloride
G It conducts electricity	H It contains many hydroxide ions	I It has a pH less than 7

Select the bo(xes) which contain statements which are true about:

1.Hydrochloric acid solution:... (7)
2. Sodium hydroxide solution: .... (7)
3. Sodium chloride solution:.. (7)

9.1.1 Descriptive Statistics of Test 4

Only two schools were involved in test 4 and the total number of pupils was 75 (see table 7.2, page 127). Table 9.1 shows descriptive statistics of the score of each part of the test and total score of test 4, while figure 9.1 shows the histograms of these tests (see appendix F-22 for the SPSS statistics).

Table 9.1: Descriptive statistics of Test 4

Test 4	N	Minim.	Maxim.	Mean	S. D.
MC	75	14	100	53 (62.6)	22.7
SCG	75	0	100	68.0	24.1
MC+ SCG	75	14	200	121	39.8
MC-SCG	75	-62.4	57.1	-15.1	24.8

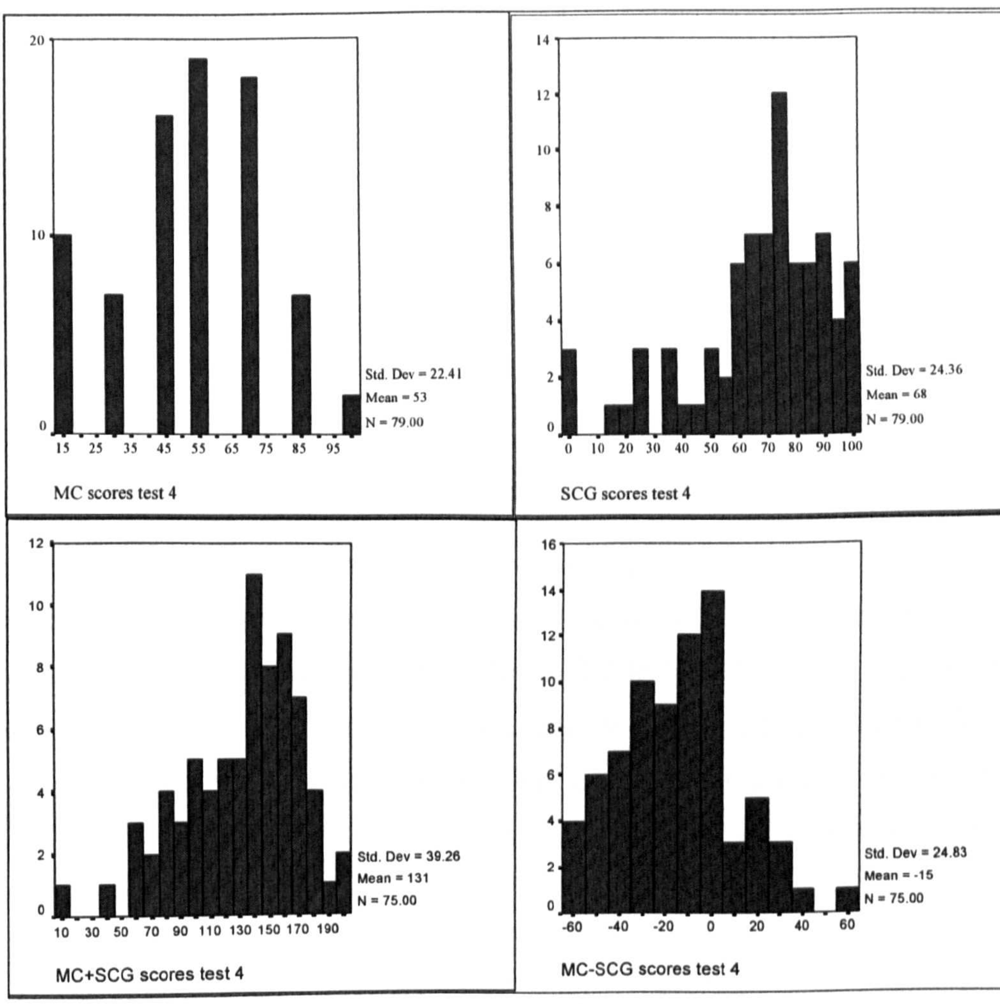


Figure 9.1: The distributions of Test 4

The SCG test was easier for the pupils than the Multiple-Choice test.

9.1.2 Correlations in Test 4

The Spearman rho correlation between the MC and SCG scores was found to be 0.48 (0.49), which is significant at the 0.01 level. The original statistical results are printed in appendix F-22 Spearman rho correlations were found between different format of assessment and cognitive tests and table 9.2 shows these correlations.

Table 9.2: Test 4 Spearman's rho correlations				
Scores	**MC**	**SCG**	**MC+SCG**	**SCG-MC**
SCG	0.48** (0.49**)			
CVSC	0.07	0.37**	0.24*	-0.30**
FDSC	0.12	0.31**	0.23*	-0.18

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

MC:	Pupils' scores on Multiple-Choice questions test.
SCG:	Pupils' scores on Structural Grid questions test
CVSC:	Pupils' scores on Convergent/Divergent test.
FDSC:	Pupils' scores on Field dependent / Field Independent test.
MC+SCG:	Sum of pupils' MC and SCG scores.
SCG-MC:	Differences between pupils' SCG and MC scores

These correlations will be discussed in detail below.

9.1.3 Convergent/Divergent Characteristic and Test 4

As seen in the table 9.2 the correlation between convergent/divergent scores and MC scores is not significant while the correlation between convergent/divergent scores and SCG scores is significant at 0.01 level. Table 9.3 shows the means and the standard deviations for each convergent/divergent group in test 4. The table shows that divergent students performed better than their convergent counterparts in both formats questions. However, in the MC test, all round pupils performed better than their divergent counterparts.

Table 9.3: Means and standard deviations of CNV/DV groups in Test 4									
CNV/DV groups	**N**	**MC**		**SCG**		**SCG+MC**		**MC- SCG**	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
CV	15	41.9	23.2	53.2	24.5	95.1	41.2	-11.3	24.1
AR	30	59.0	19.8	68.6	26.6	127.6	40.1	-9.5	24.3
DV	30	52.3	23.8	74.9	18.1	127.3	34.4	-22.5	24.6
Total	75	53	22.7	68.0	24.1	121	39.8	-15.1	24.8

Parametric and non-parametric tests were used to check whether are significant differences between convergent/divergent groups (see appendix F-23).

The following results were found:

- There is significant difference in performance between all round and convergent groups in the MC test (in favour of all round group).
- There are significant differences in performance between all the groups in the SCG and MC+SCG tests.
- There is significant difference between divergent and all round MC-SCG pupils' mean scores (in favour divergent).

In general, it can be concluded that SCG format questions favours more divergent pupils than MC format questions does in this test.

9.1.4 FD/ FIND Characteristic and Test 4

The correlation between field dependent /field independent scores and MC scores is not significant while the correlation between field dependent/ field independent scores and Grid scores is significant at 0.01 level (table 9.2). Table 9.4 shows a summary of the descriptive statistics for each field dependent/ field independent group. Appendix F-24 shows the original descriptive statistics.

Table 9.4: Means and standard deviations of FD/FIND groups in Test 4

FD/FIND groups	N	MC		SCG		MC+SCG		SCG-MC	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
FD	29	49.8	22.5	61.5	24.3	111.2	40.7	-11.7	23.0
FINT	24	54.8	22.9	69.3	25.8	124.1	39.9	-14.6	28.1
FIND	22	55.2	23.5	75.2	20.7	130.4	37.3	-20.0	23.7
Total	75	53	22.7	68.0	24.1	121	39.8	-15.1	24.8

In conclusion, table 9.4 shows that that field independent pupils' mean scores are better than field dependent mean scores in both formats of assessment. The differences between the scores of the two formats are decreasing, as a pupil becomes more field independent. However it was found that there is a statistically significant difference between field dependent and field independent group only for SCG (in favour field independent) (see appendix F-24).

9.1.5 Comparison between Test 4 and Pilot Test 1

Test 4 included some of the questions which were included in the pilot test 1. Thus, MC questions 1, 2, 3, 4, and 5 of test 4 were the same as the MC questions 1, 2, 4, 5, and 11 of the pilot test 1; and the SCG question of the test 4 was the same as the SCG question 14 of the pilot test 1. This gave the chance to investigate if the same test under different condition and with different sample size gives the same result.

It was found that the correlation between MC question and SCG question in test 4 was 0.48, while the correlation between MC question and SCG question in pilot test 1 was 0.39 (both significant at 0.01 level - 1 tailed). The two correlations are very similar. Considering that the number of the pupils for the pilot test 1 was 321 (see table 6.1) this result confirms that test 4 is giving reliable results. The SPSS statistics are presented in appendix F-25.

9.2 Test 5: Multiple-Choice vs. Grid vs. Short-Answer

Test 5 was, based on the content area of solution and it was the same test as the pilot test 2. It had three sections:

- <u>Section 1</u>: 5 Multiple-Choice questions-5 marks;
- <u>Section 2</u>: 1 Structural Communication Grid question-5 marks
- <u>Section 3</u>: 3 Short-Answer questions-5 marks

The questions were selected mainly from the chemistry book of Moore *et al.* (1999), in which the assessment questions test understanding and applying chemical concepts. Thus, the answers to the test do not require a lot memorisation and recall of chemical concepts but ability to interpret the given information and understanding of the concept of concentration in solutions and how it changes when water is added to the solution or water is evaporated from the solution. It requires arithmetic skills for answering the open-ended questions.

In addition, the test was given in two versions. Version two was different from version one only in section 2 (Structural Communication Grid question), where, for team A, the question used numerical expressions, while for team B, the same question used figures. This was done in order to test if the way that the grid was constructed had an effect on pupils' performance. The Greek test is shown in appendix E. An English translation of the test for team A and only the different section 2 for team B is shown below.

Test 5: Solutions

Team A

Section 1

1. A beaker contains 10g of sodium hydroxide (NaOH) and the volume of the solution is 250ml.We add water to the beaker until the new volume of the solution is 500ml. The new concentration of the solution is: (1)

❒ A. Doubled

❒ B. Not change

❒ C. Quadrupled

❒ D. Halved

2. In a beaker, A, we have dissolved 0.2mole of NaCl in 200ml of water. In another beaker, B, we have dissolved 0.4mol of NaCl in 400ml water. Which of the following statements is correct: (1)

❒ A. The solution in the beaker A has smaller concentration than the solution in beaker B

❒ B. The solution in the beaker A has the same concentration as the solution in the beaker B

❒ C. The solution in the beaker B has smaller concentration than the beaker A

❒ D. The solution in the beaker B has double concentration of the solution in the beaker A.

3. You want to prepare 4l of a solution of potassium hydroxide with concentration 0.1mol/l. For this purpose you will use: (1)

❒ A. 0.1moles KOH

❒ B. 1 moles KOH

❒ C. 0.4moles KOH

❒ D. 4 moles KOH

4. One pupil has mixed together two solutions of Na2CO3 with concentrations of 0.1 mol/l and 0.5mol/l respectively. The possible concentration of the new solution is: (1)

❒ A. 0.01mol/l

❒ B. 0.6mol/l

❒ C. 0.1mol/l

❒ D. 0.3mol/l

5. You prepared a NaCl solution by adding 1mole (58.44g) of NaCl to a 1-litre volumetric flask and then added water to dissolve it. When you finished, the final volume in your flask looked like figure 1.

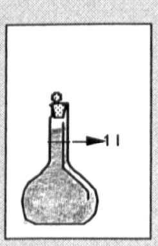


figure 1

The solution you prepared is (1)

- ❒ A. Greater than 1mol/l because you added more solvent than necessary
- ❒ B. Less than 1mol/l because you added more solvent than necessary
- ❒ C. Less than 1mol/l because you added less solvent than necessary
- ❒ D. 1mol/l because the amount of solute, not solvent determines the concentration

Section 2

6. Each box in the grid below represents beakers with aqueous solution of NaOH. Look at the boxes and answer the following questions. Each question may have more than one answer. (Boxes my be used as many times as you wish)

A 12g NaOH in 500ml	B 3g NaOH in 250ml	C 4g NaOH in 250ml
D 3g NaOH in 500ml	E 5g NaOH in 250ml	F 8g NaOH in 500ml

I. Which solution is most concentrated? .... (1)

II. Which solution is least concentrated? .... (1)

III. When solutions B and E are combined, the resulting solution has the same concentration as solution: .... (1)

IV. Which solutions have the same concentration?... (1)

V. If you evaporate half of the water from solution D, the resulting solution will have the same concentration as solution: .... (1)

Section 3

7. The concentration of the acid in a bottle is shown on the label as 0.5M

A. Explain what does this mean?... (1)

B. How many moles of sulphuric acid would you need to use to make 2litre of a solution with the same concentration as in the bottle above:.. (2)

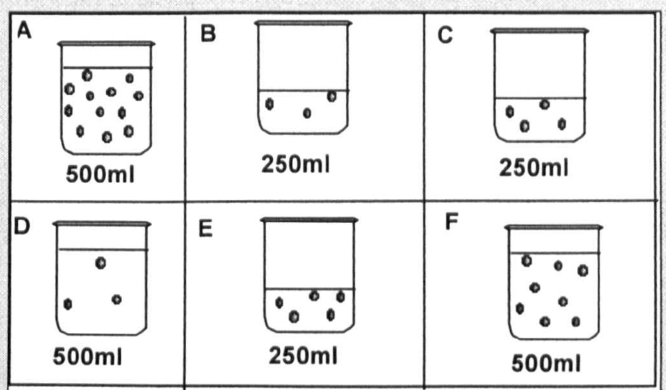
C. If you add water to the 2litre solution until the final volume is 4litre, what is the new concentration of the solution: .... (2)

Test 5: Solutions

Team B

Section 2

6. The grid below represents beakers of aqueous solutions. Each • represents a dissolved solute particle. Look at the boxes and answer the following questions. Each question may have more than one answer. (Boxes my be used as many times as you wish)



I. Which solution is most concentrated? ....

II. Which solution is least concentrated? ....

III. When solutions B and E are combined, the resulting solution has the same concentration as solution: ....

IV. Which solutions have the same concentration?..

V. If you evaporate half of the water from solution D, the resulting solution will have the same concentration as solution: ....

9.2.1 Descriptive Statistics of Test 5

Two schools involved in test 5 and the total number of pupils was 64 (table 7.2, page 127). Table 9.5 shows the descriptive statistics of test 5 (appendix. F-25 shows the original results).

Table 9.5: Descriptive statistics of Test 5

Test 5	N	Minim.	Maxim.	Mean	S. D.
MC	64	0	100	67.5	28.6
SCG	64	0	100	68.6	26.4
SA	64	0	100	50.8	35.6
TOTAL	64	30	300	186.9	70.9

Figure 9.2 shows histograms of the different formats assessment of test 5.

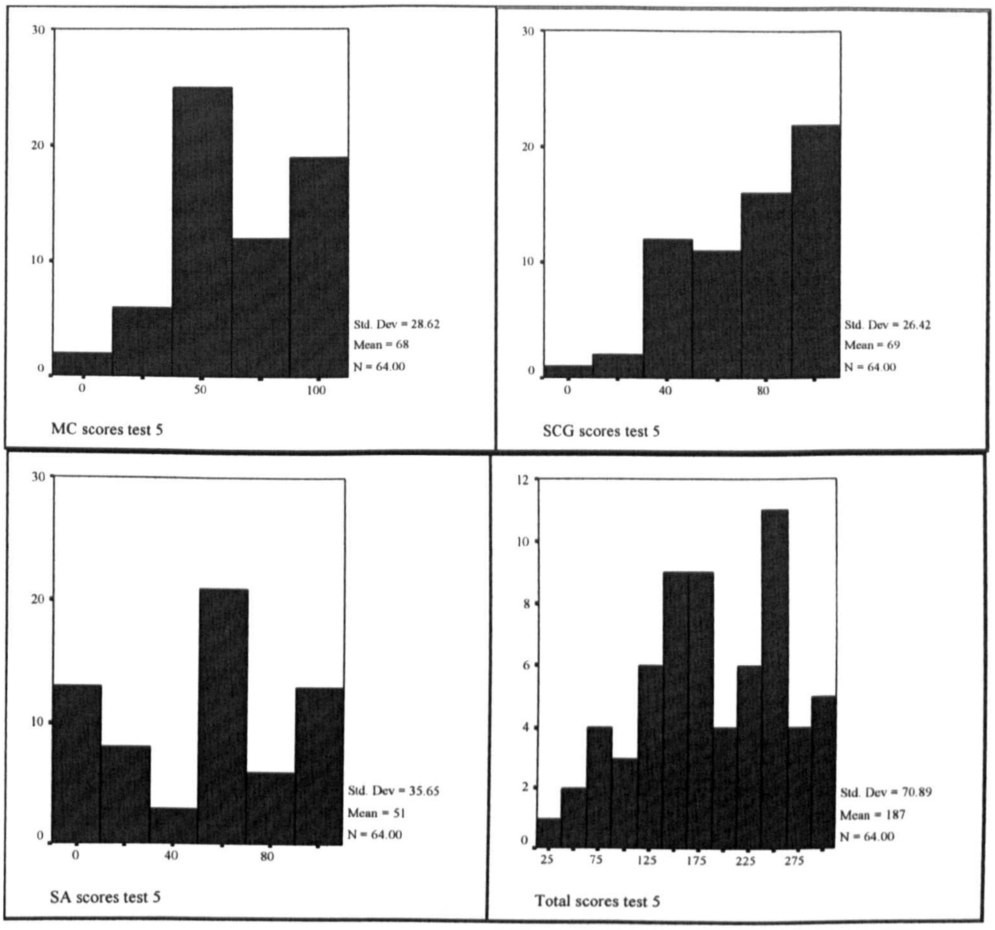


Figure 9.2: The distributions of Test 5

9.2.2 Correlations in Test 5

Table 9.6 presents the Spearman rho correlation between the different formats of assessment for test 5. All the correlations are significant at the 0.01 level and are similar to these ones which found in pilot study (see table 6.7). Also table 9.6 shows Spearman's rho correlations between different format of assessment and cognitive tests. The original statistical results are printed in appendix F-25.

Table 9.6: Test 5 Spearman's rho correlations							
Scores	**MC**	**SCG**	**SA**	**Total**	**MC-SA**	**MC-SCG**	**SCG-SA**
SCG	0.46**						
SA	0.49**	0.30**					
CVSC	0.04	0.05	-0.13	0.01	0.15	-0.05	0.17
FDSC	0.26*	0.39**	0.40**	0.47**	-0.2	-0.12	-0.11

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

MC:	Pupils' scores on Multiple-Choice questions test.
SCG:	Pupils' scores on Structural Grid questions test
SA:	Pupils' scores on Short-Answer questions test
CVSC:	Pupils' scores on Convergent/Divergent test.
FDSC:	Pupils' scores on Field dependent / Field Independent test.
Total:	Sum of pupils' MC, SCG and SA scores.
MC-SA:	Differences between pupils' MC and SA scores
MC-SCG:	Differences between pupils' MC and SCG scores
SCG-SA:	Differences between pupils' SCG and SA scores

Convergent divergent and field dependent correlations will be discussed in turn below.

9.2.3 Convergent/Divergent Characteristic and Test 5

As seen in the table 9.6, the correlations between convergent/divergent scores and each format scores are not significant. Convergent/divergent characteristic does not relate to pupils' performance for all the formats of assessment in this test. Table 9.7 confirms this, since the convergent group and the divergent group performed equally well in MC test. Moreover, the divergent group performed better than all round group.

Table 9.7: Means and standard deviations of CNV/DV groups in Test 5									
CNV/DV groups	**N**	**MC**		**SCG**		**SA**		**Total**	
		mean	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**	**mean**	**s.d.**
CV	19	70.5	27	73.2	32	60.5	34.1	204.2	67.4
AR	29	64.1	31.3	61.0	24.4	47.9	37.2	173.1	73.5
DV	16	70.0	26.3	76.9	19.6	44.4	34.4	191.3	69.3
Total	64	67.5	28.6	68.6	26.4	50.8	35.7	186.9	70.9

As in test 3 the test requires less use of words and more use of calculations and symbols. Thus, in both tests (3 and 5) the convergent/divergent characteristic does not relate to pupils' performance.

9.2.4 FD/ FIND Characteristic and Test 5

Table 9.6 shows that the Spearman rho correlation between field dependent/ independent scores and MC scores is significant at 0.05 level while the correlations between field dependent/ independent scores and the scores of the two other formats of questions are significant at 0.01 level. Table 9.8 the mean and standard deviations for each field dependent /independent groups.

Table 9.8: Means and standard deviations of FD/FIND groups in Test 5

FD/FIND groups	N	MC		SCG		SA		Total	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
FD	16	56.3	25.5	59.4	24.1	32.5	28.9	148.1	57.4
FINT	22	67.3	29.9	58.6	24	45.9	36.5	171.8	71.9
FIND	26	74.6	28.0	82.7	24.1	66.2	33.2	223.5	61.6
Total	64	67.5	28.6	68.6	26.4	50.8	35.7	186.9	70.9

Table 9.8 shows that there are differences between field independent pupils' mean scores and field dependent mean scores in all formats of questions. These differences are significant in favour field independent groups (see appendix F-27). There are no significant correlations between FD/FIND scores and differences between MC-SA, MC-SCG, SCG-SA. However, all the correlations are negative.

9.3 Comparison between Test 5 and Pilot Test 2

Test 5 was towards the end of the school year and, in both pilot study and main study, a small number of pupils sat the test. Comparing table 9.5 to table 6.6 the means score of each format of assessment are very similar to each other, and very surprisingly, the mean score for the SCG in both tables are the same. Team B performed better than team A in both tests however, there were no significant differences for the SCG question for team A and B in both the tests (see appendix F-28). The correlations between formats of questions were found to be similar in both tests (compare table 6.7 to table 9.6). This result supports the reliability of the test.

9.4 Comparison between Test 1, 2 and 4 for the same group of pupils

Table 7.2 shows that pupils of the schools 8 and 9 sat three tests (1,2,4). This was given the chance to explore what are the correlations across content areas for the same and different formats of questions for this group of pupils. Table 9.9 shows a correlation matrix between the different formats of questions in each test and for the three tests (appendix F-29 SPSS statistics).

Table 9.9: Correlations across content areas in Test 1, 2, 4

	Test 1		Test 2		Test 4	
	MC	SA	SA	SCG	MC	SCG
MC Test 1	1.00	0.54**	0.38**	0.26*	0.20*	0.28**
SA Test 1	0.54**	1.00	0.58**	0.42**	0.30**	0.34**
SA Test 2	0.38**	0.58**	1.00	0.54**	0.26*	0.39**
SCG Test 2	0.26*	0.42**	0.54**	1.00	0.31**	0.47**
MC Test 4	0.20*	0.30**	0.26*	0.31**	1.00	0.48**
SCG Test 4	0.28**	0.34**	0.39**	0.47**	0.48**	1.00

* Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.

Table 9.9 shows that the correlations between the different formats of assessment in the same content area are almost constant (around 0.5).(Test 1: MC vs. SA = 0.54; Test 2: SA vs. SCG = 0.54; Test 4: MC vs. SCG = 0.48). The correlations between the same formats of assessment in different content areas vary. The lowest correlation was found between MC test 1 and MC test 4. All the correlations are considerably less than 1.

Conclusion

Based on the results of test 4 and 5 the following conclusions can be made:
In terms of the correlations between different formats of assessment the correlation between:

- The MC and SCG scores in test 4 was found to be 0.48
- The SA and SCG scores in test 5 was found to be 0.30
- The SA and MC scores in test 5 was found to be 0.49
- The MC and SCG scores in test 5 was found to be 0.46

In terms of the convergent/divergent characteristic (see table 8.14):

- Divergent pupils surpass convergent pupils in all formats of assessment in test 4.
- None of the correlations between convergent/divergent scores and test 5 scores was significant.

Thus, like the previous study, if a question needs reading skill in order to elaborate and interpret a text given, then again the convergent/divergent style is of very important factor for success. However, in algorithmic types of questions or in questions where there is more use of symbols and less use of words, such as test 5 the convergent/divergent characteristic does not relate to pupils' performance. And in this study it seems that in relation to the convergent/divergent characteristic, the chemistry content is a factor affecting the type of questions being asked

In terms of field independent/dependent characteristic:

- Field independent pupils surpass field dependent pupils in almost all formats of assessment in both tests.
- Short-Answer formats of assessment favour more field independent pupils than objective formats of assessment do and Grid questions favour more field independent pupils than Multiple-Choice questions do.

From the above it can be concluded that some of the factors which affect pupils' performance might be:

1. The content and presentation of the test: e.g. problem solving, algorithmic type questions, explanations given, the use of text which requires linguistic skills for comprehension and interpretation of the context, the use of graphs figures and tables, the layout of the question, the use of language.
2. The format of the test: e.g. open-ended, objective test, essay, report, performance-based assessment.
3. The psychology of the individual: e.g. cognitive styles, working memory space intellectual development of the pupil, attitude towards learning.

The next chapter discusses the findings of the Perry position questionnaire.

Chapter Ten

Perry Scheme and Pupils' Performance

A Perry position questionnaire was devised to investigate pupils' perceptions of learning and the learning environment. In this research, the main aim of the Perry questionnaire was to give an indication of how pupils' responses to the Perry scheme and pupils' performance in different formats of chemistry assessment are related.

This chapter discusses the questionnaire, summaries the data of the questionnaire from the Greek pupils and analyses the correlation of each question with pupils' performance of each format of the five chemistry tests.

10.1 Construction of the Questionnaire-Method of Analysis

In his original research Perry gained his data using interviews. Various questionnaire approaches followed but the method used here follows the works of Al-Shibli (2003); Selepeng (2000) and Mackenzie (1999). Mackenzie used an approach derived from (Likert, 1932) to measure attitudes measurement without the use of scaling. Selepeng (2000) used the approach developed by (Osgood, 1952), again without using scaling. Al-Shibli used both approaches. In this study, the Al-Shibli method was used.

In this method the questionnaire had two parts: the first part consisted of ten questions (Q_1 to Q_{10}) followed the Osgood approach, and the second part consisted of eight questions (E_1 to E_8) followed the Likert approach. The following section describes, by means of examples, the method which was adopted to locate pupils' positions from their responses to the questionnaires.

The semantic differential technique developed by Osgood (1952) includes opposing statements (bipolar statements). The following example is the question Q_1.

	Statement						Statement
Q_1	In order to pass my courses, I need to study just what the teacher tells me.	1A	2A	B	2C	1C	I do not have to rely totally on the teacher. Part of my learning is to work things out myself.

The bipolar nature of the scale provided students with the opportunity to consider the two extremes carefully before choosing a position along the scale. Opposing statements were placed on a scale (5 points used here), with the given statements. In the questions Q_1, Q_3, Q_4, Q_6, Q_9 the A statements are at the left side of the questionnaires and the C statements at the right side of the questionnaires. In this case the first two boxes from the left represent A position whereas the first two boxes from the right represent C position. The box in the middle represents B position.

In the questions Q_2, Q_5, Q_7, Q_8, Q_{10} the A statements are at the right side of the questionnaires and the C statements at the left side of the questionnaires. In this case the first two boxes from the right represent A position whereas the first two boxes from the left represent C position. The following example shows an A type statement (question Q_7).

	Statement						**Statement**
Q_7	I do not believe that all scientific knowledge represents the 'absolute truth'.	1C	2C	B	2A	1A	We cannot call anything scientific knowledge if it is not absolutely true.

The second part of the questionnaire (E_1 to E_8) followed the Likert approach. In the Likert type questionnaires only one statement is given to the pupils and the pupils are asked to show their preferences by choosing a response from strongly agree-to strongly disagree. The statements might be A type or C type. If a statement is A type and the pupil strongly agree or agree with it then the pupils is in the A position. If he/she does not agree with the statement then she/he is in the C position. The other way round happens when C type statements are given. The following example shows a C type statement (question E_1)

	Statement	**SA**	**A**	**N**	**D**	**SD**
E_1	Sometimes there seem to be so many ways of looking at science that I feel confused about what is right and wrong	1C	2C	B	2A	1A

Questions E_1, E_2, E_4, and E_6 are C type statements, while questions E_3, E_5, E_6, and E_7 are A type statements.

The questionnaire was translated into Greek and the clarity of it was tested with 16 pupils and three teachers. The aim was to detect possible ambiguities and sources of confusion. Appendix C shows the English and the Greek translation of the questionnaire.

10.2 Data of Perry Questionnaire for Greek Pupils

The questionnaire was given to 523 Greek first year upper secondary pupils (Grade 10). Kendall's tau-b correlations were used to correlate responses in each of the 18 Perry questions with performance in the different formats chemistry tests. The original statistical results are printed in appendix F-30.

The questionnaire tries to identify pupils' perceptions about four broad areas:

- perceptions of pupil's role
- perceptions of teacher's role
- perceptions of the nature of scientific knowledge.
- perceptions of assessment

Each of the above areas will be considered in turn. Correlations between pupils' responses in Perry questionnaire and pupils' performance in test 1 and 2 are of greater importance for this study, because the larger sample and the larger tests made the data more reliable.

It is expected that Perry C pupils will give better answers if and only if the test gives opportunity to show Perry C type behaviour. Thus, the following outcomes are proposed:

- C Perry position pupils will prefer open questions, but they will be able to perform well in both types of question.
- A Perry position pupils will prefer closed response questions and find difficulty with open ones.
- Overall performance of Perry C position pupils will be better than Perry A position in a test with both types of question.

10.3 Pupils' Perceptions of their Role

Questions Q_1, Q_2, Q_5, E_2, E_6 are related to pupils' perceptions about their role in the learning and teaching process. Table 10.1 shows the percentages of pupils who are in each of positions A to C under the adapted Perry scheme for the questions Q_1, Q_2, Q_5, E_2, E_6 (see appendix F-35 for the SPSS original statistical results).

Table 10.1: Pupils Perry positions on questions about their role

	Perry Positions				
Pupils Response (%)	**1A**	**2A**	**3B**	**4C**	**5C**
Question Q_1	5.0	13.8	18.7	29.6	32.9
Question Q_2	4.8	13.6	34.7	27.4	19.5
Question Q_5	2.1	3.3	12.4	32.3	49.9
Question E_2	2.7	9.9	15.3	37.5	34.6
Question E_6	11.2	20.8	21.6	25.4	21.0

Table 10.2 shows the correlations (Kendall's tau-b correlation) between pupils' responses to each question and pupils' scores in each of the format in each of the chemistry tests. How the pupils' perceptions of each question related to their role correlated with their performance in different formats of assessment is discussed in turn. Most of the correlations are no significant.

Table 10.2: Kendall's tau-b correlations of pupils perceptions of their role

	Test 1 (N= 288)		Test 2 (N=185)		Test 3 (N=146)		Test 4 (N=75)		Test 5 (N= 64)		
	MC	**SA**	**SA**	**SCG**	**SA**	**SCG**	**MC**	**SCG**	**MC**	**SCG**	**SA**
Q_1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Q_2	0.18 **	0.09 *	NS	NS	NS	NS	NS	NS	NS	0.26 *	NS
Q_5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
E_2	-0.09 *	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
E_6	NS	0.09 *	0.13 *	NS	NS	NS	NS	NS	NS	NS	NS

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.
NS = no significant

Q_1:In order to pass my courses, I need to study just what the teacher tells me. // I do not have to rely totally on the teacher. Part of my learning is to work things out myself.

From table 10.2 can be seen that there is no significant correlation between pupils' responses in question Q_1 and pupils performance in any of the tests. Table 10.1 shows that the majority of pupils are in position C (62.5%). Does it mean that the majority of pupils are autonomous and independent learners or just that they do not count on their school teacher in order to pass their courses? The fact that the majority of the pupils take afternoon support classes in private institutes (frontistirio), which prepare them to pass the national examinations, might explain their response.

In general, Greek pupils pay too much heed to private teachers and they trust them more than their schools teachers (public teachers) even though private teachers are not better than their public teachers. Private teachers do not teach them differently. They just spend more time to prepare the pupils for the exams. This fact might explain that the majority of them are in position C. However it does not necessary mean that they have developed the C characteristics described by Perry.

Q_2: I cannot be wrong if I accept what the teacher says. If I question anything, I might end up failing. // I do not believe in just accepting what the teacher says without question. Success involves thinking for myself.

Table 10.2 shows that pupils' responses in question Q_2 correlate significantly with pupils' performance in both formats question in Test 1 and Structural Grid question in Test 5. This question is different from the previous one. It asks pupils to think for themselves and question teachers' statements. In that case pupils who believe that success involves thinking for themselves (pupils in position C) have better performance in both formats in Test 1 and in Structural Grid question in Test 5 than their counterparts who do not believe that success involves themselves (pupils in position A). This result is consistent with the hypothesis that overall performance of Perry C position pupils will be better than Perry A position in a test with both types of question.

Q_5: It is good to work with other students because, by listening to their points of view, I can correct my ideas. // I prefer not to work with other students because then I stand less chance of picking up wrong ideas.

Table 10.2 shows that there is no significant correlation between pupils' responses in question Q_5 and pupils performance in any of the tests. The fact that there is no tradition for collaborating and group work in the Greek educational practice might explain this result. Pupils do not have experience of working with their peers and arguing about different ideas and opinions especially in science.

E_2: Sometimes I find I learn more about a subject by discussing it with other students than I do by sitting and revising at home.

Pupils' response in question E_2 is negatively significant correlated with pupils' performances in Multiple-Choice Test 1 (see table 10.2). This means that the pupils who are in A position performed better than those who are in C, in the Multiple-Choice question in Test 1. This result is not consistent with the hypothesis that pupils in C position perform better than pupils in A position in all types of assessment. However this result may show that pupils in C position are constrained by MC questions, which they do not give them the opportunity to show their intellectual ability. It is also shows the lack of cooperating group works in Greek tradition.

E_6: I feel uncomfortable when I am left to express an opinion, not knowing the view the teacher feels.

Table 10.2 shows pupils' responses in question E_6 is significant correlated (but low) with pupils' performance in Short-Answer (Open-Ended) question in Test 1 and Test 2. Thus, pupils who feel more confident about themselves and they are not afraid to express their opinion irrespective of their teachers' opinion performed better in Open-Ended questions in Test 1 and 2. Pupils in C position in these tests are better in open-ended questions than pupils in A position.

10.4 Pupils' Perceptions about the Teacher Role

Questions Q_3, Q_4, E_3 are related to pupils' perceptions about their teachers' role. Table 10.3 shows the percentages of pupils who are in each of positions A to C (see appendix F-36 for the SPSS original statistical results) and table 9.4 shows Kendall's tau-b correlations.

Table 10.3: Pupils Perry positions on questions about the teacher role					
	Perry Positions				
Pupils Response (%)	1A	2A	3B	4C	5C
Question Q_3	8.4	9.8	20.1	20.3	41.5
Question Q_4	8.8	8.2	24.7	34.2	24.1
Question E_3	3.6	5.4	11.7	38.2	41.1

Table 10.4: Kendall's tau-b correlations of pupils perceptions of their teacher role											
	Test 1 (N= 288)		Test 2 (N=185)		Test 3 (N=146)		Test 4 (N=75)		Test 5 (N= 64)		
	MC	SA	SA	SCG	SA	SCG	MC (PK)	SCG	MC	SCG	SA
Q_3	NS	NS	0.16 **	NS	NS	NS	0.18 *	NS	NS	NS	NS
Q_4	NS	0.12 **	0.11 *	0.11 *	NS	NS	NS	NS	NS	NS	NS
E_3	NS	-0.1 *	0.17 **	NS	NS	NS	NS	NS	NS	NS	NS

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.
NS = no significant

Q_3: I believe it is the job of the teacher to supply me with all the knowledge I need. // The duty of the teacher is not to teach me everything, but to help me to think for myself.

Table 10.4 shows that pupils who have developed Perry C attitude in this question performed better in Short-Answer in Test 2 and in Multiple-Choice Partial knowledge in Test 4 than pupils who have Perry A attitude.

Q_4: I think teachers should avoid teaching materials that they know students will find difficult. // Teachers should aim to provide challenges to their students by introducing difficult topics.

Table 10.4 shows that the correlation between pupils' responses in the question Q_4 and pupils' performance in Short-Answer questions in Test 1 and Test 2 and in Structural Grid question in Test 2 are significant correlated but low. As table 8.1 (page 142) and 8.2 (page 149) shows the mean score of SA Test 1, and the mean score of SA and SCG test 2 were very low (especially SCG Test 2). These tests were difficult for the majority of the pupils therefore it is not surprising the above results. Theses correlations show that pupils who have developed Perry C attitude and who think that the teacher should challenge them by introducing difficult topics performed very well in difficult questions.

E_3: There is not any point in class teaching which includes things which will not be in the exam.

As can be seen from table 10.4 there are different patterns from pupils' responses towards Short-Answer format in Test 1 and Test 2. The correlation between pupils' responses in the question E_3 and pupils' performance in SA in Test 1 is significantly negative whereas in Test 2 the correlation is significantly positive but low. Although it was expected overall performance of Perry C position pupils would be better than A in all the types of questions and in all tests this does not happen in this case.

The answer to this contradictory result may lie in the nature of the tests. Short-Answer Test 2 included open-ended questions of the type that Greek pupils are not very familiar with and some of the questions were not included in the Greek textbook. It was not the type of the questions that pupils usually experience. The majority of the Short-Answer questions in Test 1 were from the Greek textbook and of the sort that the pupils expect. Thus, these contradictory results may show that the test 2 gave the opportunity to C position pupils to perform well when the exams include questions that have not been taught in the class, while test 1 did not give this opportunity to them.

10.5 Pupils' Perceptions about the Nature of the Scientific Knowledge

Questions Q_6, Q_7, E_1, E_5, E_7 are related to pupils' perceptions about the nature of scientific knowledge. Table 10.5 shows the percentages of pupils who are in each of positions A to C under the adapted Perry scheme for the questions Q_6, Q_7, E_1, E_5, E_7 (see appendix F-37 for the original statistics).

Table 10.5: Pupils Perry positions on questions about scientific knowledge					
	Perry Positions				
Pupils Response (%)	1A	2A	3B	4C	5C
Question Q_6	0.8	2.9	14.2	18.8	63.4
Question Q_7	15.6	15.0	41.0	15.0	13.3
Question E_1	3.5	11.7	27.5	45.2	12.1
Question E_5	6.7	10.0	19.6	36.9	26.9
Question E_7	9.1	19.5	36.0	25.6	9.8

Table 10.6 shows the Kendall's tau-b correlation between pupils' responses to each of the above questions and pupils' scores in each format of the chemistry tests.

Table 10.6: Kendall's tau-b correlations of pupils perceptions about the knowledge											
	Test 1 (N= 288)		Test 2 (N=185)		Test 3 (N=146)		Test 4 (N=75)		Test 5 (N= 64)		
	MC	SA	SA	SCG	SA	SCG	MC	SCG	MC	SCG	SA
Q_6	0.23 **	0.22 **	0.19 **	0.18 **	0.13 *	NS	NS	NS	NS	0.26 *	NS
Q_7	0.12 **	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
E_1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-0.22 *
E_5	NS	0.11 *	0.19 **	NS	NS	NS	NS	NS	NS	NS	NS
E_7	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.
NS = no significant

How the pupils' perceptions of each of the above questions correlated with their performance in different formats of assessment is discussed now.

Q_6: All one has to do in science is to memorise things. // Understanding science is the key part of science study.

Table 10.5 shows that the majority of the pupils are in C position. They believe that understanding is the key point for science. Table 10.6 shows that Q_6 correlate significantly with both format questions in Test 1; both format questions in Test 2; SA question Test 3; and SCG question Test 5. Question Q_6 is the question which correlated with the pupils' performance in most of the tests. This result shows that pupils who have the attitude to understand things in science (Perry C position) perform better than pupils who have the attitude to memorise things (Perry A position) in all type of questions and in many tests. This outcome confirms the hypothesis that pupils overall performance of Perry C position would be better than pupils overall performance of Perry A position in all the type of questions and in all tests provided that test reward C type behavior.

Questions Q_7 and E_1.and E_7 are asking similar ideas and will be discussed together.

***Q_7*: I do not believe that all scientific knowledge represents the 'absolute truth'. // We cannot call anything scientific knowledge if it is not absolutely true.**

***E_1*: Sometimes there seem to be so many ways of looking at science that I feel confused about what is right and wrong.**

***E_7*: A good thing about learning science is the fact that everything is so clear-cut: either right or wrong.**

Table 10.6 shows that there is significant positive correlation between pupils Perry position in question Q_7 and pupils' score in MC question in Test 1.

There is negative significant correlation between pupils Perry position in question E_1 and pupils' score in SA question in Test 5. However, the size of the sample is small for the Test 5 and may not reflect well the reality. All the correlations for the question E_7 are insignificant.

It seems for their responses (see table 10.5) that the Greek pupils are confused about the above questions and many of them are in position B.

***E_5*: It is a waste of time to work on problems which have no possibility of producing a clear cut, unambiguous answer.**

Table 10.6 shows that the correlations between pupils' responses in the question E_5 and pupils' performance in Short-Answer questions in Test 1 and Test 2 are significant. Correlation for SA Test 2 is higher than the correlation for SA Test 1. The SA questions of Test 2 are more open than the SA questions of Test 1. This correlation shows that pupils who have developed Perry C attitude for this question performed better than those who have not developed yet this attitude to open-ended questions. This result was consistent with what was expected.

10.6 Pupils' Perceptions about Assessment

Questions Q_8, Q_9, Q_{10}, E_4, E_8 are related to pupils' perceptions about assessment. Table 10.7 shows the percentages of pupils who are in each of positions A to C under the adapted Perry scheme for the questions related to assessment (original statistics appendix F-38).

Table 10.7: Pupils' Perry positions on questions of the assessment

	Perry positions				
Pupils Response (%)	1A	2A	3B	4C	5C
Question Q_8	19.1	20.3	28.3	19.1	13.2
Question Q_9	16.5	11.5	21.4	27.4	23.2
Question Q_{10}	7.0	5.8	16.2	19.1	51.9
Question E_4	12.5	24.8	36.5	18.5	7.7
Question E_8	2.3	5.6	17.5	35.4	39.2

Table 10.8 shows the Kendall's tau-b correlation between pupils' responses to each of the above questions and pupils' scores in each format questions of the chemistry tests.

Table 10.8: Kendall's tau-b correlations for of pupils perceptions about assessment

	Test 1 (N= 288)		Test 2 (N=185)		Test 3 (N=146)		Test 4 (N=75)		Test 5 (N= 64)		
	MC	SA	SA	SCG	SA	SCG	MC	SCG	MC	SCG	SA
Q_8	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Q_9	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Q_{10}	NS	0.11 **	NS	NS	0.15 *	NS	NS	NS	NS	NS	NS
E_4	NS	-0.13 **	NS	NS	NS	NS	NS	NS	NS	NS	NS
E_8	NS	-0.11 *	NS	NS	NS	NS	NS	NS	NS	NS	NS

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.
NS = no significant

How the pupils' perceptions of each of the above questions correlated with their performance in different formats of assessment is discussed now.

Q_8: I do not like short questions as they do not give me the chance to explain what I know and understand. // I prefer to learn the facts and then be tested on them in short questions.

Q_9: In exams I prefer questions which are based on what the lecturer taught. // In exams I like questions that give me the scope to go beyond what is taught and show my ability to think.

There are no significant correlations between pupils' responses in questions Q_8, Q_9 and pupils' performance in any of the tests (see table 10.8). This result can be explained by the fact that the questions were short and none of them gave the scope for pupils to go beyond what they have taught. Thus, those pupils who have developed C position attitude they did have the chance to show their ability and their way of thinking.

Q_{10}: I believe that what should matter in exams is the quality of my answers, not how much I write. // In exams, I expect to be rewarded for giving as much information as possible.

Table 10.8 shows that there are significant correlations between pupils' responses in question Q_{10} and pupils' performance in Short-Answer questions in Test 1 and Test 3. This means that pupils who have developed a Perry C attitude to this question performed better than those who are in Perry A position in some short-answer questions. Perhaps in some content areas, short answer questions, give an opportunity to develop ideas more deeply.

Questions E_4 and E_8 are asking similar ideas and the responses to them from the pupils was similar, that is why will be discussed them together.

E_4: If I have the choice to write comments and to offer my opinion in a question or to answer with Multiple-Choice questions I would choose to write comments.

E_8: I like exams which give me an opportunity to show I have ideas of my own

The above questions were correlated only significantly with pupils' performance in SA question in Test 1. The correlations were negative. This result can be explained from the fact that none of the test gave the opportunity to pupils to write comments and to express theirs ideas.

Conclusion

From the Perry position questionnaire the following findings are interesting for discussion:

- There were many pupils in C position in many questions. What does this fact mean when the Greek educational environment does not allow for such intellectual development and especially in a very early stage? Does this result expressing aspiration rather than reality? Is this what the teaching and learning they would like to be rather than it actually is? In other studies (Mackenzie, 1999; Selepeng, 2000; Al-Shibli, 2003) the population was drawn from University students. The percentage indicating C type attitude in all three cases tented to be low. It is possible that, with lack of experience, school pupils have higher aspirations which not reflect reality so well.
- The correlations between Perry questions and pupils' performance were low. There were significant correlations, mainly in tests 1 and 2. Does it mean that the construction of the chemistry tests did not allow C positions pupils to show their intellectual development or pupils have not yet developed intellectually according to Perry theory?

However, some useful outcomes can be made from the study of the correlations between pupils' attitudes and their performance in various formats of assessment which are listed below:

Pupils' role

- Pupils who believe that success involving thinking for themselves have shown evidence that the performed better in some of the chemistry tests.
- Pupils who feel confident about themselves and they are not afraid to express their opinion performed better in open-ended chemistry questions.
- The fact that there is no tradition for peer learning can explain that, although many pupils responded positively to the questions Q_5 and E_2, no significant correlations between this statement and pupils' performance in the chemistry tests was found.

Scientific knowledge

- Pupils who believe that deep learning and not rote learning are the key point for success in science performed better in the majority of the chemistry tests. (Q_6 correlated significantly with the majority of the tests more than any other question).
- Pupils who have developed the attitude to work with open problems, which not necessarily demand a clear-cut answer, performed better in open ended chemistry questions and in more difficult questions.

Teacher' role

- Pupils who have developed Perry C attitude and who think that the teacher should challenge them by introducing difficult topics performed very well in difficult chemistry questions.

Assessment

- It seems that pupils who prefer to answer chemistry questions that give them the opportunity to comment on an issue and show their ideas, their responses to the Perry questionnaire did not correlate significantly or correlated negative with some of their chemistry tests scores. This result shows that the pupils who developed Perry C attitude are constrained with short answer questions or objective questions. This outcome might be explained for the fact that none of the chemistry test was a fully open ended or essay type question. Therefore pupils had little opportunity to show C type responses.

Chapter Eleven

Final Conclusions and Implications for Assessment Practice

This study initially explored secondary pupils' performance in different paper-and-pencil classroom assessment formats in chemistry. At the same time it sought an understanding about which factors might influence pupil's performance. The issues that have been addressed were:

- What are the correlations between pupils' performance in different formats of assessment in the same content area?
- Are the correlations constant across different content areas?
- Do pupils' performances in different formats of assessment correlate with their cognitive characteristics and their attitudes towards learning and assessment?

This chapter discusses the findings of the study and their implications for assessment practice.

11.1 Correlations between Different Formats of Assessment

As seen in the pilot study the correlations between the different formats of assessment in the same content range between 0.25 to 0.65. In the main study the correlations between the different formats of assessment in the same content area range between 0.30 to 0.71.

Therefore from the whole study it can be concluded that between the correlations of different formats of assessment there is a significant range, and even the maximum of correlation value is considerably less than 1. This suggests that the best student found by one method is not necessarily the best student by another method. This also raises questions about the validity of the formats of the assessment. The main question is what different formats are testing. Are different formats testing different abilities and skills which involve different cognitive factors? Are different formats testing, in this study, chemistry or cognition? Are the way that the questions are presented having an impact of the pupils performance (e.g. the use of pictures, or diagrams)? In considering all the above issues the study was trying to throw some light onto some of the factors which might affect pupils' performance, and to explore how these factors correlate with pupils' performance in different formats of assessment.

11.2 Cognitive Styles, Pupils Intellectual Development and Assessment

Previous research has shown evidence that pupils' performance relates to cognitive factors such as working memory space, field dependent/field independent and convergent/divergent characteristics. Thus, it was thought that particular formats of assessment might favour different cognitive styles of individuals. It also was thought that the intellectual development of the pupils might have an impact on his/her performance in different formats of questions. Hence, in this study two of the cognitive styles, field dependent/field independent and convergent/divergent, were explored as well as the pupils' intellectual development according to the Perry scheme in relation to three formats of assessment (multiple choice, short answer and structural communication grid) in five classroom chemistry tests. The following section summarises the significant findings of the whole project.

Convergent/divergent cognitive style

Table 11.1 summarises the correlations between the convergent/divergent characteristic scores and chemistry scores for different formats of assessment in the five chemistry tests. In general, the convergent/divergent characteristic correlated with pupils' performance in assessment, where language was an important factor to perform well (e.g. test 1, 2).

Table 11.1: Spearman's rho correlations of CNV/DV groups for all the tests

	Test 1 (N= 288)		Test 2 (N=185)		Test 3 (N=146)		Test 4 (N=75)		Test 5 (N= 64)		
	MC	SA	SA	SCG	SA	SCG	MC	SCG	MC	SCG	SA
CVSC	0.34 **	0.29 **	0.32 **	0.16 *	0.12 NS	0.04 NS	0.07 NS	0.37 **	0.04 NS	0.05 NS	-0.13 NS

**Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.
NS = no significant

Thus, in assessments that require pupils to have linguistic skills in order to elaborate and interpret a text given or to explain phenomena ideas and concepts or to describe differences, the convergent/divergent style is an important factor for pupils to perform well. It is reasonable to suggest that the short answer or open ended questions favour more divergent style pupils than objective questions do, because in short answer questions pupils need to articulate their thoughts and divergent pupils were more able to do this. In objective testing, if a question needs reading skill in order to elaborate and interpret a text given, then again the convergent/divergent style is a very important factor for success.

However, in algorithmic types of questions or in questions where there is more use of symbols and less use of words, such as test 3 and 5, or MC questions 1, 2, 3, 12 of test 1 (see section 8.1), the convergent/divergent characteristic does not relate to pupils' performance. In this case the format of the questions does not have an effect on pupils performance.

Thus, from the above outcomes it seems that in relation to the convergent/divergent characteristic, the chemistry content is a factor affecting the type of questions being asked and may allow the question to be more easily tackled by, say a divergent pupil. However, in almost all the tests the divergent pupils outperformed convergent pupils and, when there are short answer questions or open-ended questions, the differences in the performance between the convergent and divergent groups become larger.

These outcomes are consistent with Runco (1986) who indicated that there were particular domains of performance, for example art and writing, that were more strongly related to divergent thinking than other areas such as music and science. These results also might explain what Hudson (1966) pointed out: *"the convergence/ divergence dimension is a measure of bias, not a level of ability"*. If pupils from a very early stage are good in arithmetic skills and poor in linguistic skills then they perform well in symbolic representation tasks and arithmetic problems and therefore they gain confidence and have motivation to work with these types of tasks that favour them. Indeed, they excel in these types of tasks. These pupils might neglect linguistic tasks, which require for them to use more effort in order to perform well, and therefore they are deskilled by these types of tasks. Furthermore, as these pupils perform well in science tasks, it is very reasonable to select physical sciences to study. On the contrary, pupils who from an early stage have acquired good verbal skills might go into arts subjects because arts subjects give them the opportunity to excel and to expand these skills. However, if pupils who are good in linguistic skills choose science, it seems that they perform better than those who do not have such skills because of their superiority in language. Linguistic skills such as comprehension and interpreting a scientific text are of paramount importance for reasoning in science (Byrne, *et al.*, 1994). The results of Johnstone and Al-Naeme's (1991) and Field and Poole's (1970) research support the above explanation.

It seems that there is a relationship between the convergent/divergent characteristic and language. Although there is a debate which dominates cognitive development, language or thinking, it seems that the quality of a child's preschool language environment emerges as vital and, as Wittgenstein (1961) argued, the limits of one's language are the limits of one's world (Sutherland, 1992). And here is the importance of the teacher's role. The teacher should extend and challenge the child to go beyond where he would otherwise have been (Vygotksy, 1986). There is a need for teachers to encourage children to make their meaning explicit, and the use of the open-ended, reports or essay assessment are useful tools for this.

Field dependent/independent cognitive style

Table 11.2 summarises the correlations for the field dependent/independent characteristic.

Table 11.2: Spearman's rho correlations of FD/FIND groups for all the tests

	Test 1 (N= 288)		Test 2 (N=185)		Test 3 (N=146)		Test 4 (N=75)		Test 5 (N= 64)		
	MC	**SA**	**SA**	**SCG**	**SA**	**SCG**	**MC**	**SCG**	**MC**	**SCG**	**SA**
FDSC	0.25 **	0.29* *	0.31 **	0.12 NS	0.32 **	0.19 *	0.12 NS	0.31 **	0.26 *	0.39 **	0.4 **

** Correlation is significant at the 0.01 level.
* Correlation is significant at the 0.05 level.
NS = no significant

Field independent pupils surpassed field dependent pupils in all the tests and in all the formats of assessment (although not always significantly). It seems that the field dependent/independent characteristic is a very important factor which influences whether pupils perform well in almost all type of assessments, and irrespective of the content of the question. This result is consistent with the majority of the research in this field (see section 3.2.4). The short answer format of assessment favours field independent pupils more than grid format of assessment does, as seen in test 2, 3.

Although the field dependent/ independent characteristic may develop naturally with experience, it may be difficult to teach someone to be field independent. However, attention should be given in the construction of the assessment to avoid confusion for those who are not able to separate the important information from the unimportant although in some cases, the ability to see the message separate from 'noise' may be an important skill to test. Thus, shredding is a necessary process for quality assessment. Superficial clues, negative and double negative expressions, or subtle aspects which can come to dominate the mental representations should be avoided (Johnstone, 2003; Crisp and Sweiry, 2003).

Interaction of the Cognitive Styles

In this study a significant correlation between convergent/divergent and field dependent/independent cognitive styles was found (0.19 significant at 0.01 level). Moreover, overall the study showed that the two cognitive characteristics influenced pupils' performance. It is reasonable to expect that these cognitive characteristics may become more dominant and pervasive in formal examinations because pupils are under pressure.

Chemistry test 1 was used by the school teachers involved in the study as a formal exam. It was found that the mean score in the chemistry test 1 of a person who is field dependent and convergent is 21.5% less than a person who is field independent and divergent. It is a matter of concern that performance in a chemistry test is so strongly related to certain psychological parameters, control over which is largely outside the individual pupil. This again adds to the ethical issue about assessment. Are we testing chemical knowledge and understanding or cognition?

Perry scheme for intellectual development and pupils' performance

There were many pupils in C position (which indicates intellectual development) in many of the questions of the Perry questionnaire. However, it is not very clear from previous research in this field whether pupils' responses express aspirations rather than the Greek reality. The correlations between Perry questions and pupils' performance were low, though moderately significant in tests 1 and 2. This raises the issue of whether the construction of the chemistry tests did not allow C position pupils to show their intellectual development, or whether pupils have not yet developed intellectually according to Perry theory. On the whole it can be summed up as follows:

- Pupils who feel confident about themselves and are not afraid to express their opinion performed better in open-ended chemistry questions.
- Pupils who believe that deep learning and not rote learning are the key point for success in science performed better in the majority of the chemistry tests.
- Pupils who have developed the attitude to work with open problems, which do not necessarily demand a clear-cut answer, performed better in open ended chemistry questions and in more difficult questions.
- Pupils who think that the teacher should challenge them by introducing difficult topics performed very well in difficult chemistry questions.

Based on all the above outcomes some potential factors affecting pupils' performance are seen in figure 11.1 which depicts them visually.

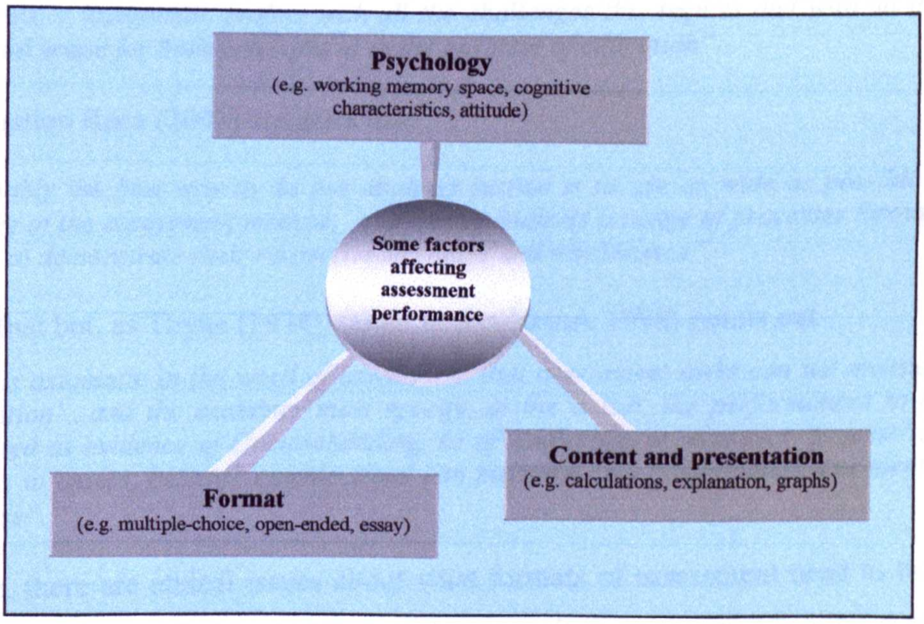


Figure 11.1: Some factors affecting assessment performance

The next section discusses some implications for a good assessment practice drawn from the study and some recommendations for further studies.

11.3 Implications for good Assessment Practice

The study has raised many issues:

1. How do we decide about the validity of one format?
2. Is this format valid for one pupil or this format valid for another pupil?
3. Is there any format of assessment which is capable of being a more valid measure for most pupils?
4. What are we testing? Are we testing cognition or understanding of a particular discipline?
5. Do particular formats of assessment deskill the pupils?
6. Do particular formats of assessment frustrate pupils and therefore make them drop out of school?

Assessment is a complex process. As Broadfoot and Black suggested (2004)

> *"Educational assessment must be understood as a social practice, an art as much as a science, a humanistic project with all the challenges this implies and with all the potential scope for both good and ill in the business of education".*

In this situation Race (2003) suggests that

> *"Probably the best way to do our students justice is to use as wide as possible a mixture of the assessment method, ... allowing students a range of processes through which to demonstrate their respective strengths and weaknesses".*

Not only that but, as Thyne (1974), (cited in Sanderson, 1998) points out

> *"...it is axiomatic in the word of assessment that assessment tasks can not measure 'cognition'...and the examiner must specify, at the outset, the performances to be accepted as evidence of Comprehending, or of Analysing, or whatever 'process' he wishes to assess, because examinations can measure only performance, not mental process".*

Therefore, there are ethical issues about what formats of assessment need to be used to properly reflect pupils learning and, at the same time, to ensure a beneficial impact on teaching and learning practice (Gipps, 1994).

This means that it is difficult to answer all the above questions fully, but it is possible to present the following guidelines for a good assessment practice:

1. Different formats may test different skills therefore we have to decide what we want to test. Do we want to test cognitive characteristics or to test knowledge and understanding?

2. Since it is impossible to use assessment to suit individuals it is not wise to conduct all assessment by one method (e.g. objective testing, or open-ended). Using a battery of different formats of assessment can achieve the following objectives:

   - The use of objective tests help those pupils who from nature or nurture have not developed the cognitive process needed and therefore do not succeed well in some of the assessment formats. Also in a multicultural world very often pupils are assessed in a language which is not their mother tongue, and this means that may not perform well in some types of assessment where language is an important aspect being able to answer them.
   - The use of open ended or problem solving tasks helps more intellectually developed pupils to expand their knowledge, their learning strategies, and to show their independence of thoughts. It seems that objective tests constrain the more intellectually developed pupils and deprive them to foster for intellectual work.
   - The use of oral examinations, open-ended assessments, essays, performance-based assessments, reports, portfolios and general alternative assessments encourages children to make their meaning explicit, to expand and enrich their vocabulary and their linguistic skills. Objective testing may deskill them linguistically.
   - Assessment should not be punitive and judgemental but empowering and humane, especially at the school level when the pupils are forming their personality, building their self-esteem, and testing themselves in a different environment from their home. Assessment practice should support human needs rather than frustrate them. This means that assessment should encourage less successful pupils in their self-esteem and help them to be less anxious about their performance, and therefore make them feel more comfortable in the school environment and stay longer in the school. After all we are human beings and we are entitled to make mistakes and to learn from them.

3. The aims of the course may tie very closely to all aspects of assessment. If one aim is knowledge and recognition then the test must reflect that. In this case objective assessment can be used. If the aim of the course is to transfer and apply knowledge, then problem solving, open-ended questions should be used. If the

aim of the course is to equip pupils with skills, then hands-on, or performance based assessment should apply.

4. Teachers should understand that education practice is a very demanding and difficult task and assessment should not be the by-product of the teaching and learning, especially in the classroom environment. Assessments need a very professional training. The process of shredding questions demands peer work, collaboration, and good faith in another person's criticism. There is a need to scrutinise the questions for ambiguities, inaccuracies, technical points and faults that might cause confusion and misunderstanding on the side of the pupils.

11.4 Recommendations for further Studies

This study identified a substantial number of questions regarding assessment practice. There is a potential for research looking at assessment, cognition and attitude across disciplines and across different levels in education. Thus, some suggestions for further studies are listed below:

(1) It could be very interesting to apply
- Similar studies within other disciplines (science or arts).
- Similar studies within primary level and university level of education
- Cross cultural studies between different curriculum and different social environments.

(2) Longitudinal studies which can use national examination results and at the same time ask pupils voluntarily to participate in attitude questionnaires or cognitive tests.

(3) Studies which could contribute to the new assessment methods which can be more fair for assessing pupils/students.

(4) Studies which could test other cognitive characteristics such as spatial visual ability.

Hopefully, these future explorations, together with this study of situation in Greece can put a small drop of knowledge into the large ocean of human knowledge to assist in design of assessment of Chemistry of school pupils.

References

Aiken, L. R. (1967). Effect on test score variance of differential weighting of item responses. *Psychological Reports, 21*(10), 585-590.

Al-Naeme, F. F. A. (1988). *A study of some psychological factors affecting performance in chemistry at secondary and tertiary levels.* M.Sc. Thesis, University of Glasgow.

Al-Naeme, F. F. A. (1991). *The Influence of various learning styles on practical problem-solving in chemistry in Scottish secondary schools.* Ph.D. Thesis, University of Glasgow.

Al-Shibli, A. A. S. (2003). *A study of science student teachers perceptions of learning in the education colleges in the Sultanate of Oman.* Ph.D. Thesis, University of Glasgow.

American Educational Association; American Psychological Association, and National Council of Measurement in Education. (1985, 20/10/2003). *Standards for educational and psychological testing.* http://seamonkey.ed.asu.edu/~alex/teaching/assessment/reliability.htm.

Andersson, B. R. (1990). Pupils' conceptions of matter and its tranformation on classroom activities (age 12-16). *Studies in Science Education, 18*, 53-85.

Arce-Ferrer, A. J., Backhoff-Escudero, E., and Pena-Gonzalez, L. I. (2001). Effects of the number of choices on the psychometric properties of multiple-choice tests. *Revista Mexicana de Psicologia, 18*(3), 337-345.

Armstrong, S. (2000). The Influence of individual cognitive style on performance in Management Education. *Educational Psychology, 20*(3), 323-340.

Arnold, J. C., and Arnold, P. L. (1970). On scoring multiple choice exams allowing for partial knowledge. *The Journal of Experimental Education, 39*(1), 8-13.

Ashcraft, H. M. (1994). *Human memory and cognition.* New York: Harper Collins College.

Asher, W. J. (2003). The rise to prominence: Educational Psychology 1920-1960. In B. Z. Zimmerman, and Schunk, D.H. (Ed.), *Educational Psychology: A Century of Contributions* (pp. 189-205). London: Lawrence Erlbaum Associates Inc.

ASQ. (undated). *Higher Scottish Examinations*. http://www.sqa.org.uk/.

Atkins, M., and Beattie, J., and Dockrell, B. (1992). *Assessment issues in higher education*. Newcastle School of Education: University of Newcastle.

Atkinson, R., and Siffrin, R. (1971). The control of Short-Term Memory. *Scientific American, 225*, 82-90.

Atkinson, R. L., Atkinson, R. G., Smith, E. E., and Bem, D. J. (1993). *Introduction to Psychology* (11th ed.). Florida: Harcourt Brace Jovanovich, Inc.

Ausubel, D. P. (1961). In defence of verbal learning. *Education Theory, 11*, 15-25.

Ausubel, D. P. (1968). *Educational Psychology a cognitive view*. New York: Holt, Rinehart and Winston.

Ausubel, D. P., Novak J.D., and Hanesian H. (1978). *Educational Psychology: A cognitive view* (2nd ed.). New York: Holt, Rinehart and Winston.

Baddeley, A. D. (1986). *Working Memory*. Oxford: University Press.

Badger, E. (1990, April). *Using different spectacles to look at student achievement: Implication for theory and practice*. Paper presented at the American Educational Research Association. Annual meeting, Boston, Massachusetts.

Bahar, M. (1999). *Investigation of Biology student's cognitive structure through word association tests, mind maps and structural communication grids*. Ph.D. Thesis, University of Glasgow.

Bahar, M., and Hansell, M. (2000). The Relationship between some psychological factors and their effects on the performance of Grid Questions and Word Association Tests. *Educational Psychology: An International Journal of Experimental Educational Psychology, 20*, 349-363.

Balla, J., and Boyle, P. (1994). Assessment of student performance: a framework of improving practice. *Assessment and Evaluation in Higher Education, 19*, 17-28.

Becker, W. E., and Johnston, C. (1999). The relationship between multiple choice and essay response questions in assessing economics understanding. *Economic Record, 75*(231), 348-357.

Bell, J. F. (1999, September). *Investigating gender differences in the science perofrmance of sixteen-year-old pupils*. Paper presented at the British Educational

Research Association Annual Conference, University of Sussex, Brighton http://www.ucles-red.cam.ac.uk/conferencepapers.htm.

Beller, M., and Gafni, N. (2000). Can item format (multiple choice vs open-ended) account for gender differences in mathematics achievement? *Sex Roles, 42*(1-2), 1-21.

Bennett, S. N. (1973). Divergent thinking abilities-a validation study. *The British Journal of Educational Psychology, 43*, 1-7.

Ben-Shakar, G., and Sinai, Y. (1991). Gender differences in multiple-choice tests: the role of differential guessing tendencies. *Journal of Educational Measurement, 28*, 23-25.

Bentham, S. (2002). *Psychology and education.* East Sussex: Routledge Modular Psychology.

Berger, E., and Golberger, L. (1979). Field dependence and short-term memory. *Perceptual and Motor Skills, 49*, 87-96.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education, 32*, 347-346.

Biggs, J., and Collins, K.F. (1982). *Evaluating the quality of learning: The SOLO taxonomy.* New York: Academic Press.

Biggs, J., and Moore, P. (1993). *The process of learning* (3rd ed.). Toronto: Prentice Hall.

Birenbaum, M., and Feldman, R. A. (1998). Relationships between learning patterns and attitudes towards two assessment formats. *Educational Research, 40*(1), 90-97.

Black, P. (1998). *Testing: friend or foe? theory and practice of assessment and testing.* London: The Falmer Press.

Bloom, B. S. (1956). *Taxonomy of educational objectives: Cognitive domain.* London: Logman.

Bodner, G. M. (1986). Constructivism: A theory of knowledge. *Journal of Chemical Education., 63*(10), 873-878.

Bodner, G. M. (1991). I have found you an argument. *Journal of Chemical Education, 68*(5), 385-388.

Boud, D. (1995). Assessment and learning: Contradictory or complementary? In P. Knight (Ed.), *Assessment for learning in higher education*. London: Kogan Page Ltd.

Boud, D. (2004, 27 Fabruary). *Aligning assessment with long term learning needs.* Paper presented at the Enhancing the student experience in Scottish higher education. Constructive alignment of learning outcomes to assessment methods, Bridge of Allan.

Boudourides, M. (1998, July, 3-6). *Constructivism and education: A shopper's guide.* Paper presented at the International Conference on the Teaching of Mathematics, Samos, Greece.

Bourne, L. F., Doninowski R. L., Loftus E.F., and Healy A.F. (1986). *Cognitive processes* (2nd ed.). New Jersey: Prentice-Hall International.

Bridgeman, B., and Morgan, R. (1994). *Relationships between differential performance on multiple-choice and essay sections of selected AP exams and measures of performance in High School and College Board Report* (94-5). New York: Educational Testing Service, Princeton, NJ.

Bridgeman, B., and Rock, D. A. (1993). Relationships among multiple-choice and open-ended analytical questions. *Journal of Educational Measurement, 30*(4), 313-329.

Broadfoot, P., and Black, P. (2004). Redefining assessment? The first ten years of assessment in education. *Assessment in Education, 11*(1), 7-26.

Brooks, G. P. (1998, October). *Perry: Fact, fiction, and outcomes assessment.* Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Brooks, V. (2002). *Assessment in secondary schools. The new teacher's guide to monitoring, assessment, recording, reporting and accountability.* Philadelphia: Open University Press.

Brown, S., Race, P., and Rust, C. (1995). Using and experiencing assessment. In P. Knight (Ed.), *Assessment for learning in higher education*. London: Kogan Page Ltd.

Bruner, J. (1996). *The culture of education.* United States America: Harvard University Press.

Bruning, R. H., Scbraw, G. J., and Ronning, R.R. (1995). *Cognitive psychology and instruction*. New Jersey: Prentice- Hall, Inc.

Bruno, J. E., and Dirkzwager, A. (1995). Determining the optimal number of alternatives to a multiple-choice test item-An information-theoretic respective. *Educational and Psychological Measurement, 55*(6), 956-966.

Bryne, M., Johnstone, A., and Pope, A. (1994). Reasoning in science: a language problem revealed? *Science education notes, 75*(272), 103-107.

Burton, E., and Sinatra, R. (1984). Relationship of cognitive style and word type for beginning readers. *Reading World, 24*, 65-67.

Burton, R., and Miller, D. (2000). Why tests are not as simple as a, b or c. *The Time Higher*.

Butcher, H. J. (1968). *Human intelligence: its nature and assessment.* London: Methuem.

Byrne, M. (2001). Factors involved in the learning of consumer studies. . *International Journal of Consumer Studies, 25*(4), 322-330.

Campbell, C. V. T., and Milne, W.J. (1972). *The principles of objective testing in Chemistry*. London: Heinemann.

Capel, S., Leask M., and Turner, T. (1999). *Learning to teach in the secondary school: A companion to school experience*. London: Routledge.

Carstens, P. W., and McKeag, R. A. (1982). *The effect of a change in item sequence order on performance in a test, re-test experiment.* U.S.: Wisconsin.

Case, R. (1974). Structures and structures, some functional limitations on the course of cognitive growth. *Cognitive Psychology, 6*, 544 - 574.

Case, R. (1985). *Intellectual development*. London: Methuen.

Case, R., and Globerson, T. (1974). Field-Independence and central computing space. *Child Development, 45*, 772-778.

Cassels, J. R. T., and Johnstone, A. H. (1983). Meaning of words and the teaching of chemistry. *Education in Chemistry, 20*(1), 10-11.

Cassels, J. R. T., and Johnstone, A. H. (1984). The effect of language on student performance on multiple-choice tests in chemistry. *Journal of Chemical Education, 61*(7), 613-615.

Casteel, C. A. (1991). Answer changing on multiple-choice test items among eight-grade readers. *Journal of Experimental Education, 59*(4), 300-309.

Caygill, R., and Eley, L. (2001). Evidence about the effects of assessment task format on student achievement. *Annual Conference of the British Educational Research Association.*

Chansarkar, B. A., and Raut-Roy, U. (1987). Student performance under different assessment situations. *Assessment and Evaluation in Higher Education, 12*(2), 115-122.

Chen, W. (2004). *An analysis of pupil difficulties in physics in relation to working memory space.* M.Sc. Thesis, University of Glasgow.

Child, D. (1993). *Psychology and the teacher* (5th ed.). London: Cassell.

Child, D., and Smithers, A. (1973). An attempted validation of the Joyce-Hudson scale of convergence and divergence. *British Journal of Educational Psychology, 43*, 57-61.

Christou, K. (2001). *Difficulties in solving algebra story problems with secondary pupils.* M.Sc. Thesis, University of Glasgow.

Cizek, G. J. (1994). The effect of altering the position of options in a multiple-choice examination. *Educational and Psychological Measurement, 54*(1), 8-20.

Cohen, R. A. (1969). Conceptual styles, culture conflict and nonverbal tests of intelligence. *American Anthropologist, 71*, 828-856.

Cotton, J. (1995). *The theory of assessment. An introduction.* London: Kogan Page.

Crisp, V., and Sweiry, E. (2003, September). *Can a picture ruin a thousand words? Physical aspects of the way exam questions are laid out and the impact of changing them.* Paper presented at the British Research Association Annual Conference www.ucles-red.cam.ac.uk, Edinburg.

Danili, E. (2001). *New teaching materials for secondary school chemistry: A study of psychological factors affecting pupil performance.* M.Sc. Thesis, University of Glasgow.

Davey, B. (1990). Field dependence-independence and reading comprehension questions: Task and reader interactions. *Contemporary of Experimental Education, 52*, 119-206.

Davis, F. B., and Fifer, G. (1959). The effect on test reliability and validity of scoring aptitude and achievement tests with weights for every choice. *Educational and Psychological Measurement, 19*, 159-170.

Davis, F. B., and Fifer, G. (1959b). The effect on test score variance of differential weighting of item responses. *Psychological reports, 21*, 585-590.

Davis, J. K. (1991). Educational implications of field dependence-independence. In S. Wapner, and J. Demick (Ed.), *Field dependence-independence: cognitive style across the lifespan* (pp. 149-175). Hillsdale, NJ: Lawrence Erlbaum Associates.

Delgado, A. R., and Prieto, G. (1998). Further evidence favoring three-option items in multiple-choice tests. *European Journal of Psychological Assessment, 14*(3), 197-201.

Didkovskaya, O. A. (2003). *Cognitive styles and problems of psychological education.* http://lsi.bas-net.by/icnnai01/paper%5C7_6%5C7_6.pdf. [2003, 12/12].

Donaldson, M. (1978). *Children's minds*. London: Biddles, Guildford, Survey,.

Dubois, T. E., and Cohen, W. (1970). Relationship between measures of psychological differentiation and intellectual ability. *Perceptual and Motor Skills, 31*, 411-416.

Edgington, E. S. (1965). Scoring formulae that correct for guessing. *Journal of Experimental Education, 33*, 345-346.

Egan, K. (1972). Structural communication-A new contribution to pedagogy. *Journal of Chemical Education, 9*(2), 63-78.

Eizenberg, N. (1988). Approaches to learning anatomy: developing a programme for preclinical medical students. In P. Ramsden (Ed.), *Improving learning: new perspectives*. London: Kogan Page.

El-Banna, H. (1987). *The development of a predictive theory of science education based upon information processing theory.* Ph.D. Thesis, University of Glasgow.

Eley, L., Caygill, R., and Crooks, T. (2001, September 13-15). *Designing and implementing a study to examine the effects of task format on student achievement.*

Paper presented at the British Educational Research Association conference, Leeds, UK.

Entwistle, A., and Entwistle, N. (1992). Experiences of understanding in revising for degree examinations. *Learning and Instruction, 2*, 1-22.

Entwistle, N. J., and Entwistle, A. (1991). Contrasting forms of understanding for degree examinations: the student experience and its implication. *Higher Education, 22*, 205-227.

Entwistle, N. J., and Ramsden, P. (1983). *Understanding student learning.* Beckenham: Groom Helm.

Entwistle, N. J., and Tait, H. (1995). Approaches to studying and perceptions of the learning environment across disciplines. *New Directions for teaching and Learning, 64*, 93-103.

Ertmer, P. A., Driscoll, M. P., and Wager W. W. (2003). The legacy of Robert Mills Gagne. In B. J. Zimmerman, and Schunk, D.H. (Ed.), *Educational Psychology: A century of contributions* (pp. 303-330). London: Lawrence Erlbaum Associates Inc.

Fabrey, L. J., and Case, S. M. (1985). Further support for changing multiple-choice answers. *Journal of Medical Education, 60*(6), 488-490.

Farr, C. W., and Moon, C. E. (2003). *New perspectives in adult basic education: the implications of field dependence/ independence in light of Sternberg's Triarchic Theory of intelligence*. Education-Line. http://www.leeds.ac.uk/educol/documents/00002719.htm.

Fatt, J. P. T. (2000). Understanding the learning styles of students: Implications for educators. *International Journal of Sociology and Social Policy, 20*(11).

Field, T. W., and Poole, M. E. (1970). Intellectual style and achievement of arts and science undergraduates. *British Journal of Educational Psychology, 40*, 338-341.

Fink, A. (Ed.). (1995). *The survey Handbook.* Thousand Oaks, CA: http://writing.colostate.edu/references/research/relval/pop2d.cfm.

Finster, D. C. (1989). Developmental Instruction, Part 1. Perry model of intellectual development. *Journal of Chemical Education, 66*(8), 659-661.

Finster, D. C. (1991). Developmental instruction: Part II application of the Perry model to general Chemistry. *Journal of Chemical Education, 68*(9), 752-756.

Fisher, R. (1995). *Teaching children to think.* UK: Stanley Thornes Ltd.

Fitch, P., and Culver, R. S. (1984). *Educational activities to stimulate intellectual development in Perry's scheme.* Paper presented at the Proceeding of the ASEE Annual Conference.

Flaugher, R. L., Melton, R.S., and Myers, C. T. (1968). Item rearrangement under typical test conditions. *Educational and Psychological Measurement, 28*, 813-824.

Frank, B. M., and Keene, D. (1993). The effect of learners' field-independence, cognitive strategy, instruction, and inherent word-list organisation on free-recall memory and strategy use. *Journal of Experimental Education, 62*(1), 14-25.

Freeman, J. (2003). Gender differences in gifted achievement in Britain and the US. *Gifted Child Quarterly, 47*(3), 202-211.

Friel, S. (1976). *An investigation into objective testing in science in a Scottish secondary school.* M.Sc. Thesis, University of Glasgow.

Friel, S., and Johnstone, A. H. (1978b). A review of the theory of objective testing. *School Science Review, 59*, 733-738.

Friel, S., and Johnstone, A. H. (1978a). Scoring systems which allow for partial knowledge. *Journal of Chemical Education, 55*(11), 717-719.

Friel, S., and Johnstone, A. H. (1979). Does the position matter? *Education in Chemistry, 56*(6), 175-175.

Friel, S., and Johnstone, A. H. (1998). Making test scores yield more information. *Education in Chemistry, 26*(3), 46-49.

Fryer, M. (1996). *Creative teaching and learning.* London: Paul Chapman.

Gabel, D. (1999). Improving teaching and learning through chemistry education research: A look to the future,. *Journal of Chemical Education, 76, 76*(4), 548-553.

Gagné, R. M. (1968). Contributions of learning to human development. *Psychological Review, 75*, 177-191.

Gagné, R. M. (1970). *The conditions of Learning* (2nd ed.). Bristol: Rinehart & Winston.

Gagné, R. M. (1977). *The conditions of learning* (3rd ed.). New York: Holt, Rinehart and Winston.

Gardner, H. (1993). *Frames of mind* (2nd ed.). London: Fontana Press.

Garnett, P. J., and Hackling, M.W. (1995). Students' alternative conceptions in chemistry: A review of research and implications for teaching and learning. *Studies in Science Education, 25*, 69-95.

Garratt, J. (1998). Introducing people to think. *University Chemistry Education, 2*(1), 29-33.

Getzels, J. W., and Jackson, P.W. (1962). *Creativity and Intelligence.* London and N.York: John Wiley and Sons INC.

Gibbs, G. (1995). Assessing student centred courses. *The Oxford Centre for Staff Development.*

Gipps, C. (1994). *Beyond testing: Towards a theory of educational assessment.* London: Routledge Falmer.

Gipps, C., and James, M. (1996). *Assessment matched to learning. Some ideas towards a pamphlet on assessment and learning.* Paper presented at the BERA Assessment policy task group, University of Lancaster.

Gipps, C., and Murphy, P. A. (1994). *A Fair test? Assessment, achievement and equity.* Buckingham - Philadelphia.

Gipps, C., and Stobart, C. (1993). *Assessment: A teachers' guide to the issues.* Newcastle: Hodder and Stoughton.

Glaser, R. (1990). Towards new models for assessment. *International Journal of Educational Research, 14*(5), 475-483.

Goldberg, A. L., and Pedulla, J. J. (2002). Performance differences according to test mode and computer familiarity on a practice graduate record exam. *Educational and Psychological Measurement, 62*(6), 1053-1067.

Goldman, B. A., and Flake, W. L. (1996). Is flexibility related to college achievement? A five-year study. *Psychological Reports, 78*, 337-338.

Goleman, D. (1996). *Emotional Intelligence. Why it can matter more than IQ.* London: Bloomsbury.

Goodenough, D. R. (1976). The role of individual differences in field dependence as a factor in learning and memory. *Psychological Bulletin, 83*, 675-694.

Goodenough, D. R., and Karp, S. A. (1961). Field dependence and intellectual functioning. *journal of Abnormal and Social Psychology, 63*, 241-246.

Gray, C. (1997). *A study of factors affecting a curriculum innovation in university.* Ph.D. Thesis, University of Glasgow.

Greer, L. (2001). Does changing the method of assessment of a module improve the performance of student? *Assessment and Evaluation in Higher Education, 26*(2), 127-138.

Grigorenko, E., and Sternberg, R. (1995). Thinking styles. In D. Saklofske, and Zeidner, M. (Ed.), *International handbook of personality and intelligence*. New York: Plenum Press.

Haghanikar, M. (2003). *Understanding and accessibility of Physics.* M.Sc. Thesis, University of Glasgow.

Haladyna, T. M., and Downing, S. M. (1993). How many options is enough for a multiple-choice test item. *Educational and Psychological Measurement, 53*(4), 999-1010.

Handy, J., and Johnstone, A. H. (1973 a). Reproducibility in objective testing. *Education in Chemistry, 10*(2), 47-48.

Handy, J., and Johnstone, A. H. (1973b). How students reason in objective tests. *Education in Chemistry, 10*(3), 99-100.

Harnish, D. L., and Linn, R. L. (1981). Analysis of item response patterns: Questionable test data and dissimilar curriculum practises. *Journal of Educational Measurement, 18*(3), 133-146.

Hartley, J. (1998). *Learning and studying: A research perspective*. London: Routledge.

Hartley, J., and Greggs, M. A. (1997). Divergent thinking in arts and science students: Contrary Imaginations at Keele revisited. *Studies in Higher Education, 22*(1), 93-97.

Hasan, S., Bagayoko, D., and Kelley, E. L. (1999). Misconceptions and the Certainty of Response Index (CRI). *Physics Education, 34*(5), 294-299.

Hassan, A. K. (2003). *An exploration of underlying concepts held by prospective students of organic chemistry.* M.Sc. Thesis, University of Glasgow.

Hassard, J. (2003). *Web extension to format methods of assessment: Performance assessment*. URL http://scied.gsu.edu/Hassard/mos/formeth.htm.

Heath, R. (1964). *The reasonable adventurer*. Pittsburgh: University of Pittsburgh Press.

Hoddinot, J. (1997). *Biggs' constructive alignment: Evaluation of a pedagogical model applied to a web course*. John hoddinott www.biology.ualberta.ca/courses.hp/bot431.hp/bot431hp.html.

Horber, D. T., and Geisinger K. F. (1983, Aprill 11-15). *The relationships of attitudes toward multiple-choice tests and convergent production, divergent production, and risk-taking.* Paper presented at the Annual Meeting of the American Educational Research Association, Montreal, Quebec.

Huck, S. W., and Bowers, W. D. (1972). Item difficulty level and sequence effects in multiple- choice achievement tests. *Journal of Educational Measurement, 9*, 105-111.

Hudson, B. (1969). Guessing in multiple-choice tests. *The School Science Review, 51*(175), 437-439.

Hudson, L. (1966). *Contrary imaginations: A Psychological study of the English schoolboy. Great Britain.* Great Britain: Penguin books Ltd.

Hudson, L. (1968). *Frames of mind.* London: Methuen.

Jenkins, E. W. (2000). What can Physics teachers learn from research in Physics education? *Physics Education, 35*(4), 245-250.

Johnstone, A. H. (1984). New stars for the teacher to steer by? *Journal of Chemical Education., 61*(10), 847- 849.

Johnstone, A. H. (1987). Cognitive development and the teaching and learning of Chemistry. *V.C.V. Tijidingen, Nov*, 45-58.

Johnstone, A. H. (1988). *Methods of assessment using grids.* Lab Talk, University of Glasgow.

Johnstone, A. H. (1993). The development of chemistry teaching: a changing response to changing demand. *Journal of Chemical Education, 70*(9), 701-705.

Johnstone, A. H. (1997). Know how your pupils learn, and teach them accordingly. *Monitoring Change in Education, SCIENCE EDUCATION IN THE 21st CENTURY.*

Johnstone, A. H. (1998). *Evaluation of innovation: a case study*: Hull: Project Improve, hefce Fund for the Development of Teaching and Learning.

Johnstone, A. H. (1999). The nature of Chemistry. *Education in Chemistry, 36*(2), 45-48.

Johnstone, A. H. (undated). *Unpublished lectures.*Unpublished manuscript, Centre for Science Education University of Glasgow.

Johnstone, A. H., and Al-Naeme, F. (1991). Room for scientific thought? *International Journal of Science Education, 13*, 187-192.

Johnstone, A. H., and Al-Naeme, F. F. (1995). Filling a curriculum gap in chemistry. *International Journal of Science Education, 17*(2), 219-232.

Johnstone, A. H., and Ambusaidi, A. (2000). Fixed response: What are we testing? *Chemistry Education Research and Practice in Europe, 1*(3), 323-328.

Johnstone, A. H., and Ambusaidi, A. (2001). Fixed-response questions with a difference. *Chemistry Education: Research and Practice in Europe, 2*(3), 313-327.

Johnstone, A. H., and Cassels, J. H. (1985). *Words that matter in science*. London: The Royal Society of Chemistry.

Johnstone, A. H., and El-Banna, H. (1986). Capacities, demands and processes: a predictive model for science education. *Education in Chemistry, 23*(3), 80-84.

Johnstone, A. H., and Wham, A.J.B. (1982). Demands of practical work. *Education in Chemistry, 19*(3), 71-73.

Johnstone, A. H., Hogg, W.R., and Ziane, M. (1993). A working memory model applied to Physics problem solving. *International Journal of Science Education, 15*(6), 663-672.

Johnstone, H. A. (2003). *Effective practice in objective assessment.* LTSN Physical Sciences Centre http://dbweb.liv.ac.uk/ltsnpsc/guides/EffectivePracticeInObjectiveAssessment/index.htm.

Jones, R. L., and Bray, E. (1992). *Assessment: From principles to action.* London: Routledge.

Jung , C. (1923). *Psychological types.* New York: Harcourt Brace.

Karageorgios, D., Kasimati, A., and Gialamas, B. (2001). A Gymanisou pupils' performance in mathematics and their attitude towards them: An attempt to explore their relationship (Η επίδωση των μαθητών Α' Γυμνασίου στα Μαθηματικά και η στάση τους απέναντι σ'αυτά: Μια προσπάθεια διερεύνησης της μεταξύ τους σχέσης). *Η Επιθεώρηση Επιστημονικών και Εκπαιδευτικών θεμάτων, 1*, 46-69.

Kellong, R. (1995). *Cognitive psychology.* London: Sage.

Kepner, M. D., and Neimark, E. D. (1984). Test-retest reliability and differential patterns of score change on the group embedded figures test. *Journal of Personality and Social Psychology, 46*(6), 1405-1413.

Kirby, J. R. (1993). Collaborative and competitive effects of verbal and spatial processes. *Learning and Instruction, 3*, 201-214.

Koffka, K. (1924). *The growth of the mind.* London: Kegan, Paul, Trench, Trubner.

Kogan, N. (1971). *Estilo cognitivo dependencia-indepencia de campo y proceso lector.* Ph.D. Thesis, University of Barcelona.

Kogan, N. (1976). *Cognitive styles in infancy and early childhood.* New Jersey: Lawrence Erlbaum Associates, Inc.

Kohler, W. (1925). *The mentality of Apes.* England: Harmondsworth, Penguin.

Kohn, A. (1993). *Punished by rewards.* Boston, Mass: Houghton, Mifflin.

Kuhn, T. (1962). *The structure of scientific revolutions* (2nd ed.). Chicago: The University of Chicago Press.

Kyoko, S. (1997, March 24-28). *Cognitive constructs measured in word problems: A comparison of students' responses in Performance-Based tasks and Multiple-Choice Tasks for Reasoning.* Paper presented at the Annual meeting of the American Educational Research Association, Chicago.

Larochelle, M., Madine, B., and Garrison, J. (1998). *Constructivism and education.* New York: Cambridge University Press.

Lefrançois, G. R. (2000). *Psychology for teaching* (10th. ed.). London: Wadsworth and Thomson.

Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology, 140*, 5-53.

Linn, L. E., and Gronlund, M.A. (1995). *Measurement and assessment in teaching* (7th ed.). New Jersey: Prentice-Hall.

Liodakis, S., Gakis, D., Theodoropoulos, D., Theodoropoulos, P., and Kallis, A. (1999). *Chemistry A' Lyceum (Χημεία α' λυκείου).* Αθήνα: Οργανισμός Εκδόσεων Διδακτικών Βιβλίων.

Little, J. B. (1966). Overcorrection and undercorrection in multiple-choice test scoring. *Journal of experimental education, 35*, 44-47.

Liu, M., and Reed, W. M. (1994). The relationship between the learning strategies and learning styles in a hypermedia environment. *Computers in Human Behavior, 10*(4), 419-439.

Lloyd-Bostock, S. M. A. (1979). Convergent-divergent thinking and arts-science orientation. *British Journal of Psychology, 70*, 155-163.

Loevinger, J. (1978). *Paradigms of personality.* New York: W. H. Freeman and Co.

Lu, C., and Suen, H. K. (1995). Assessment approaches and cognitive styles. *Journal of Educational Measurement, 32*(1), 1-17.

Luk, S. C. (1998). The relationship between cognitive style and academic achievement. *British Journal of Educational Psychology, 29*(2), 137-147.

Mackay, C. K., and Cameron, M. B. (1968). Cognitive bias in Scottish first year science and arts undergraduates. *British Journal of Educational Psychology, 38*, 315-318.

Mackenzie, A. M. (1999). *Prescription for change: Medical undergraduates' perceptions of learning in traditional and problem-based courses.* Ph.D. Thesis, University of Glasgow.

Mackenzie, A. M., Johnstone, A. H., and Brown, R. I. (2003). Learning from problem based learning. *University Chemistry Education, 7*, 13-26.

MacNicol, R. L. (1966). *Effect of varying order of item difficulty in an unspeeding verbal test.* Princeton, New Jersey: Educational Testing Service.

Marcus, A. (1963). The effect of correct response location on the difficulty level of multiple-choice questions. *Journal of Applied Psychology, 47*(1), 48-51.

Marjoribanks, K. (1978). The relation between students' convergent and divergent abilities, their academic performance, and school-related affective characteristics. *Journal of research in science teaching, 15*(3), 197-207.

Marso, R. N. (1970). Test item arrangement, testing time and performance. *Journal of Educational Measurement, 7*, 113-118.

Marton, F., and Säljö, R. (1997). Approaches to learning. In F. Marton, Hounsell, D., and Entwistle, N. (Ed.), *The experience of learning. Implications for teaching and studying in higher education* (2nd ed., pp. 39-59). Edinburgh: Scottish Academic Press.

Mathews, J. C. (1967). The Nuffield O-Level chemistry examination. *Education in Chemistry, 4*, 2-11.

Matthews, M. R. (1993). Constructivism and science education: Some epistemological problems. *Journal of Science Education and Technology, 2*(1), 359-370.

Matthews, M. R. (1998). *Constructivism and science education.* Dordrecht: Kluwer.

McInnis, C. (2004). *Repositioning assessment to enhance learning outcomes.* Paper presented at the Enhancing the student experience in Scottish higher education using assessment to motivate learning. Enhancement themes 2003-2004. Assessment workshop series-No 2., Glasgow.

Messick, S. (1984). The psychology of educational measurement. *Journal of Educational Measurement, 21*, 215-238.

Messick, S. (1988). Validity. In R. Linn (Ed.), *Educational measurement.* New York: Macmillan.

Messick, S. (1989). Validity. In R. Linn (Ed.), *Educational Measurement.* Washington: Macmillan, American Council of Education.

Messick, S. (1993). *The matter of style: Manifestations of personality in cognition, learning, and teaching.* Princeton, NJ: Educational Testing Service.

Messick, S. (1994). The matter of style: Manifestations of personality in cognition, learning, and teaching. *Educational Psychologist, 29*, 121-136.

Millar, R. (1989). Constructive criticisms. *International Journal of Science Education, 11*, 587-596.

Millar, R., and Irving, P. (1995). Academic locus of control in British undergraduate students. *British Journal of Educational Psychology, 65*(3), 331-340.

Miller, G. D. (1956). The magical number seven plus or minus two: some limits on our capacity for processing information. *Psychological Review, 63*, 81-97.

Miller, P. H. (1993). *Theories of developmental psychology.* New York: W.H. Freeman and Company.

Miller, R., Acton, C., Fullerton, D., and Maltby, J. (2002). *SPSS for social scientists.* New York: Palgrave Macmillan.

Mollenkopf, W. G. (1950). An experimental study of the effects on item analysis data of changing item placement and test time limit. *Psychometrica, 15*, 291-315.

Moore, J., Stanitski, C., Wood, J., Kotz, J., and, Joesten, M. (1998). *The chemical world concepts and applications* (Second ed. ed.). New York: Saunder College.

Morell, J. (1976). Age, sex, training, and measurement of field dependence. *Journal of Exprimental Child Psychology, 22*(1), 100-112.

Morris, E. (2003). B. F. Skinner: A Behavior analyst in educational psychology. In B. J. Zimmerman, and Schunk, D.H. (Ed.), *Educational Psychology: A century of contributions*. London: Lawrence Erlbaum Associates Inc.

Mpampiniotis, G. (Saturday 8/10/2000). Stop the examinations in Lykeio. *To Vima (newspaper)*.

Nakhleh, M. B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education, 69.*(3), 191-196.

Niaz, M. (1987). Relationship between M-space of students and M-demand of different items of general chemistry and its interpretation based upon the Neo-Piagetian Theory of Pascual-Leone. *Journal of Chemical Education, 64*(6), 502-505.

Nolen, S. B., and Haladyna, T. (1990). Personal and environmental influences on students' beliefs about effective study strategies. *Contemporary Educational Psychology, 15*(2), 116-130.

Novak, D. J. (1978). An alternative to Piagetian psychology for science and mathematics education. *Studies in Science Education, 5*, 1-30.

NSW HSC ONLINE. (2004). *Professional development. Cognitive theories of learning.* http://hsc.csu.edu.au/pro_dev/teaching_online/how_we_learn/cognitive.html.

Nurrenber, S., and Pickering, M. (1987). Concept learning versus problem solving: Is there a difference? *Journal of Chemical Education, 64*, 508-510.

Nuttall, D. L. (1972). Convergent and divergent thinking. *The British Journal of Educational Psychology, 43*, 1-7.

Oakhill, J. (1984). Why children have difficulty reasoning with three-term series problems. *British Journal of Developmental Psychology, 2*, 223-230.

Oakhill, J. (1988). The development of children's reasoning ability: Information processing approaches. In K. Richardson, and Sheldon S. (Ed.), *Cognitive development to adolescence*: LEA/OU.

Orton, A. (1992). *Learning mathematics issues, theory and classroom practice.* London: Cassell Education Series.

Osborne, J. (1996). Beyond constructivism. *Science Education, 80*(1), 53-82.

Osborne, M. (2004, 27 February). *"Constructive alignment of assessment methods with learning outcomes" An overview for the assessment workshop on 27th February 2004.* Paper presented at the Enhancing the student experience in Scottish higher education. Constructive alignment of learning outcomes to assessment methods, Bridge of Allan.

Osborne, R. J., and Cosgrove, M.M. (1983). Children's conceptions of the changes of state of water. *Journal of Research in Science Teaching, 20.*(9), 825-838.

Osgood, C. E. (1952). The nature and measurement of meaning. *Psychological Bulletin, 49*(3), 197-237.

Osgood, C. E. (1967). *The measurement of meaning* (2nd ed.). Illinois: University of Illinois Press.

Paivo, A., Clark, J.M., and Lamber, W.E. (1988). Bilingual dual-coding theory and semantic repetitione effect on recall. *Journal of Experimental Psychology: Learning Memory, and Cognition, 14*, 163-172.

Palmer, D. (2002). *An annotated bibliography of research into the teaching and learning of the physical sciences at the higher education level.* LTSN Physical Sciences http://dbweb.liv.ac.uk/ltsnpsc/AB/AB-html/AB-html.html.

Pascual-Leone, J. (1970). A mathematical model for the transition rule in Piaget's developmental stages. *Acta Psychologica, 32*, 301-345.

Pascual-Leone, J. (1976). Metasubjective problems of constructive cognition: forms of knowing and their psychological mechanisms,. *Canadian Psychological Review, 17*, 110-125.

Penner, A. M. (2003). International gender X Item difficulty interactions in mathematics and science achievement tests. *Journal of Educational Psychology, 95*(3), 650-655.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: a scheme.* New York: Holt, Rinehart & Winston.

Perry, W. G. (1981). *Cognitive and ethical growth: the making of meaning.* San Francisco: Jossey-Bass.

Perry, W. G. (1999). *Forms of ethical and intellectual development in the college years: a Scheme.* San Francisco: Jossey- Bass.

Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher, 24*(7), 5-12.

Piaget, J. (1952). *The origins of intelligence in children.* New York: International Universities Press.

Piaget, J. (1961). *The child's conception of the world.* London: Routledge and Kegan Paul.

Piaget, J. (1972). *Psychology and epistemology: Towards a theory of knowledge.* Harmondsworth: Penguin.

Piaget, J., and Inhelder, B. (1969). *The psychology of the child* (H. Weaver, Trans.). New York: Basic Books.

Pithers, R. (2002). Cognitive learning style: a review of the field dependent-field independent approach. *Journal of Vocational Education and Training, 54*(1), 117-132.

Pollitt, A., and Ahmed, A. (1999, May). *A new model of the question answering process.* Paper presented at the International Association for Educational Assessment, Bled, Slovenia http://www.ucles-red.cam.ac.uk/conferencepapers.htm.

Pollitt, A., Marriott, C., and Ahmed, A. (2000, May). *Language, contextual and cultural constraints on examination performance.* Paper presented at the International Association for Educational Assessment, Jerusalem, Israel http://www.ucles-red.cam.ac.uk/conferencepapers.htm.

Povery, R. M. (1970). Arts/Science differences: Their relationship to curriculum specialisation. *British Journal of Psychology, 61*, 55-64.

Race, P. (1995). What has assessment done for us and to us? In P. Knight (Ed.), *Assessment for learning in higher education.* London: kogan Page Ltd.

Race, P. (2003). *Designing assessment to improve Physical Sciences learning-exams.* LTSN Physical Sciences http://dbweb.liv.ac.uk/ltsnpsc/guides/designing_assessment/exams.htm [2003, 6/10/2003].

Ramsden, P. (1987). Improving teaching and learning in higher education: the case for a relational perspective. *Studies in Higher Education, 12*, 275-286.

Ramsden, P. (2003). *Learning to teach in higher education* (2nd ed.). London: Routledge Falmer.

Reid, N. (1978). *Attitude development through a science curriculum.* Ph.D. Thesis, University of Glasgow.

Reid, N. (2003). *Getting started in pedagogical research in the Physical Sciences.* Hull: LTSN Physical Science Centre http://dbweb.liv.ac.uk/ltsnpsc/guides/PedagogResearch/index.htm.

Reiff, J. (1996). At-risk middle level students or field-dependence learners? *Clearning house, 69*(4), 231-235.

Renfrew, R., and Conquest, N. (1995). *Standard Grade Chemistry.* London: Hodder and Stoughton.

Richardson, J. (1995). Mature students in higher education. II. An investigation of approaches to studying and academic performance. *Studies in Higher Education, 20*(1), 5-17.

Richardson, J. (1999). Field dependence revisited: An empirical and theoretical evaluation of issues for Education and Psychology. *ELSIN (The European Learning Styles Information Network-An International Forum).*

Richardson, J. (2000). Field dependence revisited: Personality. *ELSIN (The European Learning Styles Information Network-An International Forum).*

Richardson, J. (2001). *Researching student learning approaches to studying in campus and distance education.* UK: St Edmundsbury Press Limited, Open University Press.

Riding, R., and Caine, T. (1993). Cognitive style and GCSE performance in Mathematics, English Language and French. *Educational Psychology, 13*(1), 59-67.

Riding, R. J., and Cheema, I. (1991). Cognitive styles: an overview and integration. *Educational Psychology, 11*, 193-215.

Rippey, R. M. (1970). Rationale for confidence-scored multiple-choice tests. *Psychological Reports, 27*, 91-98.

Runco, M. A. (1986). Divergent thinking and creative performance in gifted and non gifted children. *Educational and Psychological Measurement, 46*, 375-383.

Säljö, R. (1979). *Learning in the learner's perspective. I. Some common sense conceptions* (76). Gothenburg: Reports from the Institute of Education University of Gothenburg.

Sanderson, P. (1998, September). *Cognitive proecess and discpurse in the assessment of written text.* Paper presented at the European Conference for Educational Research, University of Ljubljana, Slovenia http://www.ucles-red.cam.ac.uk/conferencepapers.htm.

Sato, T. (1975). *The construction and interpretation of S-P tables.* Tokyo: Meiji Tosho.

Sawrey, B. A. (1990). Concept learning problem solving: Revisited. *Journal of Chemical Education, 67*(3), 253-254.

Schofield, R. (1973). Guessing on objective type test items. *School Science Review, 190*(55), 170-172.

Selepeng, D. (2000). *An investigation of intellectual growth in undergraduate Biology students using the Perry Scheme.* Ph.D. thesis University of Glasgow.

Selepeng, D. B. (1995). *Teaching and learning science in a second Language.* M.Sc. Thesis, University of Glasgow.

Serumola, L. B. (2003). *A study of scientific thinking with young adolescents.* Ph.D. Thesis, University of Glasgow.

Shepard, L. (1992). What policy makers who mandate tests should know about the new psychology of intellectual ability and learning. In B. Gifford, and O'Connor, M. (Ed.), *Changing Assessments: Alternative views of aptitude, achievement and instruction.* London: Kluwer Academic Publishers.

Shipman, M. (1983). *Assessment in primary and middle schools.* London: Croom Helm.

Simpson, D., Dalgaard, K., and O'Brien, D. K. (1986). Student and faculty assumptions about the Nature of Uncertainty in Medicine and Medical Education. *The Journal of Family Practice, 23*(5), 468-472.

Sirhan, G., and Reid, N. (2001). Preparing the mind of the learner - Part 2. *University Chemistry Education, 5*, 52-58.

Skinner, B. F. (1938). *The behavior of organisms.* New York: Appleton-Century-Crofts.

Slavin, R. E. (2003). *Educational Psychology* (7th ed.). New York: Allyn and Bacon.

Smith, P. K., Cowie, H., and Blades, M. (1998). *Understanding children's development* (3rd ed.). Oxford: Bluchwell Publishers.

Solomon, J. (1994). The rise and fall of constructivism. *Studies in Science Education, 23*, 1-19.

Squire, L. R. (1987). *Memory and Brain.* New York: Oxford University Press.

Stecher, B. M. K., S. P.; Solano-Flores G.; McCaffrey, D.; Robyn, A.; Shavelson, R. J., and Haertel, E. (2000). The effects of content, format, and inquiry level on science performance assessment scores. *Applied measurement in Education, 13*(2), 139-160.

Sternberg, R. J. (1977). *Intelligence, Information processing and analogical reasoning.* Hove: Lawrence Erlbaum Associates.

Sternberg, R. J., and Grigorenko, E. L. (1997). Are cognitive styles still in style? *American Psychologist*(July), 700-712.

Struyven, K., Dochy, F., and Janssens, S. (2002). *Students' perceptions about assessment in higher education: a review.* Education-line http://www.leeds.ac.uk/educol/documents/000025.htm.

Suchting, W. A. (1992). Constructivism deconstructed. *Science and Education, 1*(3), 223-254.

Sutherland, P. (1992). *Cognitive development today: Piaget and his critics.* London U.K: Paul Chapman Publishing Ltd.

Sutton, R. (1992). *Assessment. A framework for teachers.* London: Routledge.

Tamir, P. (1990). Justifying the selection of answers in multiple-choice items. *International Journal of Science Education, 12*(5), 563-573.

Task Group On Assessment and Testing. (1987). *National Curriculum: Task Group on Assessment and Testing.* London: Department of Education and Science and the Welsh Office.

Tennant, M. (1988). *Psychology and adult learning.* London: Routledge.

Terrell, S. T. (2002, April 1-5). *The use of cognitive style as a predictor of membership in middle and High School Programs for the academically gifted.* Paper presented at the Annual meeting of the American Educational. Research Association, New Orleans, Louisiana.

Thorndike, E. L. (1898). Animal intelligence: An experimental study of the associative processes in animals. *Psychological monographs, 2*(8).

Thyne, R. L. (1974). *Princples of examining.* London: University of London Press.

Tinajero, C., and Paramo, F.M. (1998). Field dependence-independence cognitive style and academic achievement: A review of research and theory. *European Journal of Psychology of Education, 13*(2), 227-251.

Tomas, P. R., and Bain, J. D. (1984). Contextual dependence of learning Approaches: the effects of assessment. *Human Learning, 3*, 227-240.

Trigwell, K., and Prosser, M. (1991). Improving the quality of student learning: the influence of learning context and student approaches to learning on learning outcomes. *Higher Education, 22*, 251-266.

Trinkaus, J. (1991). Changing multiple-choice test answers-An informal look. *Psychological Report, part 1, 69*(3), 769-770,.

Trochim, W. M. K. (2000, 06/29/2000). *Types of reliability.* http://trochim.human.cornell.edu/kb/reltypes.htm [30/10/03.

Tulving, E. (1983). *Elements of Episodic Memory.* Oxford: Oxford University Press.

Tversky, A. (1964). On the optimal number of alternatives at a choice point. *Journal of of Mathematical Psychology, 1*, 386-391.

Unger, C. (1993, 15 April). *A call for sensitivity: Taking into account students' perspectives of understanding and learning for understanding.* Paper presented at the Annual Meeting, American Educational Research Association, Atlanta.

Von Glaserfeld, E. (1989). Cognition, construction of knowledge and teaching. *Synthese, 80*(1), 121-140.

Von Glaserfeld, E. (1990). Environment and Education. In L. P. Steffe, and Wood, T. (Ed.), *Transforming Children's Mathematics Education: International Perspectives* (pp. 200-215). Hillsdale, NJ: Lawrence Erlbaum.

Von Glaserfeld, E. (1992). Questions and answers about radical constructivism. In M. K. Pearsall (Ed.), *Scope, sequence, and coordination of secondary schools science* (Vol. 11, Relevant research, pp. 169-182). Washington DC: NSTA.

Vygotsky, L. (1978). *Mind and Society.* Cambridge, MA: Harvard University Press.

Vygotsky, L. (1986). *Thought and language* (A. Kozulin, Trans.). Cambridge, MA: The MIT Press (Originally published in Russian in 1934).

Watson, J. B. (1913). Psychology as the behaviorist views it. *Psychological Review, 20,* 158-177.

Wertheimer, M. (1923). Untersuchungen zur Lehre von der Gestalt II, Psychol (Laws of organization in perceptual forms). *Forsch, 4,* 301-356.

Wesman, A. G. (1971). Writing the test item. In R. L. Thorndike (Ed.), *Educational Measurement* (2nd ed., pp. 81-129). Washington, DC: American Council of Education.

White, R. (1998). *Learning science.* Oxford: Basil Blackwell.

Willcoxson, L., and Prosser, M. (1996). Kolb's learning style inventory (1985): review and further study of validity and reliability. *British Journal of Educational Psychology, 66*(2), 247-258.

Willey, C. (1960). The three-decision multiple-choice test: A method of increasing the sensitivity of the multiple-choice item. *Psychological Reports, 7,* 475-477.

Wilson, A. (1992). The use of grid questions in Chemistry. *Journal of Science and Mathematics Education in Southeast Asia, 15*(2), 45-52.

Witkin, H. A. (1976). Cognitive style in academic performance and in teacher-student relations. In S. Messick (Ed.), *Individuality in learning.* San Francisco: Jossey-Bass.

Witkin, H. A., and Asch, S. E. (1948a). Studies in space orientation III. Perception of the upright in the absence of visual field. *Journal of Experimental Psychology, 38,* 603-614.

Witkin, H. A., and Asch, S. E. (1948b). Studies in space orientation IV. Further experiments on perception of the upright with displaced visual fields. *Journal of Experimental Psychology, 38,* 762-782.

Witkin, H. A., and Goodenough, D.R. (1981). *Cognitive styles: Essence and origins psychological issues Monograph 51.* New York: International Universities Press.

Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., and Karp, S. A. (1962). *Psychological differentiation.* New York: Wiley.

Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., and Karp, S. A. (1974). *Psychological differentiation. Studies of development.* New York: Lawrence Erlbaum Associates Inc.

Witkin, H. A., Goodenough, D.R., Moore, C.A., and Cox, P.W. (1977). Field-dependent and field-independent cognitive styles and their educational Implications. *Review of Educational Research, 47*(1), 1-64.

Witkin, H. A., Oltman, P.K., Raskin, E., and Karp, S.A. (1971). *Embedded figures test, children's embedded figures test, group embedded figures test: Manual.* Palo Alto, CA: Consulting Psychologists Press.

Wittgenstein, L. (1961). *Tractatus logico-philosophicus.* London: Routledge and Kegan Paul.

Wolf, R. M. (1994). Performance assessment in IEA studies. *International Journal of Educational Research, 21*(3), 239-245.

Wood, C., and Sleet, R. (1993). *Creative problem solving in chemistry.* London: The Education Division, The Royal Society of Chemistry.

Wood, R. (1967). *Measurement and assessment in education and psychology. COLLECTED PAPERS 1967-87.* London: The Palmer Press.

Wood, R. (1986). The agenda for educational measurement. In D. Nuttall (Ed.), *Assessing educational achievement.* London: Falmer Press.

Wood, R. (1987). *Measurement and assessment in education and psychology.* London: Falmer Press.

Wood, R. (1991). *Assessment and testing.* Cambridge: Cambridge University Press.

Xionidou-Moskofoglou, M. (1996). *Sex discrimination in Mathematics. (Η διάκριση των δύο φύλων στα Μαθηματικά).* Ph.D. Thesis, University of Athens, Athens.

Yang, M. (2000). *Problem solving in chemistry at secondary school.* Ph.D. Thesis, University of Glasgow.

Yuh-Yin, W., and, I-Fen G. (2000). *Classroom assessment forms and their relations with cognitive components. An example from Taiwan.* Paper presented at the Annual meeting of American Educational Research Association, New Orleans, Louisiana.

Zeidner, M. (1987). Essay versus multiple-choice type classroom exams: the student's perspective. *Educational Research, 40*(1), 90-97.

List of Appendix

Appendix A

The Hidden Figure Test

Notes

I. The FD/FIND tests were presented to pupils as a booklet.
II. The answers to the Shapes are included, beginning on page appendix. A-17.

Name: ....

School: ....

Class: ....

SHAPES

Shape recognition within complex patterns

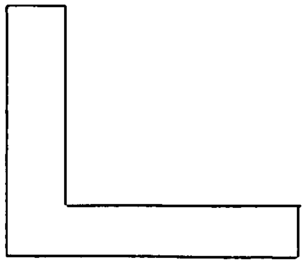
This is a test of your ability to recognize simple SHAPES, and to pick out and trace HIDDEN SHAPES within complex patterns. The results will not affect your course assessment in any way.

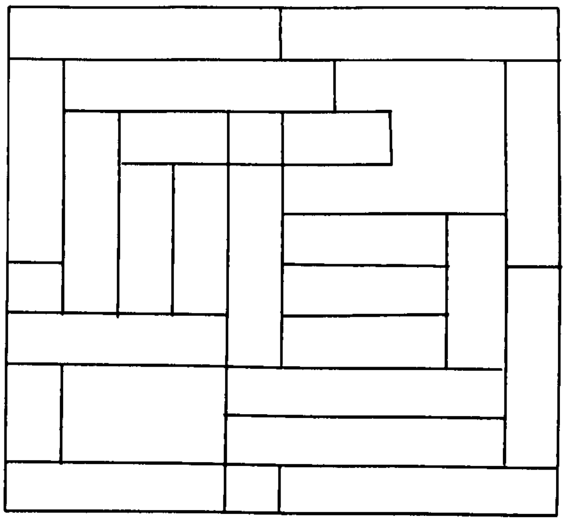
YOU ARE ALLOWED ONLY 20 MINUTES TO ANSWER ALL THE ITEMS.
TRY TO ANSWER EVERY ITEM, BUT DON'T WORRY IF YOU CAN'T.
DO AS MUCH AS YOU CAN IN THE TIME ALLOWED.
DON'T SPEND TOO MUCH TIME ON ANY ONE ITEM

DO NOT START UNTIL YOU ARE TOLD TO DO SO

LOOKING FOR HIDDEN SHAPES

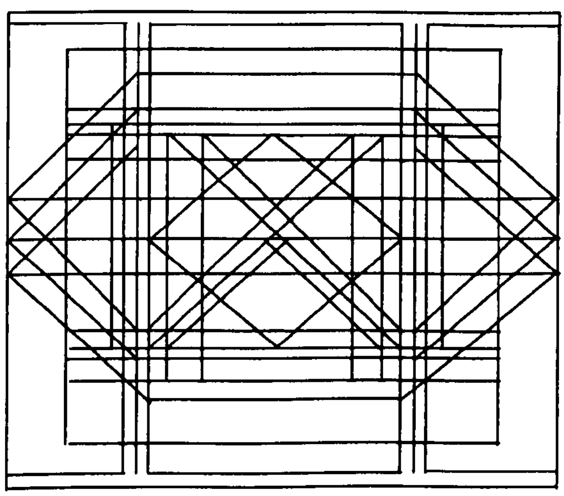
A simple geometric figure can be 'hidden' by embedding it in a complex pattern of lines. For example, the simple L-shaped figure on the left has been hidden in the pattern of lines on the right. Can you pick it out?





Using a pen, trace round the outline of the L- shaped figure to mark the position.

The same L-shaped figure is also hidden within the more complex pattern below. It is the same size, the same shape and faces in the same direction as when it appears alone. Mark its position by tracing round its outline using a pen.



(To check your answers, see page 17)

More problems of this type appear on the following pages. In each case, you are required to find a simple shape 'hidden' within a complex pattern of lines, and then, using a pen, to record the shape's position by tracing its outline.

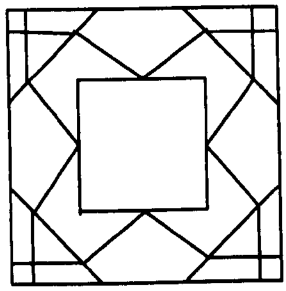
There are TWO patterns on each page. Below each pattern there is a code letter (A, or B, or C etc.) to identify which shape is hidden in that pattern.

In the last page of this booklet, you will see all the shapes you have to find, along with their corresponding code letters. Keep this page opened out until you have finished all the problems.

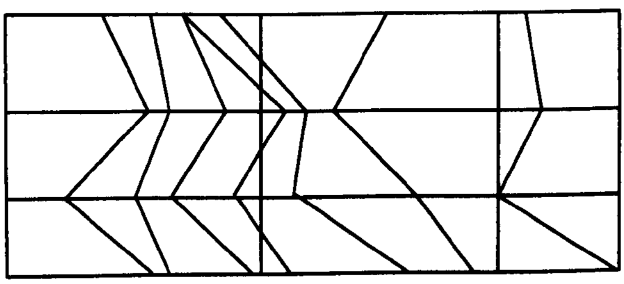
Note these points:

1. **You can refer to the page of simple shapes as often as necessary.**
2. **When it appears within a complex pattern, the required shape is always:**
   - **the same size,**
   - **has the same proportion,**
   - **and faces in the same direction as when it appears alone**
3. **Within each pattern, the shape you have to find appears only once.**
4. **Trace the required shape and only that shape for each problem.**
5. **Do the problems in order – don't skip one unless you are absolutely stuck.**

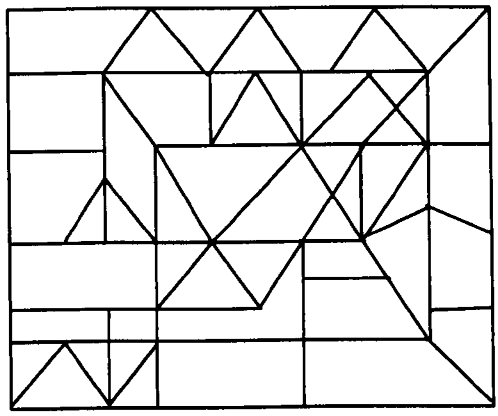
START NOW



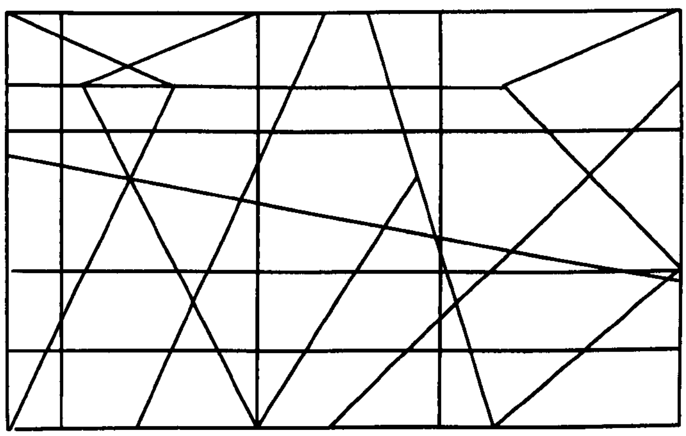
Find shape B



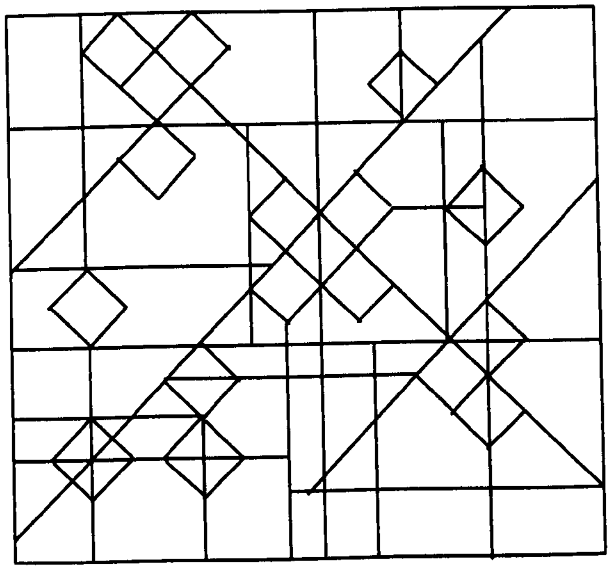
Find shape D



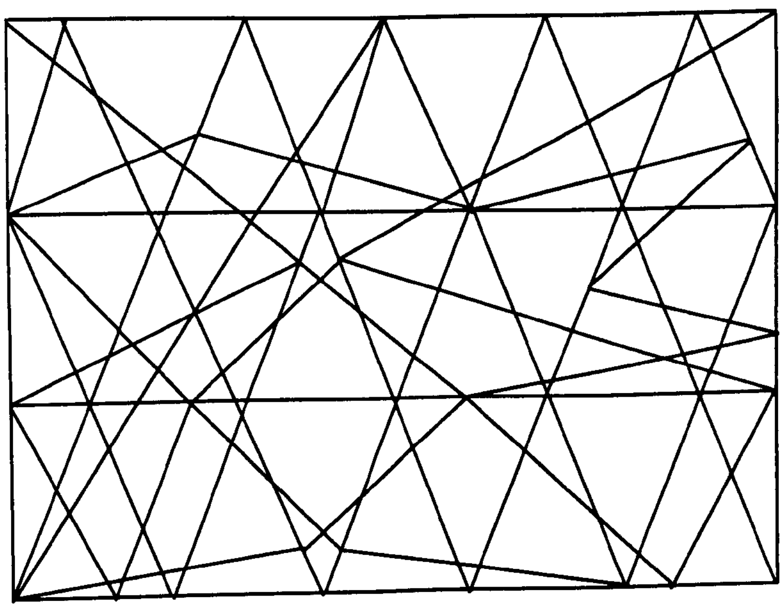
Find shape H



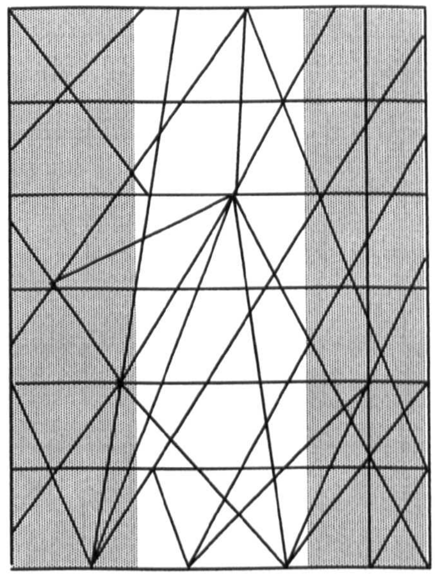
Find shape E



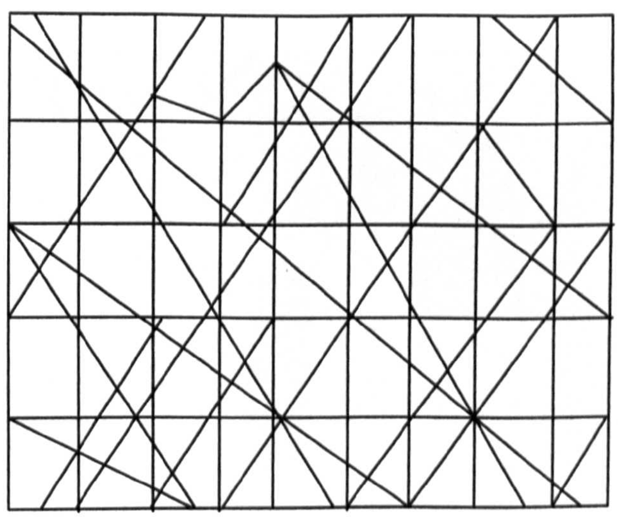
Find shape F



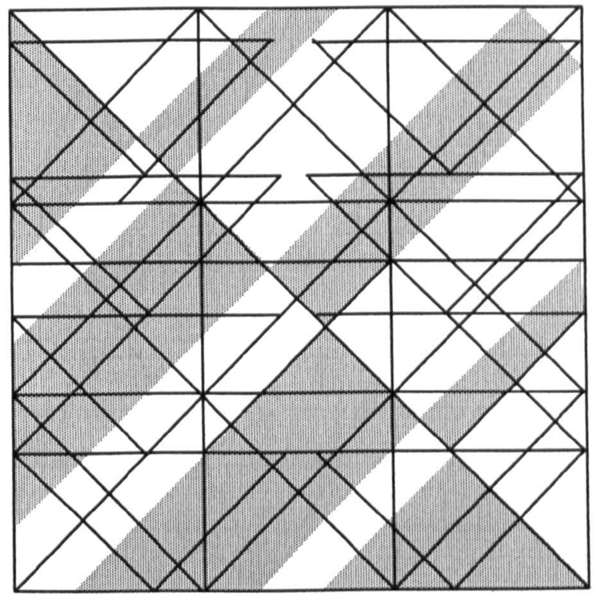
Find shape A



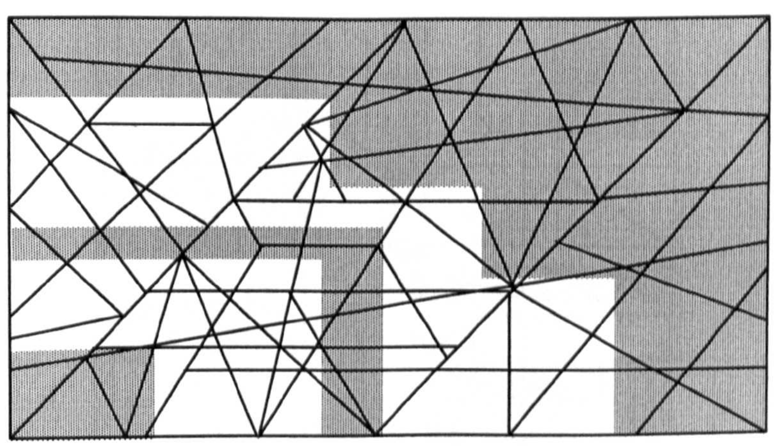
Find shape E



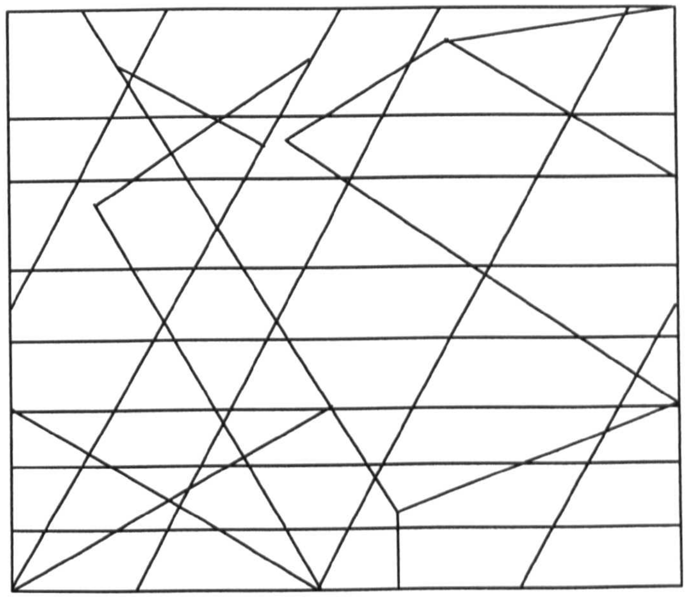
Find shape H



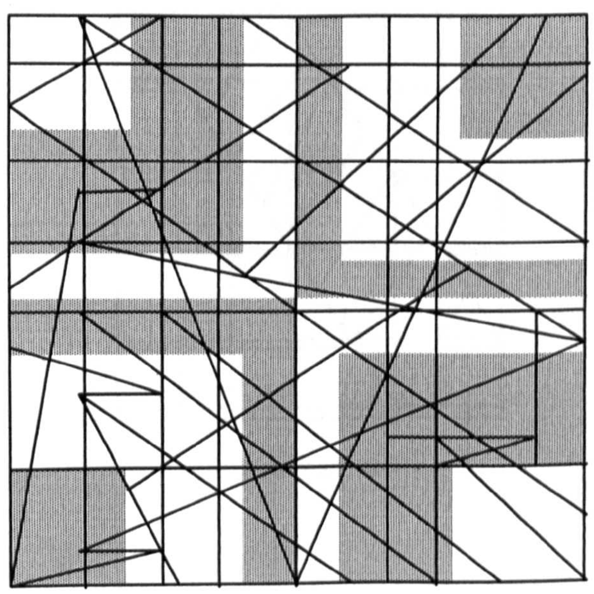
Find shape D



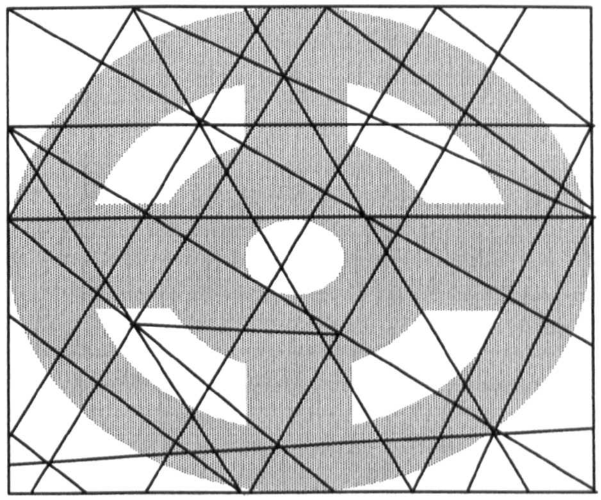
Find shape G



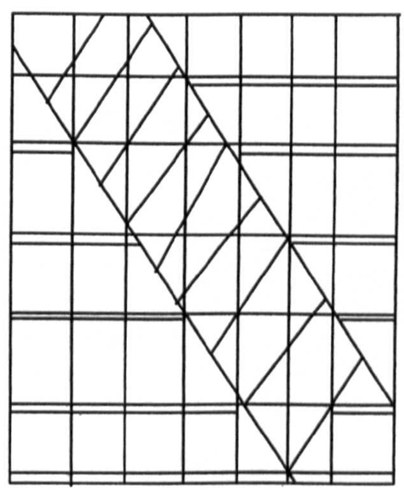
Find shape C



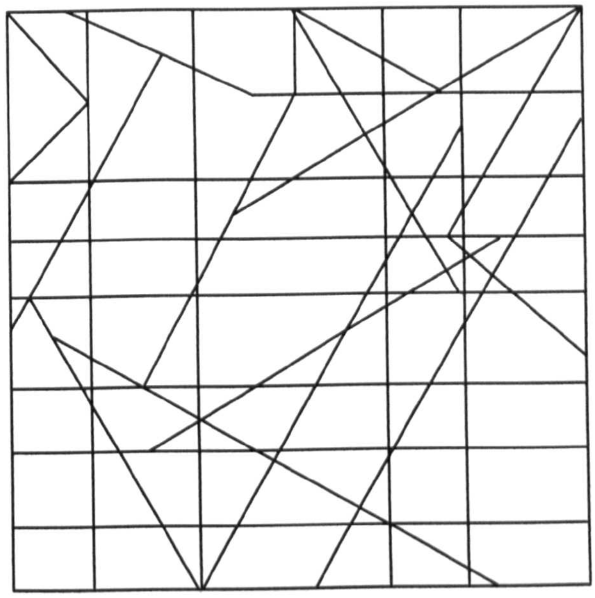
Find shape B



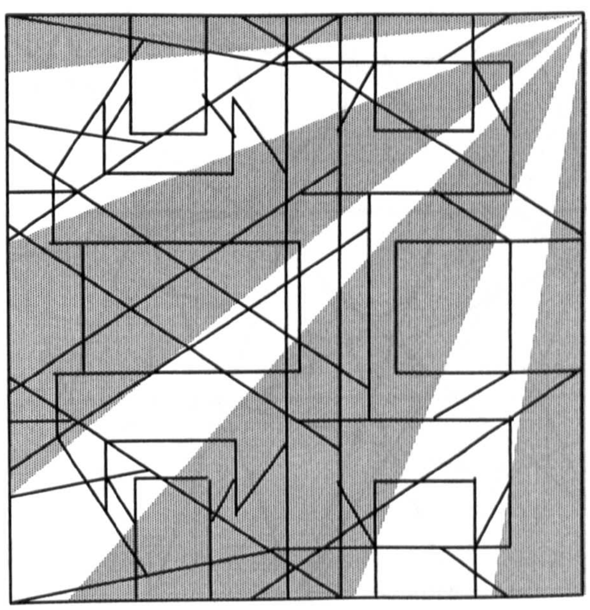
Find shape G



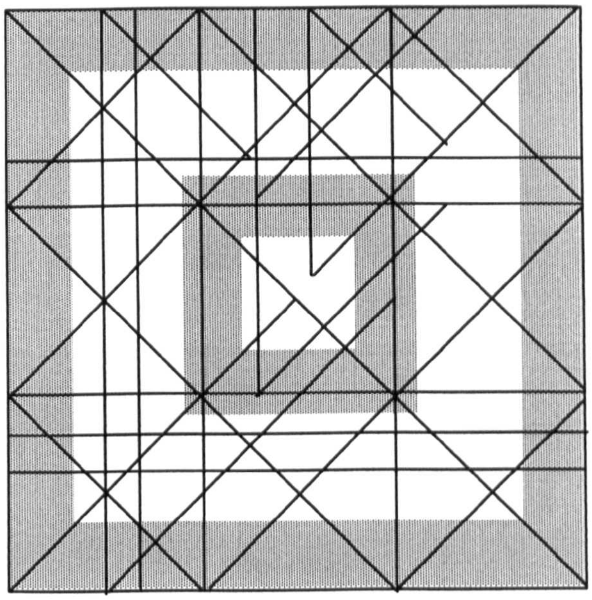
Find shape H



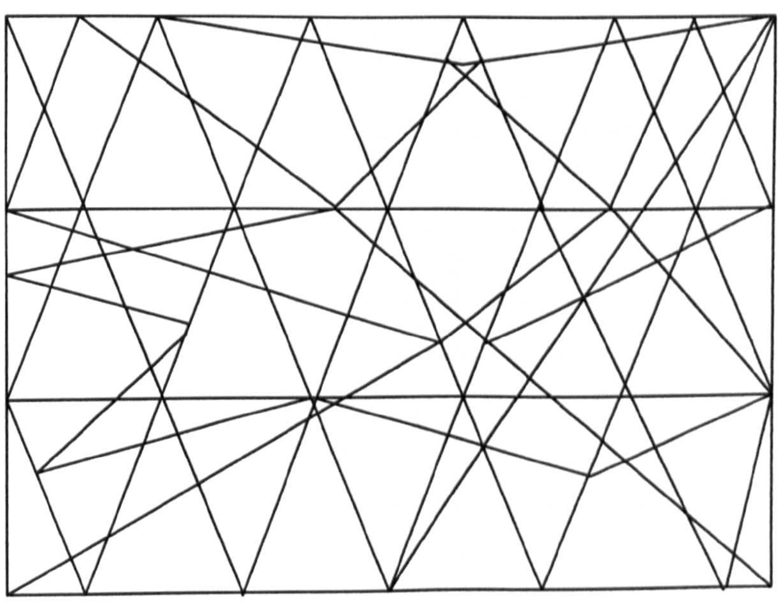
Find shape C



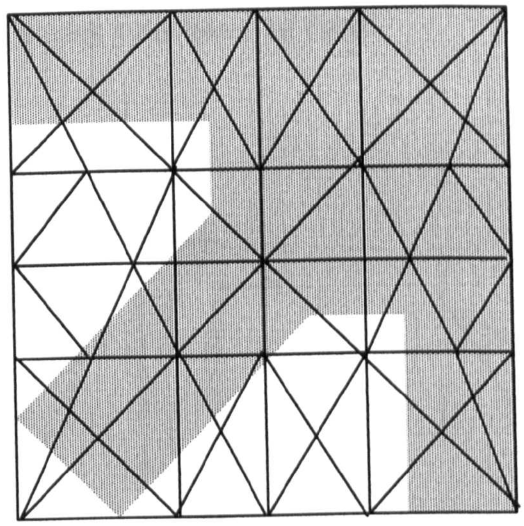
Find shape B



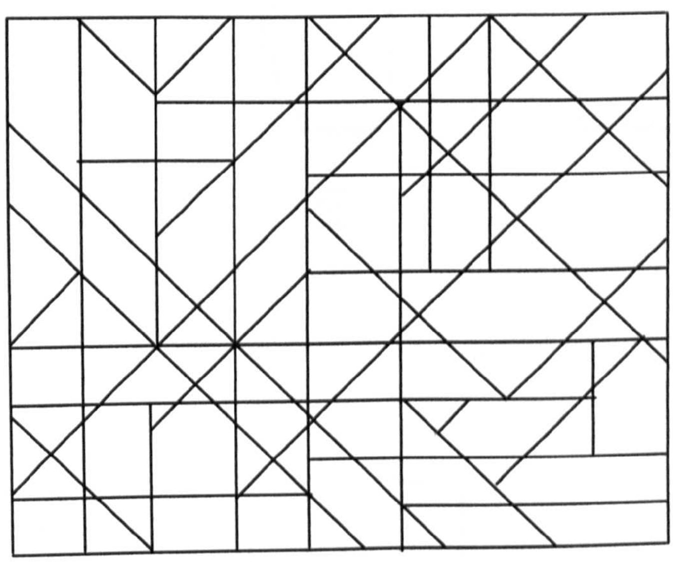
Find shape D



Find shape A

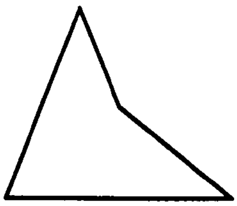


Find shape E

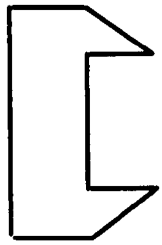


Find shape F

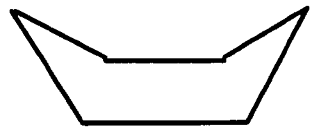
The shapes you have to find



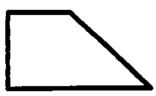
A



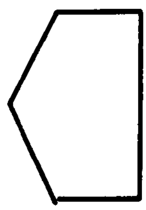
B



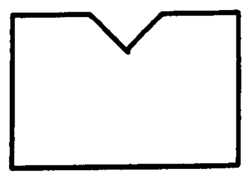
C



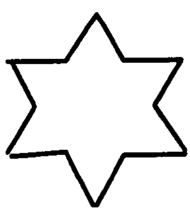
D



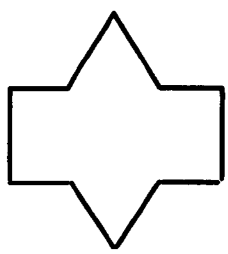
E



F

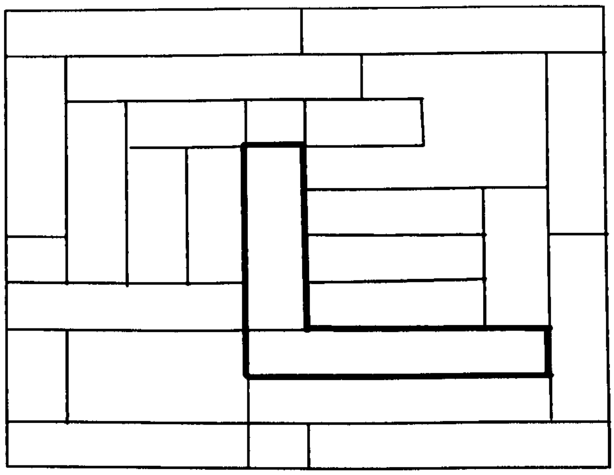


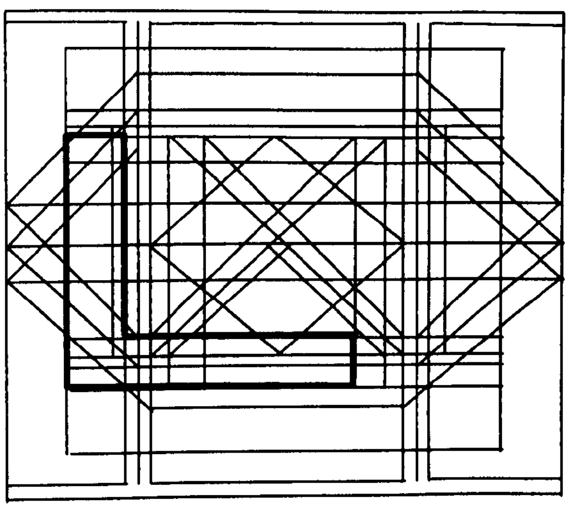
G

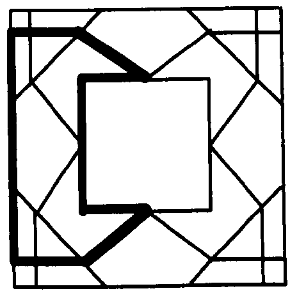


H

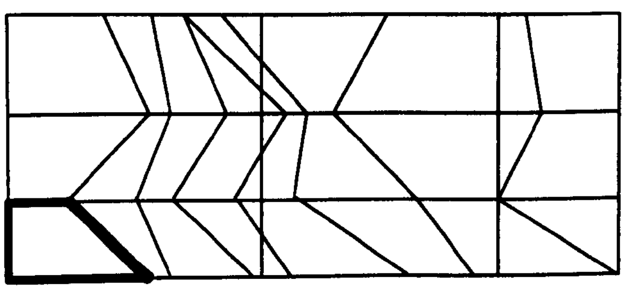
ANSWERS TO SHAPES



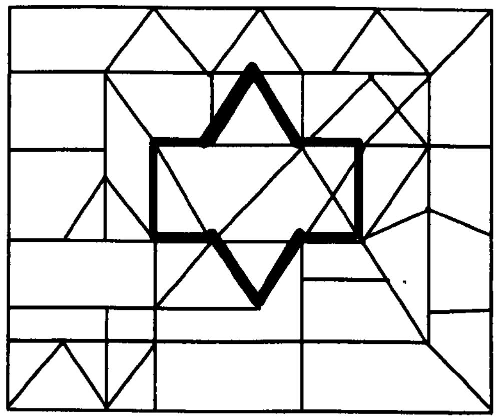




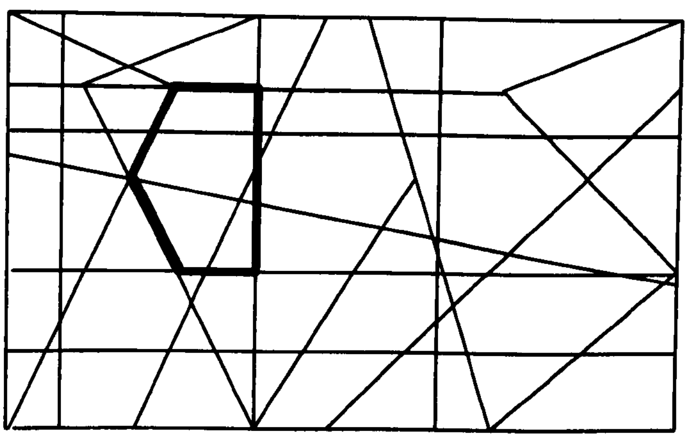
Find SHAPE B



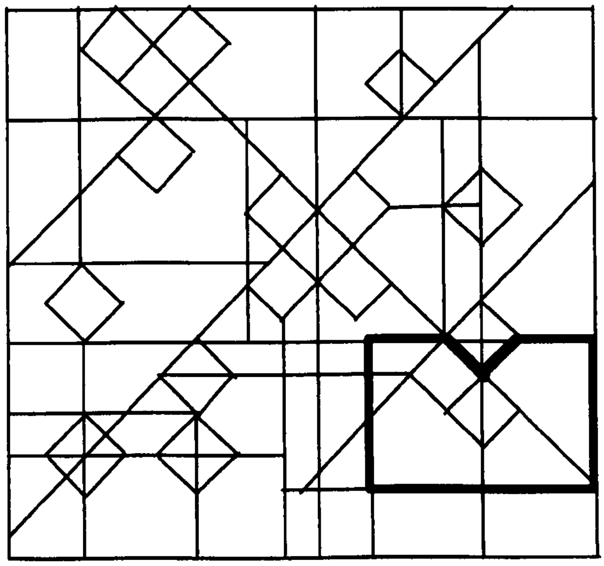
Find SHAPE D



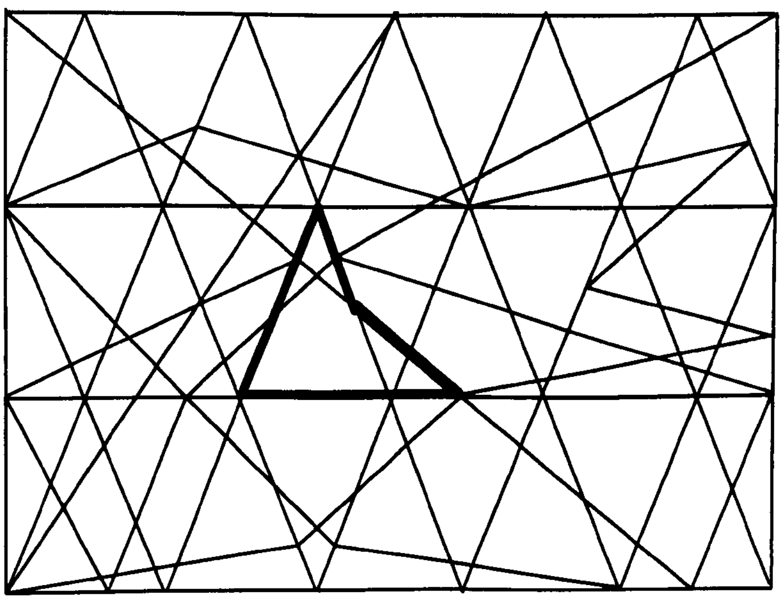
Find SHAPE H



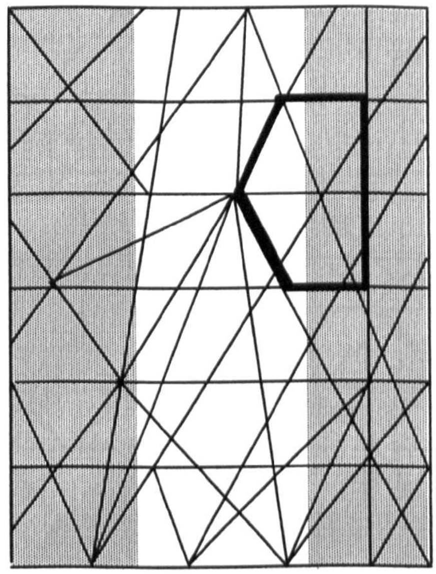
Find SHAPE E



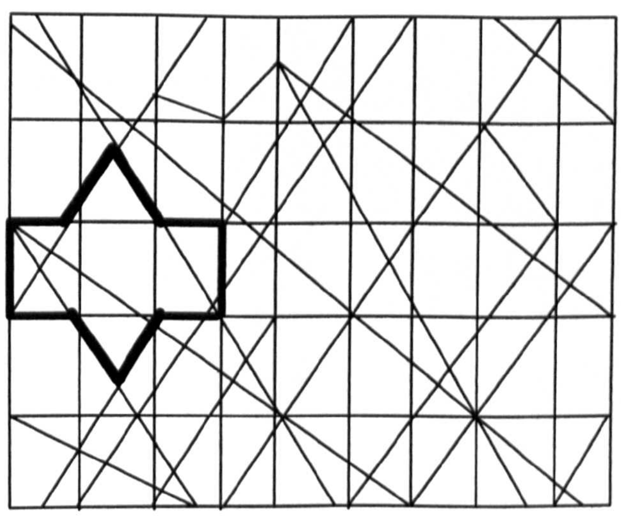
Find SHAPE F



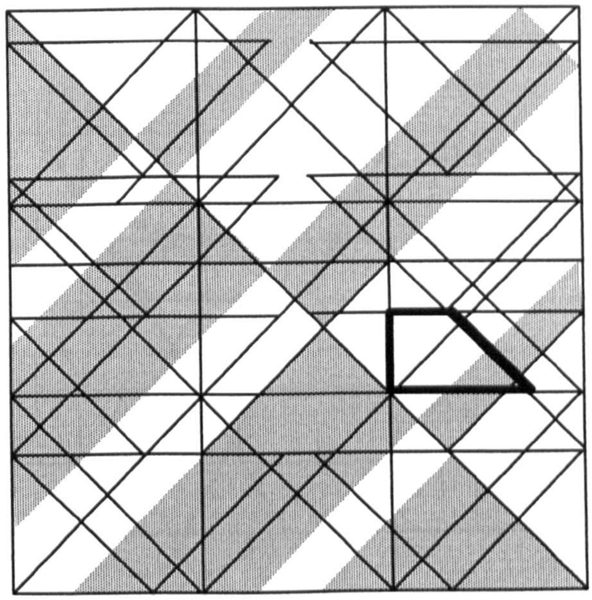
Find SHAPE A



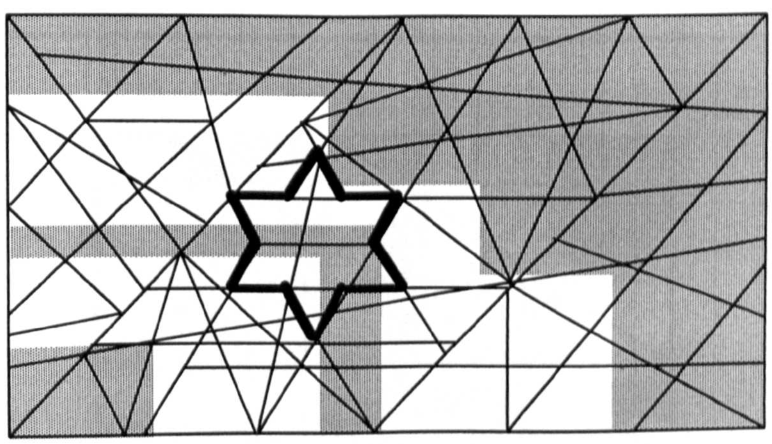
Find SHAPE E



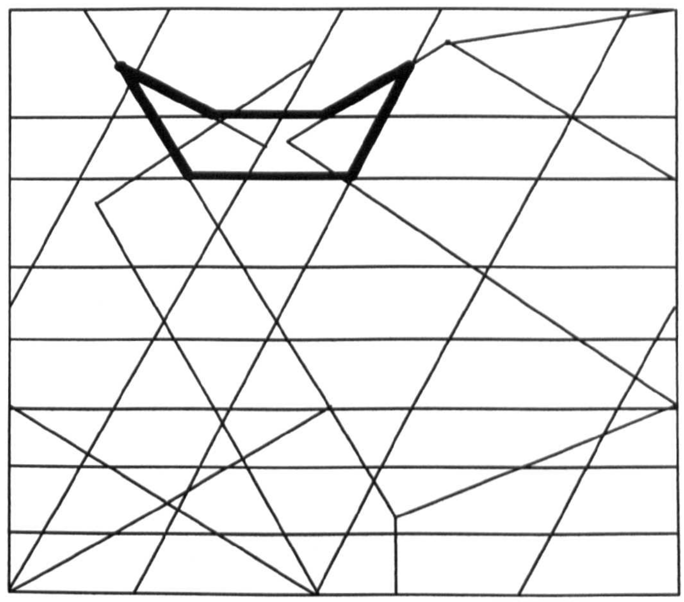
Find SHAPE H



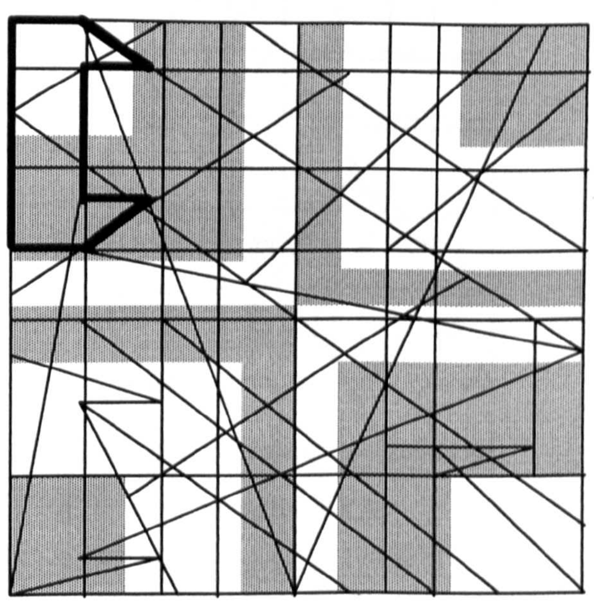
Find SHAPE D



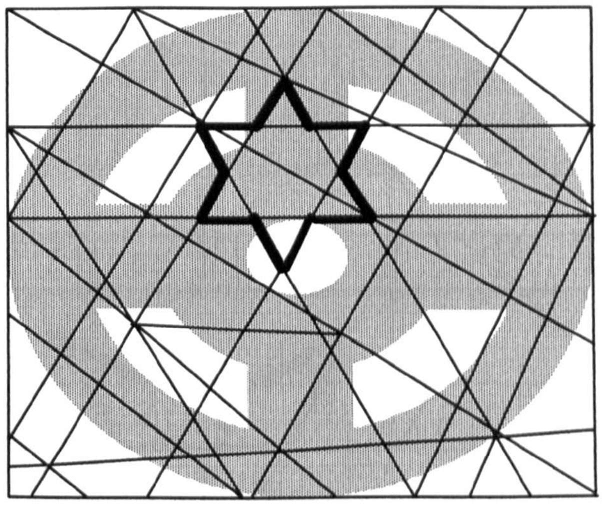
Find SHAPE G



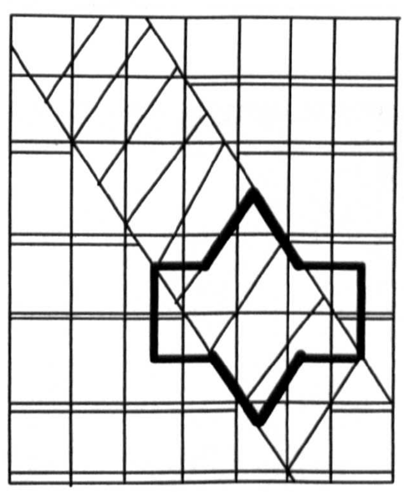
Find SHAPE C



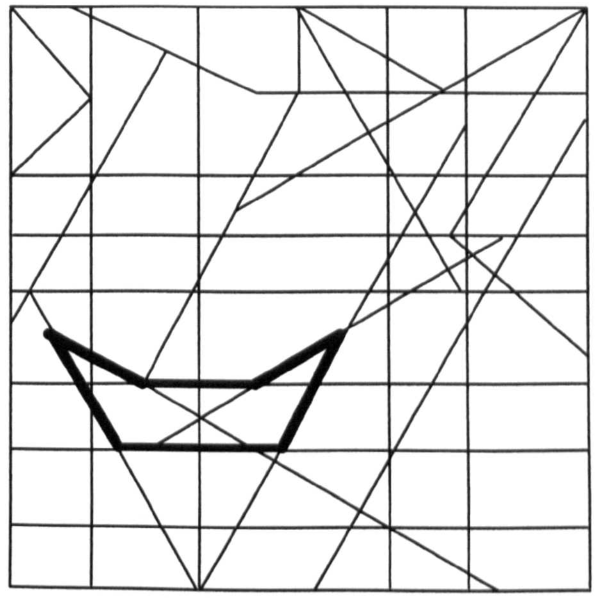
Find SHAPE B



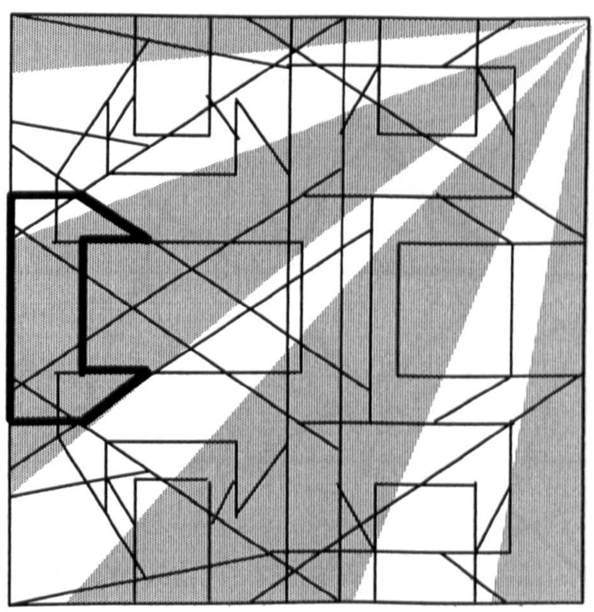
Find SHAPE G



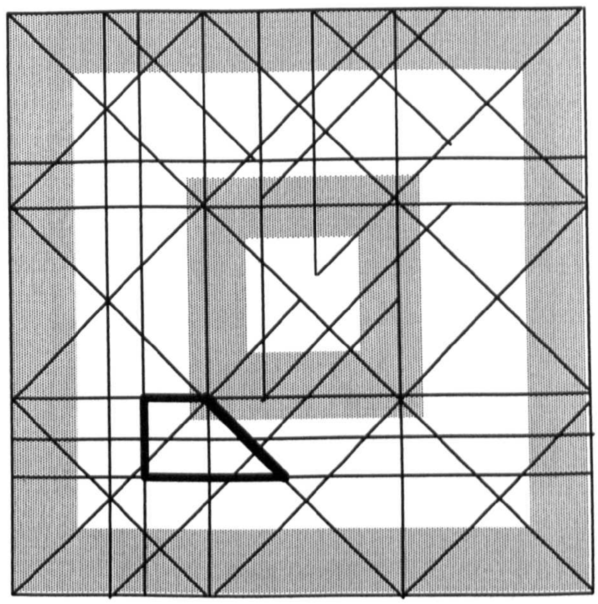
Find SHAPE H



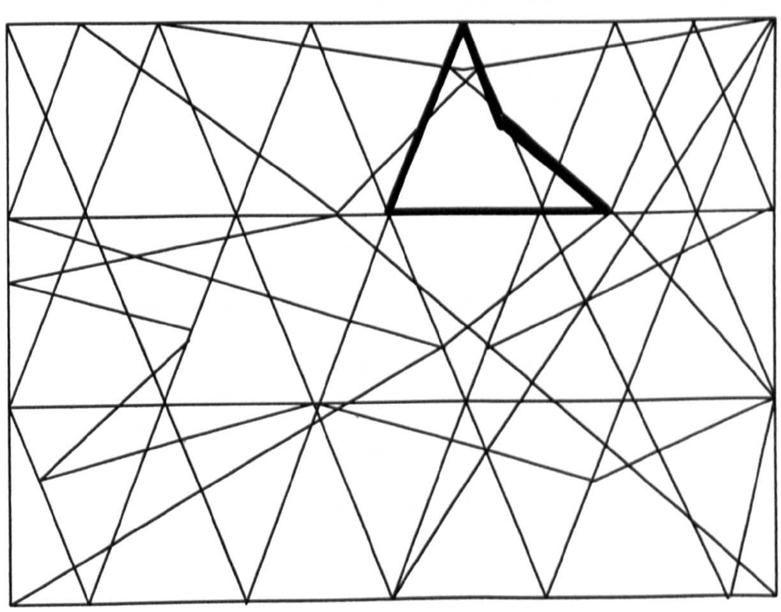
Find SHAPE C



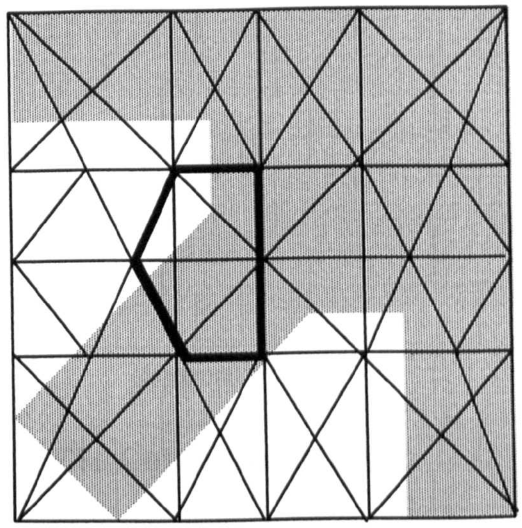
Find SHAPE B



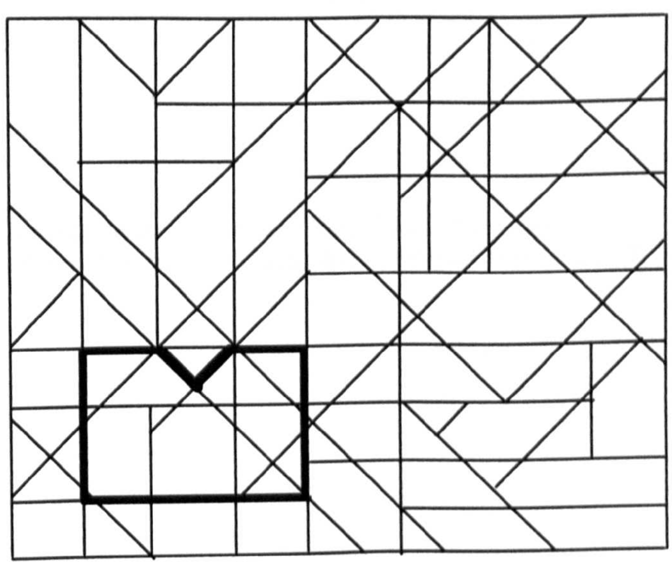
Find SHAPE D



Find SHAPE A



Find SHAPE E



Find SHAPE F

Appendix B

The Convergence Tests

Notes

I. The Greek Convergent and Divergent Test (Pages: *B-2 – B-7*)
II. The English Version of the Convergent and Divergent Test (Pages: B-8 – B-15)

Σχολείο:.. ....

Τμήμα: ....

Κωδικός μαθητή: ....

ΤΕΣΤ
ΣΥΓΚΛΙΝΟΥΣΑΣ-ΑΠΟΚΛΙΝΟΥΣΑΣ
ΣΚΕΨΗΣ

Τα παρακάτω τεστ στοχεύουν να μετρήσουν τους τρόπους σκέψης σας.
Τα αποτελέσματα δεν θα επηρεάσουν τους βαθμούς σας με κανένα τρόπο.

Κέντρο Διδακτικής των Φυσικών Επιστημών, Πανεπιστήμιο της Γλασκόβης

Τέστ 1

Όταν γράφουμε, είναι συχνά απαραίτητο να σκεφτόμαστε με πολλές διαφορετικές λέξεις που όμως έχουν το ίδιο νόημα, έτσι ώστε δε χρειάζεται να επαναλαμβάνουμε μία λέξη ξανά και ξανά. Σ' αυτό το τεστ θα σας ζητηθεί να σκεφτείτε λέξεις που έχουν το ίδιο ή παραπλήσιο νόημα με της λέξη που έχει δοθεί. Οι δεδομένες λέξεις θα είναι τέτοιες που σας είναι πολύ γνωστές.

Παράδειγμα:Εάν η λέξη ήταν βραχύς θα μπορούσες να γράψεις μερικές από τις παρακάτω λέξεις:

Βραχύς: μικρός	σύντομος	περιληπτικός	στιγμιαίος
περιορισμένος	ελλιπής	ανεπαρκής	λακωνικός
συμπαγής	συντομευμένος		

Τώρα προσπάθησε να γράψεις όσες περισσότερες λέξεις που έχουν το ίδιο νόημα με τις ακόλουθες λέξεις

1. Καλός:

....
....
....

2. Προχωρώ:

....
....
....

3. Έξυπνος:

....
....
....

4 λεπτά

<u>Τέστ 2</u>

Σ' αυτό το τεστ σας ζητείται να γράψετε όσες πιο πολλές προτάσεις μπορείτε. Κάθε πρόταση πρέπει να περιέχει τις τέσσερις λέξεις που σας δίνονται και όσες άλλες λέξεις εσείς θέλετε. Οι λέξεις πρέπει να χρησιμοποιηθούν όπως είναι και οι προτάσεις μπορεί να έχουν οποιοσδήποτε μήκος.

<u>Παράδειγμα:</u> Χώρα μυστηρίου είναι πατρίδα

1.Η χώρα του Νείλου είναι η πατρίδα του μυστηρίου.

2.Η Ελλάδα είναι χώρα μυστηρίου και πατρίδα του σύγχρονου Ευρωπαϊκού πολιτισμού.

3. Πατρίδα του ελεύθερου ανθρώπου είναι κάθε χώρα μυστηρίου και ευκαιρίας για ανεύρεση καλύτερης τύχης.

Τώρα προσπάθησε να βρεις προτάσεις με τις παρακάτω λέξεις. Αρίθμησε τις προτάσεις όπως στο παραπάνω παράδειγμα.

1. όλοι γράφουν πάνω μαθηματικών

....

....

....

....

2. πολύ είδηση έδωσε σημασία

....

....

....

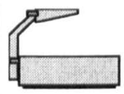
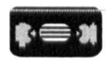
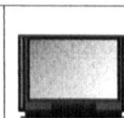
....

4 λεπτά

<u>**Τέστ 3**</u>

Αυτό είναι ένα τεστ που μετράει την ικανότητα σας να σκέφτεστε ένα αριθμό διαφορετικών συμβόλων που μπορεί να χρησιμοποιηθούν για να αντιπροσωπεύσουν ιδέες ή λέξεις. .

<u>Παράδειγμα</u>: Αν η λέξη είναι '**ηλεκτρικά**', αυτή η λέξη μπορεί να αντιπροσωπευθεί με πολλά σύμβολα ή εικόνες όπως φαίνεται παρακάτω. Όπως ξέρετε υπάρχουν ακόμα πολλά σύμβολα ή εικόνες που μπορεί να αντιπροσωπεύουν τη λέξη ηλεκτρικά

Τώρα σχεδιάστε όσα σύμβολα μπορείτε να σκεφτείτε (το πολύ μέχρι πέντε) για κάθε λέξη που σας δίνεται παρακάτω.

1. Επικοινωνία

2. Τέχνη

3. Φωτιά

4. Ευτυχία

5 λεπτά

Τεστ 4

Αυτό είναι ένα τεστ για να δεις πόσα πράγματα μπορείς να σκεφτείς απ' αυτά που μοιάζουν κατά κάποιον τρόπο.

Παράδειγμα:Τι πράγματα είναι πάντα κόκκινα ή είναι κόκκινα πιο συχνά από κάθε άλλο χρώμα; Μπορείς να χρησιμοποιήσεις μία λέξη ή πολλές για να περιγράψεις κάθε πράγμα.

Ντομάτες τούβλα αίμα

Τώρα γράψε όλα τα πράγματα που είναι **στρογγυλά** ή που είναι στρογγυλά συχνότερα απ' οποιοδήποτε άλλο σχήμα.

....	....	....	....
....	....	....	....
....	....	....	....

2 λεπτά

<u>Τεστ 5</u>

Αυτό είναι ένα τεστ της ικανότητας σου να σκέφτεσαι γρήγορα όσες περισσότερες λέξεις μπορείς που αρχίζουν με ένα γράμμα και τελειώνουν με άλλο.

<u>Παράδειγμα:</u>Οι λέξεις στο παρακάτω κατάλογο όλες αρχίζουν με Δ και τελειώνουν σε Σ.

δρομέας δυνατός διαρρήκτης διοργανωτικός

Τώρα προσπάθησε να σκεφτείς λέξεις που αρχίζουν με **Χ** και τελειώνουν σε **Α.**

(Ονόματα ανθρώπων ή τοποθεσίες δεν επιτρέπονται.)

....

....

....

2 λεπτά

Τεστ 6

Αυτό είναι ένα τεστ για να δεις πόσες ιδέες μπορείς να σκεφτείς για ένα θέμα. Σιγουρέψου ότι κατέγραψες όλες τις ιδέες που μπορείς να σκεφτείς για ένα θέμα είτε σου φαίνονται σημαντικές είτε όχι. Μην περιορίζεσαι σε μία λέξη. Αντίθετα μπορείς να χρησιμοποιήσεις μία λέξη ή μία φράση για να εκφράσεις κάθε ιδέα.

Παράδειγμα: Θέμα: 'Ένα ταξίδι με πλοίο'. Παρακάτω σου δίνονται ιδέες για ένα θέμα σαν και αυτό.

Νησιά	λιμάνι	σακίδια	κατάστρωμα
Θάλασσα φουρτουνιασμένη		σφύριγμα πλοίου	

Τώρα γράψε ιδέες που σου έρχονται στο μυαλό με θέμα **'γιορτές'**

....

....

....

3 λεπτά

ΤΕΛΟΣ

Name: ....

School: ....

Class: ....

THE CONVERGENT AND DIVERGENT TEST

These tests aim to measure your ways of thinking.
The results will NOT affect your academic work or exams in any way.

Centre for Science Education, University of Glasgow

TEST 1

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

For example:
If the word was SHORT you would write at least some of the words written below:

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

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

1. Strong:

....	....	....	....
....	....	....	....
....	....	....	....

2. Clear:

....	....	....	....
....	....	....	....
....	....	....	....

3. Dark:

....	....	....	....
....	....	....	....
....	....	....	....

4 Minutes

TEST 2

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

For example:

TAKE FEW LAND LITTLE

1. Few crops take little land.
2. A few little boats supplies to land.
3. Could you take a few little people with you to see my green land?

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

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

1. WRITE WORDS LONG OFTEN

....

....

....

....

2. FRIEND MAN YEAR CATCH

....

....

....

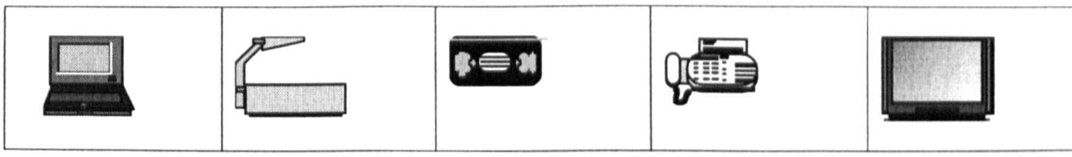
....

4 Minutes

TEST 3

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

For example:
The word is 'electronics'. This word could be represented by many symbols or drawings as shown below. As you know there are many other symbols that could represent the word 'electronics'?



Now draw as many symbols as you can think of (up to five) for each word or subject below.
Each drawing can be a complicated or as simple as you choose. (No artistry required)

1. Energy

2. Happiness

3. Technology

4. Silence

5 Minutes

TEST 4

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

For example:

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

tomatoes bricks blood

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

....	....	....	....
....	....	....	....
....	....	....	....

2 Minutes

TEST 5

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

For example:

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

sun	spin	stain	solution

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

....	....	....	....
....	....	....	....
....	....	....	....

2 Minutes

TEST 6

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

For example:

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

Number of miles	suitcases	the railway stations	people in the train

Now list all the ideas you can think about 'working in laboratories'.

....	....	....	....
....	....	....	....
....	....	....	....

3 Minutes

END OF TESTS

Appendix C
The Perry Questionnaires

<u>**Notes**</u>

I. The Greek Perry Questionnaire (Pages: *C-2 – C-3*)
II. The English Translation of The Perry Questionnaire (Pages: *C-4 – C-5*)

Με ποιο τρόπο μου αρέσει να μαθαίνω τις φυσικές επιστήμες

Ονοματεπώνυμο: ……………………………………………………………………………
Σχολείο:…………………………………….. Τμήμα:……………………………

Το ερωτηματολόγιο αυτό είναι μέρος μία έρευνας που σκοπό έχει να ανακαλύψει ποια είναι η γνώμη σας για την εκμάθηση και την διδασκαλία των φυσικών επιστημών. Οι απαντήσεις σας θα μείνουν εμπιστευτικές και δεν θα επηρεάσουν τους βαθμούς σας.

Σας δίνονται ζεύγη από αντίθετες προτάσεις με πέντε τετράγωνα μεταξύ τους. Μαρκάροντας ένα από τα τετράγωνα δείχνεις με ποια πρόταση συμφωνείς και πόσο δυνατή είναι η συμφωνία σου.

Παράδειγμα:

Πρόταση						Πρόταση
Μου αρέσει να ακούω ράδιο όταν διαβάζω						Θέλω απόλυτη ησυχία όταν διαβάζω

Αν μαρκάρεις το πρώτο αριστερό τετράγωνο σημαίνει ότι συμφωνείς απόλυτα με την αριστερή πρόταση. Αν μαρκάρεις το δεύτερο αριστερό τετράγωνο σημαίνει ότι συμφωνείς με την αριστερή πρόταση αλλά όχι τόσο απόλυτα. Αν μαρκάρεις το τρίτο τετράγωνο σημαίνει ότι είσαι ουδέτερος. Τα άλλα δύο τετράγωνα στα δεξιά δείχνουν ότι συμφωνείς με την δεξιά πρόταση.

	Πρόταση						Πρόταση
Q_1	Για να περάσω τα μαθήματα χρειάζεται να διαβάζω μόνο ότι λέει ο καθηγητής/τρια μου.						Δεν πρέπει να βασίζομαι μόνο στον καθηγητή/τρια μου. Μέρος της μάθησης μου βασίζεται σε δική μου πρωτοβουλία
Q_2	Δεν πιστεύω ότι μου λέει ο καθηγητής/τρια μου χωρίς να το εξετάζω. Η επιτυχία μου εξαρτάται και από το να σκέφτομαι μόνος μου						Δεν υπάρχει περίπτωση να κάνω λάθος αν ακολουθώ ότι λέει ο καθηγητής/τρια μου. Αν εξετάζω ταπάντα στο τέλος θα αποτύχω.
Q_3	Πιστεύω ότι δουλειά του καθηγητή/τριας μου είναι να μου παρέχει όλη την γνώση που μου χρειάζεται						Καθήκον του καθηγητή μου είναι όχι να μου διδάξει τα πάντα αλλά να με μάθει να σκέφτομαι
Q_4	Νομίζω ότι ο καθηγητής/τρια πρέπει να αποφεύγει να διδάσκει πράγματα που δυσκολεύουν τους μαθητές						Ο καθηγητής/τρια πρέπει να προκαλεί τους μαθητές του διδάσκοντας και δύσκολα πράγματα
Q_5	Είναι καλό να δουλεύω με τους συμμαθητές μου γιατί ακούγοντας και την άποψη των άλλων διορθώνω τις ιδέες μου						Δεν μου αρέσει να δουλεύω με άλλους μαζί γιατί η πιθανότητα να καταλάβω τις λάθος ιδέες είναι μικρή
Q_6	Το μόνο που χρειάζεται για να μάθει κανείς τις φυσικές επιστήμες είναι να αποστηθίζει πράγματα						Το κλειδί για να κατανοήσει κάποιος τις φυσικές επιστήμες είναι να τις καταλαβαίνει και όχι να τις αποστηθίζει
Q_7	Δεν νομίζω ότι υπάρχει 'απόλυτη αλήθεια' ακόμα και στην επιστημονική γνώση						Δεν μπορούμε να ονομάζουμε κάτι επιστημονική γνώση αν αυτό δεν είναι απολύτως αληθές
Q_8	Δεν μου αρέσουν οι σύντομες απαντήσεις γιατί δεν μου δίνουν την ευκαιρία να εξηγήσω τι ξέρω και τι καταλαβαίνω						Μου αρέσει να μαθαίνω τα γεγονότα και μετά να εξετάζομαι με σύντομες απαντήσεις

Q_9	Μου αρέσει να εξετάζομαι σε ερωτήσεις που έχω διδαχθεί						Μου αρέσει να εξετάζομαι σε ερωτήσεις που μου δίνουν την δυνατότητα να σκεφτώ και πέρα από ότι έχω διδαχθεί
Q_{10}	Πιστεύω ότι στα διαγωνίσματα σημασία έχει η ποιότητα των απαντήσεων και όχι τόσο η ποσότητα αυτών που γράφω						Στα διαγωνίσματα περιμένω να ανταμειφθώ για το γεγονός ότι απαντώ δίνοντας όσο πιο πολλές πληροφορίες μπορώ.

Σημείωσε το τετράγωνο που αντιπροσωπεύει πιο πολύ την άποψή σου.

ΣΗΜΕΙΩΣΗ: ΣΑ = Συμφωνώ Απόλυτα Σ = Συμφωνώ Ο = Είμαι Ουδέτερη/ος

Δ = Διαφωνώ ΔΡ = Διαφωνώ Ριζικά

	Πρόταση	ΣΑ	Σ	Ο	Δ	ΔΡ
E_1	Μερικές φορές υπάρχουν τόσοι διαφορετικοί τρόποι να κοιτάζεις τις φυσικές επιστήμες που αισθάνομαι μπερδεμένος/νη για το τι είναι σωστό και τι λάθος					
E_2	Μερικές φορές βρίσκω ότι μαθαίνω περισσότερα για ένα αντικείμενο αν το συζητήσω με τους συμμαθητές μου παρά να κάθομαι στο σπίτι και να κάνω επανάληψη μόνος μου					
E_3	Δεν έχει νόημα να διδασκόμαστε πράγματα στην τάξη που δεν θα πέσουν στα διαγωνίσματα					
E_4	Αν είχα την δυνατότητα να διαλέξω στο τέλος της διδασκαλίας μίας διδακτικής ενότητας μεταξύ ερωτήσεων που μου ζητάτε να κάνω σχόλια και να πω την άποψη μου και μεταξύ ερωτήσεων του τύπου πολλαπλής επιλογής θα προτιμούσα τις ερωτήσεις με τα σχόλια					
E_5	Είναι χάσιμο χρόνου να δουλεύεις προβλήματα για τα οποία δεν έχεις την πιθανότητα να βρεις μία ξεκάθαρη και σωστή απάντηση					
E_6	Νοιώθω άβολα όταν μου δίνεται η ευκαιρία να πω την άποψη μου χωρίς να ξέρω την άποψη αυτού που με ρωτάει					
E_7	Το καλό με τις φυσικές επιστήμες είναι ότι όλα είναι ξεκάθαρα, είτε σωστό είτε λάθος					
E_8	Μου αρέσουν τα διαγωνίσματα που μου δίνουν την ευκαιρία να δείξω ότι έχω δικές μου ιδέες για τα πράγματα					

Ευχαριστώ πολύ για την βοήθειά σας

Κέντρο Διδακτικής των Φυσικών Επιστημών Πανεπιστήμιο της Γλασκόβης

The Way I like to Learn Science

This questionnaire is part of a study which aims to find what your views are about teaching and learning science. Your response will be treated confidentially and will not affect your College results

You are providing with pairs of opposing statements with six boxes between. By ticking **ONE** of the boxes you can show which statement you agree with and how strongly your agreement is. Here is an example:

Statement						Statement
I like to hear radio while I am studying						I can not stand any background noise when I am studying

If you tick the first left box, it means you agree strongly with left-hand statement. If you tick the second box, it means you favour the left-hand statement but less strongly. If you tick the third box, it means you slightly favour the left-hand statement. The other two boxes on the right would show agreement with the right-hand statement. Tick (√) the box which most closely reflects your views.

	Statement						Statement
Q_1	In order to pass my courses, I need to study just what the teacher tell me						I do not have to rely totally on the teacher. Part of my learning is to work things out myself
Q_2	I do not believe in just accepting what the teacher says without question. Success involves thinking for myself						I cannot be wrong if I accept what the teacher says. If I question anything, I might end up failing
Q_3	I believe it is the job of the teacher to supply me with all the knowledge I need.						The duty of the teacher is not to teach me everything, but to help me to think for myself.
Q_4	I think teachers should avoid materials that they know pupils difficult.						Teachers should aim to provide challenges to their pupils by introducing difficult topics.
Q_5	It is good to work with other pupils because, by listening to their points of view, I can correct my ideas.						I prefer not to work with other pupils because then I stand less chance of picking up wrong ideas
Q_6	All one has to do in science is to memorise things.						Understanding science is the key part of science study.
Q_7	I do not believe that all scientific knowledge represents the ' absolute truth'.						We cannot call anything scientific knowledge if it is not absolutely true.
Q_8	I do not like short questions as the give me the chance to explain wha and understand.						I prefer to learn the facts and then be tested on them in short questions

	Statement						Statement
Q_9	In exams I prefer questions which are based on what the teacher taught.						In exams, I like questions that give me the scope to go beyond what is taught and show my ability to think
Q_{10}	I believe that what should matter in exams is the quality of my answers, not how much I write.						In exams, I expect to be rewarded for giving as much information as possible.

Tick (✓) the box which most closely reflects your views.

SA= Strongly agree A = Agree U = Uncertain

D = Disagree SD = Strongly disagree

	Statement	SA	A	U	D	SD
E_1	Sometimes there seem to be so many ways of looking at science that I feel confused about what is right and wrong.					
E_2	Sometimes I find I learn more about a subject by discussing it with other pupils than I do by sitting and revising at home.					
E_3	There is not any point in class teaching, which include things which will not be in the exam.					
E_4	If I have the choice to write comments and to offer my opinion in a question or to answer with multiple-choice questions, I would choose to write comments.					
E_5	It is a waste of time to work on problems which have no possibility of producing a clear-cut, unambiguous answer.					
E_6	I feel uncomfortable when I am left to express an opinion, not knowing the view the lecturer feels.					
E_7	A good thing about learning science is the fact that everything is so clear-cut: either right or wrong.					
E_8	I like exams which give me an opportunity to show I have ideas of my own.					

Thank you for your help.

Centre for Science Education, University of Glasgow.

Appendix D

Pilot Chemistry Test 1

Notes

I. The Greek Pilot Chemistry Test 1 (Pages: *D-2* – *D-5*)
II. The English Translation of the Pilot Chemistry Test 1 (Pages: *D-6* – *D-8*)

Ωριαίο κριτήριο αξιολόγησης

Αντικείμενο εξέτασης: Οξέα-βάσεις-άλατα-οξείδια

ΟΜΑΔΑ Α

Σχολείο..

Όνομα...

Τάξη.. Ημερομηνία ....

Μέρος 1

Κάθε ερώτηση έχει μία **μόνο** σωστή απάντηση. Βάλε σε κύκλο την σωστή απάντηση.

1. Ένα διάλυμα χλωριούχου καλίου (KCl) έχει ουδέτερο pH. Αυτό συμβαίνει γιατί:
   A. Έχει την ίδια συγκέντρωση ιόντων H^+(aq) και ιόντων OH^-(aq)
   B. Δεν υπάρχουν ιόντα H^+ (aq) και ιόντα OH^-(aq) στο διάλυμα
   C. Το χλωριούχο κάλιο είναι ένα αλάτι
   D. Έχει την ίδια συγκέντρωση ιόντων K^+ (aq) και ιόντων Cl^-(aq)
2. Μεταξύ δύο όξινων διαλυμάτων περισσότερο όξινο είναι εκείνο που:
   A. Έχει το μεγαλύτερο pH
   B. Έχει pH> 7
   C. Έχει pH < 7
   D. Έχει το μικρότερο pH
3. Διάλυμα που βρέθηκε στο εργαστήριο έχει pH = 10. Για να εξουδετερώσουμε το διάλυμα πρέπει να προσθέσουμε σε αυτό:
   A. Διάλυμα αμμωνίας
   B. Διάλυμα θειικού οξέος
   C. Διάλυμα χλωριούχου νατρίου
   D. Αποσταγμένο νερό
4. Όταν ένα οξύ αντιδρά με ανθρακικό ασβέστιο τα προϊόντα της αντίδρασης είναι:
   A. Αλάτι του ασβεστίου και υδρογόνο
   B. Αλάτι του ασβεστίου και νερό
   C. Αλάτι του ασβεστίου, νερό και διοξείδιο του άνθρακα
   D. Αλάτι του ασβεστίου, υδρογόνο, νερό και διοξείδιο του άνθρακα
5. Ποια από τις παρακάτω ουσίες όταν διαλύεται στο νερό δίνει όξινο διάλυμα;
   A. Διοξείδιο του θείου
   B. Οξείδιο του καλίου
   C. Οξείδιο του νατρίου
   D. Βρωμιούχο νάτριο
6. Ποια από τα παρακάτω ζεύγη αντιδραστηρίων θα χρησιμοποιήσεις για να φτιάξεις θειικό μόλυβδο; (Χρησιμοποίησε τον πίνακα με τις διαλυτότητες των αλάτων στο τέλος του τεστ)
   A. Νιτρικό μόλυβδο και θειικό βάριο
   B. Φωσφορικό μόλυβδο και θειικό νάτριο
   C. Φωσφορικό μόλυβδο και θειικό βάριο
   D. Νιτρικό μόλυβδο και θειικό νάτριο

7. Διάλυμα υδροξειδίου του νατρίου είναι βασικό γιατί:
   A. Περιέχει περισσότερα ιόντα υδροξυλίου OH^-(aq) από ιόντα υδρογόνου H^+ (aq)
   B. Περιέχει την ίδια συγκέντρωση ιόντων νατρίου Na^+(aq) και ιόντων υδροξυλίου OH^-(aq)
   C. Περιέχει ιόντα υδροξυλίου OH^-(aq) και όχι ιόντα υδρογόνου H^+(aq)
   D. Αλλάζει το χρώμα των δεικτών
8. Ποια από τις παρακάτω ουσίες όταν διαλύεται στο νερό δίνει αλκαλικό διάλυμα;
   A. Οξείδιο του ασβεστίου
   B. Διοξείδιο του αζώτου
   C. Διοξείδιο του άνθρακα
   D. Χλωριούχο κάλιο
9. Δίνεται η αντίδραση μεταξύ οξειδίου του χαλκού και νιτρικού οξέος:
   CuO + HNO3 → Cu(NO3)2 + H2O
   Ποια από τις παρακάτω χημικές εξισώσεις δείχνει τους κατάλληλους συντελεστές της αντίδρασης;
   A. CuO + H2NO3 → Cu(NO3)2 + H2O
   B. CuO + HNO3 → Cu(NO3)2 + H2O
   C. 2CuO + 2HNO3 → Cu(NO3)2 + H2O
   D. CuO + 2HNO3 → Cu(NO3)2 + H2O
10. Ποια από τις παρακάτω χημικές εξισώσεις δείχνει την σωστή αντίδραση μεταξύ χλωριούχου βαρίου και θειικού ψευδαργύρου:
   A. 2BaCl + ZnSO4 → Ba2SO4 + 2ZnCl
   B. BaCl2 + Zn2SO4 → BaSO4 + 2ZnCl
   C. 2BaCl2 + Zn2SO4 → Ba2SO4 + 2ZnCl2
   D. BaCl2 + ZnSO4 → BaSO4 + ZnCl2
11. Όταν το νάτριο αντιδρά με το νερό τα προϊόντα της αντίδρασης είναι:
   A. Βασικό οξείδιο και υδρογόνο
   B. Αλάτι και υδρογόνο
   C. Οξύ και υδρογόνο
   D. Βάση και υδρογόνο
12. Ποιο από τα παρακάτω μέταλλα θα αντιδράσει με ένα από τα διαλύματα;
   A. Cu και διάλυμα Fe(NO3)2
   B. Zn και διάλυμα MgCl2
   C. Fe και διάλυμα Cu(NO3)2
   D. Ag και διάλυμα HC
13. Όταν το CaCl2 διαλύεται στο νερό ποια από τις παρακάτω προτάσεις είναι σωστή;
   A. Το διάλυμα περιέχει διπλάσια συγκέντρωση ανιόντων από κατιόντα
   B. Το διάλυμα περιέχει διπλάσια συγκέντρωση κατιόντων από ανιόντα
   C. Το διάλυμα δεν περιέχει ανιόντα και κατιόντα γιατί έχει pH = 7
   D. Το διάλυμα περιέχει ίδια συγκέντρωση ανιόντων και κατιόντων

<u>Μέρος 2</u>

14. Κοίταξε καλά τον παρακάτω πίνακα και απάντησε στις παρακάτω ερωτήσεις.
    Κάθε ερώτηση μπορεί να έχει περισσότερες από μία απαντήσεις.
    (Χρησιμοποίησε το κάθε τετράγωνο όσες φορές θέλεις

Α Περιέχει πολλά ιόντα υδροξυλίου	**Β** Αντιδρά με το ανθρακικό ασβέστιο και δίνει αέριο διοξείδιο του άνθρακα	**Γ** Μετατρέπει τον παγκόσμιο δείκτη σε κόκκινο
Δ Μετατρέπει τον παγκόσμιο δείκτη σε μπλε	**Ε** Έχει pH μικρότερο από 7	**Ζ** Σχηματίζει χλωριούχες ενώσεις
Η Είναι καλός αγωγός του ηλεκτρισμού	**Θ** Έχει την ίδια συγκέντρωση ιόντων H^+ (aq) και ιόντων OH^-(aq)	**Ι** Αντιδρά με το υδροχλωρικό οξύ και δίνει αλάτι

Βρες τα τετράγωνα που περιέχουν εκφράσεις που αντιστοιχούν σε διάλυμα:

1. Υδροχλωρικού οξέος ....
2. Υδροξειδίου του νατρίου ....
3. Χλωριούχου νατρίου ....

15. Κοίταξε καλά τον παρακάτω πίνακα και απάντησε στις παρακάτω ερωτήσεις. Κάθε ερώτηση μπορεί να έχει περισσότερες από μία απαντήσεις. (Χρησιμοποίησε το κάθε τετράγωνο όσες φορές θέλεις)

Α Θειικό μαγνήσιο	**Β** Τριοξείδιο του φωσφόρου	**Γ** Νιτρικός μόλυβδος
Δ Ιωδιούχο κάλιο	**Ε** Διοξείδιο του αζώτου	**Ζ** Νιτρικό νάτριο
Η Διοξείδιο του θείου	**Θ** Οξείδιο του νατρίου	**Ι** Οξείδιο του ασβεστίου

Βρες τα τετράγωνα που περιέχουν ουσίες:

1. Που τα διαλύματά τους είναι αλκαλικά ....
2. Που τα διαλύματά τους είναι όξινα ....
3. Που προκαλούν την όξινη βροχή ....
4. Που αντιδρούν με την ουσία στο τετράγωνο Δ και
5. δίνουν αντιδράσεις καταβύθισης. ....

(Χρησιμοποίησε τον πίνακα με τις διαλυτότητες των αλάτων στο τέλος του τεστ.)

<u>Μέρος 3.</u>

16. Όταν το κάλιο αντιδρά με το νερό στο οποίο έχουμε προσθέσει δείκτη φαινολοφθαλείνης αλλάζει το χρώμα του διαλύματος σε κόκκινο. Δώσε μία εξήγηση γιατί συμβαίνει αυτό και γράψε την χημική εξίσωση της αντίδρασης.

Εξήγηση:...

Χημική εξίσωση: ....

17. Ασθενείς με στομαχικά προβλήματα υποβάλλονται σε εξέταση ακτινών X και πριν την εξέταση πίνουν ένα βαριούχο διάλυμα. Το διάλυμα είναι θειικό βάριο και νερό. Αυτό φτιάχνεται στο εργαστήριο με αντίδραση καταβύθισης (διπλής αντικατάστασης). Χρησιμοποίησε τις πληροφορίες για την διαλυτότητα των αλάτων στο νερό που σου δίνονται παρακάτω και ονόμασε δύο άλατα που θα χρησιμοποιήσεις για να φτιάξεις το θειικό βάριο. Γράψε την χημική εξίσωση της αντίδραση παρασκευής του θειικού βαρίου.

Άλατα: ....

Χημική εξίσωση: ....

18. Μια μαθήτρια βυθίζει ένα σιδερένιο καρφί σε διάλυμα θειικού χαλκού. Παρατηρεί ότι η επιφάνεια του καρφιού γίνεται καφέ. Δώσε μία εξήγηση γιατί συμβαίνει αυτό και γράψε την χημική εξίσωση της αντίδρασης.

Εξήγηση: ....

Χημική εξίσωση: ....

Πίνακας διαλυτότητας ουσιών στο νερό	
Ευδιάλυτα	**Δυσδιάλυτα**
Νιτρικός μόλυβδος	Ανθρακικό βάριο
Νιτρικό βάριο	Θειικό βάριο
Νιτρικό νάτριο	Φωσφορικός μόλυβδος
Θειικός χαλκός	Θειικός μόλυβδος
Θειικό νάτριο	Ιωδιούχος μόλυβδος
Θειικό μαγνήσιο	
Θειικό μαγνήσιο	
Ιωδιούχο κάλιο	
Ιωδιούχο βάριο	

Name: ....

School: ....

Class: ....

Acids- Bases - Salts - Oxides

<u>Section 1</u>.

Each question has only <u>ONE</u> correct answer. Tick the answer that you think is correct.

1. The solution of NaOH compound in water is alkaline because:
   - ☐ A. It has hydroxide ions OH-(aq) and no hydrogen ions H+(aq)
   - ☐ B. It has sodium ions Na+ (aq) and hydroxide ions OH-(aq)
   - ☐ C. It changes the colour of the indicators
   - ☐ D. It has more hydroxide ions OH-(aq) than hydrogen ions H+(aq)

2. A solution of potassium chloride (KCl) has a neutral pH. This is because the solution contains:
   - ☐ A. The same concentration of potassium ions (K+) and choride ions (Cl-)
   - ☐ B. The same concentration of the hydrogen ions H+(aq) and hydroxide ions OH-(aq)
   - ☐ C. No hydrogen ions H+(aq) and hydroxide ions OH-(aq)
   - ☐ D. Potassium chloride which is a salt

3. Between two acids solutions the more acid is:
   - ☐ A. The one that has the larger pH
   - ☐ B. The one that has the smaller pH
   - ☐ C. The one that has pH > 7
   - ☐ D. The one that has pH<7

4. A solution found in a lab has a pH of 10. In order to neutralise the solution what should we add?
   - ☐ A. Ammonia solution
   - ☐ B. Sodium chloride solution
   - ☐ C. Sulphuric acid solution
   - ☐ D. Distilled water

5. When an acid reacts with a calcium carbonate, the products formed are a:
   - ☐ A. Calcium salt, hydrogen and water
   - ☐ B. Calcium salt and water
   - ☐ C. Calcium salt, water and carbon dioxide
   - ☐ D. Calcium salt, hydrogen, carbon dioxide and water

6. Which compound would produce an alkaline solution when dissolved in water?
   - ☐ A. Nitrogen dioxide
   - ☐ B. Calcium oxide
   - ☐ C. Carbon dioxide
   - ☐ D. Potasium chloride

7. Which compound would produce an acidic solution when dissolved in water?
   - ☐ A. Potassium oxide
   - ☐ B. Sodium oxide
   - ☐ C. Sulphur dioxide
   - ☐ D. Sodium bromide

8. Which pair of chemical could you use to make lead sulphate?
   (Use information given at the end of the test for the solubility of some compounds)
   - ☐ A. Lead nitrate and barium sulphate
   - ☐ B. Lead nitrate and sodium sulphate
   - ☐ C. Lead phosphate and sodium sulphate
   - ☐ D. Lead phosphate and barium sulphate

9. The reaction between copper oxide and nitric acid is given below

CuO + HNO3 Cu(NO3)2 + H2O

The correct balanced equation is:

- ☐ A. CuO + H2NO3 Cu(NO3)2 + H2O
- ☐ B. CuO + 2HNO3 Cu(NO3)2 + H2O
- ☐ C. CuO + HNO3 Cu(NO3)2 + H2O
- ☐ D. 2CuO + 2HNO3 Cu(NO3)2 + H2O

10. Which is the balanced equation for the reaction of barium chloride solution with zinc sulphate solution?

- ☐ A. BaCl2 + ZnSO4 BaSO4 + ZnCl2
- ☐ B. 2BaCl + ZnSO4 Ba2SO4 + 2ZnCl
- ☐ C. BaCl2 + Zn2SO4 BaSO4 + 2ZnCl
- ☐ D. 2BaCl2 + Zn2SO4 Ba2SO4 + 2ZnCl2

11. When sodium reacts with water the products made are:

- ☐ A. a salt and hydrogen
- ☐ B. an alkaline solution and hydrogen
- ☐ C. an alkaline oxide and hydrogen
- ☐ D. an acid and hydrogen

12. Which of the following metal will react with the given solutions?

- ☐ A. Cu and Fe(NO3)2
- ☐ B. Fe and Cu(NO3)2
- ☐ C. Zn and MgCl2
- ☐ D. Ag and HCl

13. CaCl2 dissolves in water. Which of the following statements is correct:

- ☐ A. The amount of cations and anions are the same
- ☐ B. The amount of cations are double of the amount of anions
- ☐ C. The amount of anions are double of the amount of cations
- ☐ D. There are no anions and cations because it has a pH= 7

Section 2

14. Look at the boxes and answer the following questions.
Each question may have more than one answer.
(You may use the box as many times as you wish)

A Contains same number of hydrogen ions $H^+(aq)$ and hydroxide ions $OH^-(aq)$	**B** It reacts with calcium carbonate and gives carbon dioxide gas	**C** It turns universal indicator blue
D It turns universal indicator red	**E** It reacts with hydrochloric acid and gives a salt	**F** It forms compounds called chloride
G It conducts electricity	**H** It contains many hydroxide ions	**I** It has a pH less than 7

Select the box(es) which contain statements which are true about:

1. Hydrochloric acid solution
2. Sodium hydroxide solution
3. Sodium chloride solution

15. Look at the boxes and answer the following questions.

Each question may have more than one answer.
(You may use the box as many times as you wish)

A Sodiumoxide (Na_2O)	B Lead nitrate $Pb(NO_3)_2$	C Phosphorus trioxide (P_2O_3)
D Bariumiodide (BaI_2)	E Calciumoxide (CaO)	F Sodiumnitrate $NaNO_3$
G Sulphur dioxide (SO_2)	H Magnesiumsulphate $MgSO_4$	I Nitrogen dioxide NO_2

Select the box(es) which contain compounds which:

1. Produce alkaline solutions ....
2. Produce acidic solutions ....
3. Cause the acid rain ....
4. Can react with the salt in box D and give a precipitation reaction................

(Use information given at the end of the test for the solubility of some compounds)

Section 3

16. When potassium reacts with water which contains phenolphthalein indicator the color of the solution changes into red. Give an explanation why this happens and write the balanced equation for the reaction.

    Explanation: ....

    Equation: ....

17. Patients with stomach problems are given a 'barium meal' before being X-rayed. It consists of a suspension of barium sulphate in water. This salt can be prepared in the laboratory by a recipitation reaction. Using information given below for the solubility of some compounds, name two salts solution which could be mixed to prepare barium sulphate and write the balanced equation for the reaction.

    Two salts: ....

    Balanced Equation:..

18. A pupils hangs an iron nail in copper (II) sulphate solution. She notices the surface of the nail turns brown. Give an explanation why this happens and write the balanced equation for the reaction.

    Explanation: ....

    Balanced Equation: ....

Solubility of some compounds in water
(v.s = very soluble in water, i= insoluble in water)

Barium iodide (v.s)	Sodium sulphate (v.s)
Barium carbonate (i)	Copper (II) sulphate (v.s)
Barium nitrate (v.s)	Lead (II) sulphate (i)
Lead phosphate (i)	Lead nitrate (v.s)
Sodium nitrate (v.s)	Barium sulphate (i)
Magnesium sulphate (v)	

Marking scheme

Section 1: 13 marks. Thirteen Multiple-Choice questions (MC), each MC question 1 mark.

Section 2: 14 marks.

Question 14 SCG has 3 sub questions (2 marks each)

Question 14 correct answers:
1: A, D, F, G, I (0.4 mark each correct answer)
2.: C, E, G, H (0.5 mark for each correct answer)
3: A, F, G (0.66 mark for each correct answer)

Question 15SCG has 4 sub questions (2 marks each)
Question 15 correct answers:
1:A, E (1 mark each)
2: C, G, I (0.66 mark each)
3: G, I (1 mark each)
4: B (2marks)

In general if one correct and one incorrect answer are given, zero marks are awarded.

If two incorrect answers are given, zero marks are awarded. It is considered that 2 incorrect answers indicate guessing and limited understanding.

Section 3: 12 marks: Each question 4 marks (each sub question 2 marks).

Appendix E

The Greek Chemistry Tests (1, 2, 3, 4, 5)

Notes

Τεστ 1: Ατομική Θεωρία

Σχολείο..

Όνομα...

Τάξη.. Ημερομηνία ....

Μέρος 1: Κάθε ερώτηση έχει μία μόνο σωστή απάντηση. Σημειώστε την σωστή απάντηση.

1. Ποιος είναι ο όγκος σε λίτρα 240g λαδιού αν η πυκνότητα του λαδιού είναι 0,8 g/mL; (1)
   - A. 300L
   - B. 0,3L
   - C. 192L
   - D. 0,19L

2. Ποιο από τα παρακάτω αντιπροσωπεύει σωστά τα ηλεκτρικά φορτία από τα τρία βασικά σωματίδια που αποτελούν τα άτομα: (1)

	πρωτόνιο	νετρόνιο	ηλεκτρόνιο
A.	+1	0	+1
B.	+1	0	-1
C.	0	0	+1
D.	+1	+1	-1

3. Το άτομο του στοιχείου X περιέχει 13 πρωτόνια και 14 νετρόνια. Ποιο από τα παρακάτω αντιπροσωπεύει σωστά το άτομο αυτό; (1)
   - A. $^{14}_{13}X$
   - B. $^{27}_{14}X$
   - C. $^{27}_{13}X$
   - D. $^{13}_{27}X$

4. Δύο ισότοπα του άνθρακα $^{12}_{6}C$ και $^{14}_{6}C$ διαφέρουν μεταξύ τους: (1)
   - A. στους μαζικούς αριθμούς
   - B. στους ατομικούς αριθμούς
   - C. στις χημικές ιδιότητες
   - D. στον αριθμό των ηλεκτρονίων

5. Ο ατομικός αριθμός του καλίου είναι 19 και ο μαζικός αριθμός είναι 39. Ποια από τις παρακάτω προτάσεις αντιπροσωπεύει σωστά τα ατομικά σωματίδια που βρίσκονται στο ιόν του K+: (1)
   - A. 19 πρωτόνια 20 νετρόνια 19 ηλεκτρόνια
   - B. 19 πρωτόνια 20 νετρόνια 18 ηλεκτρόνια
   - C. 20 πρωτόνια 19 νετρόνια 18 ηλεκτρόνια
   - D. 20 πρωτόνια 19 νετρόνια 18 ηλεκτρόνια

6. Όταν ένας μαγνήτης περνά πάνω από ένα δείγμα που περιέχει μεταλλική σκόνη μέρος του δείγματος ελκύεται από τον μαγνήτη. Το δείγμα είναι: (1)
   - A. ένα στοιχείο
   - B. καθαρή ουσία
   - C. ομογενές μείγμα

D. ετερογενές μείγμα

7. Ποια από τις παρακάτω προτάσεις περιγράφει συνήθως ένα φυσικό φαινόμενο; (1)

A. το σκούριασμα του σιδήρου
B. η καύση του μαγνησίου στον αέρα
C. το σάπισμα του μήλου
D. η εξάτμιση του οινοπνεύματος

8. Ποια από τις παρακάτω προτάσεις περιγράφει ένα χημικό φαινόμενο; (1)

A. η καύση του ξύλου
B. η μετατροπή του νερού σε ατμό σε ένα ηλεκτρικό βραστήρα
C. η εξάχνωση του ιωδίου
D. η παραγωγή αλατιού από το θαλασσινό νερό με εξάτμιση του νερού

9. Ποια από τις παρακάτω ουσίες είναι καθαρή ουσία; (1)

A. ο αέρας
B. το γάλα
C. το διοξείδιο του άνθρακα
D. η βροχή

10. Η διαλυτότητα του AgCl στο νερό είναι μέγεθος που εκφράζει: (1)

A. τη μάζα του AgCl που μπορεί να διαλυθεί σε ορισμένη ποσότητα νερού σε ορισμένη θερμοκρασία
B. την μέγιστη μάζα του AgCl που μπορεί να διαλυθεί σε ορισμένη ποσότητα νερού σε ορισμένη θερμοκρασία
C. την μέγιστη μάζα του AgCl που μπορεί να διαλυθεί σε νερό σε ορισμένη θερμοκρασία
D. την ελάχιστη μάζα του AgCl που μπορεί να διαλυθεί σε ορισμένη ποσότητα νερού σε ορισμένη θερμοκρασία

11. Η διαλυτότητα ενός αερίου σε υγρό: (1)

A. αυξάνεται με την αύξηση της θερμοκρασίας του διαλύματος
B. μειώνεται όταν η πίεση του αερίου στην επιφάνεια του υγρού αυξάνεται
C. αυξάνεται με την αύξηση του όγκου του διαλύματος.
D. αυξάνεται με την αύξηση της πίεσης του αερίου στην επιφάνεια του υγρού

12. Ποια είναι η περιεκτικότητα στα εκατό κατά βάρος (%w/w) διαλύματος που φτιάχτηκε με προσθήκη 56g KOH σε 944g νερού; (1)

A. 59%
B. 56%
C. 5.6%
D. 5.9%

Μέρος 2

13. Δώστε τους ορισμούς των παρακάτω εννοιών:

i. ατομικός αριθμός στοιχείου:.. (1)

ii. μαζικός αριθμός στοιχείου: .... (1)

iii. ποιος από τους παραπάνω αριθμούς μπορεί να αλλάζει χωρίς να αλλάζει η ταυτότητα του στοιχείου: .... (1)

14. Μεταλλικό κομμάτι ρίχνεται σε βαθμολογημένο κύλινδρο που περιέχει 30,40mL νερού. Ο όγκος του νερού αυξάνεται σε 30,80mL. Το μέταλλο έχει μάζα 1,2g. Ποια είναι η πυκνότητα του μετάλλου; (Δείξτε αναλυτικά πως θα βρείτε την απάντηση.) (3)

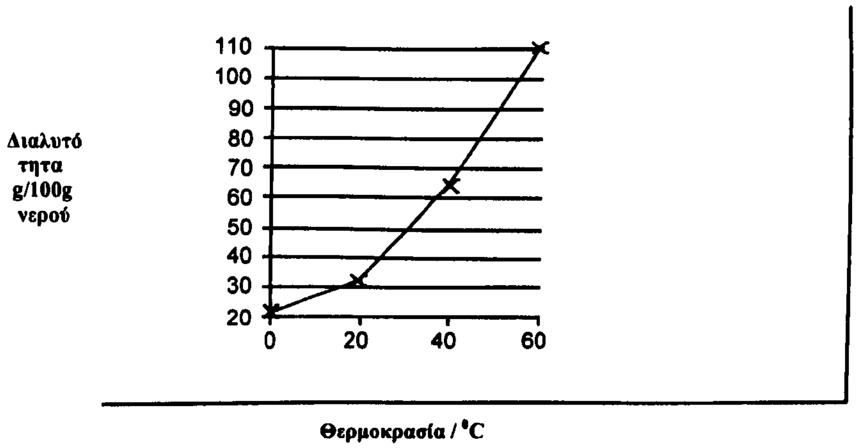
15. Ποια είναι η πιο σημαντική διαφορά μεταξύ μια χημικής ένωσης που περιέχει σίδηρο και θείο και ενός μείγματος που αποτελείται από σίδηρο και θείο: (1)

....

16. Δώστε τον αριθμό των νετρονίων, πρωτονίων και ηλεκτρονίων στα παρακάτω άτομα ή ιόντα: (2)

	νετρόνια	πρωτόνια	ηλεκτρόνια
$^{23}_{11}Na^+$	....	....	....
$^{56}_{26}Fe$	....	....	....

17. Στην παρακάτω γραφική παράσταση δείχνεται πως μεταβάλλεται η διαλυτότητα του νιτρικού καλίου με την θερμοκρασία. Κάντε χρήση της γραφικής παράστασης για να απαντήσετε στις παρακάτω ερωτήσεις:



i. Ποια είναι η μέγιστη μάζα του νιτρικού καλίου που μπορεί να διαλυθεί σε 50g νερού στους 300C: (2)

....

ii. Σε τι θερμοκρασία η διαλυτότητα του νιτρικού καλίου είναι 70%: (1)

....

iii. Πόσα g νιτρικού καλίου θα αποβληθούν αν διάλυμα που περιέχει 60g νιτρικού καλίου σε 100g νερό ψυχθεί από 600 C σε 200 C (2)

....

Καλή σας επιτυχία

Τεστ 2: Περιοδικός πίνακας – Χημικοί Δεσμοί

Σχολείο..

Όνομα..

Τάξη... Ημερομηνία ....

Σ' αυτό το τεστ μπορείτε να κάντε χρήση του περιοδικού πίνακα ή και του σχολικού σας βιβλίου.

Μέρος 1

1. Σας δίνονται τα παρακάτω στοιχεία με ατομικούς αριθμούς: 7, 12, 18, 38,54.
   a) Ποια από αυτά έχουν παρόμοιες χημικές ιδιότητες;
   .... (1)

   b) Εξηγήστε την απάντηση σας:.. (1)

2. Δύο στοιχεία, X και Y, σχηματίζουν το κάθε ένα μία χημική ένωση με το στοιχείο χλώριο. Η χλωριούχος ένωση του X είναι ιοντική στερεά ένωση που το διάλυμα της στο νερό έχει μεγάλη αγωγιμότητα. Η χλωριούχος ένωση του Y είναι μοριακή υγρή ένωση και δεν έχει αγωγιμότητα.

   a) Σε ποια κύρια ομάδα του περιοδικού πίνακα είναι πιθανό να ανήκει το στοιχείο X; (1)
   ....

   b) Εξηγήστε την απάντηση σας: .... (2)

   c) Σε ποια κύρια ομάδα του περιοδικού πίνακα είναι πιθανό να ανήκει το στοιχείο Y; (1)
   ....

   d) Εξηγήστε την απάντηση σας:..

3. Τι κοινό έχουν τα παρακάτω; $_{10}Ne$, $_{9}F^{-}$, $_{12}Mg^{2+}$: (2)

   ....

Μέρος 2

4. Κάθε τετράγωνο στον παρακάτω πίνακα αναφέρεται σε ένα στοιχείο.
   Κοιτάξτε καλά τον πίνακα και απαντήστε στις παρακάτω ερωτήσεις.
   Κάθε ερώτηση μπορεί να έχει περισσότερες από μία απαντήσεις.
   (Χρησιμοποιήστε το κάθε τετράγωνο όσες φορές θέλετε)

A το στοιχείο με δομή ηλεκτρονίων 2, 8,3	**B** το στοιχείο με ατομικό αριθμό 19	**C** Ar
D Μαγνήσιο	**E** το στοιχείο που είναι καφέ υγρό σε θερμοκρασία δωματίου	**F** Άζωτο
G Νάτριο	**H** Χλώριο	**I** το στοιχείο που έχει 1 ηλεκτρόνιο σε κάθε άτομο

Βρείτε το τετράγωνο ή τα τετράγωνα που περιέχουν:

I. Στοιχεία που ανήκουν στην ίδια ομάδα του περιοδικού πίνακα: .... (2)

II. Στοιχεία που είναι αέρια σε θερμοκρασία δωματίου: .... (2)

III. Στοιχεία των οποίων τα άτομα σχηματίζουν ιόντα με την ίδια δομή ηλεκτρόνιων με το άτομο του στοιχείου αργό: .... (2)

IV. Δύο στοιχεία που όταν ενώνονται σχηματίζουν ενώσεις του τύπου X3Y2 :................ (2)

V. Στοιχεία που σχηματίζουν ομοιοπολικούς πολικούς δεσμούς με το στοιχείο στο τετράγωνο I. .... (2)

Comments on marking the Grid questions: Each sub question of the grid was marked out of 2 marks.

Question I. Correct answers: B,G,F and E,H (0.33 marks for each correct answer for the first three and 0.5 for each correct answer for the second two). If only the first set of the answer is given, result 1 mark.

Question II: correct answers: C, F, I, H (0.25 marks for each correct answer). If more than two incorrect answers are given, zero marks are awarded

Question III: correct answer: A, H, G (0.33 for each correct answer)

Question IV: correct answer: A, D (2 marks for the two. If only one correct answer is given, zero marks are awarded)

Question V: correct answer: E, H, I (0.33 for each correct answer).

In general if two incorrect answers are given, zero marks are awarded. It is considered that 2 incorrect answers indicate guessing and limited understanding.

Τεστ 3: Mole

Σχολείο...

Όνομα..

Τάξη.. Ημερομηνία ....

Μέρος 1

1. Έχετε δύο μπαλόνια που όταν είναι άδεια έχουν το ίδιο βάρος. Το ένα μπαλόνι το γεμίζετε με 1 moles οξυγόνο, O_2, και το άλλο με 2 moles μεθάνιο, CH_4. (Ar: O =16, C = 12, H = 1)

α. Βρείτε πιο μπαλόνι τώρα, ζυγίζει περισσότερο; .... (5)

....

β. Εάν τα δύο μπαλόνια βρίσκονται κάτω από STP συνθήκες, ποιο μπαλόνι τώρα έχει μεγαλύτερο όγκο; (Εξηγήστε την απάντηση σας) : .... (5)

Μέρος 2

2. Κοιτάξτε καλά τον παρακάτω πίνακα και απαντήστε στις παρακάτω ερωτήσεις. Κάθε ερώτηση μπορεί να έχει περισσότερες από μία απαντήσεις.
   (Χρησιμοποιήστε το κάθε τετράγωνο όσες φορές θέλετε)
   (Ar: N= 14, C=12, O= 16)

A 2 NA μόρια	**B** 56 g	**Γ** 22.4 L σε STP
Δ 44 g	**E** 2mole	**Z** NA Μόρια
H 44.8 L σε STP	**Θ** 28 g	**I** 22g

I. Βρείτε τα τετράγωνα που περιέχουν ποσότητα 1mole CO_2 : .... (5)

II. Βρείτε τα τετράγωνα που περιέχουν ίδια ποσότητα N_2 με την ποσότητα στο τετράγωνο B: .... (5)

Marking scheme for the Grid question

Question A. Correct answers: C, D, F

Question B: correct answers: E, G, A

In general if one incorrect answer is given, zero marks are awarded. .

Τεστ 4: Οξέα – βάσεις- άλατα

Σχολείο...
Όνομα...
Τάξη... Ημερομηνία ....

Μέρος 1

Κάθε ερώτηση έχει μία μόνο σωστή απάντηση. Βάλτε ένα τικ (✔) στην απάντηση που νομίζετε ότι είναι σωστή και βάλτε σταυρό (✘) στις δύο απαντήσεις που νομίζετε ότι είναι πιο λάθος.
Παράδειγμα: Ένα στοιχείο έχει 92 πρωτόνια και 151 νετρόνια. Ο ατομικός αριθμός του στοιχείου είναι:

A. 59
B. 92
C. 151
D. 243

Εάν νομίζετε ότι η σωστή απάντηση είναι η B και οι πιο λάθος απαντήσεις είναι οι A και D τότε βάλτε ένα τικ (✔) στο B και από ένα σταυρό (✘) στο A και D.

✘ A. 59
✔ B. 92
C. 151
✘ D. 243

Απαντήστε στις παρακάτω ερωτήσεις χρησιμοποιώντας την παραπάνω μέθοδο.

1. Διάλυμα υδροξειδίου του νατρίου είναι βασικό γιατί: (3)
   A. Περιέχει την ίδια ποσότητα ιόντων νατρίου Na+(aq) και ιόντων υδροξυλίου OH-(aq)
   B. Περιέχει περισσότερα ιόντα υδροξυλίου OH-(aq) από ιόντα υδρογόνου H+ (aq)
   C. Περιέχει ιόντα υδροξυλίου OH-(aq) και όχι ιόντα υδρογόνου H+(aq)
   D. Αλλάζει το χρώμα των δεικτών
2. Ένα διάλυμα χλωριούχου καλίου (KCl) έχει ουδέτερο pH. Αυτό συμβαίνει γιατί: (3)
   A. Δεν υπάρχουν ιόντα H+ (aq) και ιόντα OH-(aq) στο διάλυμα
   B. Το χλωριούχο κάλιο είναι ένα αλάτι
   C. Έχει την ίδια ποσότητα ιόντων H+ (aq) και ιόντων OH-(aq)
   D. Έχει την ίδια ποσότητα ιόντων K+ (aq) και ιόντων Cl-(aq)
3. Διάλυμα που βρέθηκε στο εργαστήριο έχει pH = 10. Για να εξουδετερώσουμε το διάλυμα πρέπει να προσθέσουμε σε αυτό: (3)
   A. Διάλυμα θειικού οξέος
   B. Διάλυμα αμμωνίας
   C. Διάλυμα υδροξειδίου του νατρίου
   D. Αποσταγμένο νερό
4. Όταν ένα οξύ αντιδρά με ανθρακικό ασβέστιο τα προϊόντα της αντίδρασης είναι: (3)
   A. Αλάτι του ασβεστίου και υδρογόνο
   B. Ασβέστιο, διοξείδιο του άνθρακα και νερό
   C. Αλάτι του ασβεστίου, υδρογόνο, νερό και διοξείδιο του άνθρακα
   D. Αλάτι του ασβεστίου, νερό και διοξείδιο του άνθρακα

5. Όταν το νάτριο αντιδρά με το νερό τα προϊόντα της αντίδρασης είναι: (3)
   A. Βασικό οξείδιο και υδρογόνο
   B. Βάση και υδρογόνο
   C. Αλάτι και υδρογόνο
   D. Οξύ και υδρογόνο
6. Ποιο από τα παρακάτω διαλύματα έχει pH μικρότερο από 7; (3)
   A. Διάλυμα υδροξειδίου του νατρίου
   B. Διάλυμα χλωριούχου καλίου
   C. Διάλυμα υδροχλωρικού οξέος
   D. Αποσταγμένο νερό
7. Ποια από τα παρακάτω διαλύματα χρωματίζει το διάλυμα της φαινολοφθαλεΐνης κόκκινο: (3)
   A. HBr (aq)
   B. CO2 (aq)
   C. KCl (aq)
   D. LiOH(aq)

<u>Μέρος 2</u>

8. Κοιτάξτε καλά τον παρακάτω πίνακα και απαντήστε στις παρακάτω ερωτήσεις.
   Κάθε ερώτηση μπορεί να έχει περισσότερες από μία απαντήσεις.
   (Χρησιμοποιήστε το κάθε τετράγωνο όσες φορές θέλετε)

Α Έχει pH μικρότερο από 7	**Β** Είναι καλός αγωγός του ηλεκτρισμού	**Γ** Έχει την ίδια ποσότητα ιόντων H^+ (aq) και ιόντων OH^-(aq)
Δ Αντιδρά με το ανθρακικό ασβέστιο και δίνει αέριο διοξείδιο του άνθρακα	**Ε** Σχηματίζεται όταν το νάτριο αντιδρά με το νερό	**Ζ** Σχηματίζει χλωριούχες ενώσεις
Η Αντιδρά με το υδροχλωρικό οξύ και δίνει αλάτι	**Θ** Αποχρωματίζει το κόκκινο διάλυμα φαινολοφθαλεΐνης	**Ι** Περιέχει πολλά ιόντα υδροξυλίου

Βρείτε τα τετράγωνα που περιέχουν εκφράσεις που αντιστοιχούν σε διάλυμα:

I. Υδροχλωρικού οξέος: ....(7)

II. Υδροξειδίου του νατρίου: ....(7)

III. Χλωριούχου νατρίου: ....(7)

Τεστ 5: Διαλύματα

ΟΜΑΔΑ Α

Σχολείο: .... Τάξη: ....
Όνομα: ....
Ημερομηνία: ....

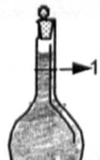
Μέρος 1

Κάθε ερώτηση έχει μία μόνο σωστή απάντηση. Βάλτε σε κύκλο την σωστή απάντηση

1. Ποτήρι περιέχει 10g υδροξειδίου του νατρίου (NaOH) και ο όγκος του διαλύματος είναι 250mL. Προσθέτουμε νερό στο ποτήρι μέχρι ο όγκος του νέου διαλύματος γίνει 500mL. Η συγκέντρωση του νέου διαλύματος είναι: (1)
   - A. Διπλάσια
   - B. Ίδια
   - C. Τετραπλάσια
   - D. Μισή

2. Σε ποτήρι Α έχουμε διαλύσει 0.2mole HCl σε 200mL νερό. Σε ποτήρι Β έχουμε διαλύσει 0.4mol HCl σε 400mL νερό. Ποια από τις παρακάτω προτάσεις είναι σωστή; (1)
   - A. Το διάλυμα στο ποτήρι Α έχει την ίδια συγκέντρωση με το διάλυμα στο ποτήρι Β
   - B. Το διάλυμα στο ποτήρι Α έχει μικρότερη συγκέντρωση από το διάλυμα στο ποτήρι Β
   - C. Το διάλυμα στο ποτήρι Β έχει μικρότερη συγκέντρωση από το διάλυμα στο ποτήρι Α
   - D. Το διάλυμα στο ποτήρι Β έχει διπλάσια συγκέντρωση από το διάλυμα στο ποτήρι Α

3. Φτιάχνετε ένα διάλυμα NaCl προσθέτοντας 1mole (58.44g) από NaCl σε ογκομετρική φιάλη του ενός λίτρου (1-L) και συμπληρώνετε με νερό για να διαλύσετε το αλάτι. Όταν έχετε τελειώσει η φιάλη δείχνει όπως την εικόνα 1.Το διάλυμα που ετοιμάσατε έχει συγκέντρωση : (1)
   - A. Μεγαλύτερη από 1M γιατί προσθέσατε περισσότερο διαλύτη από όσο χρειαζόταν.
   - B. Μικρότερη από 1M γιατί προσθέσατε περισσότερο διαλύτη από όσο χρειαζόταν.
   - C. Μικρότερη από 1M γιατί προσθέσατε λιγότερο διαλύτη από όσο χρειαζόταν.
   - D. 1M γιατί η συγκέντρωση δεν προσδιορίζεται από την ποσότητα του διαλύτη ούτε από την ποσότητα του διαλύματος.



Εικόνα 1

4. Θέλετε να φτιάξετε 4L διαλύματος καυστικού καλίου (KOH) συγκέντρωσης 0.1M. Για το σκοπό αυτό θα χρησιμοποιήσετε: (1)
   - A. 0.1moles KOH
   - B. 1 moles KOH
   - C. 0.4moles KOH
   - D. 4moles KOH

5. Ένας μαθητής ανέμειξε στο εργαστήριο διάλυμα Na2CO3 συγκέντρωσης C1 = 0.1M με διάλυμα Na2CO3 συγκέντρωσης C2 = 0.5M. Η συγκέντρωση του διαλύματος που προέκυψε από την ανάμειξη είναι: (1)
   A. 0.01M
   B. 0.6M
   C. 0.1M
   D. 0.3M

Μέρος 2

6. Ο παρακάτω πίνακας περιέχει υδατικά διαλύματα του NaOH. Κοιτάξτε καλά τον πίνακα και απαντήστε στις παρακάτω ερωτήσεις. Κάθε ερώτηση μπορεί να έχει περισσότερες από μία απαντήσεις. (Χρησιμοποιήστε το κάθε τετράγωνο όσες φορές θέλετε)

A **4g NaOH σε 250mL**	**B** **3g NaOH σε 250mL**	**C** **5g NaOH σε 250mL**
D **3g NaOH σε 500mL**	**E** **8g NaOH σε 500mL**	**F** **12g NaOH σε 500mL**

A. Ποιο διάλυμα έχει τη μεγαλύτερη συγκέντρωση; .... (1)
B. Ποιο διάλυμα έχει τη μικρότερη συγκέντρωση; .... (1)
C. Όταν προσθέσουμε τα διαλύματα B και C το διάλυμα που θα προκύψει έχει την ίδια συγκέντρωση με τα διαλύματα: .... (1)
D. Ποια διαλύματα έχουν την ίδια συγκέντρωση; .... (1)
F. Εάν εξατμίσουμε το μισό από το νερό στο ποτήρι D το διάλυμα που θα προκύψει θα έχει την ίδια συγκέντρωση με το διάλυμα: .... (1)

Μέρος 3

7. Η συγκέντρωση του διαλύματος του οξέος στο μπουκάλι είναι 0.5M.

a) Εξηγείστε τι σημαίνει αυτό;..
.... (1)

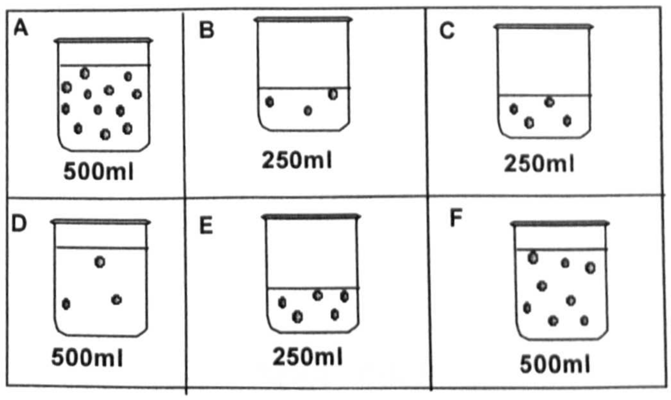
b) Βρείτε πόσα moles νιτρικού οξέος θα χρησιμοποιήσετε για να φτιάξετε 2L από αυτό το διάλυμα:
.... (2)

c) Εάν προσθέσουμε νερό στο διάλυμα των δύο λίτρων μέχρι ο όγκος του νέου διαλύματος γίνει 4L ποια θα είναι η συγκέντρωση του νέου διαλύματος;..
....(2)

ΟΜΑΔΑ Β

Μέρος 2

6. Ο παρακάτω πίνακας περιέχει εικόνες με ποτήρια που περιέχουν υδατικά διαλύματα.
Κάθε ● αντιπροσωπεύει ένα διαλυμένο σωματίδιο.
Κοιτάξτε καλά τον πίνακα και απαντήστε στις παρακάτω ερωτήσεις.
Κάθε ερώτηση μπορεί να έχει περισσότερες από μία απαντήσεις.
(Χρησιμοποιήστε το κάθε τετράγωνο όσες φορές θέλετε)



A. Ποιο διάλυμα έχει την μεγαλύτερη συγκέντρωση; .... (1)
B. Ποιο διάλυμα έχει την μικρότερη συγκέντρωση; .... (1)
C. Όταν προσθέσουμε τα διαλύματα C και E το διάλυμα που θα προκύψει έχει την ίδια συγκέντρωση με τα διαλύματα: .... (1)
D. Ποια διαλύματα έχουν την ίδια συγκέντρωση; .... (1)
F. Εάν εξατμίσουμε το μισό από το νερό στο ποτήρι A το διάλυμα που θα προκύψει θα έχει την ίδια συγκέντρωση με το διάλυμα: .... (1)

Appendix F

Statistical Tables of the Results of the Study

Pilot Chemistry Test 1 Statistics

Correlations

Correlations

		MC	SCG	OE
MC	Pearson Correlation	1	.647**	.636**
	Sig. (2-tailed)	.	.000	.000
	N	321	321	321
SCG	Pearson Correlation	.647**	1	.696**
	Sig. (2-tailed)	.000	.	.000
	N	321	321	321
OE	Pearson Correlation	.636**	.696**	1
	Sig. (2-tailed)	.000	.000	.
	N	321	321	321

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

			MC	SCG	OE
Spearman's rho	MC	Correlation Coefficient	1.000	.644**	.636**
		Sig. (2-tailed)	.	.000	.000
		N	321	321	321
	SCG	Correlation Coefficient	.644**	1.000	.664**
		Sig. (2-tailed)	.000	.	.000
		N	321	321	321
	OE	Correlation Coefficient	.636**	.664**	1.000
		Sig. (2-tailed)	.000	.000	.
		N	321	321	321

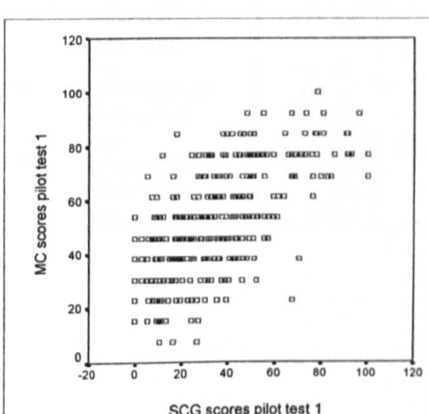
**. Correlation is significant at the .01 level (2-tailed).

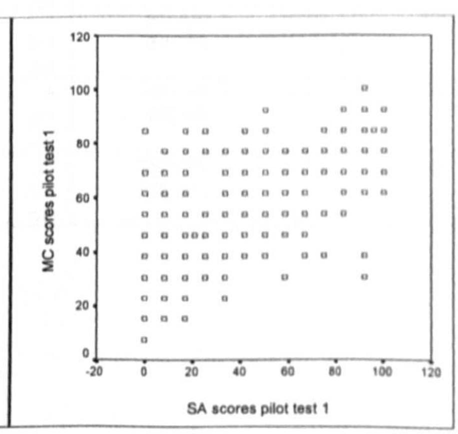
Correlations

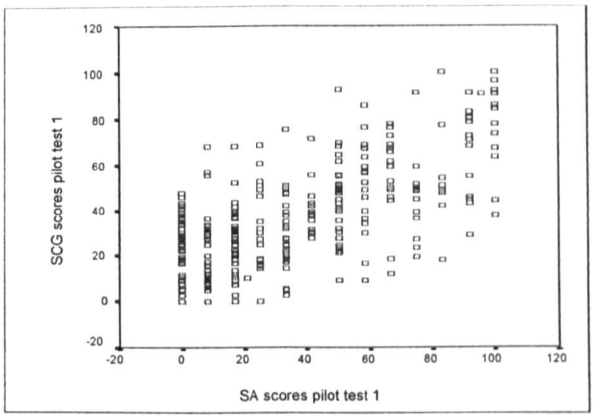
			MC	SCG	OE
Spearman's rho	MC	Correlation Coefficient	1.000	.644**	.636**
		Sig. (1-tailed)	.	.000	.000
		N	321	321	321
	SCG	Correlation Coefficient	.644**	1.000	.664**
		Sig. (1-tailed)	.000	.	.000
		N	321	321	321
	OE	Correlation Coefficient	.636**	.664**	1.000
		Sig. (1-tailed)	.000	.000	.
		N	321	321	321

**. Correlation is significant at the .01 level (1-tailed).

Scatter Plots







Oneway Analysis of Variance (ANOVA):Deference between teams

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
MC	A	81	54.80	19.626	2.181	50.46	59.14	8	100
	B	113	52.62	19.654	1.849	48.96	56.28	15	92
	C	80	51.92	20.717	2.316	47.31	56.53	8	92
	D	47	52.05	19.461	2.839	46.33	57.76	15	85
	Total	321	52.91	19.829	1.107	50.73	55.09	8	100
SCG	A	81	39.99	21.683	2.409	35.20	44.79	0	91
	B	113	34.39	25.685	2.416	29.60	39.17	0	100
	C	80	32.18	21.194	2.370	27.46	36.89	0	96
	D	47	33.95	23.043	3.361	27.19	40.72	0	100
	Total	321	35.19	23.328	1.302	32.63	37.75	0	100
OE	A	81	37.55	31.267	3.474	30.64	44.47	0	100
	B	113	36.91	32.327	3.041	30.88	42.94	0	100
	C	80	29.95	31.532	3.525	22.93	36.96	0	100
	D	47	31.21	29.048	4.237	22.68	39.73	0	92
	Total	321	34.50	31.434	1.754	31.05	37.95	0	100
TOT	A	81	132.34	63.277	7.031	118.35	146.33	18	270
	B	113	123.92	70.423	6.625	110.79	137.04	15	277
	C	80	114.05	63.900	7.144	99.83	128.27	24	289
	D	47	117.20	61.611	8.987	99.11	135.29	20	253
	Total	321	122.60	65.861	3.676	115.37	129.83	15	289

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MC	Between Groups	410.531	3	136.844	.346	.792
	Within Groups	125403.8	317	395.595		
	Total	125814.3	320			
SCG	Between Groups	2737.650	3	912.550	1.688	.170
	Within Groups	171411.3	317	540.730		
	Total	174149.0	320			
OE	Between Groups	3578.333	3	1192.778	1.210	.306
	Within Groups	312615.5	317	986.169		
	Total	316193.9	320			
TOT	Between Groups	15095.889	3	5031.963	1.162	.324
	Within Groups	1372955	317	4331.089		
	Total	1388051	320			

Gender Difference in pilot test 1

T-test

Group Statistics

	SEXC	N	Mean	Std. Deviation	Std. Error Mean
MC	F	178	53.54	20.530	1.539
	M	143	52.12	18.962	1.586
SCG	F	178	35.22	23.923	1.793
	M	143	35.14	22.650	1.894
OE	F	178	32.96	29.616	2.220
	M	143	36.42	33.566	2.807
TOT	F	178	121.72	65.507	4.910
	M	143	123.69	66.514	5.562

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MC	Equal variances assumed	1.362	.244	.637	319	.525	1.42	2.229	-2.966	5.804
	Equal variances not assumed			.642	312.818	.521	1.42	2.210	-2.929	5.766
SCG	Equal variances assumed	1.021	.313	.029	319	.977	.08	2.624	-5.086	5.238
	Equal variances not assumed			.029	310.499	.977	.08	2.608	-5.056	5.208
OE	Equal variances assumed	4.573	.033	-.981	319	.327	-3.46	3.530	-10.409	3.482
	Equal variances not assumed			-.968	285.556	.334	-3.46	3.579	-10.507	3.581
TOT	Equal variances assumed	.000	.991	-.266	319	.791	-1.97	7.407	-16.541	12.604
	Equal variances not assumed			-.265	302.275	.791	-1.97	7.419	-16.568	12.631

Group Statistics

	SEXC	N	Mean	Std. Deviation	Std. Error Mean
MC-SCG	F	178	18.323	18.5667	1.3916
	M	143	16.980	18.2715	1.5279
MC-OE	F	178	20.585	22.7120	1.7023
	M	143	15.703	25.8792	2.1641
SCG-OE	F	178	2.262	21.4719	1.6094
	M	143	-1.277	23.8780	1.9968

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MC-SCG	Equal variances assumed	.097	.756	.649	319	.517	1.343	2.0703	-2.7302	5.4162
	Equal variances not assumed			.650	306.241	.516	1.343	2.0667	-2.7237	5.4097
MC-OE	Equal variances assumed	2.706	.101	1.798	319	.073	4.882	2.7146	-.4588	10.2228
	Equal variances not assumed			1.773	284.660	.077	4.882	2.7534	-.5377	10.3016
SCG-OE	Equal variances assumed	1.909	.168	1.396	319	.164	3.539	2.5351	-1.4487	8.5266
	Equal variances not assumed			1.380	288.682	.169	3.539	2.5646	-1.5088	8.5867

Pilot Chemistry Test 2 Statistics

Correlations

Correlations

		MC pilot test 2	SCG pilot test 2	SA pilot test 2
MC pilot test 2	Pearson Correlation	1	.408**	.352**
	Sig. (1-tailed)	.	.001	.004
	N	56	56	56
SCG pilot test 2	Pearson Correlation	.408**	1	.220
	Sig. (1-tailed)	.001	.	.052
	N	56	56	56
SA pilot test 2	Pearson Correlation	.352**	.220	1
	Sig. (1-tailed)	.004	.052	.
	N	56	56	56

**. Correlation is significant at the 0.01 level (1-tailed).

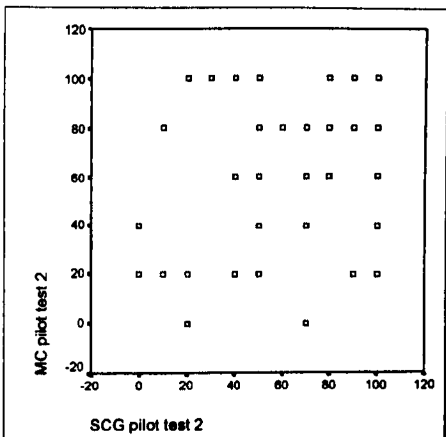
Correlations

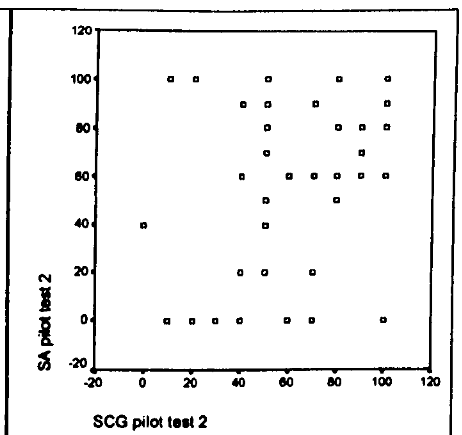
			MC pilot test 2	SCG pilot test 2	SA pilot test 2
Spearman's rho	MC pilot test 2	Correlation Coefficient	1.000	.396**	.328**
		Sig. (1-tailed)	.	.001	.007
		N	56	56	56
	SCG pilot test 2	Correlation Coefficient	.396**	1.000	.242*
		Sig. (1-tailed)	.001	.	.036
		N	56	56	56
	SA pilot test 2	Correlation Coefficient	.328**	.242*	1.000
		Sig. (1-tailed)	.007	.036	.
		N	56	56	56

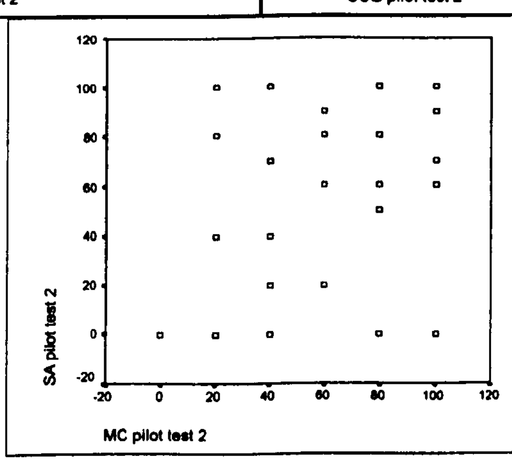
**. Correlation is significant at the .01 level (1-tailed).

*. Correlation is significant at the .05 level (1-tailed).

Scatter Plots







Pilot study Biology correlations

Correlations

			Essay	Triads	MC	SCG	SA	Plant SA
Spearman's rho	Essay	Correlation Coefficient	1.000	.443**	.490**	.264**	.404**	.334**
		Sig. (1-tailed)	.	.000	.000	.000	.000	.000
		N	631	601	602	602	631	601
	Triads	Correlation Coefficient	.443**	1.000	.584**	.342**	.399**	.465**
		Sig. (1-tailed)	.000	.	.000	.000	.000	.000
		N	601	605	594	594	605	605
	MC	Correlation Coefficient	.490**	.584**	1.000	.421**	.487**	.503**
		Sig. (1-tailed)	.000	.000	.	.000	.000	.000
		N	602	594	605	605	605	594
	SCG	Correlation Coefficient	.264**	.342**	.421**	1.000	.277**	.247**
		Sig. (1-tailed)	.000	.000	.000	.	.000	.000
		N	602	594	605	605	605	594
	SA	Correlation Coefficient	.404**	.399**	.487**	.277**	1.000	.282**
		Sig. (1-tailed)	.000	.000	.000	.000	.	.000
		N	631	605	605	605	650	605
	Plant SA	Correlation Coefficient	.334**	.465**	.503**	.247**	.282**	1.000
		Sig. (1-tailed)	.000	.000	.000	.000	.000	.
		N	601	605	594	594	605	605

**. Correlation is significant at the .01 level (1-tailed).

Cognitive Tests statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
CNV TEST	497	0	75	47.03	10.719
FDI TEST	487	0	20	7.79	4.238
Valid N (listwise)	483				

FDCAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	FD	172	34.3	35.3	35.3
	FINT	160	31.9	32.9	68.2
	FIND	155	30.9	31.8	100.0
	Total	487	97.2	100.0	
Missing	System	14	2.8		
Total		501	100.0		

CVCAT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	CV	144	28.7	29.0	29.0
	AR	206	41.1	41.4	70.4
	DV	147	29.3	29.6	100.0
	Total	497	99.2	100.0	
Missing	System	4	.8		
Total		501	100.0		

Gender difference in Cognitive tests.

Group Statistics

	SEX	N	Mean	Std. Deviation	Std. Error Mean
CVSC	F	298	47.93	10.717	.621
	M	199	45.67	10.606	.752

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
CVSC	Equal variance assumed	.073	.788	2.309	495	.021	2.26	.977	.336	4.176
	Equal variance not assumed			2.314	427.529	.021	2.26	.975	.340	4.173

Group Statistics

	SEX	N	Mean	Std. Deviation	Std. Error Mean
FDSC	F	290	7.67	4.126	.242
	M	194	7.97	4.394	.315

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
FDSC	Equal variance assumed	.296	.587	-.773	482	.440	-.30	.393	-1.075	.468
	Equal variance not assumed			-.763	395.893	.446	-.30	.398	-1.086	.478

Chemistry Test 1 Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
MC scores Test 1	288	17	100	64.29	20.393
SA scores Test 1	288	0	100	53.45	25.642
Total scores Test 1	288	32	200	117.75	42.449
MC scores - SA scores Test 1	288	-34.52	66.67	10.8424	18.57101
Valid N (listwise)	288				

Oneway Analysis of Variance (ANOVA):Deference between schools' performance

Descriptives

Total scores Test 1

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	19	153.07	35.650	8.179	135.89	170.25	83	200
3	21	109.35	40.447	8.826	90.94	127.76	36	169
4	14	131.55	38.871	10.389	109.10	153.99	67	192
5	36	105.42	37.735	6.289	92.66	118.19	48	183
7	74	103.57	36.508	4.244	95.11	112.03	32	186
8	56	144.92	37.405	4.998	134.90	154.94	42	200
9	25	128.86	36.230	7.246	113.90	143.81	40	192
10	43	94.60	41.017	6.255	81.98	107.22	35	193
Total	288	117.75	42.449	2.501	112.82	122.67	32	200

ANOVA

Total scores Test 1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	115658.5	7	16522.643	11.523	.000
Within Groups	401487.1	280	1433.883		
Total	517145.6	287			

Correlations

Correlations

		cvsc	FDSC	MC scores Test 1	SA scores Test 1	Total scores Test 1	MC scores - SA scores Test 1	SEX
cvsc	Pearson Correlation	1	.186**	.275**	.306**	.317**	-.120*	-.009
	Sig. (2-tailed)	.	.002	.000	.000	.000	.043	.876
	N	285	280	285	285	285	285	285
FDSC	Pearson Correlation	.186**	1	.350**	.295**	.347**	-.020	-.012
	Sig. (2-tailed)	.002	.	.000	.000	.000	.732	.839
	N	280	283	283	283	283	283	283
MC scores Test 1	Pearson Correlation	.275**	.350**	1	.697**	.901**	.136*	.030
	Sig. (2-tailed)	.000	.000	.	.000	.000	.021	.614
	N	285	283	288	288	288	288	288
SA scores Test 1	Pearson Correlation	.306**	.295**	.697**	1	.939**	-.616**	.018
	Sig. (2-tailed)	.000	.000	.000	.	.000	.000	.757
	N	285	283	288	288	288	288	288
Total scores Test 1	Pearson Correlation	.317**	.347**	.901**	.939**	1	-.307**	.025
	Sig. (2-tailed)	.000	.000	.000	.000	.	.000	.667
	N	285	283	288	288	288	288	288
MC scores - SA scores Test 1	Pearson Correlation	-.120*	-.020	.136*	-.616**	-.307**	1	.008
	Sig. (2-tailed)	.043	.732	.021	.000	.000	.	.899
	N	285	283	288	288	288	288	288
SEX	Pearson Correlation	-.009	-.012	.030	.018	.025	.008	1
	Sig. (2-tailed)	.876	.839	.614	.757	.667	.899	.
	N	285	283	288	288	288	288	288

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

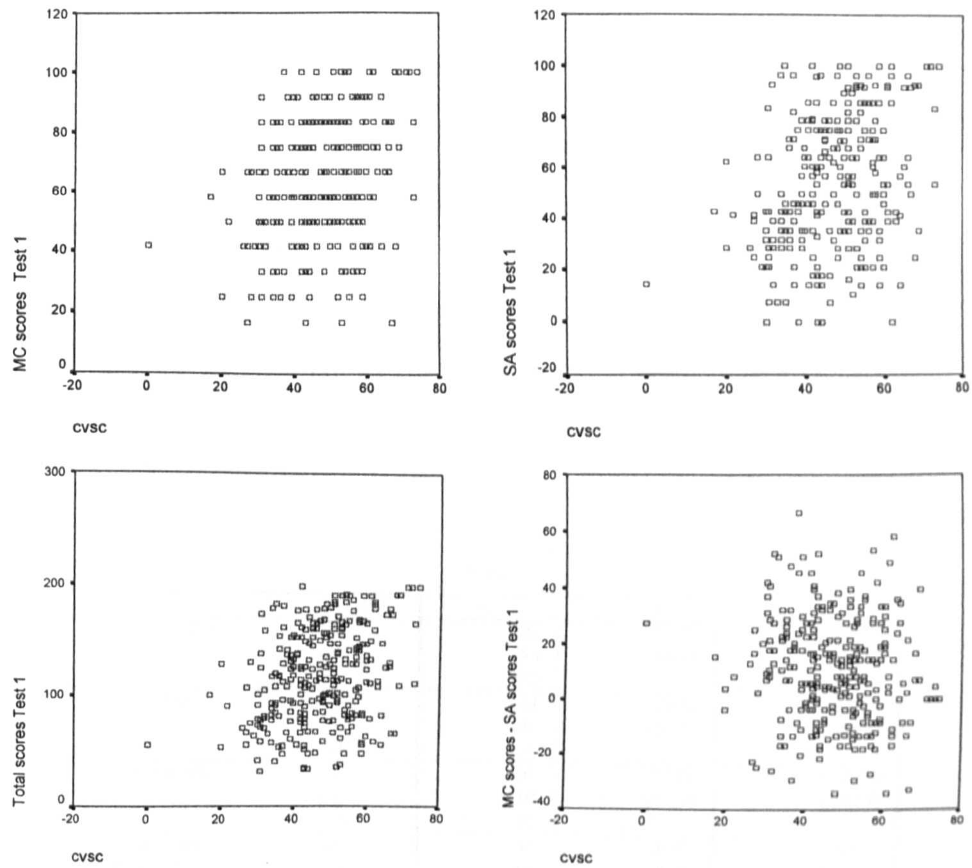
			cvsc	FDSC	MC scores Test 1	SA scores Test 1	Total scores Test 1	MC scores - SA scores Test 1
Spearman's rho	cvsc	Correlation Coefficient	1.000	.217**	.253**	.286**	.293**	-.130*
		Sig. (2-tailed)	.	.000	.000	.000	.000	.029
		N	285	280	285	285	285	285
	FDSC	Correlation Coefficient	.217**	1.000	.342**	.292**	.345**	-.026
		Sig. (2-tailed)	.000	.	.000	.000	.000	.669
		N	280	283	283	283	283	283
	MC scores Test 1	Correlation Coefficient	.253**	.342**	1.000	.710**	.904**	.092
		Sig. (2-tailed)	.000	.000	.	.000	.000	.119
		N	285	283	288	288	288	288
	SA scores Test 1	Correlation Coefficient	.286**	.292**	.710**	1.000	.938**	-.615**
		Sig. (2-tailed)	.000	.000	.000	.	.000	.000
		N	285	283	288	288	288	288
	Total scores Test 1	Correlation Coefficient	.293**	.345**	.904**	.938**	1.000	-.319**
		Sig. (2-tailed)	.000	.000	.000	.000	.	.000
		N	285	283	288	288	288	288
	MC scores - SA scores Test 1	Correlation Coefficient	-.130*	-.026	.092	-.615**	-.319**	1.000
		Sig. (2-tailed)	.029	.669	.119	.000	.000	.
		N	285	283	288	288	288	288

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Convergent/Divergent Groups statistics

Scatter plots for Convergent/Divergent scores in test 1



Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MC scores Test 1	CV	82	59.35	19.484	2.152	55.07	63.63	17	100
	AR	110	64.02	19.254	1.836	60.38	67.65	17	100
	DV	93	68.91	21.812	2.262	64.41	73.40	17	100
	Total	285	64.27	20.463	1.212	61.88	66.65	17	100
SA scores Test 1	CV	82	44.78	23.305	2.574	39.66	49.90	0	100
	AR	110	54.32	24.602	2.346	49.67	58.97	0	100
	DV	93	60.14	27.075	2.808	54.57	65.72	0	100
	Total	285	53.48	25.717	1.523	50.48	56.47	0	100
Total scores Test 1	CV	82	104.13	38.309	4.231	95.71	112.55	32	183
	AR	110	118.33	40.865	3.896	110.61	126.06	33	200
	DV	93	129.05	45.041	4.671	119.78	138.33	38	200
	Total	285	117.74	42.570	2.522	112.78	122.71	32	200
MC scores - SA scores Test 1	CV	82	14.5688	19.43932	2.14671	10.2975	18.8401	-29.76	66.67
	AR	110	9.6970	16.79206	1.60106	6.5237	12.8702	-34.52	52.38
	DV	93	8.7622	19.72237	2.04511	4.7004	12.8239	-34.52	58.33
	Total	285	10.7937	18.65307	1.10491	8.6188	12.9685	-34.52	66.67

Independent Sample Tests :

T-Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
MC scores Test 1	Equal variances assumed	1.456	.229	-3.040	173	.003	-9.56	3.144	-15.763	-3.352
	Equal variances not assumed			-3.062	172.967	.003	-9.56	3.122	-15.719	-3.396
SA scores Test 1	Equal variances assumed	6.429	.012	-3.996	173	.000	-15.36	3.845	-22.952	-7.775
	Equal variances not assumed			-4.034	172.907	.000	-15.36	3.809	-22.881	-7.846
Total scores Test 1	Equal variances assumed	3.297	.071	-3.915	173	.000	-24.92	6.366	-37.486	-12.356
	Equal variances not assumed			-3.955	172.787	.000	-24.92	6.302	-37.359	-12.483
MC scores - SA scores Test 1	Equal variances assumed	.347	.557	1.957	173	.052	5.8067	2.96765	-.05081	11.66412
	Equal variances not assumed			1.958	170.847	.052	5.8067	2.96494	-.04598	11.65929

Mann-Whitney Test

Ranks

	CVCAT	N	Mean Rank	Sum of Ranks
MC scores Test 1	CV	82	75.70	6207.50
	DV	93	98.84	9192.50
	Total	175		
SA scores Test 1	CV	82	72.74	5964.50
	DV	93	101.46	9435.50
	Total	175		
Total scores Test 1	CV	82	72.88	5976.50
	DV	93	101.33	9423.50
	Total	175		
MC scores - SA scores Test 1	CV	82	96.41	7905.50
	DV	93	80.59	7494.50
	Total	175		

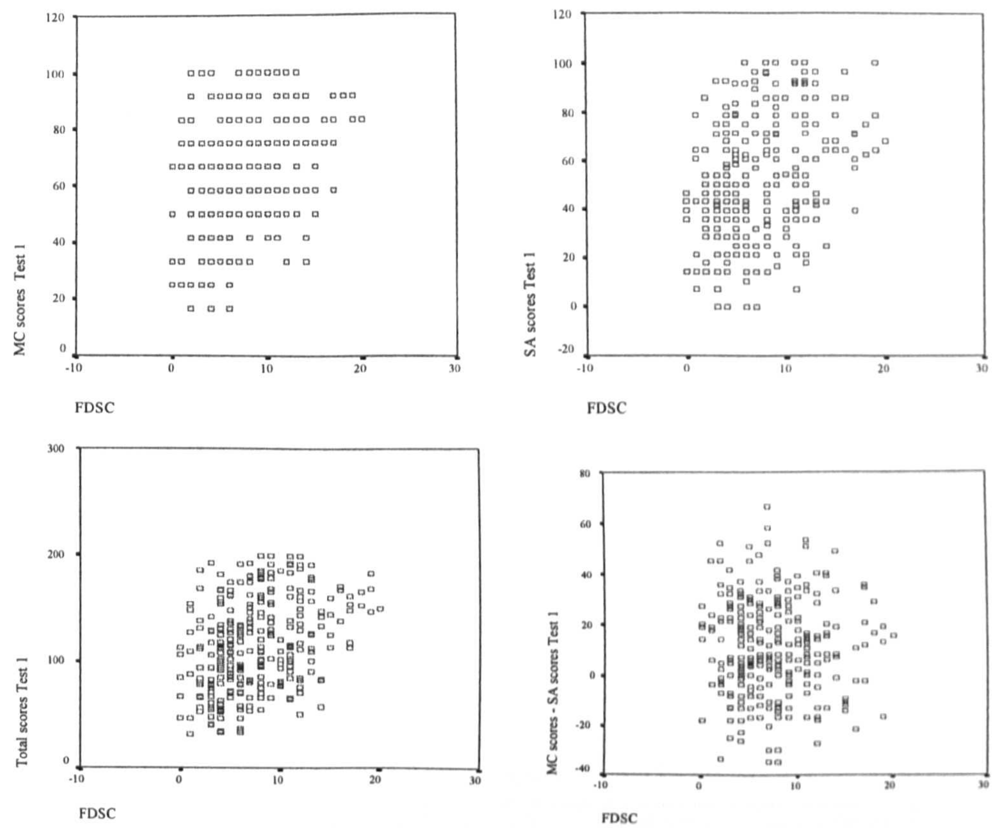
Test Statistics [a]

	MC scores Test 1	SA scores Test 1	Total scores Test 1	MC scores - SA scores Test 1
Mann-Whitney U	2804.500	2561.500	2573.500	3123.500
Wilcoxon W	6207.500	5964.500	5976.500	7494.500
Z	-3.035	-3.746	-3.707	-2.062
Asymp. Sig. (2-tailed)	.002	.000	.000	.039

a. Grouping Variable: CVCAT

Field dependent/independent Groups statistics

Scatter plots for field dependent / independent scores in test 1



Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MC scores Test 1	FD	106	57.39	20.998	2.039	53.35	61.43	17	100
	FINT	91	65.93	19.628	2.058	61.85	70.02	17	100
	FIND	86	71.41	18.011	1.942	67.55	75.28	33	100
	Total	283	64.40	20.473	1.217	62.00	66.79	17	100
SA scores Test 1	FD	106	46.49	22.494	2.185	42.16	50.82	0	93
	FINT	91	55.65	28.747	3.014	49.66	61.64	0	100
	FIND	86	59.92	23.947	2.582	54.78	65.05	7	100
	Total	283	53.52	25.642	1.524	50.52	56.52	0	100
Total scores Test 1	FD	106	103.88	39.562	3.843	96.26	111.50	32	193
	FINT	91	121.59	44.763	4.692	112.26	130.91	33	200
	FIND	86	131.33	38.670	4.170	123.04	139.62	51	200
	Total	283	117.92	42.501	2.526	112.94	122.89	32	200
MC scores - SA scores Test 1	FD	106	10.8996	18.12616	1.76057	7.4087	14.3905	-33.33	52.38
	FINT	91	10.2826	20.48289	2.14719	6.0168	14.5483	-34.52	66.67
	FIND	86	11.4964	17.33101	1.86885	7.7806	15.2122	-27.38	53.57
	Total	283	10.8826	18.62794	1.10732	8.7029	13.0622	-34.52	66.67

Independent Sample Test :

T-Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std Error Difference	Lower	Upper
MC scores Test 1	Equal variances assumed	1.501	.222	-4.901	190	.000	-14.02	2.862	-19.669	-8.380
	Equal variances not assumed			-4.980	189.390	.000	-14.02	2.816	-19.580	-8.469
SA scores Test 1	Equal variances assumed	1.412	.236	-3.996	190	.000	-13.43	3.360	-20.057	-6.799
	Equal variances not assumed			-3.970	176.876	.000	-13.43	3.383	-20.103	-6.753
Total scores Test 1	Equal variances assumed	.002	.967	-4.830	190	.000	-27.45	5.684	-38.665	-16.241
	Equal variances not assumed			-4.841	183.523	.000	-27.45	5.670	-38.640	-16.265
MC scores - SA scores Test 1	Equal variances assumed	1.540	.216	-.231	190	.817	-.5968	2.57961	-5.68516	4.49155
	Equal variances not assumed			-.232	184.917	.816	-.5968	2.56753	-5.66222	4.46861

Mann-Whitney Test

Ranks

	fdcat	N	Mean Rank	Sum of Ranks
MC scores Test 1	FD	106	80.34	8516.00
	FIND	86	116.42	10012.00
	Total	192		
SA scores Test 1	FD	106	83.48	8849.00
	FIND	86	112.55	9679.00
	Total	192		
Total scores Test 1	FD	106	80.49	8531.50
	FIND	86	116.24	9996.50
	Total	192		
MC scores - SA scores Test 1	FD	106	96.03	10179.50
	FIND	86	97.08	8348.50
	Total	192		

Test Statistics [a]

	MC scores Test 1	SA scores Test 1	Total scores Test 1	MC scores - SA scores Test 1
Mann-Whitney U	2845.000	3178.000	2880.500	4508.500
Wilcoxon W	8516.000	8849.000	8531.500	10179.500
Z	-4.504	-3.608	-4.434	-.129
Asymp. Sig. (2-tailed)	.000	.000	.000	.897

a. Grouping Variable: fdcat

Chemistry Test 2 Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SA scores test 2	185	0	100	52.24	30.661
SCG scores test 2	185	0	100	36.70	25.349
Total scores test 2	185	0	200	88.94	46.925
SCG-SA scores test 2	185	-100.0	62.5	-15.532	31.0373
Valid N (listwise)	185				

Correlations

		FDSC	cvsc	SA scores test 2	SCG scores test 2	Total scores test 2	SCG-SA scores test 2
FDSC	Pearson Correlation	1	.238**	.299**	.124	.262**	-.196**
	Sig. (2-tailed)	.	.001	.000	.095	.000	.008
	N	182	182	182	182	182	182
cvsc	Pearson Correlation	.238**	1	.320**	.197**	.315**	-.156*
	Sig. (2-tailed)	.001	.	.000	.007	.000	.034
	N	182	185	185	185	185	185
SA scores test 2	Pearson Correlation	.299**	.320**	1	.398**	.869**	-.662**
	Sig. (2-tailed)	.000	.000	.	.000	.000	.000
	N	182	185	185	185	185	185
SCG scores test 2	Pearson Correlation	.124	.197**	.398**	1	.801**	.423**
	Sig. (2-tailed)	.095	.007	.000	.	.000	.000
	N	182	185	185	185	185	185
Total scores test 2	Pearson Correlation	.262**	.315**	.869**	.801**	1	-.204**
	Sig. (2-tailed)	.000	.000	.000	.000	.	.005
	N	182	185	185	185	185	185
SCG-SA scores test	Pearson Correlation	-.196**	-.156*	-.662**	.423**	-.204**	1
	Sig. (2-tailed)	.008	.034	.000	.000	.005	.
	N	182	185	185	185	185	185

**. Correlation is significant at the 0.01 level (2-tailed).

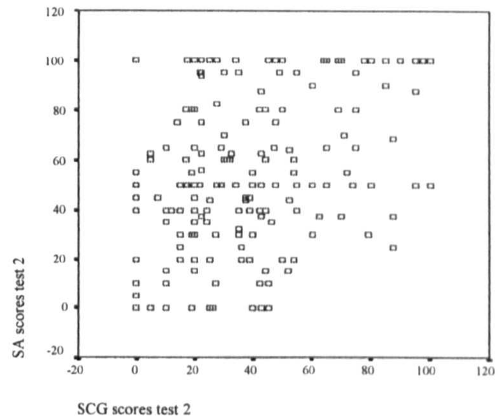
*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

			FDSC	cvsc	SA scores test 2	SCG scores test 2	Total scores test 2	SCG-SA scores test 2
Spearman's rho	FDSC	Correlation Coefficient	1.000	.247**	.308**	.117	.269**	-.193**
		Sig. (2-tailed)	.	.001	.000	.115	.000	.009
		N	182	182	182	182	182	182
	cvsc	Correlation Coefficient	.247**	1.000	.322**	.157*	.301**	-.163*
		Sig. (2-tailed)	.001	.	.000	.033	.000	.027
		N	182	185	185	185	185	185
	SA scores test 2	Correlation Coefficient	.308**	.322**	1.000	.383**	.869**	-.669**
		Sig. (2-tailed)	.000	.000	.	.000	.000	.000
		N	182	185	185	185	185	185
	SCG scores test 2	Correlation Coefficient	.117	.157*	.383**	1.000	.766**	.379**
		Sig. (2-tailed)	.115	.033	.000	.	.000	.000
		N	182	185	185	185	185	185
	Total scores test 2	Correlation Coefficient	.269**	.301**	.869**	.766**	1.000	-.248**
		Sig. (2-tailed)	.000	.000	.000	.000	.	.001
		N	182	185	185	185	185	185
	SCG-SA scores test 2	Correlation Coefficient	-.193**	-.163*	-.669**	.379**	-.248**	1.000
		Sig. (2-tailed)	.009	.027	.000	.000	.001	.
		N	182	185	185	185	185	185

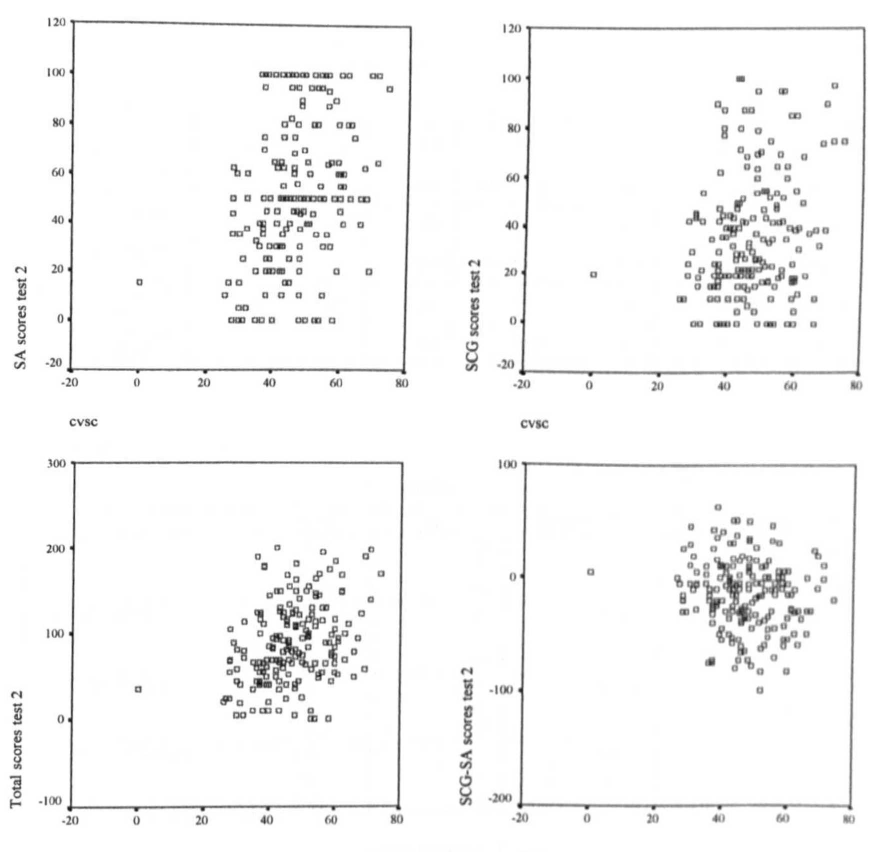
**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).



Convergent/Divergent Groups statistics

Scatter plots for_Convergent/Divergent scores in test 1



Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
SA scores test 2	CV	56	39.04	30.315	4.051	30.92	47 16	0	100
	AR	72	55.97	28.345	3.340	49.31	62 63	0	100
	DV	57	60.48	30.105	3.987	52 49	68 47	0	100
	Total	185	52.24	30.661	2.254	47.79	56.68	0	100
SCG scores test 2	CV	56	30.05	21.472	2.869	24.30	35 80	0	90
	AR	72	38.68	25.495	3.005	32.69	44 67	0	100
	DV	57	40.74	27.724	3.672	33.38	48 09	0	98
	Total	185	36.70	25.349	1.864	33.03	40 38	0	100
Total scores test 2	CV	56	69.09	43.576	5.823	57.42	80 76	5	190
	AR	72	94.66	41.717	4.916	84.85	104 46	5	200
	DV	57	101.22	50.738	6.720	87.76	114 68	0	198
	Total	185	88.94	46.925	3.450	82.13	95.75	0	200
SCG-SA scores test 2	CV	56	-8.987	29.3452	3.9214	-16.845	-1 128	-75.0	62 5
	AR	72	-17.288	34.1549	4.0252	-25.314	-9.262	-100 0	50 0
	DV	57	-19.746	27.8479	3.6885	-27.135	-12 357	-82 5	45 0
	Total	185	-15.532	31.0373	2.2819	-20.035	-11 030	-100 0	62 5

Independent Sample Test :

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SA scores test 2	Equal variances assumed	.045	.832	-3.772	111	.000	-21.44	5.684	-32.705	-10 179
	Equal variances not assumed			-3.772	110.932	.000	-21.44	5.684	-32 706	-10 179
SCG scores test 2	Equal variances assumed	4.940	.028	-2.287	111	.024	-10.68	4.671	-19 938	-1 428
	Equal variances not assumed			-2.292	105.293	.024	-10.68	4.660	-19 923	-1 443
Total scores test 2	Equal variances assumed	2.442	.121	-3.608	111	.000	-32.13	8.904	-49.770	-14 481
	Equal variances not assumed			-3.613	109.061	.000	-32.13	8.892	-49.760	-14 501
SCG-SA scores test 2	Equal variances assumed	.030	.862	1.999	111	.048	10.759	5.3811	0961	21 4219
	Equal variances not assumed			1.998	110.456	.048	10.759	5.3836	0906	21 4276

Mann-Whitney Test

Ranks

	cvcat	N	Mean Rank	Sum of Ranks
SA scores test 2	CV	56	45.54	2550.50
	DV	57	68.25	3890.50
	Total	113		
SCG scores test 2	CV	56	51.20	2867 00
	DV	57	62.70	3574 00
	Total	113		
Total scores test 2	CV	56	46.04	2578 50
	DV	57	67.76	3862 50
	Total	113		
SCG-SA scores test 2	CV	56	63.23	3541.00
	DV	57	50.88	2900 00
	Total	113		

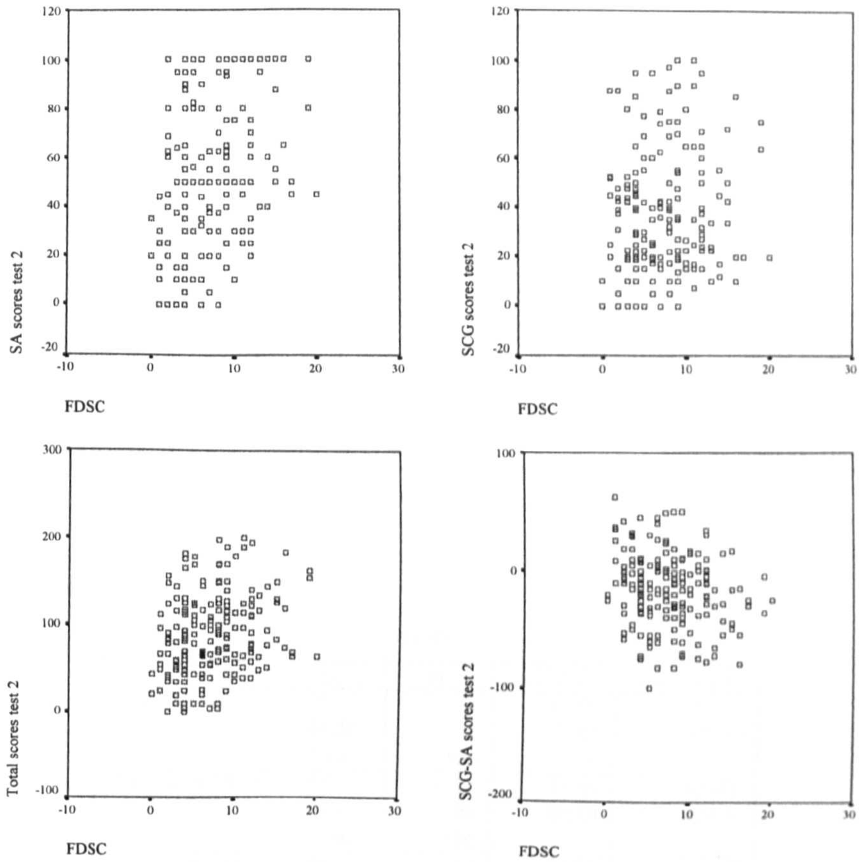
Test Statistics [a]

	SA scores test 2	SCG scores test 2	Total scores test 2	SCG-SA scores test 2
Mann-Whitney U	954.500	1271.000	982.500	1247.000
Wilcoxon W	2550.500	2867.000	2578.500	2900.000
Z	-3.695	-1.869	-3.524	-2.005
Asymp. Sig. (2-tailed)	.000	.062	.000	.045

a. Grouping Variable: cvcat

Field dependent/independent Groups statistics

Scatter plots for field dependent / independent scores in test 2



Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
SA scores test 2	FD	71	45.28	31.520	3.741	37.82	52.74	0	100
	FINT	62	53.23	30.683	3.897	45.43	61.02	0	100
	FIND	49	61.58	28.112	4.016	53.51	69.66	10	100
	Total	182	52.38	30.887	2.289	47.86	56.89	0	100
SCG scores test 2	FD	71	32.80	24.643	2.925	26.96	38.63	0	95
	FINT	62	38.25	26.226	3.331	31.59	44.91	0	100
	FIND	49	40.06	25.248	3.607	32.80	47.31	7	100
	Total	182	36.61	25.408	1.883	32.89	40.32	0	100
Total scores test 2	FD	71	78.08	47.147	5.595	66.92	89.24	0	183
	FINT	62	91.48	47.092	5.981	79.52	103.44	5	198
	FIND	49	101.64	44.918	6.417	88.74	114.54	37	200
	Total	182	88.98	47.268	3.504	82.07	95.90	0	200
SCG-SA scores test 2	FD	71	-12.486	31.2839	3.7127	-19.891	-5.081	-100.0	62.5
	FINT	62	-14.976	32.2609	4.0971	-23.169	-6.783	-82.5	50.0
	FIND	49	-21.526	28.9448	4.1350	-29.839	-13.212	-80.0	34.0
	Total	182	-15.768	31.0620	2.3025	-20.311	-11.225	-100.0	62.5

Independent Sample Test:

T-Test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SA scores test 2	Equal variances assumed	.379	.539	-2.908	118	.004	-16.30	5.605	-27.400	-5.200
	Equal variances not assumed			-2.970	110.424	.004	-16.30	5.488	-27.176	-5.424
SCG scores test 2	Equal variances assumed	.141	.708	-1.571	118	.119	-7.26	4.623	-16.415	1.894
	Equal variances not assumed			-1.564	101.717	.121	-7.26	4.644	-16.471	1.950
Total scores test 2	Equal variances assumed	.039	.844	-2.743	118	.007	-23.56	8.590	-40.571	-6.549
	Equal variances not assumed			-2.767	106.516	.007	-23.56	8.514	-40.439	-6.682
SCG-SA scores test :	Equal variances assumed	.073	.788	1.603	118	.111	9.040	5.6374	-2.1241	20.2033
	Equal variances not assumed			1.627	108.317	.107	9.040	5.5572	-1.9753	20.0545

Mann-Whitney Test

Ranks

	FDCAT	N	Mean Rank	Sum of Ranks
SA scores test 2	FD	71	52.99	3762.50
	FIND	49	71.38	3497.50
	Total	120		
SCG scores test 2	FD	71	56.65	4022.00
	FIND	49	66.08	3238.00
	Total	120		
Total scores test 2	FD	71	53.63	3808.00
	FIND	49	70.45	3452.00
	Total	120		
SCG-SA scores test 2	FD	71	64.51	4580.50
	FIND	49	54.68	2679.50
	Total	120		

Test Statistics[a]

	SA scores test 2	SCG scores test 2	Total scores test 2	SCG-SA scores test 2
Mann-Whitney U	1206.500	1466.000	1252.000	1454.500
Wilcoxon W	3762.500	4022.000	3808.000	2679.500
Z	-2.855	-1.462	-2.603	-1.522
Asymp. Sig. (2-tailed)	.004	.144	.009	.128

a. Grouping Variable: FDCAT

Chemistry Test 3 Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SA scores test 3	146	0	100	60.89	37.309
SCG scores test 3	146	0	100	67.68	36.709
Total scores test 3	146	0	200	128.58	64.584
SCG scores test3-SA scores test 3	146	-100.00	100.00	6.7945	36.16627
Valid N (listwise)	146				

Correlations

		CVSC	FDSC	SA scores test 3	SCG scores test 3	Total scores test 3	SCG scores test3- SA scores test 3
CVSC	Pearson Correlation	1	.177**	.163	.096	.148	-.070
	Sig. (2-tailed)	.	.000	.051	.251	.076	.407
	N	497	483	144	144	144	144
FDSC	Pearson Correlation	.177**	1	.303**	.185*	.278**	-.127
	Sig. (2-tailed)	.000	.	.000	.030	.001	.140
	N	483	487	137	137	137	137
SA scores test 3	Pearson Correlation	.163	.303**	1	.523**	.875**	-.501**
	Sig. (2-tailed)	.051	.000	.	.000	.000	.000
	N	144	137	146	146	146	146
SCG scores test 3	Pearson Correlation	.096	.185*	.523**	1	.870**	.476**
	Sig. (2-tailed)	.251	.030	.000	.	.000	.000
	N	144	137	146	146	146	146
Total scores test 3	Pearson Correlation	.148	.278**	.875**	.870**	1	-.019
	Sig. (2-tailed)	.076	.001	.000	.000	.	.820
	N	144	137	146	146	146	146
SCG scores test3-SA scores test 3	Pearson Correlation	-.070	-.127	-.501**	.476**	-.019	1
	Sig. (2-tailed)	.407	.140	.000	.000	.820	.
	N	144	137	146	146	146	146

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

			CVSC	FDSC	SA scores test 3	SCG scores test 3	Total scores test 3	SCG scores test3- SA scores test 3
Spearman's rho	CVSC	Correlation Coefficient	1.000	.188**	.123	.040	.089	-.035
		Sig. (2-tailed)	.	.000	.142	.636	.288	.673
		N	497	483	144	144	144	144
	FDSC	Correlation Coefficient	.188**	1.000	.315**	.191*	.274**	-.184*
		Sig. (2-tailed)	.000	.	.000	.025	.001	.032
		N	483	487	137	137	137	137
	SA scores test 3	Correlation Coefficient	.123	.315**	1.000	.548**	.883**	-.472**
		Sig. (2-tailed)	.142	.000	.	.000	.000	.000
		N	144	137	146	146	146	146
	SCG scores test 3	Correlation Coefficient	.040	.191*	.548**	1.000	.863**	.406**
		Sig. (2-tailed)	.636	.025	.000	.	.000	.000
		N	144	137	146	146	146	146
	Total scores test 3	Correlation Coefficient	.089	.274**	.883**	.863**	1.000	-.045
		Sig. (2-tailed)	.288	.001	.000	.000	.	.594
		N	144	137	146	146	146	146
	SCG scores test3-SA scores test 3	Correlation Coefficient	-.035	-.184*	-.472**	.406**	-.045	1.000
		Sig. (2-tailed)	.673	.032	.000	.000	.594	.
		N	144	137	146	146	146	146

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Convergent/Divergent Groups statistics

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
SA scores test 3	CV	46	57.72	37.174	5.481	46.68	68.76	0	100
	AR	62	61.13	39.134	4.970	51.19	71.07	0	100
	DV	36	65.14	33.753	5.626	53.72	76.56	0	100
	Total	144	61.04	37.078	3.090	54.93	67.15	0	100
SCG scores test 3	CV	46	67.91	38.697	5.706	56.42	79.40	0	100
	AR	62	64.37	39.054	4.960	54.45	74.29	0	100
	DV	36	71.78	67.91	5.072	61.48	82.07	0	100
	Total	144	67.35	36.842	3.070	61.29	73.42	0	100
Total scores test 3	CV	46	125.63	68.330	10.075	105.34	145.92	0	200
	AR	62	125.50	68.390	8.686	108.13	142.87	0	200
	DV	36	136.92	53.110	8.852	118.95	154.89	0	200
	Total	144	128.40	64.646	5.387	117.75	139.04	0	200
SCG scores test3-SA scores test 3	CV	46	10.1957	33.01153	4.86728	.3924	19.9989	-70.00	80.00
	AR	62	3.2419	37.89792	4.81304	-6.3823	12.8662	-90.00	100.00
	DV	36	6.6389	36.19010	6.03168	-5.6061	18.8839	-100.00	90.00
	Total	144	6.3125	35.84865	2.98739	.4074	12.2176	-100.00	100.00

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
SA scores test 3	Between Groups	1113.151	2	556.575	.401	.670
	Within Groups	195480.6	141	1386.387		
	Total	196593.7	143			
SCG scores test 3	Between Groups	1270.595	2	635.298	.465	.629
	Within Groups	192832.3	141	1367.605		
	Total	194102.9	143			
Total scores test 3	Between Groups	3485.470	2	1742.735	.414	.662
	Within Groups	594135.0	141	4213.723		
	Total	597620.4	143			
SCG scores test3-SA scores test 3	Between Groups	1282.022	2	641.011	.495	.610
	Within Groups	182490.9	141	1294.262		
	Total	183772.9	143			

Mann-Whitney Test

Ranks

	CVCAT	N	Mean Rank	Sum of Ranks
SA scores test 3	CV	46	39.38	1811.50
	DV	36	44.21	1591.50
	Total	82		
SCG scores test 3	CV	46	41.52	1910.00
	DV	36	41.47	1493.00
	Total	82		
Total scores test 3	CV	46	40.42	1859.50
	DV	36	42.88	1543.50
	Total	82		
SCG scores test3-SA scores test 3	CV	46	41.59	1913.00
	DV	36	41.39	1490.00
	Total	82		

Test Statistics [a]

	SA scores test 3	SCG scores test 3	Total scores test 3	SCG scores test3- SA scores test 3
Mann-Whitney U	730.500	827.000	778.500	824.000
Wilcoxon W	1811.500	1493.000	1859.500	1490.000
Z	-.924	-.010	-.465	-.038
Asymp. Sig. (2-tailed)	.355	.992	.642	.970

a. Grouping Variable: CVCAT

Field dependent/independent Groups statistics

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
SA scores test 3	FD	40	45.50	39.545	6.253	32.85	58.15	0	100
	FINT	50	61.50	36.144	5.112	51.23	71.77	0	100
	FIND	47	72.23	31.619	4.612	62.95	81.52	0	100
	Total	137	60.51	37.033	3.164	54.25	66.77	0	100
SCG scores test 3	FD	40	56.20	39.743	6.284	43.49	68.91	0	100
	FINT	50	70.24	34.284	4.848	60.50	79.98	0	100
	FIND	47	73.30	34.561	5.041	63.15	83.45	0	100
	Total	137	67.19	36.500	3.118	61.02	73.36	0	100
Total scores test 3	FD	40	101.70	73.496	11.621	78.19	125.21	0	200
	FINT	50	131.74	60.344	8.534	114.59	148.89	17	200
	FIND	47	145.53	54.204	7.907	129.62	161.45	37	200
	Total	137	127.70	64.571	5.517	116.79	138.61	0	200
SCG scores test3- SA scores test 3	FD	40	10.7000	29.75041	4.70395	1.1854	20.2146	-70.00	83.00
	FINT	50	8.7400	36.36033	5.14213	-1.5935	19.0735	-90.00	90.00
	FIND	47	1.0638	38.08423	5.55516	-10.1181	12.2458	-100.00	100.00
	Total	137	6.6788	35.18437	3.00600	.7343	12.6234	-100.00	100.00

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SA scores test 3	Equal variances assumed	4.115	.046	-3.503	85	.001	-26.73	7.632	-41.908	-11.560
	Equal variances not assumed			-3.441	74.329	.001	-26.73	7.770	-42.214	-11.254
SCG scores test 3	Equal variances assumed	1.435	.234	-2.146	85	.035	-17.10	7.966	-32.936	-1.260
	Equal variances not assumed			-2.122	77.973	.037	-17.10	8.056	-33.137	-1.059
Total scores test 3	Equal variances assumed	5.667	.020	-3.194	85	.002	-43.83	13.721	-71.113	-16.550
	Equal variances not assumed			-3.119	70.633	.003	-43.83	14.055	-71.860	-15.804
SCG scores test3- SA scores test 3	Equal variances assumed	.715	.400	1.298	85	.198	9.6362	7.42406	-5.12484	24.39719
	Equal variances not assumed			1.324	84.422	.189	9.6362	7.27921	-4.83829	24.11063

Mann-Whitney Test

Ranks

	FDCAT	N	Mean Rank	Sum of Ranks
SA scores test 3	FD	40	34.49	1379.50
	FIND	47	52.10	2448.50
	Total	87		
SCG scores test 3	FD	40	37.88	1515.00
	FIND	47	49.21	2313.00
	Total	87		
Total scores test 3	FD	40	35.81	1432.50
	FIND	47	50.97	2395.50
	Total	87		
SCG scores test3- SA scores test 3	FD	40	48.71	1948.50
	FIND	47	39.99	1879.50
	Total	87		

Test Statistics [a]

	SA scores test 3	SCG scores test 3	Total scores test 3	SCG scores test3- SA scores test 3
Mann-Whitney U	559.500	695.000	612.500	751.500
Wilcoxon W	1379.500	1515.000	1432.500	1879.500
Z	-3.298	-2.170	-2.807	-1.635
Asymp. Sig. (2-tailed)	.001	.030	.005	.102

a. Grouping Variable: FDCAT

Chemistry Test 4 Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
MC scores test 4	75	14.3	100.0	52.952	22.7426
SCG scores test 4	75	.0	100.0	68.038	24.1441
Total scores test 4	75	14.3	200.0	120.990	39.7944
MCPK socres test 4	75	14.3	100.0	62.603	21.2627
MC-SCG scores test 4	75	-62.4	57.1	-15.086	24.8342
Valid N (listwise)	75				

Correlations

		CVSC	FDSC	MC scores test 4	SCG scores test 4	MCPK socres test 4	Total scores test 4	MC-SCG scores test 4
CVSC	Pearson Correlation	1	.177**	.112	.373**	.092	.290*	-.260*
	Sig. (2-tailed)	.	.000	.339	.001	.432	.011	.024
	N	497	483	75	75	75	75	75
FDSC	Pearson Correlation	.177**	1	.124	.270*	.119	.235*	-.149
	Sig. (2-tailed)	.000	.	.289	.019	.308	.042	.201
	N	483	487	75	75	75	75	75
MC scores test 4	Pearson Correlation	.112	.124	1	.440**	.884**	.839**	.488**
	Sig. (2-tailed)	.339	.289	.	.000	.000	.000	.000
	N	75	75	75	75	75	75	75
SCG scores test 4	Pearson Correlation	.373**	.270*	.440**	1	.493**	.858**	-.569**
	Sig. (2-tailed)	.001	.019	.000	.	.000	.000	.000
	N	75	75	75	75	75	75	75
MCPK socres test 4	Pearson Correlation	.092	.119	.884**	.493**	1	.805**	.331**
	Sig. (2-tailed)	.432	.308	.000	.000	.	.000	.004
	N	75	75	75	75	75	75	75
Total scores test 4	Pearson Correlation	.290*	.235*	.839**	.858**	.805**	1	-.066
	Sig. (2-tailed)	.011	.042	.000	.000	.000	.	.571
	N	75	75	75	75	75	75	75
MC-SCG scores test 4	Pearson Correlation	-.260*	-.149	.488**	-.569**	.331**	-.066	1
	Sig. (2-tailed)	.024	.201	.000	.000	.004	.571	.
	N	75	75	75	75	75	75	75

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

			CVSC	FDSC	MC scores test 4	SCG scores test 4	MCPK socres test 4	Total scores test 4	MC-SCG scores test 4
Spearman's rho	CVSC	Correlation Coefficient	1.000	.188**	.070	.366**	.078	.243*	-.297**
		Sig. (2-tailed)	.	.000	.548	.001	.505	.036	.010
		N	497	483	75	75	75	75	75
	FDSC	Correlation Coefficient	.188**	1.000	.117	.310**	.113	.227	-.178
		Sig. (2-tailed)	.000	.	.317	.007	.335	.050	.127
		N	483	487	75	75	75	75	75
	MC scores test 4	Correlation Coefficient	.070	.117	1.000	.477**	.876**	.865**	.485**
		Sig. (2-tailed)	.548	.317	.	.000	.000	.000	.000
		N	75	75	75	75	75	75	75
	SCG scores test 4	Correlation Coefficient	.366**	.310**	.477**	1.000	.498**	.834**	-.473**
		Sig. (2-tailed)	.001	.007	.000	.	.000	.000	.000
		N	75	75	75	75	75	75	75
	MCPK socres test 4	Correlation Coefficient	.078	.113	.876**	.498**	1.000	.809**	.331**
		Sig. (2-tailed)	.505	.335	.000	.000	.	.000	.004
		N	75	75	75	75	75	75	75
	Total scores test 4	Correlation Coefficient	.243*	.227	.865**	.834**	.809**	1.000	.017
		Sig. (2-tailed)	.036	.050	.000	.000	.000	.	.887
		N	75	75	75	75	75	75	75
	MC-SCG scores test 4	Correlation Coefficient	-.297**	-.178	.485**	-.473**	.331**	.017	1.000
		Sig. (2-tailed)	.010	.127	.000	.000	.004	.887	.
		N	75	75	75	75	75	75	75

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Convergent/ Divergent Groups Statistics

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
MC scores test 4	CV	15	41.905	23.2032	5.9910	29.055	54.754	14.3	71.4
	AR	30	59.048	19.7569	3.6071	51.670	66.425	14.3	100.0
	DV	30	52.381	23.8259	4.3500	43.484	61.278	14.3	100.0
	Total	75	52.952	22.7426	2.6261	47.720	58.185	14.3	100.0
SCG scores test 4	CV	15	53.238	24.4818	6.3212	39.681	66.796	.0	85.2
	AR	30	68.587	26.6149	4.8592	58.649	78.525	.0	100.0
	DV	30	74.889	18.1008	3.3047	68.130	81.648	25.7	100.0
	Total	75	68.038	24.1441	2.7879	62.483	73.593	.0	100.0
Total scores test 4	CV	15	95.143	41.1631	10.6283	72.347	117.938	28.6	156.7
	AR	30	127.635	40.0839	7.3183	112.667	142.602	14.3	200.0
	DV	30	127.270	34.4116	6.2827	114.420	140.119	68.6	185.7
	Total	75	120.990	39.7944	4.5951	111.835	130.146	14.3	200.0
MC-SCG scores test 4	CV	15	-11.333	24.1058	6.2241	-24.683	2.016	-51.4	29.5
	AR	30	-9.540	24.3034	4.4372	-18.615	-.465	-58.1	57.1
	DV	30	-22.508	24.6267	4.4962	-31.704	-13.312	-62.4	35.7
	Total	75	-15.086	24.8342	2.8676	-20.800	-9.372	-62.4	57.1

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MC scores test 4	Between Groups	2955.102	2	1477.551	3.012	.055
	Within Groups	35319.728	72	490.552		
	Total	38274.830	74			
SCG scores test 4	Between Groups	4702.650	2	2351.325	4.405	.016
	Within Groups	38434.747	72	533.816		
	Total	43137.397	74			
Total scores test 4	Between Groups	12528.863	2	6264.432	4.310	.017
	Within Groups	104657.0	72	1453.569		
	Total	117185.8	74			
MC-SCG scores test 4	Between Groups	2786.641	2	1393.320	2.341	.104
	Within Groups	42851.980	72	595.166		
	Total	45638.621	74			

Test Statistics[a]

	MC scores test 4	SCG scores test 4	Total scores test 4	MC-SCG scores test 4
Mann-Whitney U	138.000	128.000	124.000	222.000
Wilcoxon W	258.000	248.000	244.000	342.000
Z	-2.156	-2.339	-2.432	-.072
Asymp. Sig. (2-tailed)	.031	.019	.015	.942

a. Grouping Variable: CVCAT

Mann-Whitney Test

Ranks

	CVCAT	N	Mean Rank	Sum of Ranks
MC-SCG scores test 4	2	30	35.25	1057.50
	3	30	25.75	772.50
	Total	60		

Test Statistics [a]

	MC-SCG scores test 4
Mann-Whitney U	307.500
Wilcoxon W	772.500
Z	-2.107
Asymp. Sig. (2-tailed)	.035

a. Grouping Variable: CVCAT

Field dependent/independent Groups Statistics

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
MC scores test 4	FD	29	49.754	22.4650	4.1716	41.208	58.299	14.3	85.7
	FINT	24	54.762	22.9450	4.6836	45.073	64.451	14.3	100.0
	FIND	22	55.195	23.4512	4.9998	44.797	65.592	14.3	100.0
	Total	75	52.952	22.7426	2.6261	47.720	58.185	14.3	100.0
SCG scores test 4	FD	29	61.494	24.2599	4.5050	52.266	70.722	.0	93.3
	FINT	24	69.345	25.7648	5.2592	58.466	80.225	.0	100.0
	FIND	22	75.238	20.6639	4.4055	66.076	84.400	20.0	100.0
	Total	75	68.038	24.1441	2.7879	62.483	73.593	.0	100.0
Total scores test 4	FD	29	111.248	40.7111	7.5599	95.762	126.734	14.3	174.8
	FINT	24	124.107	39.9030	8.1452	107.258	140.957	37.1	185.7
	FIND	22	130.433	37.2954	7.9514	113.897	146.969	62.9	200.0
	Total	75	120.990	39.7944	4.5951	111.835	130.146	14.3	200.0
MC-SCG scores test 4	FD	29	-11.741	23.0010	4.2712	-20.490	-2.991	-62.4	29.5
	FINT	24	-14.583	28.0774	5.7313	-26.439	-2.727	-57.1	57.1
	FIND	22	-20.043	23.7268	5.0586	-30.563	-9.523	-60.0	22.9
	Total	75	-15.086	24.8342	2.8676	-20.800	-9.372	-62.4	57.1

Ranks

	FDCAT	N	Mean Rank	Sum of Ranks
MC scores test 4	4	29	24.52	711.00
	6	22	27.95	615.00
	Total	51		
SCG scores test 4	4	29	21.67	628.50
	6	22	31.70	697.50
	Total	51		
Total scores test 4	4	29	22.93	665.00
	6	22	30.05	661.00
	Total	51		
MC-SCG scores test 4	4	29	28.48	826.00
	6	22	22.73	500.00
	Total	51		

Test Statistics [a]

	MC scores test 4	SCG scores test 4	Total scores test 4	MC-SCG scores test 4
Mann-Whitney U	276.000	193.500	230.000	247.000
Wilcoxon W	711.000	628.500	665.000	500.000
Z	-.832	-2.391	-1.693	-1.370
Asymp. Sig. (2-tailed)	.405	.017	.090	.171

a. Grouping Variable: FDCAT

Correlations for Comparison Test 4 and Pilot Test 1

Correlations

			MC124511	SCG14
Spearman's rho	MC124511	Correlation Coefficient	1.000	.387**
		Sig. (2-tailed)	.	.000
		N	321	318
	SCG14	Correlation Coefficient	.387**	1.000
		Sig. (2-tailed)	.000	.
		N	318	318

**. Correlation is significant at the .01 level (2-tailed).

Chemistry Test 5 Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
MC scores test 5	64	0	100	67.50	28.619
SCG scores test 5	64	0	100	68.59	26.420
SA scores test 5	64	0	100	50.78	35.648
Total scores test 5	64	30	300	186.88	70.887
Valid N (listwise)	64				

Correlations

			CVSC	FDSC	MC scores test 5	SCG scores test 5	SA scores test 5	Total scores test 5	MC-SA scores test 5	MC-SCG scores test 5	SCG-SA scores test 5
Spearman's rho	CVSC	Correlation Coefficient	1.000	.188**	.036	.054	-.132	.006	.151	-.051	.171
		Sig. (2-tailed)	.	.000	.780	.671	.297	.963	.233	.691	.178
		N	497	483	64	64	64	64	64	64	64
	FDSC	Correlation Coefficient	.188**	1.000	.264*	.390**	.398**	.471**	-.197	-.116	-.110
		Sig. (2-tailed)	.000	.	.035	.001	.001	.000	.118	.361	.388
		N	483	487	64	64	64	64	64	64	64
	MC scores test 5	Correlation Coefficient	.036	.264*	1.000	.457**	.491**	.813**	.270*	.587**	-.195
		Sig. (2-tailed)	.780	.035	.	.000	.000	.000	.031	.000	.123
		N	64	64	64	64	64	64	64	64	64
	SCG scores test 5	Correlation Coefficient	.054	.390**	.457**	1.000	.304*	.713**	.025	-.417**	.338**
		Sig. (2-tailed)	.671	.001	.000	.	.015	.000	.847	.001	.006
		N	64	64	64	64	64	64	64	64	64
	SA scores test 5	Correlation Coefficient	-.132	.398**	.491**	.304*	1.000	.800**	-.667**	.217	-.768**
		Sig. (2-tailed)	.297	.001	.000	.015	.	.000	.000	.085	.000
		N	64	64	64	64	64	64	64	64	64
	Total scores test 5	Correlation Coefficient	.006	.471**	.813**	.713**	.800**	1.000	-.219	.171	-.327**
		Sig. (2-tailed)	.963	.000	.000	.000	.000	.	.082	.177	.008
		N	64	64	64	64	64	64	64	64	64
	MC-SA scores test 5	Correlation Coefficient	.151	-.197	.270*	.025	-.667**	-.219	1.000	.270*	.667**
		Sig. (2-tailed)	.233	.118	.031	.847	.000	.082	.	.031	.000
		N	64	64	64	64	64	64	64	64	64
	MC-SCG scores test 5	Correlation Coefficient	-.051	-.116	.587**	-.417**	.217	.171	.270*	1.000	-.480**
		Sig. (2-tailed)	.691	.361	.000	.001	.085	.177	.031	.	.000
		N	64	64	64	64	64	64	64	64	64
	SCG-SA scores test 5	Correlation Coefficient	.171	-.110	-.195	.338**	-.768**	-.327**	.667**	-.480**	1.000
		Sig. (2-tailed)	.178	.388	.123	.006	.000	.008	.000	.000	.
		N	64	64	64	64	64	64	64	64	64

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Convergent/ Divergent Groups Statistics

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
MC scores test 5	CV	19	70.53	26.972	6.188	57.53	83.53	20	100
	AR	29	64.14	31.341	5.820	52.22	76.06	0	100
	DV	16	70.00	26.331	6.583	55.97	84.03	20	100
	Total	64	67.50	28.619	3.577	60.35	74.65	0	100
SCG scores test 5	CV	19	73.16	31.981	7.337	57.74	88.57	0	100
	AR	29	61.03	24.399	4.531	51.75	70.32	20	100
	DV	16	76.88	19.568	4.892	66.45	87.30	40	100
	Total	64	68.59	26.420	3.302	61.99	75.19	0	100
SA scores test 5	CV	19	60.53	34.071	7.816	44.10	76.95	0	100
	AR	29	47.93	37.166	6.901	33.79	62.07	0	100
	DV	16	44.38	34.442	8.610	26.02	62.73	0	100
	Total	64	50.78	35.648	4.456	41.88	59.69	0	100
Total scores test 5	CV	19	204.21	67.439	15.471	171.71	236.71	80	300
	AR	29	173.10	73.490	13.647	145.15	201.06	30	300
	DV	16	191.25	69.270	17.318	154.34	228.16	70	300
	Total	64	186.88	70.887	8.861	169.17	204.58	30	300

Field dependent/independent Groups Statistics

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
MC scores test 5	FD	16	56.25	25.528	6.382	42.65	69.85	0	100
	FINT	22	67.27	29.949	6.385	53.99	80.55	20	100
	FIND	26	74.62	28.033	5.498	63.29	85.94	0	100
	Total	64	67.50	28.619	3.577	60.35	74.65	0	100
SCG scores test 5	FD	16	59.38	24.075	6.019	46.55	72.20	30	100
	FINT	22	58.64	23.963	5.109	48.01	69.26	0	100
	FIND	26	82.69	24.093	4.725	72.96	92.42	20	100
	Total	64	68.59	26.420	3.302	61.99	75.19	0	100
SA scores test 5	FD	16	32.50	28.868	7.217	17.12	47.88	0	80
	FINT	22	45.91	36.470	7.776	29.74	62.08	0	100
	FIND	26	66.15	33.236	6.518	52.73	79.58	0	100
	Total	64	50.78	35.648	4.456	41.88	59.69	0	100
Total scores test 5	FD	16	148.13	57.413	14.353	117.53	178.72	50	250
	FINT	22	171.82	71.889	15.327	139.94	203.69	60	300
	FIND	26	223.46	61.575	12.076	198.59	248.33	30	300
	Total	64	186.88	70.887	8.861	169.17	204.58	30	300

Independent Sample Test:

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
MC scores test 5	Between Groups	3342.483	2	1671.241	2.113	.130
	Within Groups	48257.517	61	791.107		
	Total	51600.000	63			
SCG scores test 5	Between Groups	8709.058	2	4354.529	7.532	.001
	Within Groups	35264.379	61	578.105		
	Total	43973.438	63			
SA scores test 5	Between Groups	12013.735	2	6006.867	5.385	.007
	Within Groups	68047.203	61	1115.528		
	Total	80060.938	63			
Total scores test 5	Between Groups	63815.516	2	31907.758	7.700	.001
	Within Groups	252759.5	61	4143.598		
	Total	316575.0	63			

Ranks

	FDCAT	N	Mean Rank	Sum of Ranks
MC scores test 5	FD	16	16.00	256.00
	FIND	26	24.88	647.00
	Total	42		
SCG scores test 5	FD	16	14.53	232.50
	FIND	26	25.79	670.50
	Total	42		
SA scores test 5	FD	16	14.22	227.50
	FIND	26	25.98	675.50
	Total	42		
Total scores test 5	FD	16	12.63	202.00
	FIND	26	26.96	701.00
	Total	42		

Mann-Whitney

Test Statistics[a]

	MC scores test 5	SCG scores test 5	SA scores test 5	Total scores test 5
Mann-Whitney U	120.000	96.500	91.500	66.000
Wilcoxon W	256.000	232.500	227.500	202.000
Z	-2.345	-2.953	-3.089	-3.685
Asymp. Sig. (2-tailed)	.019	.003	.002	.000

a. Grouping Variable: FDCAT

Differences between Teams for Chemistry Test 5 and Pilot Test 2

Chemistry Test 5

Group Statistics

	TEAMT5	N	Mean	Std. Deviation	Std. Error Mean
SA scores test 5	A	32	49.38	34.355	6.073
	B	32	52.19	37.394	6.610

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SA scores test 5	Equal variances assumed	1.009	.319	-.313	62	.755	-2.81	8.977	-20.756	15.131
	Equal variances not assumed			-.313	61.560	.755	-2.81	8.977	-20.759	15.134

Pilot Chemistry Test 2

Group Statistics

	TEAM	N	Mean	Std. Deviation	Std. Error Mean
SCG	A	27	65.19	32.030	6.164
	B	29	71.72	29.889	5.550

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SCG	Equal variances assumed	.274	.602	-.790	54	.433	-6.54	8.274	-23.127	10.049
	Equal variances not assumed			-.788	52.938	.434	-6.54	8.295	-23.177	10.099

Correlations for the same group for Test 1, 2 and 4

Correlations

			MC scores Test 1	SA scores Test 1	SA scores test 2	SCG scores test 2	MC scores test 4	SCG scores test 4
Spearman's rho	MC scores Test 1	Correlation Coefficient	1.000	.537**	.380**	.256*	.204*	.281**
		Sig. (1-tailed)	.	.000	.000	.011	.046	.010
		N	81	81	79	79	69	69
	SA scores Test 1	Correlation Coefficient	.537**	1.000	.582**	.422**	.298**	.335**
		Sig. (1-tailed)	.000	.	.000	.000	.006	.002
		N	81	81	79	79	69	69
	SA scores test 2	Correlation Coefficient	.380**	.582**	1.000	.537**	.259*	.394**
		Sig. (1-tailed)	.000	.000	.	.000	.013	.000
		N	79	79	85	85	74	74
	SCG scores test 2	Correlation Coefficient	.256*	.422**	.537**	1.000	.308**	.471**
		Sig. (1-tailed)	.011	.000	.000	.	.004	.000
		N	79	79	85	85	74	74
	MC scores test 4	Correlation Coefficient	.204*	.298**	.259*	.308**	1.000	.477**
		Sig. (1-tailed)	.046	.006	.013	.004	.	.000
		N	69	69	74	74	75	75
	SCG scores test 4	Correlation Coefficient	.281**	.335**	.394**	.471**	.477**	1.000
		Sig. (1-tailed)	.010	.002	.000	.000	.000	.
		N	69	69	74	74	75	75

**. Correlation is significant at the .01 level (1-tailed).

*. Correlation is significant at the .05 level (1-tailed).

Perry Scheme Statistics

Test 1 Correlations

Correlations

			Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	E1	E2	E3	E4	E5	E6	E7	E8	MC1	SA1
Kendall's t	Q1	Correlation C	1.000	.206*	.088	.090	-.086	.022	.044	.020	.103*	.027	.046	.037	.159*	.091	.019	.006	.031	.127*	.033	.043
		Sig. (2-tailed)	.	.000	.075	.068	.096	.671	.380	.687	.036	.589	.363	.464	.002	.066	.699	.895	.531	.013	.484	.339
		N	279	277	279	278	279	278	277	278	275	274	276	278	278	277	278	277	278	278	279	279
	Q2	Correlation C	.206*	1.000	.092	-.005	-.085	.092	.046	.050	.113*	-.042	.015	-.137*	.080	.070	.015	.066	.017	.071	.175*	.090*
		Sig. (2-tailed)	.000	.	.066	.914	.100	.077	.353	.310	.023	.406	.764	.007	.117	.157	.762	.181	.728	.162	.000	.046
		N	277	278	278	278	278	277	276	277	274	273	276	277	277	276	277	276	277	277	278	278
	Q3	Correlation C	.088	.092	1.000	.031	.001	.105*	.000	.049	.049	.020	.163*	-.003	.102*	.066	.048	-.021	.064	.012	.053	.058
		Sig. (2-tailed)	.075	.066	.	.534	.985	.044	.999	.319	.327	.695	.001	.953	.046	.185	.332	.673	.196	.811	.260	.204
		N	279	278	280	279	280	279	278	279	276	275	277	279	279	278	279	278	279	279	280	280
	Q4	Correlation C	.090	-.005	.031	1.000	.060	.093	.012	.028	.166*	.066	-.099	-.057	.212*	.110*	.202*	.138*	-.040	.086	.074	.124*
		Sig. (2-tailed)	.068	.914	.534	.	.245	.072	.805	.569	.001	.194	.052	.260	.000	.026	.000	.005	.423	.089	.112	.006
		N	278	278	279	279	279	278	277	278	275	274	277	278	278	277	278	277	278	278	279	279
	Q5	Correlation C	-.086	-.085	.001	.060	1.000	.025	.052	.023	.040	.019	-.030	.205*	.062	.086	.157*	-.022	.058	-.006	.021	.015
		Sig. (2-tailed)	.096	.100	.985	.245	.	.643	.312	.657	.438	.726	.571	.000	.240	.093	.002	.660	.260	.909	.661	.745
		N	279	278	280	279	280	279	278	279	276	275	277	279	279	278	279	278	279	279	280	280
	Q6	Correlation C	.022	.092	.105*	.093	.025	1.000	-.001	-.056	-.009	.242*	.000	-.037	.164*	.004	.136*	.103*	-.045	-.009	.231*	.218*
		Sig. (2-tailed)	.671	.077	.044	.072	.643	.	.986	.278	.857	.000	.997	.488	.002	.939	.009	.045	.388	.868	.000	.000
		N	278	277	279	278	279	279	277	278	275	274	276	278	278	277	278	277	278	278	279	279
	Q7	Correlation C	.044	.046	.000	.012	.052	-.001	1.000	-.009	-.066	-.015	.015	.037	.021	.043	-.036	.079	.197*	.024	.115*	.033
		Sig. (2-tailed)	.380	.353	.999	.805	.312	.986	.	.850	.184	.773	.768	.466	.685	.389	.467	.109	.000	.641	.014	.469
		N	277	276	278	277	278	277	278	277	274	273	275	277	277	276	277	276	277	277	278	278
	Q8	Correlation C	.020	.050	.049	.028	.023	-.056	-.009	1.000	.076	.005	.018	-.042	.071	.227*	.085	-.012	-.091	-.050	.044	.023
		Sig. (2-tailed)	.687	.310	.319	.569	.657	.278	.850	.	.121	.919	.714	.403	.158	.000	.082	.805	.064	.323	.346	.612
		N	278	277	279	278	279	278	277	279	275	274	276	278	278	277	278	277	278	278	279	279
	Q9	Correlation C	.103*	.113*	.049	.166*	.040	-.009	-.066	.076	1.000	.042	-.102*	.124*	.219*	.109*	.188*	.029	-.025	.134*	-.005	.042
		Sig. (2-tailed)	.036	.023	.327	.001	.438	.857	.184	.121	.	.408	.044	.013	.000	.026	.000	.546	.604	.008	.915	.350
		N	275	274	276	275	276	275	274	275	276	275	274	276	276	275	276	275	276	276	276	276
	Q10	Correlation C	.027	-.042	.020	.066	.019	.242*	-.015	.005	.042	1.000	.060	.041	.122*	-.044	.078	.082	-.062	.060	.069	.113*
		Sig. (2-tailed)	.589	.406	.695	.194	.726	.000	.773	.919	.408	.	.251	.424	.020	.385	.125	.105	.223	.256	.154	.015
		N	274	273	275	274	275	274	273	274	275	275	273	275	275	274	275	274	275	275	275	275
	E1	Correlation C	.046	.015	.163*	-.099	-.030	.000	.015	.018	-.102*	.060	1.000	-.008	-.036	-.012	-.118*	.000	.184*	.010	-.016	-.011
		Sig. (2-tailed)	.363	.764	.001	.052	.571	.997	.768	.714	.044	.251	.	.877	.490	.814	.020	.999	.000	.842	.742	.806
		N	276	276	277	277	277	276	275	276	274	273	277	277	277	276	277	276	277	277	277	277
	E2	Correlation C	.037	-.137*	-.003	-.057	.205*	-.037	.037	-.042	.124*	.041	-.008	1.000	-.037	-.062	-.023	-.040	.045	.116*	-.093	-.023
		Sig. (2-tailed)	.464	.007	.953	.260	.000	.488	.466	.403	.013	.424	.877	.	.476	.215	.645	.425	.373	.025	.051	.612
		N	278	277	279	278	279	278	277	278	276	275	277	279	279	278	279	278	279	279	279	279
	E3	Correlation C	.159*	.080	.102*	.212*	.062	.164*	.021	.071	.219*	.122*	-.036	-.037	1.000	.152*	.218*	.107*	-.038	.068	.040	.101*
		Sig. (2-tailed)	.002	.117	.046	.000	.240	.002	.685	.158	.000	.020	.490	.476	.	.003	.000	.033	.453	.193	.405	.029
		N	278	277	279	278	279	278	277	278	276	275	277	279	279	278	279	278	279	279	279	279
	E4	Correlation C	.091	.070	.066	.110*	.086	.004	.043	.227*	.109*	-.044	-.012	-.062	.152*	1.000	.100*	.075	-.112*	.121*	-.037	-.127*
		Sig. (2-tailed)	.066	.157	.185	.026	.093	.939	.389	.000	.026	.385	.814	.215	.003	.	.043	.126	.023	.017	.431	.005
		N	277	276	278	277	278	277	276	277	275	274	276	278	278	278	278	277	278	278	278	278
	E5	Correlation C	.019	.015	.048	.202*	.157*	.136*	-.036	.085	.188*	.078	-.118*	-.023	.218*	.100*	1.000	.094	-.101*	-.040	.075	.110*
		Sig. (2-tailed)	.699	.762	.332	.000	.002	.009	.467	.082	.000	.125	.020	.645	.000	.043	.	.055	.041	.429	.112	.015
		N	278	277	279	278	279	278	277	278	276	275	277	279	279	278	279	278	279	279	279	279
	E6	Correlation C	.006	.066	-.021	.138*	-.022	.103*	.079	-.012	.029	.082	.000	-.040	.107*	.075	.094	1.000	-.008	-.047	.012	.093*
		Sig. (2-tailed)	.895	.181	.673	.005	.660	.045	.109	.805	.546	.105	.999	.425	.033	.126	.055	.	.867	.355	.802	.038
		N	277	276	278	277	278	277	276	277	275	274	276	278	278	277	278	278	278	278	278	278
	E7	Correlation C	.031	.017	.064	-.040	.058	-.045	.197*	-.091	-.025	-.062	.184*	.045	-.038	-.112*	-.101*	-.008	1.000	.075	-.021	-.045
		Sig. (2-tailed)	.531	.728	.196	.423	.260	.388	.000	.064	.604	.223	.000	.373	.453	.023	.041	.867	.	.138	.646	.325
		N	278	277	279	278	279	278	277	278	276	275	277	279	279	278	279	278	279	279	279	279
	E8	Correlation C	.127*	.071	.012	.086	-.006	-.009	.024	-.050	.134*	.060	.010	.116*	.068	.121*	-.040	-.047	.075	1.000	-.074	-.108*
		Sig. (2-tailed)	.013	.162	.811	.089	.909	.868	.641	.323	.008	.256	.842	.025	.193	.017	.429	.355	.138	.	.127	.021
		N	278	277	279	278	279	278	277	278	276	275	277	279	279	278	279	278	279	279	279	279
	MC1	Correlation C	.033	.175*	.053	.074	.021	.231*	.115*	.044	-.005	.069	-.016	-.093	.040	-.037	.075	.012	-.021	-.074	1.000	.540*
		Sig. (2-tailed)	.484	.000	.260	.112	.661	.000	.014	.346	.915	.154	.742	.051	.405	.431	.112	.802	.646	.127	.	.000
		N	279	278	280	279	280	279	278	279	276	275	277	279	279	278	279	278	279	279	280	280
	SA1	Correlation C	.043	.090*	.058	.124*	.015	.218*	.033	.023	.042	.113*	-.011	-.023	.101*	-.127*	.110*	.093*	-.045	-.108*	.540*	1.000
		Sig. (2-tailed)	.339	.046	.204	.006	.745	.000	.469	.612	.350	.015	.806	.612	.029	.005	.015	.038	.325	.021	.000	.
		N	279	278	280	279	280	279	278	279	276	275	277	279	279	278	279	278	279	279	280	280

**Correlation is significant at the .01 level (2-tailed).

*Correlation is significant at the .05 level (2-tailed).

Test 2 Correlations

Correlations

			SA 2	SCG 2	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Kendall's tau_b	SA 2	Correlation Coeffi	1.000	.273**	.025	.009	.162**	.108	.071	.193**	.012	.039	.003	.084
		Sig. (2-tailed)	.	.000	.664	.876	.005	.060	.230	.001	.838	.494	.963	.151
		N	181	181	179	178	179	179	179	178	177	178	176	175
	SCG 2	Correlation Coeffi	.273**	1.000	.068	.101	.042	.113*	-.059	.180**	-.022	.009	.088	.006
		Sig. (2-tailed)	.000	.	.227	.077	.461	.044	.308	.003	.693	.870	.118	.923
		N	181	181	179	178	179	179	179	178	177	178	176	175
	Q1	Correlation Coeffi	.025	.068	1.000	.241**	.133*	.141*	-.006	.129*	.015	-.028	.110	.039
		Sig. (2-tailed)	.664	.227	.	.000	.032	.022	.922	.050	.816	.650	.078	.536
		N	179	179	179	178	179	179	179	178	177	178	176	175
	Q2	Correlation Coeffi	.009	.101	.241**	1.000	.198**	.084	-.004	-.074	.057	.072	.171**	-.090
		Sig. (2-tailed)	.876	.077	.000	.	.001	.175	.951	.262	.365	.244	.006	.159
		N	178	178	178	178	178	178	178	177	176	177	175	174
	Q3	Correlation Coeffi	.162**	.042	.133*	.198**	1.000	.167**	.010	.097	-.033	.000	.120	-.042
		Sig. (2-tailed)	.005	.461	.032	.001	.	.007	.877	.138	.590	.994	.053	.509
		N	179	179	179	178	179	179	179	178	177	178	176	175
	Q4	Correlation Coeffi	.108	.113*	.141*	.084	.167**	1.000	-.105	.047	.212**	.067	.218**	.120
		Sig. (2-tailed)	.060	.044	.022	.175	.007	.	.098	.468	.001	.269	.000	.058
		N	179	179	179	178	179	179	179	178	177	178	176	175
	Q5	Correlation Coeffi	.071	-.059	-.006	-.004	.010	-.105	1.000	.100	.064	-.036	.064	.113
		Sig. (2-tailed)	.230	.308	.922	.951	.877	.098	.	.137	.319	.568	.316	.084
		N	179	179	179	178	179	179	179	178	177	178	176	175
	Q6	Correlation Coeffi	.193**	.180**	.129*	-.074	.097	.047	.100	1.000	.013	-.086	-.024	.095
		Sig. (2-tailed)	.001	.003	.050	.262	.138	.468	.137	.	.849	.184	.709	.155
		N	178	178	178	177	178	178	178	178	176	177	175	174
	Q7	Correlation Coeffi	.012	-.022	.015	.057	-.033	.212**	.064	.013	1.000	-.020	.059	-.010
		Sig. (2-tailed)	.838	.693	.816	.365	.590	.001	.319	.849	.	.745	.343	.869
		N	177	177	177	176	177	177	177	176	177	176	174	173
	Q8	Correlation Coeffi	.039	.009	-.028	.072	.000	.067	-.036	-.086	-.020	1.000	.068	-.002
		Sig. (2-tailed)	.494	.870	.650	.244	.994	.269	.568	.184	.745	.	.269	.968
		N	178	178	178	177	178	178	178	177	176	178	175	174
	Q9	Correlation Coeffi	.003	.088	.110	.171**	.120	.218**	.064	-.024	.059	.068	1.000	.094
		Sig. (2-tailed)	.963	.118	.078	.006	.053	.000	.316	.709	.343	.269	.	.135
		N	176	176	176	175	176	176	176	175	174	175	176	175
	Q10	Correlation Coeffi	.084	.006	.039	-.090	-.042	.120	.113	.095	-.010	-.002	.094	1.000
		Sig. (2-tailed)	.151	.923	.536	.159	.509	.058	.084	.155	.869	.968	.135	.
		N	175	175	175	174	175	175	175	174	173	174	175	175

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Correlations

			SA 2	SCG 2	E1	E2	E3	E4	E5	E6	E7	E8
Kendall's tau_b	SA 2	Correlation Coeffi	1.000	.273**	-.010	-.051	.173**	.025	.185**	.122*	-.018	-.050
		Sig. (2-tailed)	.	.000	.859	.383	.003	.659	.001	.032	.751	.394
		N	181	181	179	180	179	179	179	179	179	179
	SCG 2	Correlation Coeffi	.273**	1.000	-.012	-.059	.059	-.012	.088	.034	-.082	.003
		Sig. (2-tailed)	.000	.	.838	.305	.309	.829	.118	.547	.145	.952
		N	181	181	179	180	179	179	179	179	179	179
	E1	Correlation Coeffi	-.010	-.012	1.000	.039	-.058	-.067	-.048	-.026	.184**	-.043
		Sig. (2-tailed)	.859	.838	.	.541	.364	.283	.440	.674	.003	.503
		N	179	179	179	179	178	178	178	178	178	178
	E2	Correlation Coeffi	-.051	-.059	.039	1.000	-.148*	-.134*	-.092	.000	.018	.112
		Sig. (2-tailed)	.383	.305	.541	.	.021	.033	.142	1.000	.773	.081
		N	180	180	179	180	179	179	179	179	179	179
	E3	Correlation Coeffi	.173**	.059	-.058	-.148*	1.000	.194**	.200**	.102	-.087	.068
		Sig. (2-tailed)	.003	.309	.364	.021	.	.002	.002	.102	.169	.292
		N	179	179	178	179	179	178	178	178	178	178
	E4	Correlation Coeffi	.025	-.012	-.067	-.134*	.194**	1.000	.179**	.173**	-.047	.161*
		Sig. (2-tailed)	.659	.829	.283	.033	.002	.	.004	.005	.451	.010
		N	179	179	178	179	178	179	179	179	179	179
	E5	Correlation Coeffi	.185**	.088	-.048	-.092	.200**	.179**	1.000	.006	.045	.023
		Sig. (2-tailed)	.001	.118	.440	.142	.002	.004	.	.924	.472	.710
		N	179	179	178	179	178	179	179	179	179	179
	E6	Correlation Coeffi	.122*	.034	-.026	.000	.102	.173**	.006	1.000	.021	.011
		Sig. (2-tailed)	.032	.547	.674	1.000	.102	.005	.924	.	.727	.857
		N	179	179	178	179	178	179	179	179	179	179
	E7	Correlation Coeffi	-.018	-.082	.184**	.018	-.087	-.047	.045	.021	1.000	.030
		Sig. (2-tailed)	.751	.145	.003	.773	.169	.451	.472	.727	.	.639
		N	179	179	178	179	178	179	179	179	179	179
	E8	Correlation Coeffi	-.050	.003	-.043	.112	.068	.161*	.023	.011	.030	1.000
		Sig. (2-tailed)	.394	.952	.503	.081	.292	.010	.710	.857	.639	
		N	179	179	178	179	178	179	179	179	179	179

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Test 3 Correlations

Correlations

			SA 3	SCG 3	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Kendall's tau_b	SA 3	Correlation Coefficie	1.000	.434**	.032	-.090	.061	-.015	.029	.132	.001	.017	-.045	.148*
		Sig. (2-tailed)	.	.000	.637	.184	.368	.821	.680	.063	.984	.804	.503	.032
		N	146	146	140	140	139	140	139	140	138	140	137	137
	SCG 3	Correlation Coefficie	.434**	1.000	-.052	-.087	-.081	.013	-.049	.050	.019	-.050	.087	.035
		Sig. (2-tailed)	.000	.	.452	.206	.239	.846	.484	.486	.782	.460	.204	.613
		N	146	146	140	140	139	140	139	140	138	140	137	137
	Q1	Correlation Coefficie	.032	-.052	1.000	.192**	.075*	.091*	-.055	.095*	.016	-.014	.094**	.032
		Sig. (2-tailed)	.637	.452	.	.000	.039	.012	.145	.013	.669	.693	.009	.389
		N	140	140	523	521	522	522	522	521	518	522	513	512
	Q2	Correlation Coefficie	-.090	-.087	.192**	1.000	.077*	.047	-.021	.082*	.053	.048	.112**	-.018
		Sig. (2-tailed)	.184	.206	.000	.	.034	.193	.579	.030	.142	.184	.002	.635
		N	140	140	521	522	521	522	521	520	517	521	512	511
	Q3	Correlation Coefficie	.061	-.081	.075*	.077*	1.000	.097**	.047	.094*	.011	.036	.079*	.031
		Sig. (2-tailed)	.368	.239	.039	.034	.	.008	.214	.013	.755	.320	.029	.405
		N	139	139	522	521	523	522	522	521	518	522	513	512
	Q4	Correlation Coefficie	-.015	.013	.091*	.047	.097**	1.000	.017	.066	.036	.047	.188**	.049
		Sig. (2-tailed)	.821	.846	.012	.193	.008	.	.656	.080	.327	.185	.000	.188
		N	140	140	522	522	522	523	522	521	518	522	513	512
	Q5	Correlation Coefficie	.029	-.049	-.055	-.021	.047	.017	1.000	.015	.006	-.002	.003	.036
		Sig. (2-tailed)	.680	.484	.145	.579	.214	.656	.	.703	.874	.962	.941	.354
		N	139	139	522	521	522	522	523	521	518	522	513	512
	Q6	Correlation Coefficie	.132	.050	.095*	.082*	.094*	.066	.015	1.000	.008	-.074*	.002	.169**
		Sig. (2-tailed)	.063	.486	.013	.030	.013	.080	.703	.	.838	.047	.968	.000
		N	140	140	521	520	521	521	521	522	517	521	512	511
	Q7	Correlation Coefficie	.001	.019	.016	.053	.011	.036	.006	.008	1.000	.031	-.022	-.041
		Sig. (2-tailed)	.984	.782	.669	.142	.755	.327	.874	.838	.	.379	.548	.268
		N	138	138	518	517	518	518	518	517	519	518	509	508
	Q8	Correlation Coefficie	.017	-.050	-.014	.048	.036	.047	-.002	-.074*	.031	1.000	.096**	-.005
		Sig. (2-tailed)	.804	.460	.693	.184	.320	.185	.962	.047	.379	.	.007	.895
		N	140	140	522	521	522	522	522	521	518	523	513	512
	Q9	Correlation Coefficie	-.045	.087	.094**	.112**	.079*	.188**	.003	.002	-.022	.096**	1.000	.016
		Sig. (2-tailed)	.503	.204	.009	.002	.029	.000	.941	.968	.548	.007	.	.672
		N	137	137	513	512	513	513	513	512	509	513	514	513
	Q10	Correlation Coefficie	.148*	.035	.032	-.018	.031	.049	.036	.169**	-.041	-.005	.016	1.000
		Sig. (2-tailed)	.032	.613	.389	.635	.405	.188	.354	.000	.268	.895	.672	.
		N	137	137	512	511	512	512	512	511	508	512	513	513

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Correlations

			SA 3	SCG 3	E1	E2	E3	E4	E5	E6	E7	E8
Kendall's tau_b	SA 3	Correlation Coefficien	1.000	.434**	-.067	.019	.047	.068	.038	.031	-.025	.046
		Sig. (2-tailed)	.	.000	.331	.783	.503	.322	.583	.648	.713	.505
		N	146	146	140	140	140	138	138	137	136	137
	SCG 3	Correlation Coefficien	.434**	1.000	-.045	-.019	.043	.116	.034	.036	.051	-.035
		Sig. (2-tailed)	.000	.	.517	.787	.545	.097	.626	.601	.470	.617
		N	146	146	140	140	140	138	138	137	136	137
	E1	Correlation Coefficien	-.067	-.045	1.000	.021	-.070	-.014	-.138**	-.006	.141**	.023
		Sig. (2-tailed)	.331	.517	.	.570	.065	.699	.000	.880	.000	.547
		N	140	140	520	520	518	517	518	516	516	517
	E2	Correlation Coefficien	.019	-.019	.021	1.000	-.028	-.095**	-.047	-.068	.000	.099**
		Sig. (2-tailed)	.783	.787	.570	.	.459	.010	.207	.062	.993	.009
		N	140	140	520	523	521	520	521	519	519	520
	E3	Correlation Coefficien	.047	.043	-.070	-.028	1.000	.127**	.239**	.065	-.081*	.088*
		Sig. (2-tailed)	.503	.545	.065	.459	.	.001	.000	.080	.031	.022
		N	140	140	518	521	521	518	519	517	517	518
	E4	Correlation Coefficien	.068	.116	-.014	-.095**	.127**	1.000	.103**	.054	-.027	.094*
		Sig. (2-tailed)	.322	.097	.699	.010	.001	.	.005	.129	.461	.011
		N	138	138	517	520	518	520	520	518	518	519
	E5	Correlation Coefficien	.038	.034	-.138**	-.047	.239**	.103**	1.000	.104**	-.051	.003
		Sig. (2-tailed)	.583	.626	.000	.207	.000	.005	.	.004	.165	.941
		N	138	138	518	521	519	520	521	519	519	520
	E6	Correlation Coefficien	.031	.036	-.006	-.068	.065	.054	.104**	1.000	.008	-.018
		Sig. (2-tailed)	.648	.601	.880	.062	.080	.129	.004	.	.823	.622
		N	137	137	516	519	517	518	519	519	518	519
	E7	Correlation Coefficien	-.025	.051	.141**	.000	-.081*	-.027	-.051	.008	1.000	-.012
		Sig. (2-tailed)	.713	.470	.000	.993	.031	.461	.165	.823	.	.754
		N	136	136	516	519	517	518	519	518	519	519
	E8	Correlation Coefficien	.046	-.035	.023	.099**	.088*	.094*	.003	-.018	-.012	1.000
		Sig. (2-tailed)	.505	.617	.547	.009	.022	.011	.941	.622	.754	.
		N	137	137	517	520	518	519	520	519	519	520

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Test 4 Correlations

Correlations

			MC 4	SCG 4	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Kendall's tau	MC 4	Correlation Coeff	1.000	.357*	.171	.084	.093	.081	.063	.070	.148	-.012	-.037	-.167
		Sig. (2-tailed)	.	.000	.073	.381	.328	.389	.524	.490	.117	.900	.692	.087
		N	75	75	74	73	74	74	74	73	74	73	73	72
	SCG 4	Correlation Coeff	.357*	1.000	.067	.125	.157	.033	.089	.173	.159	-.016	.083	-.136
		Sig. (2-tailed)	.000	.	.452	.165	.079	.710	.338	.070	.074	.859	.350	.138
		N	75	75	74	73	74	74	74	73	74	73	73	72
	Q1	Correlation Coeff	.171	.067	1.000	.192*	.075*	.091*	-.055	.095*	.016	-.014	.094*	.032
		Sig. (2-tailed)	.073	.452	.	.000	.039	.012	.145	.013	.669	.693	.009	.389
		N	74	74	523	521	522	522	522	521	518	522	513	512
	Q2	Correlation Coeff	.084	.125	.192*	1.000	.077*	.047	-.021	.082*	.053	.048	.112*	-.018
		Sig. (2-tailed)	.381	.165	.000	.	.034	.193	.579	.030	.142	.184	.002	.635
		N	73	73	521	522	521	522	521	520	517	521	512	511
	Q3	Correlation Coeff	.093	.157	.075*	.077*	1.000	.097*	.047	.094*	.011	.036	.079*	.031
		Sig. (2-tailed)	.328	.079	.039	.034	.	.008	.214	.013	.755	.320	.029	.405
		N	74	74	522	521	523	522	522	521	518	522	513	512
	Q4	Correlation Coeff	.081	.033	.091*	.047	.097*	1.000	.017	.066	.036	.047	.188*	.049
		Sig. (2-tailed)	.389	.710	.012	.193	.008	.	.656	.080	.327	.185	.000	.188
		N	74	74	522	522	522	523	522	521	518	522	513	512
	Q5	Correlation Coeff	.063	.089	-.055	-.021	.047	.017	1.000	.015	.006	-.002	.003	.036
		Sig. (2-tailed)	.524	.338	.145	.579	.214	.656	.	.703	.874	.962	.941	.354
		N	74	74	522	521	522	522	523	521	518	522	513	512
	Q6	Correlation Coeff	.070	.173	.095*	.082*	.094*	.066	.015	1.000	.008	-.074*	.002	.169*
		Sig. (2-tailed)	.490	.070	.013	.030	.013	.080	.703	.	.838	.047	.968	.000
		N	73	73	521	520	521	521	521	522	517	521	512	511
	Q7	Correlation Coeff	.148	.159	.016	.053	.011	.036	.006	.008	1.000	.031	-.022	-.041
		Sig. (2-tailed)	.117	.074	.669	.142	.755	.327	.874	.838	.	.379	.548	.268
		N	74	74	518	517	518	518	518	517	519	518	509	508
	Q8	Correlation Coeff	-.012	-.016	-.014	.048	.036	.047	-.002	-.074*	.031	1.000	.096*	-.005
		Sig. (2-tailed)	.900	.859	.693	.184	.320	.185	.962	.047	.379	.	.007	.895
		N	73	73	522	521	522	522	522	521	518	523	513	512
	Q9	Correlation Coeff	-.037	.083	.094*	.112*	.079*	.188*	.003	.002	-.022	.096*	1.000	.016
		Sig. (2-tailed)	.692	.350	.009	.002	.029	.000	.941	.968	.548	.007	.	.672
		N	73	73	513	512	513	513	513	512	509	513	514	513
	Q10	Correlation Coeff	-.167	-.136	.032	-.018	.031	.049	.036	.169*	-.041	-.005	.016	1.000
		Sig. (2-tailed)	.087	.138	.389	.635	.405	.188	.354	.000	.268	.895	.672	.
		N	72	72	512	511	512	512	512	511	508	512	513	513

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Correlations

			MC 4	SCG 4	E1	E2	E3	E4	E5	E6	E7	E8
Kendall's tau_b	MC 4	Correlation Coefficient	1.000	.357**	.118	-.031	.114	-.036	.075	.004	.096	-.120
		Sig. (2-tailed)	.	.000	.215	.745	.241	.706	.430	.965	.306	.211
		N	75	75	74	74	74	74	74	74	74	74
	SCG 4	Correlation Coefficient	.357**	1.000	.105	.075	.095	.011	.167	.023	.103	-.075
		Sig. (2-tailed)	.000	.	.245	.409	.298	.899	.063	.796	.246	.404
		N	75	75	74	74	74	74	74	74	74	74
	E1	Correlation Coefficient	.118	.105	1.000	.021	-.070	-.014	-.138**	-.006	.141**	.023
		Sig. (2-tailed)	.215	.245	.	.570	.065	.699	.000	.880	.000	.547
		N	74	74	520	520	518	517	518	516	516	517
	E2	Correlation Coefficient	-.031	.075	.021	1.000	-.028	-.095**	-.047	-.068	.000	.099**
		Sig. (2-tailed)	.745	.409	.570	.	.459	.010	.207	.062	.993	.009
		N	74	74	520	523	521	520	521	519	519	520
	E3	Correlation Coefficient	.114	.095	-.070	-.028	1.000	.127**	.239**	.065	-.081*	.088*
		Sig. (2-tailed)	.241	.298	.065	.459	.	.001	.000	.080	.031	.022
		N	74	74	518	521	521	518	519	517	517	518
	E4	Correlation Coefficient	-.036	.011	-.014	-.095**	.127**	1.000	.103**	.054	-.027	.094*
		Sig. (2-tailed)	.706	.899	.699	.010	.001	.	.005	.129	.461	.011
		N	74	74	517	520	518	520	520	518	518	519
	E5	Correlation Coefficient	.075	.167	-.138**	-.047	.239**	.103**	1.000	.104**	-.051	.003
		Sig. (2-tailed)	.430	.063	.000	.207	.000	.005	.	.004	.165	.941
		N	74	74	518	521	519	520	521	519	519	520
	E6	Correlation Coefficient	.004	.023	-.006	-.068	.065	.054	.104**	1.000	.008	-.018
		Sig. (2-tailed)	.965	.796	.880	.062	.080	.129	.004	.	.823	.622
		N	74	74	516	519	517	518	519	519	518	519
	E7	Correlation Coefficient	.096	.103	.141**	.000	-.081*	-.027	-.051	.008	1.000	-.012
		Sig. (2-tailed)	.306	.246	.000	.993	.031	.461	.165	.823	.	.754
		N	74	74	516	519	517	518	519	518	519	519
	E8	Correlation Coefficient	-.120	-.075	.023	.099**	.088*	.094*	.003	-.018	-.012	1.000
		Sig. (2-tailed)	.211	.404	.547	.009	.022	.011	.941	.622	.754	.
		N	74	74	517	520	518	519	520	519	519	520

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Test 5 Correlations

Correlations

			MC 5	SCG 5	SA 5	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Kendall's tau_b	MC 5	Correlation Coefficie	1.000	.346**	.408**	-.125	-.035	-.097	.114	-.054	.073	.026	-.090	-.050	-.078
		Sig. (2-tailed)	.	.000	.000	.231	.738	.358	.272	.623	.498	.804	.381	.632	.473
		N	64	64	64	64	64	63	64	63	64	63	64	62	62
	SCG 5	Correlation Coefficie	.346**	1.000	.232*	.079	.257*	.087	.063	-.012	.259*	.167	-.019	.097	-.111
		Sig. (2-tailed)	.000	.	.017	.432	.011	.397	.530	.908	.013	.098	.846	.339	.292
		N	64	64	64	64	64	63	64	63	64	63	64	62	62
	SA 5	Correlation Coefficie	.408**	.232*	1.000	.044	-.028	-.101	.013	.066	.065	-.113	-.033	-.011	-.048
		Sig. (2-tailed)	.000	.017	.	.669	.787	.334	.900	.536	.536	.274	.741	.918	.650
		N	64	64	64	64	64	63	64	63	64	63	64	62	62
	Q1	Correlation Coefficie	-.125	.079	.044	1.000	.192**	.075*	.091*	-.055	.095*	.016	-.014	.094**	.032
		Sig. (2-tailed)	.231	.432	.669	.	.000	.039	.012	.145	.013	.669	.693	.009	.389
		N	64	64	64	523	521	522	522	522	521	518	522	513	512
	Q2	Correlation Coefficie	-.035	.257*	-.028	.192**	1.000	.077*	.047	-.021	.082*	.053	.048	.112**	-.018
		Sig. (2-tailed)	.738	.011	.787	.000	.	.034	.193	.579	.030	.142	.184	.002	.635
		N	64	64	64	521	522	521	522	521	520	517	521	512	511
	Q3	Correlation Coefficie	-.097	.087	-.101	.075*	.077*	1.000	.097**	.047	.094*	.011	.036	.079*	.031
		Sig. (2-tailed)	.358	.397	.334	.039	.034	.	.008	.214	.013	.755	.320	.029	.405
		N	63	63	63	522	521	523	522	522	521	518	522	513	512
	Q4	Correlation Coefficie	.114	.063	.013	.091*	.047	.097**	1.000	.017	.066	.036	.047	.188**	.049
		Sig. (2-tailed)	.272	.530	.900	.012	.193	.008	.	.656	.080	.327	.185	.000	.188
		N	64	64	64	522	522	522	523	522	521	518	522	513	512
	Q5	Correlation Coefficie	-.054	-.012	.066	-.055	-.021	.047	.017	1.000	.015	.006	-.002	.003	.036
		Sig. (2-tailed)	.623	.908	.536	.145	.579	.214	.656	.	.703	.874	.962	.941	.354
		N	63	63	63	522	521	522	522	523	521	518	522	513	512
	Q6	Correlation Coefficie	.073	.259*	.065	.095*	.082*	.094*	.066	.015	1.000	.008	-.074*	.002	.169**
		Sig. (2-tailed)	.498	.013	.536	.013	.030	.013	.080	.703	.	.838	.047	.968	.000
		N	64	64	64	521	520	521	521	521	522	517	521	512	511
	Q7	Correlation Coefficie	.026	.167	-.113	.016	.053	.011	.036	.006	.008	1.000	.031	-.022	-.041
		Sig. (2-tailed)	.804	.098	.274	.669	.142	.755	.327	.874	.838	.	.379	.548	.268
		N	63	63	63	518	517	518	518	518	517	519	518	509	508
	Q8	Correlation Coefficie	-.090	-.019	-.033	-.014	.048	.036	.047	-.002	-.074*	.031	1.000	.096**	-.005
		Sig. (2-tailed)	.381	.846	.741	.693	.184	.320	.185	.962	.047	.379	.	.007	.895
		N	64	64	64	522	521	522	522	522	521	518	523	513	512
	Q9	Correlation Coefficie	-.050	.097	-.011	.094**	.112**	.079*	.188**	.003	.002	-.022	.096**	1.000	.016
		Sig. (2-tailed)	.632	.339	.918	.009	.002	.029	.000	.941	.968	.548	.007	.	.672
		N	62	62	62	513	512	513	513	513	512	509	513	514	513
	Q10	Correlation Coefficie	-.078	-.111	-.048	.032	-.018	.031	.049	.036	.169**	-.041	-.005	.016	1.000
		Sig. (2-tailed)	.473	.292	.650	.389	.635	.405	.188	.354	.000	.268	.895	.672	.
		N	62	62	62	512	511	512	512	512	511	508	512	513	513

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Correlations

			MC 5	SCG 5	SA 5	E1	E2	E3	E4	E5	E6	E7	E8
Kendall's tau_b	MC 5	Correlation Coefficient	1.000	.346**	.408**	-.155	-.065	.006	-.110	.027	.060	-.110	-.015
		Sig. (2-tailed)	.	.000	.000	.136	.540	.953	.290	.797	.556	.288	.884
		N	64	64	64	64	64	64	64	64	64	64	64
	SCG 5	Correlation Coefficient	.346**	1.000	.232*	-.168	.068	.113	-.050	.047	-.123	.040	-.010
		Sig. (2-tailed)	.000	.	.017	.097	.506	.278	.618	.648	.211	.694	.920
		N	64	64	64	64	64	64	64	64	64	64	64
	SA 5	Correlation Coefficient	.408**	.232*	1.000	-.224*	-.088	.019	-.177	.117	.020	-.083	-.144
		Sig. (2-tailed)	.000	.017	.	.029	.396	.861	.084	.263	.841	.417	.165
		N	64	64	64	64	64	64	64	64	64	64	64
	E1	Correlation Coefficient	-.155	-.168	-.224*	1.000	.021	-.070	-.014	-.138**	-.006	.141**	.023
		Sig. (2-tailed)	.136	.097	.029	.	.570	.065	.699	.000	.880	.000	.547
		N	64	64	64	520	520	518	517	518	516	518	517
	E2	Correlation Coefficient	-.065	.068	-.088	.021	1.000	-.028	-.095**	-.047	-.068	.000	.099**
		Sig. (2-tailed)	.540	.506	.396	.570	.	.459	.010	.207	.062	.993	.009
		N	64	64	64	520	523	521	520	521	519	519	520
	E3	Correlation Coefficient	.006	.113	.019	-.070	-.028	1.000	.127**	.239**	.065	-.081*	.088*
		Sig. (2-tailed)	.953	.278	.861	.065	.459	.	.001	.000	.080	.031	.022
		N	64	64	64	518	521	521	518	519	517	517	518
	E4	Correlation Coefficient	-.110	-.050	-.177	-.014	-.095**	.127**	1.000	.103**	.054	-.027	.094*
		Sig. (2-tailed)	.290	.618	.084	.699	.010	.001	.	.005	.129	.461	.011
		N	64	64	64	517	520	518	520	520	518	518	519
	E5	Correlation Coefficient	.027	.047	.117	-.138**	-.047	.239**	.103**	1.000	.104**	-.051	.003
		Sig. (2-tailed)	.797	.648	.263	.000	.207	.000	.005	.	.004	.165	.941
		N	64	64	64	518	521	519	520	521	519	519	520
	E6	Correlation Coefficient	.060	-.123	.020	-.006	-.068	.065	.054	.104**	1.000	.008	-.018
		Sig. (2-tailed)	.556	.211	.841	.880	.062	.080	.129	.004	.	.823	.622
		N	64	64	64	516	519	517	518	519	519	518	519
	E7	Correlation Coefficient	-.110	.040	-.083	.141**	.000	-.081*	-.027	-.051	.008	1.000	-.012
		Sig. (2-tailed)	.288	.694	.417	.000	.993	.031	.461	.165	.823	.	.754
		N	64	64	64	518	519	517	518	519	518	519	519
	E8	Correlation Coefficient	-.015	-.010	-.144	.023	.099**	.088*	.094*	.003	-.018	-.012	1.000
		Sig. (2-tailed)	.884	.920	.165	.547	.009	.022	.011	.941	.622	.754	.
		N	64	64	64	517	520	518	519	520	519	519	520

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Frequency Table

Q1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1A	26	5.0	5.0	5.0
	2A	72	13.7	13.8	18.7
	3B	98	18.7	18.7	37.5
	4C	155	29.6	29.6	67.1
	5C	172	32.8	32.9	100.0
	Total	523	99.8	100.0	
Missing	System	1	.2		
Total		524	100.0		

Q2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	102	19.5	19.5	19.5
	2	143	27.3	27.4	46.9
	3	181	34.5	34.7	81.6
	4	71	13.5	13.6	95.2
	5	25	4.8	4.8	100.0
	Total	522	99.6	100.0	
Missing	System	2	.4		
Total		524	100.0		

Q5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	261	49.8	49.9	49.9
	2	169	32.3	32.3	82.2
	3	65	12.4	12.4	94.6
	4	17	3.2	3.3	97.9
	5	11	2.1	2.1	100.0
	Total	523	99.8	100.0	
Missing	System	1	.2		
Total		524	100.0		

E2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	181	34.5	34.6	34.6
	2	196	37.4	37.5	72.1
	3	80	15.3	15.3	87.4
	4	52	9.9	9.9	97.3
	5	14	2.7	2.7	100.0
	Total	523	99.8	100.0	
Missing	System	1	.2		
Total		524	100.0		

E6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	58	11.1	11.2	11.2
	2	108	20.6	20.8	32.0
	3	112	21.4	21.6	53.6
	4	132	25.2	25.4	79.0
	5	109	20.8	21.0	100.0
	Total	519	99.0	100.0	
Missing	System	5	1.0		
Total		524	100.0		

Q3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	44	8.4	8.4	8.4
	2	51	9.7	9.8	18.2
	3	105	20.0	20.1	38.2
	4	106	20.2	20.3	58.5
	5	217	41.4	41.5	100.0
	Total	523	99.8	100.0	
Missing	System	1	.2		
Total		524	100.0		

Q4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	46	8.8	8.8	8.8
	2	43	8.2	8.2	17.0
	3	129	24.6	24.7	41.7
	4	179	34.2	34.2	75.9
	5	126	24.0	24.1	100.0
	Total	523	99.8	100.0	
Missing	System	1	.2		
Total		524	100.0		

E3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	19	3.6	3.6	3.6
	2	28	5.3	5.4	9.0
	3	61	11.6	11.7	20.7
	4	199	38.0	38.2	58.9
	5	214	40.8	41.1	100.0
	Total	521	99.4	100.0	
Missing	System	3	.6		
Total		524	100.0		

Q6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	4	.8	.8	.8
	2	15	2.9	2.9	3.6
	3	74	14.1	14.2	17.8
	4	98	18.7	18.8	36.6
	5	331	63.2	63.4	100.0
	Total	522	99.6	100.0	
Missing	System	2	.4		
Total		524	100.0		

Q7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	69	13.2	13.3	13.3
	2	78	14.9	15.0	28.3
	3	213	40.6	41.0	69.4
	4	78	14.9	15.0	84.4
	5	81	15.5	15.6	100.0
	Total	519	99.0	100.0	
Missing	System	5	1.0		
Total		524	100.0		

E1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	63	12.0	12.1	12.1
	2	235	44.8	45.2	57.3
	3	143	27.3	27.5	84.8
	4	61	11.6	11.7	96.5
	5	18	3.4	3.5	100.0
	Total	520	99.2	100.0	
Missing	System	4	.8		
Total		524	100.0		

E5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	35	6.7	6.7	6.7
	2	52	9.9	10.0	16.7
	3	102	19.5	19.6	36.3
	4	192	36.6	36.9	73.1
	5	140	26.7	26.9	100.0
	Total	521	99.4	100.0	
Missing	System	3	.6		
Total		524	100.0		

E7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	47	9.0	9.1	9.1
	2	101	19.3	19.5	28.5
	3	187	35.7	36.0	64.5
	4	133	25.4	25.6	90.2
	5	51	9.7	9.8	100.0
	Total	519	99.0	100.0	
Missing	System	5	1.0		
Total		524	100.0		

Q8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	69	13.2	13.2	13.2
	2	100	19.1	19.1	32.3
	3	148	28.2	28.3	60.6
	4	106	20.2	20.3	80.9
	5	100	19.1	19.1	100.0
	Total	523	99.8	100.0	
Missing	System	1	.2		
Total		524	100.0		

Q9

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	85	16.2	16.5	16.5
	2	59	11.3	11.5	28.0
	3	110	21.0	21.4	49.4
	4	141	26.9	27.4	76.8
	5	119	22.7	23.2	100.0
	Total	514	98.1	100.0	
Missing	System	10	1.9		
Total		524	100.0		

Q10

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	266	50.8	51.9	51.9
	2	98	18.7	19.1	71.0
	3	83	15.8	16.2	87.1
	4	30	5.7	5.8	93.0
	5	36	6.9	7.0	100.0
	Total	513	97.9	100.0	
Missing	System	11	2.1		
Total		524	100.0		

E4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	40	7.6	7.7	7.7
	2	96	18.3	18.5	26.2
	3	190	36.3	36.5	62.7
	4	129	24.6	24.8	87.5
	5	65	12.4	12.5	100.0
	Total	520	99.2	100.0	
Missing	System	4	.8		
Total		524	100.0		

E8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	204	38.9	39.2	39.2
	2	184	35.1	35.4	74.6
	3	91	17.4	17.5	92.1
	4	29	5.5	5.6	97.7
	5	12	2.3	2.3	100.0
	Total	520	99.2	100.0	
Missing	System	4	.8		
Total		524	100.0		

Appendix G

The Data of the Two Cognitive tests
The Data of the Perry Questionnaire

AA	SEX	CVSC	FD SC	AA	SEX	CVSC	FD SC
10101	F	67	5	20111	F	59	14
10102	F	35	11	20112	F	64	7
10103	M	65	6	20113	F	56	6
10104	M	42	5	20115	F	55	7
10105	F	47	5	20116	M	35	7
10106	M	51	6	20117	M	46	7
10107	F	58	5	20118	M	50	9
10108	F	41	4	20119	F	52	5
10109	M	43	4	20120	F	43	8
10110	M	64	3	20121	F	54	.
10111	F	55	11	20122	F	41	14
10112	M	73	5	20201	F	40	5
10113	M	43	8	20202	F	57	.
10114	M	43	11	20203	F	59	10
10115	M	61	12	20204	F	41	6
10116	F	72	12	20205	M	50	5
10117	F	31	7	20206	M	66	4
10118	M	57	3	20207	F	46	5
10119	M	49	9	20208	F	35	1
20101	M	48	18	20209	M	43	5
20102	F	44	16	20210	F	50	7
20103	M	39	9	20211	F	57	3
20104	F	43	16	20212	M	48	3
20105	M	42	14	20213	M	54	7
20106	F	6	7	20214	M	49	.
20107	F	58	3	20215	F	32	2
20108	F	43	9	20216	F	52	4
20109	F	52	4	20217	F	57	4
20110	F	.	5	20218	F	66	4
20111	F	59	14	20219	F	40	4
20112	F	64	7	20220	F	46	.
20113	F	56	6	20221	F	47	6
20115	F	55	7	20222	M	46	3
20116	M	35	7	20223	F	39	2
20117	M	46	7	20224	F	61	13
20118	M	50	9	20225	F	62	17
20119	F	52	5	20301	M	64	3
20120	F	43	8	20302	M	53	12
20121	F	54	.	20303	M	48	6
20122	F	41	14	20304	M	57	9
20201	F	40	5	20305	F	54	7
20202	F	57	.	20307	F	45	5
20203	F	59	10	20308	F	36	1
20204	F	41	6	20309	M	36	.
20205	M	50	5	20310	M	40	16
20206	M	66	4	20311	F	47	4
20207	F	46	5	20312	F	50	4
20208	F	35	1	20313	F	59	6
20209	M	43	5	20314	F	37	.
20210	F	50	7	20315	F	41	12

20316	F	47	4	50309	M	41	4
20317	F	48	13	50310	F	51	11
20318	F	42	8	50311	F	43	6
20319	F	46	5	50312	M	49	19
20321	F	45	10	50313	M	33	11
20323	F	52	6	50314	F	27	11
30301	F	43	12	50315	M	54	14
30302	M	55	9	50316	F	56	13
30303	F	42	5	50317	F	52	.
30304	F	64	8	50318	M	44	6
30305	M	64	17	50319	F	34	3
30306	F	49	8	50320	F	40	17
30307	F	53	3	50401	M	34	3
30308	F	39	7	50402	M	35	5
30309	M	37	1	50403	M	34	6
30310	F	60	11	50404	F	51	3
30311	F	53	12	50406	M	44	1
30312	F	39	7	50407		.	11
30313	F	31	6	50408	F	59	7
30314	M	51	11	50409	F	39	5
30316	M	40	6	50410	F	50	10
30317	M	44	7	50411	F	54	0
30318	M	65	7	50412	F	32	0
30319	F	58	15	50414	F	42	0
30320	M	43	14	50415	F	51	15
30321	F	59	12	50416	M	51	10
30322	F	52	6	50417	M	39	8
30323	F	49	4	50418	M	54	10
40202	F	53	9	50419	F	57	12
40203	F	51	13	50420	F	56	8
40204	F	50	3	50422	M	35	5
40205	F	27	6	60101	M	40	14
40207	M	57	18	60102	F	44	8
40208	F	20	8	60103	F	54	2
40209	F	45	18	60104	M	28	6
40210	F	22	13	60105	M	48	4
40212	F	45	.	60106	F	36	9
40216	M	47	6	60107	F	42	15
40218	M	30	7	60108	F	43	9
40221	F	51	9	60109	F	71	8
40223	F	45	17	60110	M	38	5
40224	M	43	8	60111	F	46	7
40225	F	51	10	60112	M	43	3
50301	F	58	8	60113	M	38	10
50302	M	34	5	60114	M	47	9
50303	M	34	13	60115	M	51	7
50304	M	48	8	60116	M	55	6
50305	F	42	9	60117	M	52	6
50306	F	47	11	60118	M	37	7
50307	F	43	5	60201	F	52	5
50308	F	57	12	60202	F	38	1

60203	F	48	9	70107		.	2
60204	F	46	2	70108	M	46	3
60205	M	56	3	70109	F	55	10
60206	F	44	8	70110	F	39	5
60207	M	49	12	70111	M	35	8
60208	F	32	3	70112	F	59	14
60209	M	48	12	70113	F	55	6
60210	F	37	8	70114	F	17	13
60211	F	41	8	70115	F	43	7
60212	F	52	1	70116	F	47	10
60213	F	45	10	70117	F	68	8
60214	F	46	.	70118	M	41	11
60215	F	45	5	70119	F	41	6
60216	M	43	2	70120	F	73	12
60217	M	37	2	70121	F	35	8
60218	F	42	3	70122		.	13
60301	F	54	4	70123	M	31	16
60302	F	41	2	70124	F	48	8
60303	M	60	8	70125	M	44	4
60304	F	60	18	70126	M	60	13
60305	F	37	9	70127	F	34	5
60306	F	47	5	70201	F	49	6
60307	M	67	8	70202	F	55	2
60308	F	37	10	70203	M	28	3
60309	F	54	11	70204	F	54	9
60311	F	44	3	70205	F	42	5
60312	F	28	7	70206	M	42	13
60314	F	56	15	70207	F	52	7
60315	F	56	9	70208	F	53	11
60316	F	64	12	70209	F	51	9
60317	F	48	12	70210	F	41	4
60318	F	60	16	70211	M	36	14
60319	F	49	12	70212	M	56	5
60402	M	28	6	70213	M	30	.
60404	M	43	10	70215	F	58	15
60405	F	48	.	70216	M	37	8
60406	M	40	9	70217	M	46	11
60407	F	45	13	70219	F	45	4
60408	M	48	.	70220	M	46	.
60409	F	36	11	70221	F	61	10
60410	F	45	11	70222	M	49	5
60411	F	35	6	70223	M	36	4
60412	F	46	9	70224	F	62	10
60414	F	46	11	70225	M	37	4
70101	F	57	3	70226	F	38	3
70102	F	48	14	70301	F	43	4
70103	M	44	2	70302	F	41	5
70104	F	52	6	70303	F	44	6
70105	F	51	11	70304	F	31	1
70106	F	52	11	70305	M	40	13
				70306	M	36	17

70307	M	34	3	80205	M	48	19
70308	F	59	2	80206	F	43	2
70310	M	31	13	80207	M	37	4
70311	F	35	4	80210	M	30	3
70312	M	58	11	80211	F	60	9
70313	F	45	1	80212	F	56	12
70314	M	67	2	80213	M	51	9
70315	M	36	6	80214	F	50	6
70316	M	52	6	80215	M	43	15
70317	M	54	1	80216	M	50	9
70318	M	51	8	80217	M	46	12
70319	F	42	4	80218	F	50	7
70320	F	46	8	80219	M	54	3
70321	M	42	3	80220	F	57	11
70322	F	45	11	80222	M	62	8
70323	M	20	2	80223	M	32	4
70325	F	51	.	80224	M	45	5
70326	F	48	5	80225	M	30	4
80101	M	42	4	80226	M	50	4
80102	F	43	5	80227	F	52	15
80103	F	61	2	80228	F	54	9
80104	F	42	1	80229	M	61	7
80105	F	53	4	80230	M	29	4
80106	F	44	16	90201	F	36	4
80107	M	58	4	90202	M	63	17
80108	F	39	7	90203	M	30	4
80109	F	52	19	90204	F	61	14
80110	F	69	11	90205	M	59	14
80111	M	74	8	90206	F	48	10
80112	M	55	9	90207	M	62	8
80113	F	60	4	90208	F	60	4
80114	F	37	4	90209	F	58	8
80115	F	46	13	90210	F	51	13
80116	M	37	7	90211	F	56	12
80117	M	47	2	90212	M	49	12
80118	M	57	12	90213	F	39	9
80119	F	54	2	90215	M	45	9
80120	M	42	11	90216	F	66	13
80121	F	53	5	90217	M	40	1
80122	F	48	12	90218	F	66	3
80123	F	41	2	90219	F	38	5
80124	F	48	6	90220	M	27	4
80125	F	53	8	90221	M	50	9
80126	M	43	4	90222	F	60	6
80127	M	46	9	90223	F	49	9
80129	F	51	9	90224	F	54	4
80130	F	57	5	90225	M	38	17
80131	F	71	9	90226	M	59	16
80201	F	47	5	90227	F	59	6
80202	M	58	4	90228	M	69	8
80203	F	48	7	90229	M	44	12
80204	M	37	1				

90230	M	35	3	110406	M	45	5
90231	F	52	11	110407	M	68	14
100101	F	42	12	110408	F	61	6
100103	F	53	12	110409	F	31	13
100104	F	43	12	110410	F	42	4
100106	F	40	6	110411	M	58	8
100107	M	28	4	110412	F	65	15
100108	F	43	9	110413	M	70	7
100109	F	41	8	110414	M	46	5
100110	M	38	7	110415	F	42	3
100111	M	32	2	110416	M	46	7
100112	F	39	4	110417	F	51	10
100113	F	66	2	110418	F	75	15
100115	F	30	4	110419	F	48	3
100116	F	60	5	110420	M	52	9
100117	F	31	2	110421	F	39	4
100118	M	26	6	110422	F	56	13
100119	M	47	20	110423	F	43	8
100120	M	43	4	110424	M	36	13
100121	M	44	1	110425	F	49	14
100122	F	45	7	110426	F	32	10
100123	F	38	1	120101	F	64	13
100124	M	36	10	120102	F	41	13
100401	F	32	8	120103	F	69	8
100402	M	48	8	120104	F	63	13
100403	M	32	7	120105	M	45	10
100404	F	53	6	120106	F	47	13
100406	F	63	5	120107	M	48	18
100408	F	37	7	120108	M	51	7
100409	F	39	3	120109	M	36	11
100410	F	0	3	120110	F	35	5
100411	F	56	6	120111	M	55	10
100412	M	42	10	120112	F	37	5
100413	F	28	1	120113	F	50	6
100414	M	55	3	120114	M	41	11
100415	F	68	7	120115	F	36	8
100416	M	40	8	120116	M	41	11
100417	F	59	6	120117	M	29	8
100419	F	62	7	120118	F	47	7
100420	M	62	8	120119	M	38	6
100421	F	43	4	120120	M	53	5
100422	F	35	4	120121	F	56	8
100423	F	50	14	120122	F	57	6
100424	M	31	3	120123	M	51	4
100426	F	55	4	120124	F	47	12
100428	F	59	6	120125	F	23	5
110401	M	43	7	120401	M	57	16
110402	M	60	11	120402	F	42	11
110403	F	46	3	120403	M	48	7
110404	M	71	13	120404	F	43	9
110405	F	68	5	120405	F	32	5

110406	M	45	5
110407	M	68	14
110408	F	61	6
110409	F	31	13
110410	F	42	4
110411	M	58	8
110412	F	65	15
110413	M	70	7
110414	M	46	5
110415	F	42	3
110416	M	46	7
110417	F	51	10
110418	F	75	15
110419	F	48	3
110420	M	52	9
110421	F	39	4
110422	F	56	13
110423	F	43	8
110424	M	36	13
110425	F	49	14
110426	F	32	10
120101	F	64	13
120102	F	41	13
120103	F	69	8
120104	F	63	13
120105	M	45	10
120106	F	47	13
120107	M	48	18
120108	M	51	7
120109	M	36	11
120110	F	35	5
120111	M	55	10
120112	F	37	5
120113	F	50	6
120114	M	41	11
120115	F	36	8
120116	M	41	11
120117	M	29	8
120118	F	47	7
120119	M	38	6
120120	M	53	5
120121	F	56	8
120122	F	57	6
120123	M	51	4
120124	F	47	12
120125	F	23	5
120401	M	57	16
120402	F	42	11
120403	M	48	7
120404	F	43	9
120405	F	32	5
120406	M	43	15
120407	M	47	5
120408	M	36	6
120409	M	36	11
120410		.	.
120411	F	51	18
120412	F	39	1
120413	F	55	5
120414	M	31	14
120415	M	35	17
120416	M	38	11
120417	M	43	8
120418	M	49	10
120419	F	42	9
120420	F	48	7

PERRY QUESTIONNAIRE DATA

AA	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	E1	E2	E3	E4	E5	E6	E7	E8
10101	5	4	4	5	5	5	3	3	4	5	5	5	5	3	4	4	3	4
10102	2	5	2	4	4	5	2	4	5	5	4	5	5	4	4	5	2	4
10103	5	5	1	5	5	5	1	3	5	5	1	1	5	1	5	5	1	5
10104	4	5	3	1	5	5	1	1	5	5	4	5	3	1	3	5	2	4
10105	2	2	5	1	5	5	1	1	4	5	4	5	4	2	5	5	1	5
10106	4	5	5	5	4	5	3	1	4	5	5	4	5	2	1	5	4	5
10107	5	3	5	4	4	5	1	4	1	5	4	5	5	3	4	4	3	4
10108	5	5	5	3	5	5	3	2	1	5	3	4	1	3	1	1	3	5
10109	4	3	1	5	4	5	3	3	5	5	3	5	3	1	4	4	3	5
10110	2	3	5	3	5	4	1	1	3	5	4	5	3	1	2	3	1	5
10111	5	5	5	5	5	5	5	3	5	5	2	1	5	4	5	4	2	4
10112	1	3	5	4	5	4	5	1	2	5	4	4	4	1	2	3	4	5
10113	5	4	5	4	5	5	3	5	4	1	4	1	5	2	3	3	4	3
10114	2	3	2	4	3	5	2	1	5	3	4	3	5	3	3	2	4	5
10115	4	4	4	3	4	5	4	3	4	5	4	4	4	2	5	3	4	3
10116	5	5	5	3	5	5	1	2	2	5	4	4	5	3	4	4	3	5
10117	5	5	5	1	2	5	5	1	3	5	4	5	4	2	2	4	4	5
10118	5	4	3	2	5	5	3	1	3	4	2	3	4	3	3	4	2	5
10119	4	3	3	5	4	5	3	1	2	5	3	3	4	3	4	3	3	5
20101	4	4	4	3	3	4	3	3	3	3	4	4	5	3	5	3	3	4
20102	4	3	5	5	5	5	4	5	4	3	5	3	5	3	4	5	4	3
20103	3	4	5	5	2	5	5	1	3	5	5	1	3	4	5	5	5	5
20104	4	4	4	4	5	5	3	3	4	5	4	4	5	3	4	4	4	4
20105	4	4	3	4	4	5	5	2	4	5	4	3	5	3	4	4	3	5

20106	4	4	3	4	5	5	3	3	2	3	3	4	4	2	4	2	3	3
20107	5	5	4	4	4	5	2	4	4	4	3	4	4	4	5	5	4	4
20108	3	2	5	5	5	5	1	5	5	5	4	2	5	4	5	5	5	5
20109	5	4	2	3	4	4	3	5	3	5	4	3	4	3	4	5	4	4
20110	5	5	1	5	5	5	1	1	5	3	4	2	5	2	1	1	2	2
20111	4	3	5	4	4	5	2	3	5	5	2	3	5	3	5	5	2	4
20112	4	3	4	4	4	5	4	2	4	3	5	4	2	4	4	5	4	5
20113	5	4	5	5	4	5	1	4	5	5	3	4	5	4	5	4	3	5
20115	3	4	4	4	4	5	5	3	2	3	4	4	2	3	3	5	4	4
20116	4	3	3	3	4	4	1	1	2	5	4	4	4	3	5	5	3	4
20117	3	4	3	3	4	5	4	2	3	5	2	4	4	3	4	2	3	3
20118	4	4	1	4	4	5	3	3	4	5	2	3	5	3	5	2	4	3
20119	3	5	3	5	5	3	.	3	5	3	2	5	5	2	5	5	1	5
20120	2	3	4	4	5	5	3	3	3	4	3	5	4	2	5	4	3	3
20122	5	3	5	4	4	5	5	5	1	3	4	5	5	5	3	4	1	3
20201	3	3	5	3	4	3	4	3	3	3	4	2	4	3	3	3	4	3
20203	4	3	3	4	3	5	4	5	5	5	3	4	5	3	5	4	3	5
20204	3	3	5	4	5	4	4	4	4	2	3	4	5	2	3	.	.	.
20205	5	5	5	4	3	4	5	4	4	1	5	4	5	4	4	5	3	5
20206	5	4	5	5	5	5	3	3	4	3	4	5	4	3	5	4	4	3
20207	4	3	3	4	4	4	3	3	2	3	3	4	4	3	3	4	3	4
20208	2	2	5	1	4	4	3	4	4	2	3	4	4	2	4	4	3	1
20209	3	5	1	3	4	3	5	3	3	3	3	3	3	3	3	3	3	3
20210	3	4	5	4	4	3	4	3	4	5	4	2	5	3	3	4	4	3
20211	2	3	5	5	2	5	5	2	1	3	5	5	2	3	1	1	4	4
20212	5	5	5	3	4	5	2	1	1	3	5	4	1	1	1	1	5	1
20213	2	3	3	4	4	5	3	3	3	3	3	3	4	3	4	3	.	4
20215	4	4	5	3	3	4	2	3	.	.	4	4	4	2	3	5	5	3
20216	3	1	5	5	5	3	3	1	4	2	.	5	5	3	3	4	4	3
20217	5	3	3	2	5	5	4	4	2	4	4	4	3	.	.	.	.	.
20218	3	4	4	5	4	3	1	5	3	4	3	2	4	4	4	4	4	4
20219	3	3	2	2	2	4	2	3	.	.	4	3	5	1	3	3	2	4
20221	4	3	3	4	3	4	3	3	.	.	4	2	3	3	3	3	3	3
20222	4	5	4	3	5	5	3	4	3	4	3	4	4	3	4	3	3	3
20223	2	3	4	4	5	4	2	3	3	5	3	4	4	4	3	3	3	4
20224	5	3	2	4	4	4	5	3	4	4	3	4	4	3	4	4	3	4
20225	4	4	2	4	5	5	2	2	4	2	3	2	5	2	4	2	4	2
20301	2	2	2	4	2	4	3	5	5	3	3	2	5	5	4	1	3	5
20302	4	3	4	3	4	5	5	4	5	5	4	3	5	3	5	5	2	5
20303	3	2	1	1	2	2	3	2	2	3	3	1	4	5	4	2	3	5
20304	4	5	4	5	4	5	2	1	4	1	4	2	5	4	5	4	1	4
20305	5	1	2	5	5	4	1	1	1	1	4	5	3	2	3	5	4	4
20307	5	2	1	5	4	4	3	2	4	3	4	5	4	3	4	2	1	3
20308	5	5	4	4	4	5	3	3	5	3	1	4	5	2	5	5	2	4
20310	5	4	5	3	4	5	4	2	5	5	4	2	5	4	2	2	2	5
20311	4	4	3	4	5	4	3	3	2	3	2	4	5	2	5	5	3	2
20312	4	3	4	3	2	4	4	4	4	5	2	4	5	3	2	5	2	5
20313	4	3	4	2	4	5	4	3	4	5	3	4	3	3	2	4	4	4
20315	4	4	5	5	5	5	3	4	3	5	3	4	5	3	4	4	3	4
20316	4	4	3	3	5	5	2	4	3	1	3	2	4	4	4	2	3	4

20317	4	5	3	5	3	5	4	3	3	4	4	4	5	3	5	5	4	4
20318	4	3	4	5	5	5	3	3	4	5	4	4	4	2	4	5	4	4
20319	4	5	5	4	5	5	5	4	5	2	4	5	5	4	2	5	1	5
20321	4	5	5	3	4	5	2	5	3	5	4	2	3	2	5	4	4	4
20323	4	3	4	5	4	5	3	3	4	3	4	4	5	3	4	2	3	5
30301	2	4	3	5	4	5	3	2	3	5	3	2	5	2	3	2	1	5
30302	2	4	3	4	5	5	3	4	1	5	2	2	5	1	5	5	3	3
30303	4	5	5	4	4	5	3	4	5	5	4	4	4	3	5	4	3	4
30304	5	5	5	3	5	3	3	3	5	1	3	5	5	3	5	1	3	5
30305	3	5	3	3	4	5	5	3	3	5	3	4	5	2	4	2	3	5
30306	2	3	3	5	5	5	1	5	5	5	2	5	5	2	5	5	3	5
30307	4	3	5	4	5	5	3	4	2	5	4	4	5	3	4	3	4	5
30308	4	2	5	5	4	4	1	4	4	5	4	4	4	5	3	4	3	3
30309	.	4	5	2	3	5	5	3	2	5	4	3	4	4	3	5	3	5
30310	5	4	4	5	5	3	2	4	5	4	4	4	5	5	3	2	3	5
30311	5	4	5	4	3	4	2	3	4	3	4	4	4	2	4	2	3	4
30312	5	4	2	4	4	4	2	3	3	4	3	4	4	4	5	2	2	5
30313	4	3	5	2	5	2	3	3	2	4	4	5	3	2	3	2	4	4
30314	2	2	5	4	5	5	3	4	5	4	2	4	4	4	4	4	2	4
30316	4	2	1	2	5	4	5	2	1	4	4	5	4	1	3	4	3	4
30317	2	3	4	1	4	3	3	3	4	4	3	4	3	2	4	3	3	3
30318	2	3	5	4	5	3	1	5	4	4	4	5	1	.	4	1	2	5
30319	4	1	1	1	5	5	2	4	2	5	4	5	3	2	4	2	2	2
30320	5	3	5	4	5	5	4	1	4	5	2	2	5	3	5	3	5	5
30321	2	3	2	1	5	3	2	2	4	1	3	5	4	4	4	2	3	5
30322	5	4	1	4	5	4	1	1	5	1	4	5	4	4	4	5	3	5
30323	4	5	5	3	4	5	2	3	5	5	5	1	5	3	5	5	4	4
40202	4	5	5	4	5	5	4	4	3	4	4	4	4	4	4	4	2	3
40203	4	4	5	4	5	5	1	3	4	5	4	4	5	3	5	3	2	4
40204	4	3	3	3	5	5	3	1	4	5	4	5	5	2	4	4	3	3
40205	4	4	5	5	5	5	3	3	3	5	4	4	4	3	3	4	3	3
40207	1	5	4	4	5	5	1	3	4	4	2	4	5	3	4	2	2	4
40208	4	5	5	4	4	5	3	3	3	5	4	4	4	3	3	3	4	5
40209	1	3	5	5	5	5	4	3	1	3	3	3	3	5	2	2	4	5
40210	3	2	3	5	5	4	1	5	3	3	5	4	4	4	5	1	1	5
40212	2	3	5	4	5	5	3	1	1	5	4	4	4	4	4	5	3	2
40216	5	4	3	2	5	5	3	4	3	5	4	5	5	3	3	2	2	4
40218	3	3	3	1	5	5	3	1	3	1	3	5	5	3	3	2	2	5
40221	4	4	5	5	5	5	4	3	4	4	3	5	4	3	3	1	3	5
40223	5	3	5	3	2	5	3	1	3	5	3	5	4	3	4	4	2	4
40224	5	4	4	3	1	5	3	4	1	5	5	3	4	1	4	1	4	4
40225	3	4	3	3	3	4	5	3	4	4	4	4	4	3	4	3	2	4
50301	4	4	5	4	5	5	3	1	3	4	4	4	4	1	3	2	5	5
50302	5	4	1	5	5	1	2	5	5	4	4	5	5	2	5	4	4	4
50303	3	5	1	4	5	5	5	4	5	5	2	5	5	5	5	3	3	5
50304	4	2	5	3	4	4	3	3	5	5	3	5	4	1	4	4	3	4
50305	3	2	5	4	4	5	3	2	2	5	4	4	4	2	2	4	2	2
50306	5	4	5	4	3	5	3	2	3	5	4	3	5	3	4	5	2	4
50307	2	4	5	3	4	3	3	2	4	2	4	5	2	1	3	5	3	4
50308	5	3	2	5	4	2	3	3	5	5	3	5	5	3	5	4	3	4

50309	1	5	5	4	4	2	3	4	5	2	4	5	4	1	5	1	1	5
50310	2	3	2	3	5	4	1	4	1	3	3	3	4	2	5	3	3	4
50311	4	4	5	5	5	5	4	2	4	4	4	5	4	3	4	4	5	5
50312	5	4	4	5	5	5	3	1	5	4	4	5	4	3	4	2	3	5
50313	1	1	5	5	5	3	4	1	3	1	5	4	2	3	5	4	3	5
50314	4	2	4	5	5	5	1	2	4	5	4	5	5	5	4	4	5	4
50315	5	5	5	2	5	5	2	5	5	5	4	2	5	2	3	1	1	5
50316	2	4	1	5	5	5	2	4	2	5	4	3	4	2	4	1	3	4
50317	5	5	4	3	4	5	4	3	3	4	4	5	5	3	5	2	1	5
50318	4	2	5	5	5	5	1	2	2	5	5	2	5	3	4	5	3	4
50319	3	3	5	2	5	5	4	3	1	1	2	2	4	3	4	5	2	3
50320	4	4	5	5	5	5	2	4	5	4	2	4	5	4	5	4	2	5
50401	1	2	5	5	5	2	1	5	1	4	4	5	4	2	5	2	4	4
50402	5	2	5	4	2	5	2	4	4	5	4	2	4	3	4	1	1	4
50403	4	3	5	1	4	5	2	3	5	5	4	4	5	2	3	2	4	5
50404	5	4	3	4	5	5	5	2	2	1	3	5	5	4	5	3	2	1
50406	3	3	3	3	5	4	3	3	3	3	5	4	5	4	3	2	5	5
50407	5	2	3	5	4	3	4	4	4	3	4	4	5	4	4	.	3	5
50408	5	1	2	5	4	4	1	4	5	4	4	4	5	3	4	5	2	5
50409	4	1	4	4	4	5	2	1	5	5	4	4	4	2	3	3	2	3
50410	5	5	5	5	5	5	5	5	5	5	4	3	5	5	5	5	3	5
50411	3	3	4	5	4	3	2	4	5	4	4	3	5	4	4	5	3	4
50412	4	2	3	4	5	3	3	1	4	1	3	4	1	2	3	3	3	5
50414	5	2	3	5	2	5	2	2	1	1	3	1	4	2	5	3	2	5
50415	3	4	4	4	4	4	4	4	3	4	2	4	4	1	2	4	2	3
50416	4	3	4	3	5	5	3	3	4	5	4	5	4	3	4	3	3	3
50417	1	3	5	1	4	5	5	1	1	5	5	1	2	1	4	1	4	5
50418	5	3	5	2	2	3	5	4	1	4	5	3	4	5	2	3	5	4
50419	4	4	3	3	4	4	3	3	4	4	4	3	4	4	3	3	2	4
50420	2	4	5	5	3	5	1	1	3	2	4	5	5	3	5	5	1	5
50422	4	3	5	4	3	5	4	3	5	5	2	2	5	2	3	5	4	5
60101	2	5	5	5	4	4	3	5	4	5	4	2	4	3	4	3	4	4
60102	5	5	5	1	5	5	1	1	1	5	4	5	1	1	2	5	2	5
60103	3	3	2	1	5	5	3	2	1	5	3	5	5	2	3	5	3	1
60104	2	3	2	3	5	5	2	3	4	5	4	3	4	3	4	3	4	4
60105	5	4	5	5	1	5	3	5	5	1	3	3	5	4	5	3	5	5
60106	5	4	4	5	5	5	1	2	4	5	2	5	4	3	4	2	2	5
60107	5	4	3	4	5	5	.	3	1	5	4	2	5	3	5	4	4	3
60108	5	4	4	4	4	5	4	2	2	5	4	3	4	2	4	3	4	4
60109	2	4	5	3	5	5	3	4	4	4	4	5	5	3	5	3	3	3
60110	5	2	3	4	4	5	3	2	3	5	2	4	4	3	4	5	3	4
60111	3	4	4	3	3	5	1	3	2	5	4	4	3	3	4	2	3	4
60112	5	5	3	2	5	5	3	1	4	2	3	5	3	1	3	2	2	5
60113	3	3	4	4	3	5	3	4	3	4	2	3	3	3	5	4	3	4
60114	4	3	4	3	4	2	3	4	4	5	4	4	4	3	4	3	2	4
60115	4	5	3	4	5	5	5	3	3	5	2	5	5	1	5	5	2	4
60116	5	3	3	5	3	5	3	2	4	3	4	3	5	3	4	1	3	5
60117	5	5	5	1	5	5	1	1	1	5	4	4	4	5	5	5	1	5
60118	2	5	2	3	5	5	4	3	3	2	3	4	2	.	.	.	.	.
60201	4	3	5	2	4	5	4	1	2	2	5	5	5	1	5	5	4	2

60202	5	3	1	5	4	5	2	5	5	5	3	4	5	4	4	5	3	4
60203	3	2	3	5	5	5	4	5	4	5	5	4	5	5	4	4	4	5
60204	4	3	5	3	3	5	1	2	4	5	4	5	4	1	3	5	1	5
60205	3	2	3	5	3	5	4	1	5	5	3	2	5	2	5	5	1	5
60206	4	3	3	5	3	5	2	3	1	5	2	4	5	2	4	3	2	3
60207	2	4	2	3	4	4	3	4	5	5	4	5	4	3	5	2	3	4
60208	2	1	5	4	4	5	2	5	1	3	3	4	3	1	2	4	1	4
60209	3	4	2	3	5	3	3	4	4	5	4	4	4	3	3	4	4	3
60210	3	5	5	5	5	5	1	3	1	1	5	4	5	2	2	4	2	4
60211	3	3	1	1	4	3	2	2	2	3	3	3	4	3	3	4	4	2
60212	5	3	1	5	1	5	3	5	2	5	4	5	1	5	5	5	5	5
60213	4	4	4	4	4	3	2	4	4	4	2	4	5	4	4	4	3	4
60214	5	5	2	4	5	4	5	5	4	5	4	5	5	4	4	5	4	5
60215	3	3	2	1	5	5	1	5	1	5	3	5	4	2	2	3	4	4
60216	3	5	5	3	5	3	1	2	3	4	4	5	4	3	3	1	3	5
60217	1	5	5	5	5	4	3	3	4	3	3	4	5	3	4	5	3	4
60218	5	5	3	4	3	5	5	2	5	5	1	4	5	2	5	3	4	5
60301	4	5	4	5	5	5	2	2	2	5	4	5	4	3	3	5	5	5
60302	5	2	1	3	3	5	3	4	3	2	4	3	4	3	5	3	4	3
60303	1	3	5	5	5	3	3	5	1	5	3	2	5	3	5	4	3	1
60304	5	2	5	5	4	4	3	5	4	5	3	3	5	4	4	3	3	5
60305	5	4	3	2	4	5	4	3	3	5	4	4	3	2	4	3	4	4
60306	5	4	5	5	2	5	5	1	2	5	5	3	2	1	1	4	5	2
60307	3	2	5	3	4	5	2	3	2	1	4	5	4	3	5	3	3	4
60308	5	3	3	3	5	5	1	1	3	5	4	4	5	5	5	3	2	4
60309	5	4	3	4	4	4	3	4	4	4	3	4	5	2	2	4	3	4
60311	4	3	2	4	2	3	3	2	3	3	4	4	4	2	3	3	2	4
60312	4	4	5	5	4	5	4	4	3	4	4	4	3	4	4	4	5	3
60314	2	3	3	3	4	5	1	5	1	4	3	3	4	2	4	4	3	4
60315	5	3	2	4	4	5	3	5	1	1	4	2	4	3	3	4	2	3
60316	3	4	3	3	3	5	4	1	1	1	3	4	2	1	2	3	4	3
60317	5	2	5	1	5	5	1	5	5	5	2	5	5	2	4	2	3	4
60318	5	4	5	4	5	5	1	4	5	5	4	2	5	4	4	2	2	4
60319	2	2	5	5	4	4	3	5	4	5	1	4	4	4	2	4	2	2
60402	5	4	5	3	4	3	4	2	2	5	4	5	5	3	4	2	3	5
60404	4	3	5	4	4	5	3	3	5	5	3	5	2	3	5	3	4	5
60405	2	2	5	2	3	4	3	1	1	4	4	3	3	4	2	4	4	3
60406	4	4	5	5	4	5	4	3	4	5	4	5	4	3	5	3	1	4
60407	4	4	3	4	5	4	2	3	4	5	1	3	5	4	5	5	3	3
60408	5	3	3	3	4	3	3	4	4	3	3	3	5	3	4	3	4	4
60409	5	3	5	4	5	5	3	2	4	5	3	4	5	4	4	5	4	5
60410	4	3	3	4	3	3	2	3	3	3	1	4	4	4	5	3	4	3
60411	4	3	4	3	5	5	3	3	2	2	5	4	4	2	4	1	3	4
60412	5	4	5	4	4	5	3	2	1	3	4	5	4	3	2	4	3	4
60414	5	5	5	5	3	4	3	5	4	5	3	3	5	4	4	5	4	5
70101	5	1	5	4	5	5	4	5	5	5	4	4	5	2	4	4	5	4
70102	3	3	5	3	3	5	3	3	5	2	4	3	5	3	4	4	3	4
70103	5	3	3	1	2	3	1	5	3	5	3	4	4	4	4	3	3	2
70104	5	5	3	4	4	5	1	1	3	5	4	5	4	3	5	2	3	5
70105	5	3	3	5	5	5	4	2	2	5	4	5	5	2	3	5	3	2

70106	3	2	5	1	4	3	3	5	5	5	4	5	5	3	2	5	3	5
70107	5	2	2	4	5	3	2	2	4	5	3	3	5	4	5	4	4	5
70108	3	2	1	4	5	4	3	1	1	5	5	4	5	2	1	3	4	5
70109	5	3	5	5	5	3	3	1	1	1	4	5	5	1	1	1	3	5
70110	5	5	4	3	5	3	1	1	1	1	4	3	3	4	1	4	5	4
70111	1	3	3	3	5	5	3	1	5	3	3	5	3	3	1	2	5	4
70112	2	4	4	3	5	5	2	2	4	5	2	2	5	3	5	5	2	3
70113	5	1	5	1	3	3	5	1	5	5	4	5	2	1	1	1	5	5
70114	4	2	4	5	4	5	3	2	3	5	4	4	5	4	2	4	2	4
70115	5	4	4	5	3	4	3	2	5	2	4	2	4	3	3	2	2	4
70116	3	4	3	5	5	5	2	3	4	4	4	2	3	4	4	3	4	3
70117	3	2	5	1	5	5	3	1	3	1	4	5	5	5	4	2	3	5
70118	5	3	3	3	5	4	4	3	3	4	4	3	4	2	4	4	3	4
70119	5	3	3	4	4	4	3	1	5	5	4	5	5	2	4	1	3	5
70120	5	3	3	4	4	3	4	4	4	5	3	4	5	3	5	5	3	4
70121	4	3	5	3	5	5	3	4	3	5	4	5	4	4	4	3	2	3
70122	4	3	4	3	4	5	2	3	4	5	4	5	2	2	5	4	3	5
70123	4	2	5	4	5	5	2	2	3	5	4	5	5	4	4	3	2	4
70124	5	2	5	4	5	3	3	4	3	5	3	5	4	5	4	3	4	5
70125	5	3	3	4	5	4	3	2	1	5	4	4	3	3	3	3	3	4
70126	4	1	5	4	3	5	3	5	3	5	4	3	4	5	2	3	1	5
70127	3	4	3	3	5	3	3	1	1	3	3	3	3	4	4	2	3	3
70201	5	3	1	3	5	3	3	3	1	5	4	3	3	2	4	2	3	4
70202	4	4	5	3	4	5	3	3	4	5	4	4	4	2	3	4	3	4
70203	4	3	4	3	3	5	1	1	4	5	3	5	4	1	1	2	5	5
70204	1	1	4	4	5	5	2	2	1	5	4	5	4	1	4	5	2	3
70205	3	2	5	4	5	3	.	2	2	4	4	4	4	3	4	4	2	3
70206	4	4	4	4	3	5	3	1	5	4	4	5	5	1	3	3	4	5
70207	3	4	5	3	4	5	3	3	4	5	4	4	4	2	3	4	3	4
70208	5	.	4	.	4	5	2	2	4	4	.	4	4	3	4	3	2	4
70209	5	4	5	4	4	5	3	4	4	5	4	4	5	4	5	2	2	4
70210	3	4	5	4	5	5	3	2	2	5	4	3	5	2	4	5	5	2
70211	5	3	5	5	4	5	3	2	3	5	2	5	4	3	5	5	1	5
70212	4	4	4	3	5	4	3	2	3	5	3	4	4	2	4	2	3	3
70213	3	4	3	2	4	3	3	2	2	3	3	3	2	1	1	4	3	4
70215	2	3	4	5	4	5	5	3	2	4	4	4	2	2	4	4	5	2
70216	3	5	5	3	5	5	3	3	1	5	3	4	3	2	2	4	3	4
70217	2	5	4	1	3	5	4	4	1	5	4	4	1	1	3	4	2	3
70219	5	3	5	1	5	3	5	5	5	1	5	5	4	5	1	1	2	5
70220	4	2	4	3	5	4	4	5	4	5	4	4	4	3	4	2	3	4
70221	4	2	2	1	4	4	3	2	2	4	4	5	1	2	2	2	4	3
70222	3	4	3	4	5	3	3	3	2	3	3	5	4	1	2	3	3	4
70223	5	5	2	4	1	5	1	2	.	.	4	4	1	3	1	2	1	4
70224	5	4	5	4	5	5	3	4	4	5	3	4	5	4	5	2	1	4
70225	3	3	3	4	4	4	3	2	5	1	3	3	4	1	3	3	3	4
70226	5	5	3	5	1	5	5	1	1	5	4	1	3	1	1	5	5	5
70301	1	3	5	4	5	4	2	4	5	5	4	5	5	4	4	1	4	4
70302	2	4	2	3	4	3	3	4	3	2	2	2	3	4	4	2	3	3
70303	2	4	3	4	5	5	1	1	2	5	5	4	5	2	3	2	5	5
70304	1	3	1	5	5	5	5	5	1	5	5	3	2	4	4	3	1	5

70305	3	1	4	4	5	3	3	4	4	5	4	5	4	4	2	2	3	5
70306	3	4	5	3	5	3	2	1	3	5	4	2	5	3	4	3	2	3
70307	1	1	1	5	5	5	5	1	5	5	2	4	5	4	4	5	3	4
70308	4	3	2	3	5	5	5	3	1	5	4	5	4	5	2	5	4	5
70310	5	5	3	1	1	1	5	1	3	3	5	4	1	1	1	5	5	5
70311	2	2	3	4	5	3	3	4	4	3	3	4	4	3	4	3	3	4
70312	2	3	5	3	4	5	1	3	1	4	3	2	3	3	1	2	3	1
70313	4	2	3	4	4	4	2	3	2	4	4	4	4	3	4	4	2	5
70314	3	1	5	2	5	4	3	2	1	1	4	5	4	2	4	2	3	5
70315	2	5	1	1	5	3	3	1	4	5	4	5	1	3	4	4	3	4
70316	4	3	4	2	3	5	2	4	3	5	1	5	5	2	4	2	2	5
70317	2	3	1	3	5	5	3	5	5	5	2	5	4	5	4	2	2	5
70318	4	4	4	4	3	5	2	3	3	5	3	1	4	2	4	4	2	3
70319	4	2	5	4	5	5	2	3	2	5	4	4	4	3	4	3	4	5
70320	2	2	3	4	5	5	3	1	5	4	3	5	4	1	4	1	3	3
70321	1	3	5	5	5	3	1	3	5	5	3	1	1	3	5	5	1	4
70322	2	3	4	5	5	5	1	5	5	4	4	5	4	3	5	4	2	5
70323	4	2	3	4	4	4	4	2	2	4	2	5	2	2	3	1	2	2
70326	4	4	4	4	3	5	3	2	2	5	4	3	4	3	2	3	4	5
80101	4	4	3	3	3	5	3	4	3	4	4	4	4	3	4	5	1	3
80102	4	2	5	3	5	5	3	5	3	3	5	5	3	2	3	1	4	5
80103	2	3	3	4	5	4	3	4	3	5	3	5	4	3	4	4	3	5
80104	4	3	4	3	4	5	3	3	4	3	4	4	4	2	4	1	3	4
80105	5	4	2	3	5	5	3	4	3	5	4	5	4	5	3	5	3	5
80106	4	4	5	5	5	4	4	1	4	3	3	5	5	2	5	2	4	2
80107	4	5	5	4	5	5	3	3	4	4	4	5	4	3	4	3	5	4
80108	3	3	4	3	5	5	2	3	4	5	5	5	3	3	2	4	4	3
80109	4	5	5	3	5	5	4	4	2	5	4	4	5	2	4	3	2	5
80110	2	5	5	4	5	5	5	4	5	5	1	5	5	3	5	2	5	4
80111	4	4	3	3	5	5	4	3	4	3	5	5	4	3	4	5	4	5
80112	5	5	5	3	5	5	3	5	4	3	4	3	5	4	5	3	1	2
80113	5	5	5	5	5	5	5	1	5	1	1	5	5	5	5	5	4	5
80114	5	2	5	2	5	5	3	2	1	3	5	4	4	1	4	1	5	3
80115	3	4	3	3	5	5	4	5	3	3	3	4	4	5	4	4	3	4
80116	5	5	5	3	4	5	1	5	5	3	4	3	5	3	3	4	4	4
80117	4	3	5	3	5	5	3	2	3	1	4	5	5	3	3	5	2	5
80118	4	4	3	3	5	5	4	3	3	5	4	5	4	3	4	5	1	4
80119	5	4	3	4	5	5	3	4	4	4	4	3	4	3	4	3	4	3
80120	4	3	3	5	3	5	3	4	5	3	2	3	4	3	4	3	1	4
80121	4	4	5	4	4	5	3	5	5	5	5	4	5	5	4	5	4	5
80122	5	5	4	5	4	3	5	3	5	4	3	5	4	4	2	5	3	5
80123	5	4	5	5	4	5	5	5	4	5	5	5	5	3	2	2	5	5
80124	5	3	5	4	3	5	1	3	4	5	3	2	5	3	5	2	4	5
80125	4	3	4	4	4	4	4	2	4	4	3	4	5	2	3	3	4	4
80126	5	5	5	3	5	5	1	3	4	5	4	5	3	1	5	1	1	4
80127	4	3	5	4	3	4	3	3	5	5	3	4	5	2	3	2	3	5
80129	5	5	5	5	5	4	5	4	5	5	5	4	5	4	5	2	5	5
80130	3	3	4	4	5	5	3	3	3	3	5	5	5	1	3	5	3	3
80131	3	4	4	5	5	5	5	3	5	5	4	4	5	3	5	2	4	4
80201	4	3	5	3	4	5	1	1	1	2	4	1	1	1	3	4	5	3

80202	2	2	2	1	5	5	3	2	4	5	4	4	4	1	5	3	4	5
80203	2	2	1	1	4	5	3	1	1	4	5	5	4	1	2	3	3	3
80204	3	2	2	3	5	5	3	1	.	.	3	4	5	3	4	2	4	5
80205	4	3	3	4	2	2	4	3	3	4	4	3	4	3	5	3	3	3
80206	5	4	1	4	4	3	3	4	5	4	3	5	4	3	4	4	3	5
80207	4	3	5	5	4	4	2	4	4	4	2	4	4	2	4	4	2	4
80210	5	5	4	1	3	4	1	4	4	3	1	5	5	4	1	3	1	1
80211	4	3	5	4	5	5	3	4	3	5	3	4	5	3	5	4	4	5
80212	5	4	4	4	5	4	4	4	3	3	2	4	5	3	4	4	4	5
80213	3	3	4	4	4	5	4	1	5	5	4	4	5	1	4	4	4	4
80214	3	3	5	5	5	5	3	2	5	5	4	5	5	2	4	4	5	5
80215	4	4	3	2	4	5	1	2	5	4	4	2	3	4	4	3	5	3
80216	3	2	4	2	4	5	3	1	3	5	4	4	4	1	4	4	4	4
80217	3	3	4	4	4	5	3	3	3	5	3	5	4	2	4	5	3	5
80218	3	3	5	5	4	4	2	3	5	5	5	4	5	3	4	3	3	4
80219	4	3	3	4	4	5	2	2	3	4	3	3	5	3	2	2	2	5
80220	2	2	3	4	5	4	5	4	4	4	4	4	2	3	4	3	4	4
80222	5	4	4	5	5	4	4	3	5	5	3	4	5	3	4	4	4	4
80223	5	4	4	4	4	5	1	4	4	5	4	2	4	3	4	3	2	5
80224	3	2	5	5	5	5	3	3	3	.	4	3	5	3	5	3	1	2
80225	3	4	3	2	3	4	2	1	4	5	4	4	3	2	4	2	2	5
80226	4	4	4	2	4	5	1	5	1	5	4	4	3	2	1	1	3	4
80227	5	5	3	5	3	5	3	3	4	3	4	2	5	2	2	5	5	3
80228	4	2	5	4	5	5	4	4	5	4	3	5	5	3	5	5	3	5
80229	2	1	4	2	5	5	1	2	.	.	2	5	2	2	5	1	3	1
80230	2	1	1	2	5	4	3	2	4	3	3	4	5	2	5	4	4	4
90201	4	4	5	3	4	5	3	.	2	5	4	3	4	4	5	2	3	4
90202	4	5	4	3	4	5	3	3	5	4	2	3	5	4	4	1	1	5
90203	1	3	1	3	5	5	5	3	1	3	1	3	5	2	3	5	3	1
90204	3	3	2	2	4	3	5	5	1	5	5	4	3	2	3	3	4	5
90205	4	3	2	1	5	3	1	1	1	5	5	5	3	2	3	5	3	4
90206	5	3	5	1	4	4	3	3	1	4	4	5	1	1	1	2	5	4
90207	5	2	5	2	5	5	3	1	5	4	4	5	5	1	3	1	4	4
90208	5	4	5	5	5	5	1	3	5	4	2	5	3	1	5	3	4	5
90209	4	3	5	3	4	5	5	2	2	5	4	3	4	4	5	1	5	4
90210	4	4	3	4	3	5	4	4	5	3	4	5	5	3	4	3	4	4
90211	3	3	5	1	5	3	5	1	1	5	5	4	4	3	3	5	5	4
90212	3	2	3	3	4	5	1	3	1	5	4	5	5	2	4	3	2	3
90215	5	4	5	4	3	5	2	4	4	4	3	2	4	2	3	2	3	5
90216	5	5	5	5	5	5	5	2	5	5	5	5	5	3	4	4	4	5
90217	4	3	2	3	3	4	3	5	1	5	3	5	2	2	1	1	3	3
90218	4	2	2	1	5	5	2	2	3	5	3	4	5	2	3	2	2	4
90220	5	.	3	5	5	2	3	4	1	4	4	5	1	1	1	2	5	4
90221	2	3	1	3	5	5	3	4	2	3	4	5	4	1	4	3	4	3
90222	2	3	2	2	5	5	4	2	4	2	4	3	4	3	4	2	4	4
90223	3	2	2	2	5	5	5	3	1	5	4	5	4	2	3	2	4	2
90224	4	3	5	5	4	5	4	1	1	2	4	2	5	5	3	5	3	5
90225	3	4	4	4	4	5	3	4	4	5	5	4	4	1	1	2	5	4
90226	5	2	5	4	3	5	3	2	2	4	4	4	4	2	4	3	2	2
90227	4	3	5	3	4	5	4	5	2	2	4	5	4	4	3	4	4	4

90228	5	5	5	3	4	5	3	1	4	4	5	4	5	2	5	1	4	5
90229	3	3	5	5	5	5	3	3	5	5	2	5	5	3	4	2	2	3
90230	1	3	1	3	1	5	1	1	1	5	2	1	1	5	3	5	3	5
90231	2	4	5	3	4	.	4	3	3	2	4	5	4	3	3	3	4	4
100101	5	5	5	4	1	5	1	1	4	1	4	3	4	3	5	1	5	5
100103	3	2	2	4	4	3	3	4	1	2	2	4	2	4	3	3	3	4
100104	5	5	1	2	1	4	3	3	1	1	1	2	5	3	1	4	1	4
100106	5	5	5	4	3	2	3	2	5	3	5	3	5	4	3	5	4	5
100107	1	2	2	2	4	3	2	2	4	5	4	4	4	2	4	2	2	4
100108	4	4	4	1	3	4	3	4	1	2	3	5	5	4	3	2	5	5
100109	1	4	5	4	3	4	1	2	4	3	3	5	2	2	1	1	1	5
100110	5	5	4	3	5	3	3	1	1	1	2	4	4	3	3	2	3	5
100111	2	3	5	4	5	5	3	5	2	2	3	4	4	4	2	3	4	4
100112	2	2	2	1	5	5	3	3	4	4	4	5	3	5	3	4	3	5
100113	3	5	4	5	3	5	5	1	5	4	2	4	3	3	4	5	4	5
100115	5	4	4	4	5	5	2	1	4	3	4	5	4	3	3	2	3	3
100116	5	4	3	4	5	5	5	4	4	1	5	4	2	3	5	5	3	3
100117	1	4	5	1	5	3	2	4	4	1	4	3	3	4	3	1	4	4
100118	4	5	5	1	5	3	.	4	4	4	4	5	4	4	2	3	4	5
100119	5	1	1	5	5	5	2	1	1	5	3	5	2	1	2	1	4	5
100120	5	3	4	4	5	5	3	1	1	5	2	5	5	3	4	4	3	5
100121	2	1	2	5	5	4	5	1	2	4	2	5	2	1	5	1	3	2
100122	1	5	1	3	4	4	2	5	3	2	4	2	3	1	3	5	5	4
100123	1	3	5	3	1	3	2	5	1	2	4	2	5	4	3	1	2	2
100124	2	2	4	4	2	2	1	4	5	4	2	4	4	1	2	2	3	2
100401	5	3	2	5	5	5	2	2	5	5	3	5	5	5	5	4	3	5
100402	5	4	2	3	5	4	4	4	.	.	.	.	.	.	.	.	.	.
100403	2	4	4	4	2	3	3	1	1	4	4	3	5	1	5	4	3	3
100404	5	2	5	3	5	5	3	3	5	4	3	5	4	4	5	4	3	3
100406	4	3	5	5	3	5	4	2	3	5	3	5	5	3	5	5	5	5
100408	4	3	4	2	5	5	2	4	5	4	3	5	3	2	3	2	4	5
100409	1	3	1	1	4	3	3	3	3	1	3	5	3	2	3	1	4	5
100411	1	5	5	3	4	5	3	5	1	4	5	2	5	2	5	2	3	4
100412	2	3	1	4	4	5	4	1	3	5	4	5	4	5	1	2	1	4
100413	5	2	5	5	5	5	5	1	1	5	1	2	.	5	5	2	1	5
100414	4	3	3	4	4	5	3	5	3	5	4	3	5	4	3	2	3	4
100415	4	4	4	4	4	5	4	2	4	4	2	4	4	2	4	4	4	4
100416	4	3	3	5	4	5	4	5	3	4	1	3	4	4	5	2	3	5
100419	2	5	5	3	5	2	3	3	4	4	5	3	3	5	1	2	2	5
100420	3	3	1	5	5	5	4	1	5	5	1	2	5	1	1	1	1	5
100421	5	3	4	3	5	3	4	2	5	5	.	5	4	3	3	2	2	5
100422	4	3	2	3	5	2	3	3	5	5	3	4	5	3	2	2	4	4
100426	3	5	5	3	5	3	3	1	5	3	3	4	4	2	5	2	4	3
110101	2	3	3	2	4	3	5	5	1	5	5	4	.	5	1	1	4	3
110102	4	3	4	4	5	5	1	2	5	5	3	5	5	4	4	2	3	4
110103	2	5	1	1	5	3	5	3	2	5	4	5	5	5	1	1	1	5
110104	5	4	3	4	4	5	1	3	4	5	3	5	4	3	3	3	4	5
110105	4	3	2	4	5	5	4	3	3	4	4	4	4	3	5	5	3	3
110106	1	2	5	1	5	3	4	1	1	5	4	5	5	4	2	2	3	3
110107	4	4	3	3	5	5	3	4	3	5	5	5	5	5	2	3	2	5

110108	5	5	2	3	5	4	5	1	3	3	5	4	5	3	5	4	2	1
110109	5	5	5	4	5	5	2	2	3	4	2	5	5	4	4	2	3	4
110110	5	4	2	4	3	5	5	4	5	4	4	2	5	4	5	4	2	5
110111	4	2	5	2	4	4	1	1	3	5	4	4	1	1	4	3	5	4
110112	5	5	4	4	5	3	4	4	1	5	4	5	1	3	2	1	3	5
110113	5	2	1	2	4	3	3	2	1	5	5	4	3	3	4	4	3	4
110114	5	5	4	4	4	5	1	2	5	5	4	4	4	2	4	5	2	5
110115	5	5	5	4	4	5	5	3	4	5	2	5	3	2	5	4	5	3
110116	5	1	1	3	5	5	5	2	3	4	3	5	3	4	5	1	3	2
110117	4	4	4	4	4	5	4	1	4	5	5	2	5	1	5	5	2	5
110118	2	4	1	3	4	5	3	4	5	5	4	5	5	3	5	1	4	4
110119	3	5	5	3	4	5	3	3	4	3	5	2	2	3	1	5	3	4
110120	4	5	3	4	4	4	2	3	3	5	2	4	5	3	5	4	3	4
110121	5	5	5	5	4	5	4	5	5	5	4	5	5	2	2	4	4	5
110122	5	4	3	3	5	5	1	1	5	5	5	3	4	2	2	3	2	4
110123	4	1	4	3	3	5	5	3	3	1	2	4	3	3	1	2	1	3
110124	2	2	1	4	3	3	2	1	4	5	1	4	3	3	5	3	2	3
110125	4	4	4	3	5	4	5	5	.	.	4	4	4	4	3	4	4	4
110126	4	4	3	3	5	2	1	4	2	1	3	5	3	5	5	4	4	3
110127	2	3	4	2	4	5	4	1	2	2	4	5	4	4	2	4	4	2
110201	5	3	5	5	3	5	3	1	5	3	4	5	5	2	5	5	1	5
110204	5	3	5	5	3	5	3	1	5	3	3	4	4	3	5	5	3	4
110205	4	3	4	5	5	4	3	2	2	5	4	5	4	2	3	2	3	5
110211	4	5	2	5	4	5	5	2	2	5	3	4	5	2	2	3	4	4
110212	5	4	5	5	4	5	1	3	4	5	4	4	3	3	3	5	1	2
110213	4	3	3	3	4	4	3	2	4	3	4	4	4	2	3	2	3	3
110215	3	3	2	3	5	5	3	2	3	5	3	4	4	3	4	4	2	5
110220	5	3	5	4	4	5	2	2	4	5	4	4	5	5	5	2	3	5
110222	4	4	5	5	5	4	5	4	1	5	4	5	3	1	3	3	2	4
110227	4	3	4	2	4	5	1	3	3	5	4	4	5	3	4	4	2	3
110401	2	5	3	2	3	4	3	4	4	4	2	4	4	3	4	5	3	5
110402	3	4	4	4	3	5	1	2	4	5	2	3	5	3	4	2	2	4
110403	4	3	4	5	3	4	3	2	2	5	4	4	4	2	1	3	4	2
110404	3	5	5	4	5	.	4	2	5	3	2	2	4	4	4	5	3	5
110405	5	5	5	3	5	5	3	4	3	5	4	5	5	1	5	1	2	4
110406	3	4	5	4	5	5	3	3	5	5	3	5	4	3	5	3	5	5
110407	5	4	5	2	5	5	5	4	1	4	5	4	2	5	2	1	3	5
110408	4	4	4	2	4	5	1	1	1	5	3	3	4	4	3	4	2	4
110409	3	4	3	4	5	5	3	3	3	5	3	4	4	2	5	3	4	3
110410	2	1	4	3	5	5	4	3	4	5	5	4	5	2	5	3	3	4
110411	3	3	1	1	3	5	5	1	5	5	3	4	1	3	1	3	3	3
110412	3	3	2	3	4	4	1	3	4	3	3	4	4	4	4	4	2	4
110413	5	5	4	4	4	4	3	2	2	5	2	3	4	2	5	4	2	4
110414	4	3	5	5	5	4	1	1	1	5	5	4	3	2	4	5	2	5
110415	4	3	3	4	1	5	3	2	3	5	4	3	2	2	4	5	2	3
110416	5	3	5	2	5	4	1	1	5	3	4	5	5	3	4	2	3	1
110417	3	3	4	4	4	4	3	3	4	3	3	4	4	4	4	3	4	3
110418	2	4	1	5	4	5	2	3	1	5	4	4	4	4	4	5	3	5
110419	2	4	5	3	4	5	3	5	1	5	4	4	4	5	2	5	4	4
110420	5	4	3	5	4	4	2	1	.	.	4	4	5	4	5	3	4	5

110421	3	4	5	4	5	4	2	2	5	5	3	5	5	3	4	4	3	4
110422	4	3	5	5	5	3	3	2	4	5	5	4	4	2	4	4	1	5
110423	5	4	5	4	5	5	4	3	4	5	3	1	5	4	4	1	4	3
110424	5	3	5	4	5	5	3	2	1	4	3	4	5	2	5	2	3	4
110425	3	3	5	3	5	3	3	2	4	5	4	5	5	3	4	2	3	4
110426	3	4	4	4	5	5	4	3	4	5	3	5	5	2	5	2	4	3
120101	5	1	5	1	5	5	5	3	1	5	4	5	4	1	2	4	4	5
120102	5	4	5	3	4	5	5	4	4	3	5	3	4	3	5	2	4	3
120103	5	5	4	5	5	5	3	3	4	5	2	3	5	3	5	3	3	5
120104	2	3	4	4	4	5	3	2	2	3	3	5	4	2	3	1	3	5
120105	5	5	5	1	5	5	3	2	4	3	3	4	4	1	3	1	3	5
120106	3	3	5	5	3	2	.	5	5	4	3	4	5	3	4	3	2	5
120107	3	3	3	3	3	5	1	5	3	5	5	5	5	3	5	4	3	3
120108	5	2	3	1	5	5	3	2	3	5	4	3	4	3	5	5	4	5
120109	5	5	5	4	5	4	4	5	5	1	2	4	5	4	5	5	4	1
120110	2	1	5	5	5	1	4	4	5	2	5	4	4	3	4	4	2	5
120111	4	5	3	4	3	5	3	1	4	3	3	4	5	3	4	2	1	5
120112	5	5	4	3	5	4	3	3	3	5	2	5	4	3	4	3	3	5
120113	4	5	5	5	5	5	5	4	5	5	4	4	5	5	5	5	5	5
120114	5	3	2	3	5	3	2	2	4	3	3	5	5	1	4	1	1	5
120115	3	2	2	4	5	5	3	2	2	4	4	4	3	2	4	4	3	4
120116	1	1	5	5	5	5	5	1	3	5	3	4	3	2	4	4	3	5
120117	3	3	5	4	5	4	2	5	1	5	3	5	5	3	4	2	3	5
120118	5	4	3	4	4	3	2	4	.	.	5	3	5	3	4	4	5	5
120119	3	3	5	4	5	1	1	3	5	5	3	4	5	4	5	4	3	2
120120	5	5	4	5	5	5	3	3	5	5	5	5	5	3	5	1	3	5
120121	5	3	5	4	5	4	5	5	5	2	5	4	4	4	5	3	4	4
120122	4	3	5	3	3	4	3	5	3	5	3	4	4	4	4	3	3	4
120123	3	4	3	4	5	3	4	2	3	5	3	2	5	3	5	4	2	4
120124	2	3	4	2	5	5	3	5	2	3	3	5	5	2	4	4	5	4
120125	3	3	5	3	3	5	3	1	3	5	1	3	3	5	4	4	4	4
120401	4	3	5	2	5	5	2	3	5	4	3	5	5	2	3	3	2	5
120402	3	3	3	1	4	5	2	2	1	5	4	3	2	3	2	5	2	4
120403	5	5	5	4	5	5	3	2	3	5	2	5	4	3	4	5	4	3
120404	3	4	5	5	5	5	3	3	3	5	4	2	4	2	3	2	4	3
120405	4	4	5	4	5	5	3	2	3	5	2	4	4	1	5	3	3	4
120406	4	2	4	3	4	5	1	3	4	3	3	2	4	2	5	3	3	4
120407	4	3	5	4	5	5	3	3	4	3	3	5	5	2	5	4	3	5
120408	3	1	5	1	5	5	1	1	1	5	1	5	5	1	5	4	1	5
120409	3	5	1	3	4	5	3	3	5	3	3	3	3	4	4	2	5	5
120411	4	5	5	5	5	5	1	3	4	5	3	4	4	4	4	2	2	4
120412	2	3	1	4	5	2	3	4	2	4	2	2	5	2	3	4	3	2
120413	4	3	3	4	4	5	3	3	4	3	3	3	4	2	5	4	3	5
120414	5	3	5	4	5	5	4	3	4	5	2	4	3	2	2	4	4	5
120415	5	3	4	4	.	5	1	2	3	4	3	4	5	2	4	5	2	3
120416	5	4	5	4	4	5	3	2	5	4	3	5	4	3	4	4	3	4
120417	3	2	5	5	5	4	3	3	5	5	3	4	5	3	4	1	2	4
120418	3	5	5	5	5	3	5	3	5	3	4	5	5	3	5	2	4	5
120419	5	3	.	4	5	5	3	5	3	2	4	4	4	3	4	1	5	3
120420	5	3	4	4	4	3	2	5	4	4	3	5	4	4	3	4	3	5

Appendix H

Data of the Chemistry Tests

PILOT TEST 1

AA	School	SEX	Team	MC 1	SCG 1	SA 1
101	1	M	A	7.0	6.6	4.0
102	1	F	A	9.0	9.4	8.0
103	1	F	A	5.0	6.0	5.0
104	1	F	A	5.0	4.3	6.0
105	1	M	A	7.0	2.6	.0
106	1	F	B	12.0	11.3	11.0
107	1	M	B	6.0	1.4	2.5
108	1	F	B	9.0	5.7	6.0
109	1	F	B	10.0	8.3	7.0
110	1	F	B	3.0	2.0	4.0
111	1	M	C	10.0	3.8	3.0
112	1	F	C	8.0	5.1	1.0
113	1	F	C	6.0	1.0	.0
114	1	F	C	4.0	1.5	1.0
115	1	M	C	8.0	4.5	1.0
116	1	M	D	8.0	6.3	11.0
117	1	F	D	5.0	2.4	.0
118	1	F	D	5.0	2.5	.0
119	1	F	D	4.0	4.6	1.0
120	1	F	D	9.0	3.9	1.0
201	2	M	A	10.0	4.6	1.0
202	2	F	A	4.0	.9	1.0
203	2	F	A	7.0	7.4	3.0
204	2	M	A	4.0	5.2	.0
205	2	M	A	4.0	2.4	.0
206	2	F	A	6.0	.8	.0
207	2	F	A	9.0	9.5	6.0
208	2	F	A	10.0	10.6	4.0
209	2	F	A	4.0	.7	.0
210	2	F	A	4.0	5.4	2.0
211	2	F	A	3.0	1.1	.0
212	2	M	A	5.0	6.5	3.0
213	2	M	A	5.0	3.5	3.0
214	2	M	B	5.0	4.1	.0
215	2	F	B	2.0	.0	.0
216	2	M	B	5.0	6.7	.0
217	2	M	B	6.0	2.9	2.0
218	2	F	B	7.0	7.0	4.0
219	2	F	B	5.0	1.2	2.0
220	2	M	B	3.0	.0	1.0
221	2	M	B	2.0	.0	.0
222	2	F	B	10.0	9.7	6.0
223	2	F	B	3.0	2.5	.0
224	2	M	B	5.0	4.2	.0
225	2	F	B	6.0	3.5	2.0
226	2	F	C	8.0	5.0	5.0
227	2	M	C	7.0	6.4	.0
228	2	F	C	7.0	2.5	10.0

229	2	M	C	5.0	2.7	.0
230	2	F	C	4.0	.0	.0
231	2	F	C	3.0	3.2	.0
232	2	M	C	6.0	4.5	1.0
233	2	F	C	5.0	2.1	3.0
234	2	F	C	4.0	.0	.0
235	2	M	C	6.0	4.0	.0
236	2	F	C	7.0	8.5	3.0
237	2	M	C	9.0	6.9	8.0
238	2	M	C	6.0	1.6	.0
239	2	M	D	6.0	3.2	.0
240	2	F	D	7.0	7.1	4.0
241	2	F	D	10.0	7.0	6.0
242	2	M	D	6.0	4.4	1.0
243	2	M	D	4.0	.0	.0
244	2	F	D	5.0	.0	2.0
245	2	F	D	3.0	.8	4.0
246	2	F	D	3.0	5.5	2.0
247	2	F	D	3.0	1.6	.0
248	2	M	D	5.0	.0	1.0
249	2	F	D	6.0	5.6	7.0
30101	3	M	A	10.0	4.2	5.0
30102	3	F	A	9.0	4.9	4.0
30103	3	M	A	7.0	7.3	2.0
30104	3	M	A	5.0	5.1	9.0
30105	3	M	A	6.0	5.5	4.0
30106	3	M	A	6.0	5.1	2.0
30107	3	M	A	8.0	5.9	10.0
30108	3	M	A	12.0	9.4	12.0
30109	3	F	A	6.0	2.4	1.0
30110	3	M	A	9.0	6.4	11.0
30111	3	F	A	6.0	2.8	1.0
30112	3	F	A	9.0	10.7	7.0
30113	3	M	A	8.0	8.6	8.0
30114	3	M	A	1.0	1.5	.0
30115	3	M	A	4.0	.0	.0
30116	3	M	A	10.0	6.0	11.0
30117	3	M	A	10.0	1.6	1.0
30118	3	F	A	8.0	4.6	2.0
30119	3	F	A	10.0	5.4	5.0
30120	3	F	A	10.0	10.9	8.0
30121	3	M	A	8.0	5.3	4.0
30122	3	F	A	11.0	9.0	6.0
30123	3	F	A	7.0	4.8	.0
30124	3	M	A	6.0	4.5	3.0
30125	3	F	A	6.0	4.9	3.0
30126	3	F	A	10.0	9.4	7.0
30127	3	M	A	9.0	4.1	11.0
30128	3	F	A	7.0	3.8	.0
30129	3	F	A	7.0	1.7	8.0

30130	3	F	A	7.0	3.0	6.0
30131	3	M	A	9.0	9.6	8.0
30132	3	F	A	2.0	1.5	1.0
30133	3	M	A	7.0	4.2	5.0
30134	3	F	A	10.0	9.2	8.0
30135	3	M	A	12.0	6.7	10.0
30136	3	M	A	7.0	3.5	4.0
30137	3	M	A	13.0	11.0	11.0
30138	3	M	A	3.0	3.7	2.0
30139	3	F	B	10.0	4.4	5.0
30140	3	F	B	11.0	5.3	5.0
30141	3	F	B	9.0	7.1	6.0
30142	3	M	B	4.0	6.4	11.0
30143	3	M	B	5.0	4.7	.0
30144	3	M	B	7.0	5.9	10.0
30145	3	M	B	8.0	6.2	12.0
30146	3	M	B	6.0	6.8	6.0
30147	3	F	B	4.0	.4	2.0
30148	3	F	B	4.0	.4	4.0
30149	3	M	B	10.0	14.0	12.0
30150	3	M	B	5.0	.7	1.0
30151	3	F	B	4.0	.0	.0
30152	3	F	B	8.0	6.8	10.0
30153	3	F	B	10.0	3.4	4.0
30154	3	F	B	5.0	3.4	6.0
30155	3	M	B	9.0	9.6	7.0
30156	3	F	B	12.0	10.3	12.0
30157	3	F	B	11.0	5.3	.0
30158	3	M	B	9.0	11.2	11.0
30159	3	F	B	4.0	1.0	2.0
30160	3	F	B	10.0	7.4	8.0
30161	3	F	B	7.0	5.2	2.0
30162	3	M	B	5.0	2.8	1.0
30163	3	M	B	7.0	3.3	9.0
30164	3	F	B	6.0	4.0	1.0
30165	3	F	B	5.0	4.3	2.0
30166	3	F	B	8.0	4.3	5.0
30167	3	M	B	4.0	4.2	3.0
30168	3	M	B	10.0	10.2	8.0
30169	3	F	B	9.0	5.1	7.0
30170	3	F	B	7.0	1.5	2.0
30171	3	F	B	7.0	3.1	6.0
30172	3	F	B	9.0	2.3	2.0
30173	3	M	B	10.0	6.3	9.0
30174	3	M	B	11.0	11.3	11.0
30175	3	M	B	5.0	.0	1.0
30176	3	F	B	11.0	12.7	12.0
30177	3	M	B	5.0	2.3	.0
30178	3	M	B	7.0	.0	.0
30179	3	M	B	9.0	6.9	9.0

30180	3	M	B	7.0	4.8	7.0
30181	3	F	B	10.0	6.8	9.0
30182	3	M	B	8.0	5.9	4.0
30183	3	F	B	3.0	1.3	.0
30184	3	M	B	10.0	12.9	12.0
30185	3	F	B	9.0	.7	4.0
30186	3	F	B	10.0	9.6	3.0
30187	3	M	B	9.0	6.7	10.0
30188	3	F	B	10.0	13.0	6.0
30189	3	M	B	6.0	3.9	4.0
30190	3	M	B	11.0	7.1	10.0
30191	3	F	B	10.0	7.9	7.0
30192	3	M	B	6.0	2.6	3.0
30193	3	F	B	2.0	1.6	2.0
30194	3	M	B	8.0	6.4	7.0
30195	3	F	B	11.0	12.8	11.0
30196	3	F	B	7.0	3.1	2.0
30197	3	F	B	8.0	8.3	8.0
30198	3	F	B	10.0	6.9	7.0
30199	3	M	B	5.0	1.3	1.0
30200	3	M	B	5.0	2.7	4.0
30201	3	M	B	5.0	2.6	4.0
30202	3	M	B	5.0	3.1	4.0
30203	3	M	B	8.0	10.7	8.0
30204	3	M	C	8.0	4.9	.0
30205	3	M	C	11.0	12.7	11.5
30206	3	M	C	6.0	2.6	8.0
30207	3	F	C	8.0	2.3	7.0
30208	3	F	C	7.0	6.8	10.0
30209	3	F	C	7.0	4.6	2.0
30210	3	M	C	7.0	4.5	6.0
30211	3	F	C	11.0	6.3	6.0
30212	3	F	C	6.0	6.0	6.0
30213	3	F	C	12.0	7.7	6.0
30214	3	F	C	2.0	.7	1.0
30215	3	F	C	6.0	8.0	1.0
30216	3	F	C	7.0	6.4	8.0
30217	3	M	C	6.0	3.3	6.0
30218	3	M	C	6.0	3.0	4.0
30219	3	M	C	4.0	1.0	.0
30220	3	M	C	8.0	3.5	1.0
30221	3	M	C	10.0	4.5	2.0
30222	3	F	C	11.0	5.5	9.0
30223	3	F	C	12.0	13.5	12.0
30224	3	F	C	7.0	7.8	1.0
30225	3	M	C	4.0	3.9	.0
30226	3	M	C	7.0	4.0	.0
30227	3	F	C	4.0	3.3	.0
30228	3	M	C	8.0	3.8	4.0
30229	3	F	C	11.0	2.5	3.0

30230	3	F	C	8.0	5.3	5.0
30231	3	F	C	5.0	2.2	1.0
30232	3	M	C	8.0	8.9	7.0
401	4	M	A	7.0	1.3	7.0
402	4	M	A	5.0	.0	.0
403	4	F	A	6.0	6.1	2.0
404	4	F	A	11.0	10.8	10.0
405	4	M	A	7.0	4.1	2.0
406	4	M	A	8.0	5.9	5.0
407	4	F	A	8.0	4.5	.0
408	4	F	A	8.0	6.9	6.0
409	4	M	A	8.0	8.6	6.0
410	4	M	A	4.0	5.6	2.0
411	4	M	A	5.0	5.7	.0
412	4	M	B	5.0	6.7	6.0
413	4	F	B	5.0	1.5	.0
414	4	F	B	4.0	1.2	2.0
415	4	F	B	3.0	4.9	.0
416	4	F	B	5.0	3.5	.0
417	4	M	B	9.0	3.9	6.0
418	4	F	B	7.0	.0	1.0
419	4	F	B	3.0	1.5	.0
420	4	M	B	6.0	1.6	.0
421	4	M	B	5.0	.0	.0
422	4	M	B	4.0	.0	.0
501	5	M	A	2.0	1.9	2.0
502	5	F	A	7.0	6.0	.0
503	5	M	A	5.0	4.8	.0
504	5	M	A	6.0	7.1	3.0
505	5	F	A	11.0	6.5	5.0
506	5	M	A	4.0	3.9	2.0
507	5	F	B	6.0	3.4	2.0
508	5	F	B	8.0	6.0	5.0
509	5	M	B	7.0	4.2	5.0
510	5	F	B	6.0	1.1	.0
511	5	M	B	2.0	3.8	2.0
512	5	F	C	6.0	1.2	2.0
513	5	F	C	9.0	7.0	8.0
514	5	F	C	2.0	3.4	2.0
515	5	M	C	9.0	5.5	.0
516	5	M	C	6.0	1.5	1.0
517	5	F	D	7.0	2.6	2.0
518	5	F	D	5.0	6.2	8.0
519	5	M	D	8.0	1.3	6.0
520	5	F	D	7.0	4.5	4.0
521	5	M	D	9.0	7.8	6.0
522	5	F	D	9.0	4.7	1.0
601	6	F	A	7.0	2.7	9.0
602	6	F	A	11.0	10.2	11.0

603	6	F	A	6.0	6.4	.0
604	6	F	B	5.0	5.9	.0
605	6	F	B	4.0	2.0	3.0
606	6	F	B	5.0	7.2	6.0
607	6	M	B	8.0	1.0	1.0
608	6	F	B	6.0	2.5	.0
609	6	M	B	6.0	3.1	.0
610	6	M	B	9.0	9.5	11.0
611	6	M	B	9.0	3.8	9.0
612	6	F	B	5.0	4.3	1.0
613	6	M	C	2.0	1.3	1.0
614	6	F	C	1.0	2.3	.0
615	6	F	C	3.0	9.5	1.0
616	6	F	C	9.0	5.5	5.0
617	6	M	C	10.0	12.0	12.0
618	6	M	C	2.0	1.4	1.0
619	6	F	C	10.0	7.0	9.0
620	6	F	C	11.0	5.8	2.0
621	6	F	C	6.0	.0	.0
622	6	M	C	1.0	3.7	.0
623	6	M	C	4.0	.4	.0
624	6	F	C	6.0	5.6	6.0
625	6	F	C	4.0	1.7	1.0
626	6	F	C	6.0	1.9	1.0
627	6	F	C	6.0	.4	.0
628	6	F	C	6.0	3.0	2.0
629	6	M	C	8.0	4.6	4.0
630	6	M	C	7.0	2.4	4.0
631	6	M	C	9.0	4.2	7.0
632	6	F	C	10.0	5.3	12.0
633	6	F	C	6.0	5.1	.0
634	6	M	C	12.0	10.3	12.0
635	6	F	C	4.0	4.4	2.0
636	6	M	D	10.0	10.0	5.0
637	6	F	D	8.0	4.5	2.0
638	6	F	D	10.0	6.7	4.0
639	6	F	D	11.0	6.9	3.0
640	6	F	D	9.0	6.7	4.0
641	6	M	D	10.0	12.0	7.0
642	6	M	D	10.0	7.7	11.0
643	6	M	D	7.0	5.5	5.0
644	6	F	D	2.0	.7	.0
645	6	F	D	5.0	5.0	6.0
646	6	M	D	3.0	3.4	.0
647	6	M	D	4.0	2.2	3.0
648	6	M	D	4.0	2.8	1.0
649	6	F	D	8.0	2.3	.0
650	6	F	D	9.0	3.9	5.0
651	6	F	D	7.0	1.1	1.0
652	6	F	D	10.0	7.6	10.0

653	6	F	D	3.0	2.7	.0
654	6	M	D	5.0	9.9	11.0
655	6	M	D	10.0	7.2	9.0
701	7	F	A	10.0	12.8	9.0
702	7	F	A	7.0	8.0	7.0
703	7	F	A	8.0	8.9	12.0
704	7	M	A	9.0	11.8	12.0
705	7	M	A	4.0	7.3	7.0
706	7	F	B	4.0	.0	3.0
707	7	F	B	5.0	1.6	.0
708	7	F	B	10.0	12.9	12.0
709	7	F	B	6.0	7.8	5.0
710	7	M	B	8.0	3.8	1.0
711	7	F	B	9.0	11.6	11.0
712	7	F	C	7.0	8.3	9.0
713	7	M	C	6.0	5.3	4.0
714	7	F	C	8.0	2.5	4.0
715	7	F	C	11.0	10.9	12.0
716	7	F	C	3.0	4.2	.0
717	7	F	D	10.0	6.2	8.0
718	7	F	D	9.0	14.0	10.0
719	7	F	D	6.0	2.5	2.0
720	7	M	D	9.0	9.5	2.0
721	7	F	D	5.0	.4	.0

PILOT TEST 2

AA	Team	MC 2	SCG 2	SA 2	AA	Team	MC 2	SCG 2	SA 2
301	A	4	3	0	330	B	5	5	5
302	A	3	3	1	331	B	0	1	0
303	A	4	1	5	332	B	5	5	0
304	A	5	1	5	333	B	3	5	3
305	A	3	3	1	334	B	4	5	5
306	A	4	5	5	335	B	2	3	4
307	A	1	3	4	336	B	4	3	3
308	A	5	5	3	337	B	4	5	3
309	A	4	4	3	338	B	4	5	4
310	A	5	4	5	339	B	2	0	2
311	A	1	0	2	340	B	4	5	5
312	A	5	5	5	341	B	5	3	5
313	A	3	2	1	342	B	2	5	5
314	A	2	4	1	343	B	5	5	0
315	A	3	3	5	344	B	4	3	3
316	A	3	4	5	345	B	3	4	3
317	A	4	5	4	346	B	3	4	4
318	A	3	3	5	347	B	4	5	4
319	A	4	4	3	348	B	1	1	5
320	A	4	5	5	349	B	5	2	0
321	A	3	5	3	350	B	4	4	3
322	A	1	1	0	351	B	1	5	0
323	A	2	3	2	352	B	4	4	3
324	A	5	5	5	353	B	5	5	4
325	A	5	5	5	354	B	3	2	5
326	A	1	2	0	355	B	5	2	3
327	A	4	5	0	356	B	2	4	0
328	B	0	4	0	329	B	1	5	4

TEST 1

AA	School	Sex	MC1	SA1	AA	School	Sex	MC1	SA1
10101	1	F	10	11.0	40212	4	M	7	8.0
10102	1	F	10	12.0	40216	4	M	8	7.5
10103	1	M	10	11.0	40221	4	M	6	2.0
10104	1	M	10	9.5	40223	4	F	11	8.5
10105	1	F	7	7.5	40224	4	F	5	4.0
10106	1	M	7	9.0	40225	4	F	8	6.5
10107	1	F	6	7.0	50301	5	M	9	10.0
10108	1	F	11	9.0	50302	5	F	4	7.0
10109	1	M	6	7.0	50303	5	F	10	13.5
10110	1	M	5	5.0	50304	5	M	4	9.5
10111	1	F	12	11.0	50305	5	M	9	11.0
10112	1	M	10	10.0	50307	5	M	6	3.0
10113	1	M	10	11.5	50308	5	F	7	12.0
10114	1	M	6	5.0	50310	5	M	10	11.0
10115	1	M	12	11.0	50311	5	F	6	3.0
10116	1	F	12	12.0	50312	5	F	10	14.0
10117	1	F	11	10.0	50313	5	M	7	1.0
10118	1	M	8	9.0	50314	5	M	5	3.5
10119	1	M	10	8.5	50315	5	M	7	3.5
30301	3	M	9	10.5	50316	5	F	11	12.0
30302	3	F	10	12.0	50317	5	M	10	12.5
30303	3	F	8	5.0	50318	5	F	7	10.5
30304	3	M	5	2.0	50319	5	F	9	6.0
30305	3	F	11	8.0	50320	5	F	7	8.5
30306	3	F	8	5.0	50401	5	F	3	4.5
30307	3	F	4	4.0	50402	5	F	6	6.0
30308	3	M	7	11.0	50403	5	F	6	4.0
30309	3	F	4	2.0	50404	5	F	6	4.0
30310	3	F	10	7.0	50406	5	M	3	6.0
30311	3	F	9	13.0	50407	5	M	7	6.0
30312	3	F	9	11.0	50408	5	M	7	3.5
30313	3	M	4	3.5	50409	5	F	6	6.5
30314	3	M	9	5.5	50410	5	F	5	5.0
30316	3	M	8	9.5	50411	5	M	4	2.0
30317	3	M	6	8.5	50412	5	M	8	5.5
30318	3	F	8	8.5	50414	5	F	6	5.0
30320	3	F	5	6.0	50415	5	F	7	9.5
30321	3	F	6	5.0	50416	5	M	9	5.0
30322	3	F	3	1.5	50417	5	M	7	4.0
30323	3	F	7	8.0	50418	5	F	8	5.0
40202	4	F	12	11.0	50419	5	F	4	7.0
40203	4	F	12	11.0	50420	5	F	5	5.5
40204	4	M	7	8.5	70101	7	F	8	5.5
40205	4	F	8	5.0	70102	7	F	4	3.5
40207	4	F	11	7.5	70103	7	F	6	2.5
40208	4	F	8	7.5	70104	7	F	7	5.5
40209	4	F	11	9.0	70105	7	M	7	8.0
40210	4	M	6	5.0	70106	7	F	6	7.5

AA	School	Sex	MC1	SA1	AA	School	Sex	MC1	SA1
70107	7	F	7	5.0	70305	7	F	8	8.5
70108	7	F	5	1.0	70306	7	M	10	10.0
70109	7	M	6	4.5	70307	7	F	7	5.0
70110	7	F	10	4.5	70308	7	F	3	4.5
70111	7	M	9	6.5	70311	7	F	7	5.0
70112	7	M	10	9.0	70312	7	F	11	11.0
70113	7	F	7	3.0	70313	7	F	9	11.0
70114	7	F	7	6.0	70314	7	F	2	7.0
70115	7	F	8	2.0	70315	7	M	10	5.0
70116	7	M	8	4.5	70316	7	F	5	7.5
70117	7	F	5	3.5	70317	7	F	8	3.0
70118	7	F	9	9.0	70318	7	F	12	12.0
70119	7	M	5	2.0	70319	7	M	7	8.0
70120	7	F	7	7.5	70320	7	M	6	9.0
70121	7	F	8	6.0	70321	7	F	4	6.5
70122	7	F	10	10.5	70322	7	F	6	8.0
70123	7	F	9	9.0	70323	7	F	3	4.0
70124	7	M	6	6.5	70325	7	M	7	6.0
70125	7	M	4	2.0	70326	7	M	7	4.0
70126	7	M	8	6.5	80101	8	F	9	7.0
70127	7	F	6	5.5	80102	8	M	8	8.5
70201	7	M	8	8.5	80103	8	F	7	7.5
70202	7	M	9	5.5	80104	8	F	8	8.5
70203	7	F	3	7.0	80105	8	F	11	9.0
70204	7	M	10	11.5	80106	8	F	9	13.5
70205	7	F	5	3.5	80107	8	F	9	13.0
70206	7	M	9	5.0	80108	8	M	9	8.0
70207	7	M	10	8.0	80109	8	M	10	9.0
70208	7	F	8	7.0	80110	8	F	12	13.0
70209	7	M	10	11.5	80111	8	F	12	14.0
70210	7	F	9	11.0	80112	8	F	8	10.5
70211	7	F	9	9.5	80113	8	F	5	3.0
70212	7	F	4	5.5	80114	8	M	12	11.5
70213	7	F	5	4.5	80115	8	F	11	10.5
70215	7	M	8	11.0	80116	8	M	8	13.5
70216	7	M	7	5.5	80117	8	M	10	12.0
70217	7	M	6	5.0	80118	8	F	9	8.5
70219	7	M	6	6.5	80119	8	M	12	12.0
70220	7	F	6	2.5	80120	8	M	12	14.0
70221	7	M	5	5.5	80121	8	F	10	11.0
70222	7	F	9	8.5	80122	8	F	10	10.5
70223	7	M	3	4.0	80123	8	M	11	6.5
70224	7	M	12	12.0	80125	8	M	8	13.5
70225	7	M	8	6.5	80126	8	M	7	7.5
70226	7	M	8	10.5	80127	8	M	12	11.0
70301	7	M	4	.0	80129	8	M	10	11.5
70303	7	F	4	.0	80130	8	F	7	10.0
70304	7	M	3	1.0	80131	8	M	12	14.0

AA	School	Sex	MC1	SA1	AA	School	Sex	MC1	SA1
10101	1	F	10	11.0	40212	4	M	7	8.0
10102	1	F	10	12.0	40216	4	M	8	7.5
10103	1	M	10	11.0	40221	4	M	6	2.0
10104	1	M	10	9.5	40223	4	F	11	8.5
10105	1	F	7	7.5	40224	4	F	5	4.0
10106	1	M	7	9.0	40225	4	F	8	6.5
10107	1	F	6	7.0	50301	5	M	9	10.0
10108	1	F	11	9.0	50302	5	F	4	7.0
10109	1	M	6	7.0	50303	5	F	10	13.5
10110	1	M	5	5.0	50304	5	M	4	9.5
10111	1	F	12	11.0	50305	5	M	9	11.0
10112	1	M	10	10.0	50307	5	M	6	3.0
10113	1	M	10	11.5	50308	5	F	7	12.0
10114	1	M	6	5.0	50310	5	M	10	11.0
10115	1	M	12	11.0	50311	5	F	6	3.0
10116	1	F	12	12.0	50312	5	F	10	14.0
10117	1	F	11	10.0	50313	5	M	7	1.0
10118	1	M	8	9.0	50314	5	M	5	3.5
10119	1	M	10	8.5	50315	5	M	7	3.5
30301	3	M	9	10.5	50316	5	F	11	12.0
30302	3	F	10	12.0	50317	5	M	10	12.5
30303	3	F	8	5.0	50318	5	F	7	10.5
30304	3	M	5	2.0	50319	5	F	9	6.0
30305	3	F	11	8.0	50320	5	F	7	8.5
30306	3	F	8	5.0	50401	5	F	3	4.5
30307	3	F	4	4.0	50402	5	F	6	6.0
30308	3	M	7	11.0	50403	5	F	6	4.0
30309	3	F	4	2.0	50404	5	F	6	4.0
30310	3	F	10	7.0	50406	5	M	3	6.0
30311	3	F	9	13.0	50407	5	M	7	6.0
30312	3	F	9	11.0	50408	5	M	7	3.5
30313	3	M	4	3.5	50409	5	F	6	6.5
30314	3	M	9	5.5	50410	5	F	5	5.0
30316	3	M	8	9.5	50411	5	M	4	2.0
30317	3	M	6	8.5	50412	5	M	8	5.5
30318	3	F	8	8.5	50414	5	F	6	5.0
30320	3	F	5	6.0	50415	5	F	7	9.5
30321	3	F	6	5.0	50416	5	M	9	5.0
30322	3	F	3	1.5	50417	5	M	7	4.0
30323	3	F	7	8.0	50418	5	F	8	5.0
40202	4	F	12	11.0	50419	5	F	4	7.0
40203	4	F	12	11.0	50420	5	F	5	5.5
40204	4	M	7	8.5	70101	7	F	8	5.5
40205	4	F	8	5.0	70102	7	F	4	3.5
40207	4	F	11	7.5	70103	7	F	6	2.5
40208	4	F	8	7.5	70104	7	F	7	5.5
40209	4	F	11	9.0	70105	7	M	7	8.0
40210	4	M	6	5.0	70106	7	F	6	7.5

AA	School	Sex	MC1	SA1	AA	School	Sex	MC1	SA1
70107	7	F	7	5.0	70305	7	F	8	8.5
70108	7	F	5	1.0	70306	7	M	10	10.0
70109	7	M	6	4.5	70307	7	F	7	5.0
70110	7	F	10	4.5	70308	7	F	3	4.5
70111	7	M	9	6.5	70311	7	F	7	5.0
70112	7	M	10	9.0	70312	7	F	11	11.0
70113	7	F	7	3.0	70313	7	F	9	11.0
70114	7	F	7	6.0	70314	7	F	2	7.0
70115	7	F	8	2.0	70315	7	M	10	5.0
70116	7	M	8	4.5	70316	7	F	5	7.5
70117	7	F	5	3.5	70317	7	F	8	3.0
70118	7	F	9	9.0	70318	7	F	12	12.0
70119	7	M	5	2.0	70319	7	M	7	8.0
70120	7	F	7	7.5	70320	7	M	6	9.0
70121	7	F	8	6.0	70321	7	F	4	6.5
70122	7	F	10	10.5	70322	7	F	6	8.0
70123	7	F	9	9.0	70323	7	F	3	4.0
70124	7	M	6	6.5	70325	7	M	7	6.0
70125	7	M	4	2.0	70326	7	M	7	4.0
70126	7	M	8	6.5	80101	8	F	9	7.0
70127	7	F	6	5.5	80102	8	M	8	8.5
70201	7	M	8	8.5	80103	8	F	7	7.5
70202	7	M	9	5.5	80104	8	F	8	8.5
70203	7	F	3	7.0	80105	8	F	11	9.0
70204	7	M	10	11.5	80106	8	F	9	13.5
70205	7	F	5	3.5	80107	8	F	9	13.0
70206	7	M	9	5.0	80108	8	M	9	8.0
70207	7	M	10	8.0	80109	8	M	10	9.0
70208	7	F	8	7.0	80110	8	F	12	13.0
70209	7	M	10	11.5	80111	8	F	12	14.0
70210	7	F	9	11.0	80112	8	F	8	10.5
70211	7	F	9	9.5	80113	8	F	5	3.0
70212	7	F	4	5.5	80114	8	M	12	11.5
70213	7	F	5	4.5	80115	8	F	11	10.5
70215	7	M	8	11.0	80116	8	M	8	13.5
70216	7	M	7	5.5	80117	8	M	10	12.0
70217	7	M	6	5.0	80118	8	F	9	8.5
70219	7	M	6	6.5	80119	8	M	12	12.0
70220	7	F	6	2.5	80120	8	M	12	14.0
70221	7	M	5	5.5	80121	8	F	10	11.0
70222	7	F	9	8.5	80122	8	F	10	10.5
70223	7	M	3	4.0	80123	8	M	11	6.5
70224	7	M	12	12.0	80125	8	M	8	13.5
70225	7	M	8	6.5	80126	8	M	7	7.5
70226	7	M	8	10.5	80127	8	M	12	11.0
70301	7	M	4	.0	80129	8	M	10	11.5
70303	7	F	4	.0	80130	8	F	7	10.0
70304	7	M	3	1.0	80131	8	M	12	14.0

AA	School	Sex	MC1	SA1	AA	School	Sex	MC1	SA1
80201	8	M	8	7.0	100101	10	M	7	2.5
80202	8	M	6	7.0	100103	10	F	6	3.0
80207	8	M	7	10.0	100104	10	F	4	2.5
80210	8	M	5	.0	100106	10	F	7	5.0
80211	8	M	10	7.5	100107	10	F	8	9.0
80212	8	F	11	13.5	100108	10	F	7	3.0
80213	8	M	10	14.0	100109	10	M	11	12.0
80214	8	F	6	6.0	100110	10	F	8	.0
80215	8	M	9	12.0	100111	10	M	8	2.0
80216	8	F	6	7.5	100112	10	F	3	5.0
80217	8	F	10	11.0	100113	10	M	8	9.0
80218	8	F	11	12.5	100115	10	F	8	5.0
80219	8	F	12	13.0	100116	10	M	10	9.0
80220	8	M	9	3.0	100117	10	F	6	4.0
80222	8	M	10	13.5	100118	10	F	5	4.0
80223	8	F	8	13.0	100119	10	F	10	9.5
80224	8	M	10	11.0	100120	10	M	2	2.5
80225	8	F	6	6.0	100121	10	F	10	9.0
80226	8	F	11	9.0	100122	10	F	9	10.0
80227	8	M	6	9.0	100123	10	M	8	6.0
80228	8	M	7	10.0	100124	10	F	6	4.5
80229	8	F	7	13.0	100401	10	M	5	4.0
80230	8	F	5	3.0	100402	10	F	8	4.0
90201	9	F	9	6.0	100403	10	M	6	4.5
90202	9	M	9	5.5	100404	10	F	2	3.0
90203	9	M	7	3.0	100406	10	M	8	6.0
90204	9	F	11	6.0	100408	10	M	4	3.0
90206	9	M	6	4.0	100409	10	F	5	5.0
90207	9	M	9	12.0	100410	10	M	5	2.0
90208	9	F	11	10.5	100411	10	M	6	5.0
90209	9	F	11	7.0	100412	10	F	7	5.0
90211	9	F	7	10.0	100414	10	F	3	6.0
90212	9	F	10	10.5	100415	10	F	12	13.0
90213	9	M	9	7.0	100416	10	M	11	9.0
90216	9	M	10	13.5	100417	10	M	5	2.0
90218	9	F	9	7.5	100419	10	F	7	.0
90219	9	F	11	6.5	100420	10	F	10	14.0
90220	9	F	2	5.5	100421	10	M	4	3.0
90221	9	F	11	9.0	100422	10	M	6	5.0
90222	9	F	9	7.0	100423	10	M	10	9.0
90223	9	M	8	8.5	100424	10	F	6	3.0
90224	9	M	8	9.5	100426	10	F	6	6.0
90226	9	M	10	12.0	100428	10	F	4	2.0
90227	9	F	11	14.0					
90228	9	F	9	5.0					
90229	9	M	9	6.0					
90230	9	F	4	1.0					
90231	9	M	9	9.0					

TEST 2

AA	School	SEX	SA2	SCG2	AA	School	SEX	SA2	SCG2
60101	6	M	10	8	60318	6	F	10	6
60102	6	F	4	5	60319	6	F	10	9
60103	6	M	10	9	60402	6	F	4	2
60104	6	M	5	5	60404	6	F	8	4
60105	6	M	9	2	60405	6	M	4	2
60106	6	M	10	10	60406	6	F	7	7
60107	6	M	10	9	60407	6	F	10	2
60108	6	M	5	5	60408	6	F	4	2
60109	6	M	10	10	60409	6	M	10	4
60110	6	F	10	10	60410	6	F	3	3
60112	6	F	5	8	60411	6	F	3	2
60113	6	F	10	8	60412	6	M	6	4
60116	6	M	5	8	60414	6	F	5	4
60117	6	F	10	10	80101	8	F	7	3
60118	6	M	4	2	80102	8	M	3	2
60201	6	F	10	6	80103	8	F	6	3
60202	6	F	3	0	80104	8	F	3	2
60203	6	F	10	9	80105	8	F	0	0
60204	6	F	7	3	80106	8	F	10	2
60205	6	F	6	9	80107	8	F	9	9
60206	6	F	5	5	80108	8	M	2	2
60207	6	M	5	4	80109	8	M	8	8
60208	6	M	4	3	80110	8	F	10	9
60209	6	F	3	4	80111	8	F	10	8
60210	6	F	7	2	80112	8	F	10	7
60211	6	F	6	3	80113	8	F	6	0
60212	6	M	4	3	80114	8	M	10	2
60213	6	F	5	5	80115	8	F	10	3
60214	6	F	5	7	80116	8	M	4	0
60215	6	F	8	2	80117	8	M	8	4
60216	6	M	6	3	80118	8	F	7	7
60217	6	F	0	1	80119	8	M	0	0
60218	6	F	5	4	80120	8	M	10	10
60301	6	F	10	5	80121	8	F	8	4
60302	6	F	5	7	80122	8	F	2	5
60303	6	F	10	4	80123	8	M	4	4
60305	6	F	8	2	80124	8	F	9	6
60306	6	F	6	5	80125	8	M	10	4
60307	6	F	6	2	80126	8	M	8	5
60308	6	F	5	3	80127	8	M	8	1
60309	6	M	5	2	80129	8	M	10	6
60311	6	F	4	0	80130	8	F	3	6
60312	6	M	6	2	80131	8	M	7	8
60314	6	F	9	4	80201	8	M	10	3
60315	6	M	9	4	80202	8	M	0	0
60316	6	F	8	2	80203	8	M	3	8
60317	6	F	5	4	80204	8	M	4	1

AA	School	SEX	SA2	SCG2	AA	School	SEX	SA2	SCG2
80205	8	F	10	6	90228	9	F	2	4
80206	8	F	2	2	90229	9	M	5	3
80207	8	M	10	3	90230	9	F	0	1
80210	8	M	2	4	90231	9	M	8	2
80211	8	M	6	2	100101	10	M	2	5
80212	8	F	10	10	100103	10	F	4	2
80213	8	M	6	4	100104	10	F	3	4
80214	8	F	0	3	100106	10	F	0	4
80215	8	M	6	7	100107	10	F	4	2
80216	8	F	4	4	100109	10	M	3	4
80217	8	F	6	3	100110	10	F	2	4
80218	8	F	5	2	100112	10	F	3	4
80219	8	F	10	5	100113	10	M	4	4
80220	8	M	3	4	100115	10	F	0	5
80222	8	M	10	7	100116	10	M	5	6
80223	8	F	6	5	100117	10	F	3	2
80224	8	M	10	7	100118	10	F	1	1
80225	8	F	4	5	100119	10	F	5	2
80226	8	F	7	5	100120	10	M	4	1
80227	8	M	5	3	100121	10	F	2	5
80228	8	M	6	5	100122	10	F	4	4
80229	8	F	6	4	100123	10	M	1	5
80230	8	F	6	3	100124	10	F	3	2
90201	9	F	4	2	100401	10	M	5	2
90202	9	M	5	2	100402	10	F	0	1
90203	9	M	1	0	100403	10	M	1	0
90204	9	F	4	1	100404	10	F	0	1
90205	9	M	6	2	100406	10	M	8	2
90206	9	M	1	3	100408	10	M	4	2
90207	9	M	10	5	100409	10	F	5	0
90208	9	F	5	4	100410	10	M	2	2
90209	9	F	5	4	100411	10	M	4	2
90210	9	F	4	2	100412	10	F	3	3
90212	9	F	7	7	100413	10	M	0	3
90213	9	M	3	4	100414	10	F	1	4
90215	9	F	2	1	100415	10	F	5	7
90216	9	M	4	1	100416	10	M	0	1
90217	9	M	2	0	100417	10	M	2	3
90218	9	F	5	0	100420	10	F	8	7
90219	9	F	1	0	100421	10	M	1	0
90220	9	F	2	1	100422	10	M	2	2
90222	9	F	6	1	100423	10	M	4	6
90223	9	M	5	0	100424	10	F	0	2
90224	9	M	5	2	100426	10	F	3	2
90225	9	M	5	2					
90226	9	M	7	1					
90227	9	F	8	2					

TEST 3

AA	School	SEX	SA3	SCG3	AA	School	SEX	SA3	SCG3
20101	2	M	9.0	10.0	20313	2	F	5.0	7.3
20102	2	F	10.0	6.7	20315	2	F	5.0	1.7
20103	2	M	3.0	10.0	20316	2	F	7.0	.0
20104	2	F	10.0	10.0	20317	2	F	10.0	10.0
20105	2	M	2.0	3.3	20319	2	F	.0	.0
20106	2	F	.0	4.3	20321	2	F	5.0	.0
20107	2	F	10.0	10.0	20323	2	F	10.0	10.0
20108	2	F	10.0	10.0	60101	6	M	5.5	8.3
20109	2	F	.0	.0	60102	6	F	5.0	10.0
20110	2	F	.0	8.3	60104	6	M	6.0	4.0
20111	2	F	9.0	5.0	60105	6	M	.0	5.0
20112	2	F	1.0	10.0	60106	6	F	10.0	10.0
20113	2	F	4.0	6.7	60107	6	F	10.0	10.0
20115	2	F	2.0	8.3	60108	6	F	10.0	3.3
20116	2	M	9.0	8.3	60109	6	F	10.0	10.0
20117	2	M	6.0	7.3	60110	6	M	10.0	10.0
20118	2	M	10.0	10.0	60111	6	F	10.0	8.3
20119	2	F	.0	.0	60113	6	M	10.0	10.0
20120	2	F	4.0	5.6	60115	6	M	10.0	10.0
20121	2	F	9.0	6.7	60116	6	M	6.5	10.0
20122	2	F	9.0	8.3	60117	6	M	9.0	.0
20201	2	F	1.0	.0	60118	6	M	2.0	9.0
20202	2	F	10.0	10.0	60201	6	F	10.0	10.0
20204	2	F	4.0	10.0	60202	6	F	5.0	10.0
20206	2	M	8.0	10.0	60203	6	F	10.0	10.0
20208	2	F	3.0	7.3	60206	6	F	6.0	5.0
20209	2	M	1.0	8.0	60209	6	M	.0	10.0
20211	2	F	9.0	10.0	60210	6	F	10.0	10.0
20212	2	M	4.0	5.6	60211	6	F	10.0	10.0
20213	2	M	.0	7.3	60212	6	F	10.0	8.3
20214	2	M	1.0	.0	60213	6	F	7.0	9.0
20215	2	F	.0	.0	60214	6	F	10.0	10.0
20217	2	F	10.0	5.6	60215	6	F	4.0	7.0
20218	2	F	4.0	5.0	60217	6	M	.0	.0
20219	2	F	9.0	10.0	60218	6	F	.0	.0
20220	2	F	2.0	10.0	60301	6	F	2.0	7.0
20221	2	F	.0	7.3	60302	6	F	.0	5.0
20222	2	M	9.0	10.0	60303	6	M	5.0	5.0
20224	2	F	6.0	10.0	60304	6	F	8.0	9.0
20225	2	F	5.0	10.0	60305	6	F	9.0	10.0
20301	2	M	5.0	5.6	60306	6	F	5.0	2.0
20304	2	M	7.0	6.6	60307	6	M	5.0	7.0
20305	2	F	.0	2.3	60308	6	F	2.0	10.0
20307	2	F	.0	.0	60309	6	F	7.0	7.0
20309	2	M	8.0	1.0	60311	6	F	8.0	8.3
20310	2	M	10.0	10.0	60312	6	F	10.0	10.0
20312	2	F	7.0	10.0	60314	6	F	10.0	7.0

AA	School	SEX	SA3	SCG3	AA	School	SEX	SA3	SCG3
60315	6	F	4.0	.0	120120	12	M	.0	.0
60316	6	F	10.0	10.0	120121	12	F	4.0	5.0
60317	6	F	10.0	7.0	120122	12	F	9.0	10.0
60318	6	F	10.0	10.0	120123	12	M	10.0	10.0
60319	6	F	10.0	10.0	120124	12	F	2.0	1.7
60402	6	M	4.0	.0	120125	12	F	.0	5.0
60404	6	M	.0	5.0	120401	12	M	10.0	5.0
60405	6	F	10.0	10.0	120402	12	F	5.0	1.7
60406	6	M	4.0	2.0	120403	12	M	2.0	.0
60408	6	M	.0	10.0	120405	12	F	5.0	1.7
60409	6	F	9.0	10.0	120407	12	M	9.0	10.0
60410	6	F	10.0	10.0	120409	12	M	8.0	10.0
60411	6	F	.0	4.0	120410	12		10.0	10.0
60412	6	F	5.0	.0	120411	12	F	9.0	3.4
60414	6	F	6.0	2.0	120412	12	F	3.0	3.4
120101	12	F	10.0	.0	120414	12	M	10.0	10.0
120102	12	F	4.0	1.7	120415	12	M	3.0	10.0
120104	12	F	10.0	10.0	120416	12	M	9.0	10.0
120105	12	M	4.0	6.7	120417	12	M	10.0	10.0
120107	12	M	2.0	10.0	120418	12	M	4.0	5.0
120108	12	M	10.0	10.0	120419	12	F	10.0	10.0
120109	12	M	10.0	10.0	120420	12	F	10.0	6.6
120110	12	F	4.0	6.7					
120111	12	M	10.0	10.0					
120112	12	F	10.0	10.0					
120114	12	M	5.0	.0					
120115	12	F	10.0	9.0					
120116	12	M	10.0	10.0					
120117	12	M	.0	1.7					
120119	12	M	7.0	10.0					

TEST 4

AA	MC4	SCG4	AA	MC4	SCG4
80101	18	17.9	80225	9	12.6
80102	6	15.6	80227	15	19.6
80103	15	15.6	80228	9	14.7
80106	12	12.4	80229	6	15.6
80107	12	16.5	80230	15	14.2
80108	3	13.3	90201	3	9.5
80109	21	21.0	90202	3	15.6
80110	9	17.9	90203	6	8.9
80111	18	21.0	90204	3	13.8
80112	18	19.3	90205	6	12.4
80113	12	16.1	90206	18	14.2
80114	15	17.9	90207	12	18.7
80116	3	4.8	90208	9	17.3
80117	15	15.6	90209	15	18.7
80118	9	5.4	90210	15	15.9
80119	18	12.4	90212	9	17.9
80120	15	18.7	90214	15	5.6
80121	3	16.1	90215	12	.0
80122	12	17.0	90216	18	18.7
80123	9	2.8	90217	6	14.2
80124	15	11.4	90218	9	11.0
80125	21	13.5	90219	15	15.6
80126	15	19.6	90220	12	12.4
80127	6	6.9	90221	12	12.4
80128	9	10.4	90222	3	13.8
80129	12	7.7	90223	12	15.9
80130	9	16.1	90224	9	11.0
80131	15	18.0	90225	15	16.5
80201	12	14.2	90226	12	14.6
80202	9	7.7	90227	15	21.0
80203	15	13.2	90228	9	21.0
80205	12	17.3	90229	9	4.2
80206	3	.0	90230	6	.0
80207	3	13.8	90231	12	18.7
80208	9	15.9			
80209	15	21.0			
80212	15	21.0			
80213	12	19.6			
80214	12	17.9			
80215	12	19.6			
80217	3	15.2			
80218	12	13.8			
80222	9	17.3			
80223	12	11.2			
80224	18	18.7			

TEST 5

AA	Team	MC5	SCG5	SA5	AA	Team	MC5	SCG5	SA5
110401	B	100	40	40	120113	A	60	70	20
110402	A	100	100	100	120114	A	20	50	100
110403	B	60	40	20	120115	A	60	0	60
110405	A	60	90	60	120116	A	100	100	60
110406	B	0	50	0	120117	B	40	40	0
110408	B	60	70	40	120118	B	20	40	0
110410	A	60	30	40	120119	B	60	20	70
110411	A	60	70	0	120120	B	40	70	0
110412	A	100	60	60	120121	B	20	50	0
110413	A	100	80	100	120122	B	40	40	0
110414	A	40	30	0	120123	B	100	80	60
110415	A	60	30	10	120125	A	20	60	60
110416	B	80	70	20	120401	B	60	90	60
110417	B	100	100	60	120402	B	20	70	80
110418	B	80	80	20	120403	A	40	70	60
110419	A	80	50	0	120404	B	100	100	100
110420	B	100	40	60	120405	B	80	90	80
110421	B	40	100	20	120406	B	60	20	100
110422	B	100	80	80	120407	A	80	90	50
110423	A	20	70	0	120408	A	100	60	60
110424	A	60	100	0	120409	A	80	100	60
110425	B	0	30	0	120411	B	60	40	80
110426	B	100	100	100	120412	A	60	40	60
120102	B	60	100	60	120413	B	40	50	60
120103	A	80	100	50	120414	A	100	90	100
120104	B	100	100	60	120415	A	100	90	100
120105	A	60	70	10	120416	A	100	100	60
120106	A	80	100	50	120417	B	100	50	100
120107	B	80	100	100	120418	B	60	80	100
120108	B	100	70	100	120419	A	100	80	70
120109	A	80	100	100	120420	A	40	60	60
120110	A	80	50	0					
120111	A	80	100	20					
120113	A	60	70	20					
120114	A	20	50	100					
120115	A	60	0	60					
120116	A	100	100	60					
120117	B	40	40	0					
120118	B	20	40	0					
120119	B	60	20	70					
120120	B	40	70	0					
120121	B	20	50	0					
120122	B	40	40	0					
120123	B	100	80	60					