An Investigation of the Science Senior Certificate Examination: Its Value for Industry and Curriculum 2005

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Declaration

I declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Education at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University, nor has it been prepared under the aegis or with the assistance of any other body or organisation outside of the University of the Witwatersrand, Johannesburg. All help received with the preparation and/or presentation of this thesis has been clearly acknowledged on the next page.

Carolyn Louise Smollan

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Abstract

This research aims to assess the value of the Science Senior Certificate examination for both industry and Curriculum 2005. It does this by looking at the ways in which the Senior Certificate examination fits the needs of industry and the critical and specific outcomes of Curriculum 2005. A questionnaire was used to obtain feedback from a sample of engineering companies on their views of the current Senior Certificate examination as a tool for employment practices. They were also asked about the scientific knowledge, skills and values which they require of school leavers as prospective employees. The Senior Certificate examinations of the GDE (Gauteng Department of Education) and the IEB (Independent Examinations Board) were analysed. Criteria used for the analysis were derived from Blooms Taxonomy, and the critical and specific outcomes of Curriculum 2005. The results from the questionnaires and the examination analyses were compared. It was found that firstly: there was a poor match between the current examinations and the needs of the Engineering Industry and secondly; most of the learning outcomes specified by Curriculum 2005 are not assessed. The conclusion was reached that the format of the current examination must change if Curriculum 2005 is to succeed and if the needs of industry are to be met. Recommendations are made in this regard.

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Abbreviations

GDE	-Gauteng Department of Education
HG	-Higher Grade
IEB	-Independent Examinations Board
NQF	-National Qualifications Framework
SAQA	-South African Qualifications Authority
SG	-Standard Grade

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Chapter 1

Introduction

1.1 Background.

Traditional assessment practices consist of testing and examinations, which provide certificates and lists of marks. Tests and examination are carried out in formal, controlled situations, usually in classrooms or halls, carefully monitored to prevent 'cheating'. Fixed allocations of time are specified in order to complete formally constructed sets of questions. The results of these assessments are regarded as very important and as measures of achievement. Assessment in the traditional sense is primarily used for the selection of young people for further study, apprenticeship, training or careers (Horton, 1990).

Traditional testing is generally recognised today, as having limitations as an assessment tool for the recognition of the wide range competencies and skills deemed necessary by industry. New advances in technology demand new competencies.
Stobart and Gipps (1997, p.24) have stated that

"technological developments demand better educated, more thoughtful and flexible workers across the labour market, to strengthen the country's technological base and to foster a spirit of enterprise and initiative."

The current Senior Certificate examination is a traditional form of assessment. It is a summative evaluation at the end of the school years. It is "the deliberate and overt measurement of educational performance in order to provide information for purposes beyond the immediate interactive learning situation." (Broadfoot, 1996, p.6). This certificate is used in order to enable access into further study at tertiary institutions (not a concern of this study) and also in the application for further training or for job opportunities.

In South Africa, out of every 1000 students beginning school, only 150 will continue with tertiary education (Watson, in Charoux, 1993). The others will attempt to join the job market, competing for a limited number of jobs. The final summative assessment, reflecting their cumulative years of learning, is the Senior Certificate examination. This would presumably be a reference of their competence, which they carry with them from the school learning experience into the job market. Issues of validity, reliability and 'fairness' are therefore critical if pupils' "life-choices" are determined by the results of the assessment. The issue of life and/or job opportunities is even more important in a country with a history of inequality in school and career opportunities.

1.2 Statement of the Problem.

In order to address the inequalities in education and hence in opportunity, inherited from the past government, a new curriculum, Curriculum 2005, is at present being introduced in South African schools. This new curriculum proposes a new emphasis on the outcomes of learning relating to the mastery of skills, values and learning, as opposed to the traditional "syllabus oriented", content driven, curriculum of the past. This research will look at science as a subject to be part of the Natural Sciences in Curriculum 2005. In line with the aims of the new curriculum, assessment should produce "evidence that the learner has achieved the specific outcome" (Government Gazette, 1997, p.16), for example to "Apply scientific knowledge and skills to problems in innovative ways." (Specific outcome 3 for the Natural Sciences, Government Gazette, 1997, p.143). The specific outcomes in the natural sciences learning area do not include any detail regarding the content of the learning. This enables teachers to use their own discretion in order to give content and meaning to the outcomes, and hence to enable learners to acquire the skills, processes and principles, outlined in Curriculum 2005, effectively. It also means that the setting of standardised external examinations, in order to assess skills, values and competencies, may become more difficult. Since the curriculum is driven by assessment (Bernstein, 1975), together with these substantial curriculum changes comes the challenge of developing new assessment practices.

This change towards skills based learning, which is in line with world-wide trends, would also involve a change in assessment. This change would require moving away from the traditional Senior Certificate examination, which has in the past been norm referenced and summative, towards a more criterion referenced, formative, continuous assessment (Chisholm, 1999). If the current method of assessment, the Senior Certificate examination, does not assess the critical outcomes described by the new curriculum, new methods of assessment may need to be developed.

However, in the process of developing new assessment procedures we should take care not to throw out the "baby with the bath water". We need to ensure that what is valuable, if anything, in the past assessment practices is maintained, and what is not valuable is changed. Shufflebeam (1985) has cautioned that drastic changes to a system should be carefully considered and should take place over a long period of time.

The proposed changes in curriculum seen in other in countries such as the USA, Australia, New Zealand, France, Germany and Scotland (Horton, 1990; Stobart and Gipps, 1990; and Berlak et al, 1992) are attempts to address an apparent mismatch between what is provided in the schools and what is needed in industry (Broadfoot, 1996; Gipps and Murphy, 1994). This research asks if there is a mismatch in South Africa from the perspective of employers, or whether the science Senior Certificate examination in fact does satisfy their requirements, in terms of what is learned in the science curriculum and what is assessed in the final examination.

Curriculum 2005 claims that the proposed outcomes based education is geared to the job market. This research also asks whether the needs of industry are met by the skills and values specified for Curriculum 2005.

Moreover, research has shown that for new assessment practices to carry 'cultural capital' the assessment practices must carry with them the approval of employers (Jansen, 1993). Should prospective employers choose to continue to place a "currency" on the Senior Certificate Examination as a "predictor of future performance", society, through the schools, will choose to continue with the academic assessment practices as they stand today. There is always the fear that change will result in the lowering of standards and therefore any proposed change should carry with it the confidence of the society (of which industry is an important part).

For South Africa, given its history of inequity, the dilemmas of education and assessment are of extreme importance "since selection and its legitimation are the crucial mechanisms for regulating the aspirations of the masses for the very few openings in the modern employment sector" (Broadfoot, 1996, p.25).

1.3 Research Questions.

The central problem that this research addresses is whether there is a match or mismatch between: the current science Senior Certificate examination and the needs of industry and; the current science Senior Certificate examination and the outcomes of Curriculum 2005.

In addressing this problem the following questions will be asked:

1. What are the skills, knowledge and values, which the current Senior Certificate Science examination is testing?

2. Are the skills, values and knowledge which are assessed in the examination, reflective of the needs of the employers with reference to the job opportunities available to school leavers at present, and is the Senior Certificate therefore a valuable tool for employment practices?

3. Does the current examination meet any of the requirements of Curriculum 2005?

1.4 The Study.

In attempting to answer the research questions posed, this study undertakes an analysis of the science examinations of the past four years in Gauteng and an analysis of industry's perceptions of the Senior Certificate examination. The first analysis attempts to establish what it is that the examinations do assess, and if any of the proposed critical and specific outcomes for the natural sciences in Curriculum 2005 (Government Gazette, 1997) are tested. The analysis also explores whether there have been any changes in assessment practices over the last four years towards those required by Curriculum 2005.

The second analysis, a needs analysis regarding knowledge, skills, and values required by prospective employers, is undertaken by means of a questionnaire to a sample of engineering companies. The Engineering field was selected as a group of employers who would most likely employ school leavers with science as one of their subjects. The perceptions of the Engineering Industry regarding the current Senior Certificate is also be explored.

The examination analysis is then compared with the analysis of the perceptions of industry and the match-mismatch between these two is evaluated.

1.5 The Report.

The remainder of this report is structured as follows.

Chapter 2 consists of the literature review. This begins with a brief introduction regarding current theories of curriculum and learning and situates these in society. The discussion continues with an in-depth review of assessment, its functions, and issues of validity, reliability and equity with reference to assessment. Finally there is a discussion on change in assessment with reference to the future of Curriculum 2005.

In chapter 3 the research design and methodology, are discussed and justified.

Chapter 4 discusses the data gathered from the examination analyses and from the Engineering Industry. A comparison is made between the data gathered from the examination analyses, and industry and the match-mismatch between the two is discussed.

In chapter 5 conclusions are drawn, based on the interpretation of the results from the analyses, regarding the mismatch which emerged between, the examination and the needs of industry, and the examination and Curriculum 2005. Suggestions are made for a more balanced assessment which may meet the needs of industry and Curriculum 2005.

Chapter 2

Literature Review

2.1 Introduction.

Students "work to pass, not to know; and outraged science takes her revenge. They do pass, and they don't know." (T.H. Huxley, 1874, in Bibby, 1959, in Stobart and Gipps, 1997). It seems that the debate on the effectiveness of testing as part of learning rages on through the centuries.

The school is an environment created to enable learning to take place. Learning is directed by a curriculum, which defines the aims of the learning process. A curriculum is usually defined as a course of study, during which the student undergoes different sets of experiences which enable specific learning to take place.

Societies construct, through a process of continuous valorisation, symbolic forms, which are translated and expressed through the developed curriculum (Thompson, 1990). In this way a body of educational knowledge, as prescribed in a curriculum, is transmitted from generation to generation in schools.

2.2 Relationships between Curriculum and Society.

It is within the school that the societal inheritance is handed down. However, there is considerable debate as to the functions and purposes of schooling and curriculum in relation to society.

Oakshot (1986), Macintyre (1981) and Hirst (1974) argue that schooling is more than a means towards a career or job opportunity. It should develop a whole person. Michael Oakshot expresses the view that school is "a serious and orderly initiation into an intellectual, imaginative, moral and emotional inheritance" (1986, p.5), a place where the mind is emancipated by the different opportunities offered. As such it is a very special place where the learner is initiated into the "the mysteries of the human condition" (ibid, p.7). Macintyre (1981) similarly, argues that any knowledge or skill learned is defined by more than just "external goods" i.e. the competency of that skill or knowledge, but also the "internal goods", which implies a spiritual enrichment from the knowledge and skill which benefits the learner and society. Hirst (1974) argues that a total education must include the "forms of knowledge under various labels such as mathematics, physical science" (ibid, p.96) and the relationships between these. These forms are related by complex ways of thinking and these complexities of thought should be extended to other areas such as experiences, attitudes or skills.

The above arguments for schooling as an 'upliftment' of the whole person are compelling. However, other arguments suggest that schooling should be more focussed on job and career opportunities. Wexler (in Taylor, 1993) has claimed that it is the responsibility of curriculum developers to produce a curriculum which enables educators to disperse knowledge in the school which is tailored for a more appropriate future i.e. knowledge which sets up a 'future prospect' for the school leaver. In addition to being a place for the "subjectivities" of life as argued by Oakfield, Macintyre and Hirst above, the school must also be seen in the light of the reality of the South African situation today. The current unemployment must be addressed and any prescribed curriculum must produce school leavers who are flexible and enabled to seize an opportunity when it presents itself.

Debates on whether the curriculum should be directed by the economy or whether it has a role developing the whole person, seem irrelevant given the current and increasing unemployment. Mahommed (1999) argues that curriculum, and hence assessment, since the one drives the other, must be aligned to the work place. Since the needs of the economy (based on current unemployment) and the needs of future industrialisation will drive education, it seems that the economy holds the reins in South Africa. Bernstein's much quoted statement (1993, p.2) rings true in relation to the economic control in South Africa today

"how a society selects, classifies, distributes, transmits and evaluates the educational knowledge it considers to be public, reflects both the distribution of power and the principle of social control"

For this reason the planning of any curriculum in South Africa cannot ignore the needs of industry. It must as far as is possible, attempt to ensure that school leavers are equipped to find employment and thus assist in economic development. Industry will therefore be a resource in this research to determine what industry perceives as "high status" knowledge.

The aims of a curriculum are realised in the pedagogic relationship between teachers, learners and the curriculum descriptions in the school. The success of the curriculum, i.e. whether its aims are achieved, is evaluated through assessment procedures. The following sections will deal more specifically with assessment in relation to the curriculum.

2.3 Assessment.

Although a key function of assessment is to evaluate learning, arguments have been put forward that assessment also functions to differentiate between individuals, hence enables the selection of those seen as competent by the job market. Broadfoot (1996, in Stobart and Gipps, 1997, p.11) describes assessment as

"a device used within societies with mass educational provision as a mechanism of social control; as a rational, and justifiable, basis for the allocation of 'unequally desirable social roles' as individuals are required to demonstrate competence through a certification procedure based on competition".

Stobart and Gipps (1997, p.120) have agreed that the purpose of examinations is "to maintain the social order and select the competent". It is part of a process designed to give a specific form to the process of education whereby at each level of learning the most competent proceed. At the end of each level of learning those most suited to further study or specific job opportunities are selected on the basis of "results". If the selection procedures at the end of a learning process are valid and reliable, then failure to achieve will be accepted as a fair reflection of an individual not having reached specified levels of knowledge and skill, and the results will be accepted as a gateway to future choices.

In developing countries, such as our own, the examination and its effects have an important role to play in the maintenance of the social order and the selection of the competent (Stobart and Gipps, 1997). The Senior Certificate Examination results must therefore be seen and accepted as selecting the competent fairly. This research will look at the science Senior Certificate Examination as an assessment tool, in relation to its reliability and validity, as a reference for selection for employment in the market place. Much research has been done on assessment techniques but much less on "studies of their effects". (Broadfoot, 1996, p.13). This research will address the broader issue of the needs of society in relation to the assessment process as it stands today and the perceptions and use of the science Senior Certificate Examination as a tool for selection of candidates for specific jobs.

In South Africa today the government is, for the time being, until a viable alternative is developed, committed to a national accreditation and certification system, which today stands as the Senior Certificate Examination. Each province manages its own examination process. The question arises as to what skills and knowledge are presently assessed by this examination. If the matriculation examination is used as a mode of selection of students into future roles and careers, are the skills and knowledge compatible with the expectations of those selecting prospective students or employees? This research looks at those pupils entering employment straight from school and the importance of the secondary school certificate for them as a means by which to enter the job market.

In order to set up an analytic framework within which to address the research questions the following aspects of assessment will be discussed in the rest of this literature review:

- functions of assessment
- modes of assessment
- validity and reliability in assessment
- bias in assessment
- curriculum change and assessment
- public examinations as an assessment tool.

2.3.1 *Functions of Assessment.*

Tests and examinations as forms of assessment have essentially a dual function. Gipps and Murphy (1996) have distinguished these functions as formative and summative assessment.

a) Formative assessment is that which supports the learning process. As such it enables the teacher to evaluate what the learner has learned, as well as his/her own teaching and then to make decisions on the ways in which the teaching and learning should continue.

b) Summative assessment takes place at the end of a program of learning or part of a curriculum, in order to produce evidence upon which future decisions such as further education and career choices are made by individuals. Broadfoot (1996, p.5) has described summative assessment as, " deliberate and overt measurement of educational performance in order to provide information for purposes beyond the immediate instructive learning situation" (Broadfoot, 1996, p.6).

Since the Senior Certificate examination is a "one off" set of examinations with no feedback into the learning process of the pupil, it is not a formative assessment. It may have an indirect formative role to play by maintaining goals towards which the teaching process in Grades 11 and 12 (for those still to write the examinations) is directed, possibly improving teaching and learning from year to year. Schools, which have preliminary/mock/practice examinations before the final examination, may provide formative feedback to learners in order to improve learning necessary for the final examination. However there seems to be little concrete evidence supporting the theory that testing assists in raising standards (Stobart and Gipps, 1997, p.5). In fact Stobart and Gipps (1997, p.5) argue that "teaching to the test is usually narrowing".

The Senior Certificate examination is predominantly a one off test at the end of the Grade 12 learning year, with no feedback into the learning process of the learner who has written the examination. It is therefore a summative assessment and the results provide a basis of choice and opportunities for further learning or employment.

As it stands today it seems that many schools are teaching towards the format of the Senior Certificate Examination and, in my experience, coaching towards specific subject examinations. This entails learning by rote, with short term memory skills, and an effective 'cracking of the system' (in the words of an experienced colleague) which may result in high achievement but with very little lasting meaningful learning.

Madaus (1998) has framed a number of principles as regards the impact of testing on instruction, which have implications for our system (in Stobart and Gipps, 1997, p.5).

1. If the results of an examination are considered important by teachers, students and administrators, it does not matter if this consideration is true or false. Hence if the job market perceives examination results as an important prerequisite for job selection, it does not matter whether this is fair for the selection or not.
2. Changes take place in teaching when test results are used to make important social decisions.
3. When important decisions are made on test results, teachers will teach to the test.
4. Past examinations effectively guide the curriculum.
5. The form of the questions in high stakes testing will determine the mode of instruction as in teaching to the test resulting in rote learning as mentioned above.
6. Society will treat tests as a major goal of schooling if the test results are the sole or even partial determinant of future life choices.
7. The examining body has the ultimate control in high stakes testing.

The Senior Certificate is perceived to have high "cultural capital" in the society in general in South Africa, as evidenced by the publicity and concern with poor results at each year end. South African society will continue to consider testing and the final Senior Certificate Examination as the goal of teaching in high schools if the test results are the determinants of future life choices. One of the aspects of this research will investigate the extent to which the examination results have "high cultural capital" amongst employers.

Research has shown that there is "an apparent mismatch between the output of schools and the labour market" (Stobart and Gipps, 1997, p.25), with high numbers of unqualified school leavers and high unemployment, both in developing countries, and increasingly in developed countries. In order to address this discrepancy, Zimbabwe introduced a vocationally oriented curriculum in order to equip learners with the necessary skills to obtain employment in the labour market after their schooling. It seemed however that employment agencies persisted with academic criteria for employment decisions (Schwartz, 1993). As a result the schools have continued to proceed with academic learning towards a final academic examination and the proposed vocational curriculum has not been successful.

In South Africa it is not clear whether industry is using the Senior Certificate as a bench mark for appointment i.e. does it in fact have high cultural capital? Do employers claim to want vocational training, yet still rely heavily on the Senior Certificate Examination results for decision making, as was seen to be the case in Zimbabwe? According to Madaus if the job market perceives the examination to have cultural capital, it does not matter whether there has been effective learning of required skills and knowledge. In terms of school leavers with science as a subject, this research attempts to explore the match or mismatch in the South African System today.

2.3.2 *Modes of Assessment.*

Aside from the differences in physical layout and forms of assessment, there seem to be two differentiating modes of reporting learned knowledge, skills and values in use today. These are norm and criterion referenced assessment.

A. Norm referenced assessment.

This form of assessment involves the high reliability of measurements, which are used to determine a pass or fail. The process is controlled by experts, who collect, process and distribute the marks through the standardising of a test against the population group. Within the process the marks are graded using distribution levels and curves to ensure a fixed percentage of students gain a pass. Ultimately therefore the grade obtained is dependent upon the achievement of others against which individual scores are compared and moderated, not on personal achievement. The manipulation of test scores in this way seems unfair. However since this method is based on assumptions of normal distribution it is fair if the population is 'normal' (in the statistical sense). This method moderates examinations to prevent low or high marks in a particular test which may have been too difficult or too easy than those in other years and therefore not "fair". It is currently claimed that the Senior Certificate examination is norm referenced.

B. Criterion referenced assessment.

In this mode of assessment very clear specifications of skills required must be described against which a student's performance is compared in order to achieve a pass. The mode of assessment therefore encourages individual effort and demonstration of what has been learned. It is individual effort which is assessed and not a result which is a comparison against others. Outcomes based systems such as the proposed Curriculum 2005 are "founded on criterion-referenced assessment" (Kraak, 1999, p.40).

Learners must be able to demonstrate that they can apply desired outcomes within a certain context. Deacon and Parker (1999, p.61) have commented that outcomes are thus a mechanism "for providing a picture of what a learner can do". The assessment of these outcomes in a public system such as the Senior Certificate examination will be very difficult to achieve. Wood (1991, p.91) has stated that by its nature "to implement criterion referencing in large scale examinations is problematical as efforts to date show".

This form of assessment presents problems in the classroom context. It is difficult to obtain universal understanding of the specified outcomes, for example, is it possible to have a universal meaning for specific outcome number 3 (Government Gazette, 1997, p.153) "application of scientific knowledge and skills to problems in innovative ways"? Even within similar contexts, differences in meaning are ascribed to scientific problems and the assessment thereof, as was found in the pilot study carried out to test the tool developed for the analysis of the examinations as described in chapter 3. Difficulties in obtaining shared meaning for desired outcomes present problems in validity and reliability from a teacher's perspective (Watson, 1998). This will be addressed later in this chapter.

In a multicultural world, as in South Africa, "a plurality of meanings and differences, and contradictions in perspectives are inevitable" (Berlak et al, 1992, p.14). Different groups have different histories and different world interests and concerns. The interpretations of which knowledge content is valuable, and the interpretation of what is proficiency in outcomes and assessment criteria would be no exception. In a society where differences are valued it would not be desirable to have total consensus. Criterion referenced testing caters for flexibility in assessment needed in a multicultural environment. However, in this light, aspects of validity and reliability in assessment are crucial if assessments are to have any meaningful function in education and society.

2.3.3 *Validity and Reliability in Assessment.*

If the Senior Certificate Examination carries much with it in terms of future opportunity, then the validity and reliability of the examination is of prime importance, since the weight of future decision making falls heavily on the results of the examination.

A. Validity.

The concept of validity refers to how well a test result reflects the skills, knowledge and values which it intends to assess (Harlen, 1994). Validity ensures that a test measures what it is supposed to measure. If a test is compatible with the purpose of the assessment, then the test has validity.

There are several kinds of validity which have been described:

a) Criterion related validity (as concurrent validity): This aspect of validity relates to the present. Are the results obtained indicative of what is known at present by the learner (Stobart and Gipps, 1990; Wiliam, 1998)? Do the results obtained in the Senior Certificate examination reflect the knowledge of scientific principles which the learner "knows" at the end of Grade 12? In the analysis of the examinations, if the questions cover a broad base of the content knowledge expected at this level of learning and the scoring of the questions is reliable, then the examination would have concurrent validity.

b) Construct validity: This refers to the extent to which the underlying skills are tested with reference to a particular purpose (Stobart and Gipps, 1990; Wiliam, 1998). Does the science Senior Certificate examination test underlying skills expected by employers in the work situations which are available in the Engineering Industry?

c) Content validity or descriptive validity: This is more straightforward than construct validity. It concerns whether the test covers the relevant areas of content and skill as specified in a syllabus for a particular domain (Stobart and Gipps, 1990; Wiliam, 1998). For example, does the science paper cover knowledge regarding forces as specified in the curriculum, and does it test problem-solving skills relating to unknown situations of several forces acting on a point?

d) Curricular validity (William, 1998; Wood, 1991): Curricular validity is the extent to which the test assesses the objectives of the curriculum. The science Senior Certificate examination will be analysed as regards its curricular validity.

e) Instructional validity (William, 1998; Wood, 1991): Instructional validity relates to a correspondence between what a test demands and the appropriateness of the instruction which precedes it. In order to have instructional validity, adequacy of preparation is essential. Instructional validity is dependent upon the reliability of the teachers and the school. Equal standards would need to exist in all schools, and be maintained, in order that an external examination such as the Senior Certificate examination would have instructional validity. Given the differences in standards of teaching within South African schools, instructional validity would seem to be poor. This is beyond the scope of this research paper.

f) Backwash (or washback) validity: This refers to what happens as a consequence of other validity's which a test may have. In the case of the Senior Certificate Examination, the testing may well have concurrent and predictive validity and therefore as a consequence, teachers may coach to the test. This will jeopardise the predictive validity of the test, by artificially inflating a students' achievement (Wiliam, 1998). Assessing the backwash validity of the Senior Certificate examination is not part of this study, but comment will be made on this aspect of validity in chapter 5.

g) Intrinsic validity: Do the results of the assessment agree with other assessments of the same knowledge and skills? If a preliminary examination is not used as a means of comparison then the Senior Certificate Examination cannot be "seen" to have intrinsic validity. However if employers use their own methods of assessment and these correlate with the results obtained in the Senior Certificate Examination then it does have intrinsic validity (Wiliam, 1998).

h) Face validity: Does the test have the confidence of those involved and does it mean what it is supposed to (Wiliam, 1998)? Does the Senior Certificate Examination have the confidence of employers and is it used as a selection criterion? If so it has face validity.

i) Criterion related validity (as predictive validity): What is it that we need to know in order to predict performance? Is a test able to predict future performance (Stobart and Gipps, 1990; Wiliam, 1998)? If the Senior Certificate Examination is used as a measure for job acceptance then this aspect of assessment validity is of the utmost importance in the process of the setting of the examination papers. If the Certificate does not have predictive validity and yet is used as a gateway for employment by industry, then industry will be disadvantaged as a result of the employment of school leavers who do not perform in the job situation as expected. A real concern is that many school leavers will be discriminated against in the job market through poor results in a test which does not have predictive validity.

Most validity theorists seem to have concluded today that all the aspects of validity are "no more than strands within a cable of validity argument" (Cronbach, 1988 in Wood, 1991). The validity of testing is always questionable and the descriptions above assist in analysing examinations, as in this study, to ensure some validity in a test. Validity is a unitary concept and ultimately

"always refers to the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of interpretations and actions based on test scores" (Wood, 1991, p.146).

On the basis of this argument there is in fact no valid test without due consideration to the interpretation and purpose of the test. Stobart and Gipps (1997) have concurred that it is the use of the test which determines its validity. If inappropriate judgements are made by industry in the use of the Senior Certificate results then the validity of the examination is at stake.

What aspects of validity are present in the current examination format and system?
Is the Senior Certificate Examination testing aspects of knowledge and skills which are required for the selection of school leavers for specific job opportunities in the

South African economy? Does the examination have concurrent, content and curricular validity in that the certificate ensures that the learners have acquired the relevant knowledge as specified by the curriculum? Mahomed (1999, p.160) has stated that "The current [South African] curriculum [and therefore the assessment thereof] is not keeping sufficient pace with globalising patterns of modern life". Does the examination predict future performance in the job market i.e. does it have predictive validity, and is this what is expected by employers in using the examination results as a selective tool? Does the examination have face validity in that it carries with it the confidence of industry, and is job opportunity therefore dependent upon the examination results? If this is not the case then the aspects of validity of the Senior Certificate examination needs to be re-examined, unless its purpose is merely to select for tertiary education.

B. Reliability.

The traditional definitions of reliability refer to the consistency of results, which implies a theoretical situation where two identical students would get the same results with the same testing (Wiliam, 1998). Since this is not possible reliability must be achieved other ways.

Firstly, reliability can be achieved by a test-retest, which involves testing the same content twice with a similar or same test. The marks achieved by a student should be the same each time. The second test cannot be given too soon after the first test since answers may be recalled, nor too long after, since the content may be forgotten or more may have been learned in the interval. Secondly, reliability could be achieved through the markers by a mark remark consistency exercise, where the same test remarked by a different marker will score the same result. This reliability becomes more difficult to achieve as the test becomes more interpretive. Multiple choice items are not an issue for marker reliability. However, the more complex a test becomes, the less easy it is to establish reliability. The third and most common test of reliability is the use of parallel forms or split half reliability. Parallel testing involves the testing with a similar test administered on two different occasions. The setting of a parallel test is easier to formulate with multiple choice items than with essays or comprehension. A split half test on the other hand takes, say, all even numbers in one test and odd numbers for the other test assuming that they would have random difficulty and the two tests administered separately would produce the same result for the same pupil.

In addition to these aspects of reliability which attempt to ensure consistency of results Stobart and Gipps (1997) have described three further aspects of reliability:

- reliability as dependability in providing accurate (and therefore valid) information about the performance of an individual;

- reliability as disclosure, which refers to the extent to which the evidence of learning is disclosed (as in criterion and construct validity) by the manner of testing;

- reliability as fidelity, in that the evidence of learning which is disclosed by the testing is recorded faithfully.

The first two aspects of the above are linked to the validity of the results. The third concerns process and the reliability of the actual marking and recording of the marks. Are there safeguards at each point in the process to ensure reliability? What then of fidelity, which refers to the control of the process given the vast numbers of pupils examined at the school leaving stage and the problems associated with security of distribution, supervision and recollection to the final marking process and release of examination results? Given the magnitude of the examination process these aspects need to be examined if one is determined to have examinations which are reliable. This would be the basis for further investigation if the society felt that reliability is questionable.

The Senior Certificate Examination does not have mark-remark reliability, unless, a remark is specifically requested by a student. However it does have a marking memorandum for each examination, which is built into the examination marking process. A memorandum is described for all markers in order that the marking conforms to specific mark allocations for correct answers. Norm referencing also provides some reliability but not the consistency of a mark-remark exercise. The Senior Certificate Examination also does not have test re-test reliability, since there is no preliminary test with which the examination is compared. This did happen in the past where a test score of supposedly similar testing was submitted by the school for comparison in order to arrive at a more reliable final score. This is the intention for the 1999 year end, since a "send in mark" has been requested from the schools. However this also may be problematic given the current differences between schools.

How, therefore, is the Senior Certificate examination regulated as far as reliability of assessment is concerned? In October 1995 the South African Qualifications Act provided for the establishment of a single body, the South African Qualifications Authority (SAQA), which is representative of the major stakeholders in education in the country (Van der Horst and Mc Donald, 1997). One of SAQA's responsibilities is, through the co ordination of the Education, Training and Quality Assurance (ETQA) bodies to ensure that nationally agreed standards are maintained at learning levels where learners are accredited (Pahad, 1997). In doing so they should take care to monitor reliability and validity in the examinations which will result in the maintenance of quality in assessment and certification. The Ministerial Committee Investigation into the Senior Certificate Investigation (Pretoria, 1998) showed that "although most provincial departments of education [have] such systems on paper, the actual functioning of these systems left much to be desired" (Pahad, 1999, p.273). It seems that much work is to be done in ensuring the quality of our system. In this light it may be that alternative assessment processes would be more relevant and valid, even at the expense of reliability (comment to be made regarding this in chapter 5).

Reliability is ultimately concerned with the consistency of examination performance.

" The reliability of grades is, in an important sense, the bottom line of the examining system"(Wood, 1991, p.134) and "The aim should be to strive for high reliability and good validity simultaneously, which defines the measurement task in a nutshell" (ibid, p.143).

The trend today seems to show a shift in emphasis from reliability to validity and towards criterion referenced testing in order to recognise positive achievement by learners. These moves have been prompted by the issues of "fairness" in education which have been a concern over the last two decades throughout the world (Gipps and Murphy, 1994). The trend towards criterion referenced testing is to be followed in South Africa with Curriculum 2005, in response to pressures from society to reduce the gross inequalities inherited from the past (Kraak, 1991).

2.3.4 *Equity in Assessment.*

With the change of government in South Africa from a minority to a democratic government, the issue of equity in education and therefore in assessment is a major concern. There is a difference between equality and equity.

Equal means the same which implies that all learners are given the same opportunities. What this does not recognise is that learners with different backgrounds and resources may not benefit equally from the same opportunities and thus may achieve unequal outcomes.

Equity, on the other hand, recognises unequal starting points and suggests that different experiences might be necessary in order that all reach the same outcomes. This is the model that Curriculum 2005 is working with. There is a concerted effort to correct the imbalances of the past and to develop an integrated educational system which will provide equitable opportunities for all, and which will result in the achievement of the same outcomes. Gipps and Murphy (1997) have stated that if there is no equity in educational opportunity then the fairness of the test is called into question. A concern of many is that Curriculum 2005 will not ensure equality of outcomes, precisely because there are such differences in resources across the country. Some argue that there will always be some differences in learning achievement. "Differences in performance are real whether biological or environmental" (Gipps and Murphy, 1994, p.6).

Notwithstanding these differences, Parker and Rennie (1998) have described certain elements which are prerequisites for equitable assessment. Firstly, 'curriculum fidelity', which implies the synchronising of the curri ·lum, teaching and assessment. This is the same as curricular validity and instructional validity discussed in the previous section. Secondly, in relation to 'diversity and opportunity', the assessment procedures should not work to the advantage of some nor to the disadvantage of others. Thirdly, the 'values and ethics' of assessments procedure within the society should be carefully considered.

Test-makers have a role to play in the equity of assessment, in the assurance of validity, reliability, gender sensitivity and the attention to a mode of meaningful questioning which attempts to ensure relevance for all as far as language and background is concerned. A further concern is the format of the questions which should give all learners an opportunity to demonstrate their 'knowing'. It has been suggested, albeit controversially, that written answers favour girls and multiple choice favours boys (Murphy in Parker and Rennie, 1998).

Despite these aspects, which could assist in ensuring equitable assessment, it is only if educational policy ensures a level playing field that "a national examination [will] be an equitable technology for making decisions about individuals, schools or districts" (Madaus in Stobart and Gipps, 1997, p.32) and be valid in its assessment. The reality of the South African educational system and of most educational systems is that the playing fields are not level. If this is true, then national examinations will always discriminate against some, and the examination will not be a reflection of what pupils know, but rather that which they do not know. Is an examination therefore, as Broadfoot (1996) has suggested, merely a tool for societal control - to position people rather than giving them free and equal choice and opportunity?

Gipps and Murphy (1994) have also posed the question of whether the use of standardised testing is considered as 'equal opportunity' in the sense that pupils are all given identical treatment in the writing of the examination. However, given that all learners are not given the same preparation, how does this impact on assessment procedures which should be equitable? The Senior Certificate Examination as it stands today, may well be criticised in this regard as not giving equal opportunity, since the preparation for the examination differs considerably between schools. Gipps and Murphy (1997) have stressed their belief that equity must concern itself with fair educational access for all. They have further expressed the belief that with the best intentions there is no possibility of guaranteeing equality for all. Therefore there is no way to ensure equality of outcomes as expressed by Berlak et al (1992, p.90) who have stated that

"Schools in a democracy have an obligation to pursue policies aimed at achieving equality of outcomes or results".

Furthermore any attempts by those in control of an assessment process to ensure equality of outcomes by manipulating test items in the attempts to be "fair" do "violence to the skill being assessed" (Gipps and Murphy, 1997, p.55).

The more predominant the use of the examination as a predictive tool, the more important are the issues of equity. If candidates for a specific job are to be differentiated according to the Senior Certificate examination, and if there is no equality of opportunity, the decision making process may unjustly deny opportunities to some. The broader issues, of whether the examination is a fair assessment of the knowledge skills and values of the learner, are beyond the scope of this research.

Ultimately what is important, is that a reliable and valid record of the abilities of the learner, is reflected in any final assessment, such as the Senior Certificate examination. Black (in Parker and Rennie, 1998) argues for teacher assessment over a period of time which he feels builds a far more reliable record of the abilities of a learner. However his research consistently showed that teacher-based assessment does not carry the same status as external examinations. If the matriculation examination continues to carry high status as a legitimating factor for equivalent performance by different groups of learners, then teacher based assessment, even if more valid or reliable, will not be an option for the assessment of Curriculum 2005.

2.3.5 *Bias in Assessment.*

Bias in assessment occurs when the methods of testing rely on narrow techniques which favour one group or another. For example, traditional examinations which seem to test mainly convergent thinking, is biased against divergent thinkers. Differences in assessment results due to bias are always a problem. It has been the case in South Africa in the past when examinations were tailored to a minority group. The political argument for separate examination boards for different race groups may have been in defence of the prevention of bias, where examinations could be tailored to a specific group.

In reality examinations are always just a sample of the material considered to be learned, and will be set by one or more, but always limited, members of the profession, and therefore are likely to always involve controversy.

Most of the formal examinations contain multiple choice questions despite the controversy surrounding their validity in assessing knowledge and skill. Multiple choice questions have been thought to penalise some learners and advantage others (Wood, 1991). Gifted, creative and non-conformist thinkers will read more into a question than is intended and therefore choose an incorrect answer. The correct answer selection also depends very much on language ability and comprehension which leads to bias. Research however has shown that if the time limit is extended for second language learners they will be able to perform as well as first language learners (Labre and Froman, 1984, in Wood, 1991).

Multiple choice questions are a popular mode of questioning in large scale external examinations since they have a high reliability as regards the marking even with many different markers (Wood, 1991). They are an attempt to eliminate subjectivity by removing the arbitrary allocation of marks which may be influenced by personal preference and bias (Schofield, 1972).

In examinations consisting of problem solving, verbal reasoning, explanation of concepts and diagrams drawn, the reliability in the marking process is more questionable. Bias against learners may occur as a result of inconsistencies among markers. Neatness and handwriting may cause an unintentional lower mark allocation to an answer (Wood, 1991). Therefore the choice is for questions to be structured with answers which are "right scientific fact or calculation" (Wood, 1991, p.63) which are easier to mark with a higher reliability.

From the above discussion, it is clear that boys or girls or various race groups are bound in some way to be disadvantaged by a test. In addition to the more obvious differences as a result of race, gender or culture "if differences in interest and motivation are considered to be biasing factors, then all tests or assessment methods may be said to have a certain amount of bias" (Hironymous and Hoover in Wood, 1991, p.171). Pahad (1999, p.272) has agreed that in reality no assessment task "rooted in the real world can be entirely culture-fair".

In the light of these arguments, it is therefore not possible to conceive of a test which is completely lacking in bias, particularly in a multicultural society. If all bias is removed, then any creative, challenging or interesting questions must be sacrificed for simple direct questioning which is completely factual and content driven and biased.

2.3.6 *Curriculum Change and Assessment.*

Berlak et al (1992) have argued that the curriculum reform movement of the 80's has produced a major paradox. Society and the industrial world have different needs from the past and structural changes in education must take place. In order for curriculum changes to be implemented successfully modes of assessment must be changed. Yet society has demanded greater dependency on mass administered tests by external examination boards (Harlen, 1994) for increased accountability. This has strengthened existing structures and the accompanying forms of control.

Stobart and Gipps (1997) have clearly stated that assessment shapes curriculum. Therefore while a national examination remains in a specified narrow form there will be little, if any, change in the curriculum. With the introduction of Curriculum 2005, there are clearly changes to be made to assessment processes if the new outcomes based education is to continue into Grades 10, 11 and 12. Gipps and Murphy (1994) have pointed out that it is important how definitions of achievement are structured. If this definition continues to be linked to the current form of the Senior Certificate examination, then it will in turn drive the curriculum to maintain its academic path in Grades 10, 11 and 12.

What is important is that the assessment is linked directly to its purpose as Stobart and Gipps (1997, p.103) have proposed. Does the matriculation assessment support the purpose of serving as a guide to choices in employment, by testing what it is that industry expects has been learned? Is the matriculation certificate a reliable and valid reflection of the individuals learned skills and knowledge? On the other hand would an outcomes based education with new forms of assessment be a more reliable and valid way of predicting future performance of school leavers in terms of the expectancies of employers? New forms of continuous assessment, in themselves, present many problems regarding teacher bias in evaluation (Watson, A., personal communication).

The function of research in the light of change is twofold. Firstly, research that takes place after change has happened, provides feedback on the perceptions and success or otherwise of the change. Secondly, research that takes place before change, which investigates the old, can establish if there is anything valuable which may work to the advantage of the new system. If indeed curriculum is driven by assessment, then if the old assessments are not compatible with the aims and outcomes of the new curriculum, the assessment process must be changed. In this investigation of the examinations an attempt will be made to investigate whether the mode of testing of the Senior Certificate has any relevance to Curriculum 2005.

In the final analysis "Educational assessment has a constructive focus where the main aim is to help rather than sentence the individual" (Gipps and Murphy, 1994, p.261).

2.3.7 *Assessment of Scientific Competence.*

Science is "not just a body of knowledge it is an activi ˙ (Eggleston and Kerr, 1969, p.154). Although a comment made some years back, this quote remains relevant today. Bloom (in Eggleston and Kerr, 1967) listed several components of scientific ability, which formed the basis for his taxonomy which still guides assessment in Gauteng today. These components are divided into levels and include knowledge, comprehension, application, analysis, synthesis and evaluation. Within these levels the scientific abilities of critical analysis, creativity, deduction and inference, open-mindedness, realism, accuracy, dexterity, numeracy, literacy and persistence, are included. In an assessment of the scientific ability of the learner as many as possible of these characteristics should be included if the test is to be a valid assessment of scientific skill and knowledge. Many of these abilities such as creativity, open-mindedness and inference are difficult to test in a written examination, since open-ended answers are difficult to mark with reliability.

If final assessments at the end of a period of scientific study do not involve assessment tasks other than a written examination, many components of what is considered scientific ability may not be tested. If the test is therefore considered by societal bodies to be a reflection of scientific ability, the grade obtained in a formal test may not be valid. This research will explore which aspects of competence in science the current school leaving examinations assess.

The problem, with traditional examination procedures, such as multiple choice and written problem solving questions and explanation (discussed above), have resulted in many countries moving to broader assessment techniques involving more descriptive school leaving certificates. These provide a better link between general education and vocational training (Broadfoot, 1996). Broadfoot has further expressed the belief that traditional mass assessment procedures are the greatest stumbling block to innovation in classroom practice, and this would certainly apply to the sciences.

Curriculum 2005 collapses the boundaries between theoretical and applied or experiential knowledge. In order to succeed with this, a change in the assessment practices, which have remained more or less the same in South Africa for more than 40 decades, must be introduced. This is further substantiated by Schoenfeld (in Morgan, 1998) who has claimed that the success of any curriculum development is related to the extent to which the assessment used reflects and supports the aims of the curriculum. The characteristics of current assessment in South Africa seems to be in conflict with the aims of Curriculum 2005 for the sciences, which values effort, creativity, problem solving and communication skills in practical tasks as demonstrated outcomes of learning. The analysis of the science Senior Certificate examinations will provide data on the value, if any, of the current assessment of science, for future assessments to meet the needs of Curriculum 2005.

2.4 Concluding Remarks.

This chapter has discussed many of the theoretical issues related to assessment procedures such as: formative and summative assessment; norm and criterion referenced assessment; validity and reliability; equity; bias; curriculum change; and assessment of scientific competence. Comment was made as to the relevance of many of these to the present examination process in South Africa and the implications for the new Curriculum 2005. The issues of validity and reliability were discussed in order to draw conclusions as to the reliability and validity of the Senior Certificate examination as a test and as a tool for employment practice.

The concern at present to introduce a system of learning, which provides equitable opportunities and fair choice of job prospects for all, places the focus on the methods of assessment and the results thereof. Since the current Senior Certificate examination seems to have a gate-keeping role to play in future opportunities, bias in assessment was discussed as this would disadvantage the results achieved by some learners.

With the many questions asked in the literature review in mind, the research methodology, to be described in the next chapter, was developed in order to explore the match- mismatch between the examination, the needs of industry and Curriculum 2005.

Chapter 3

Methodology and Research Design

3.1 Introduction.

This research explores the empirical and theoretical fields of assessment (Brown and Dowling, 1998). The empirical field is that area of experience into which a controlled and systematic investigation takes place for the validation of theory. The empirical setting is the position in the empirical field in which the research is to take place. This investigation takes place in two empirical settings, the first is the science Senior Certificate examination in Gauteng, and the second is the Engineering Industry in Gauteng. The theoretical field is a meaningful set of interrelated theories and facts. It is a body of knowledge permitting deductions to be made, which are then tested empirically (Cohen and Manion, 1994). In this research the theoretical field is that of assessment practices and their validity and reliability, in relation to purpose and society.

This research takes the form of a formal evaluation of the science Senior Certificate examination. The "evaluation object" (Worthen and Sanders, 1987, p.7) is the examination. The purpose of the evaluation is to provide information as to the value of the matriculation examination as an "assessment tool" for Grade 12 school leavers who enter the job market and as a useful assessment of the outcomes of Curriculum 2005. The means of the evaluation is an analysis of past examination papers and a survey of employers in selected industries which employ school leavers with a matriculation certificate. The analysis of the examination papers also looks at the extent to which the new outcomes are incorporated, both in relation to the Engineering Industry and to Curriculum 2005.

3.2 Formative and Summative Evaluation.

Worthen and Sanders (1987) distinguish between formative and summative evaluation. Formative evaluation takes place during the development of a program in order to enable improvements to be made by the developers. Summative evaluation is conducted at the end of a program to provide judgement of its merit or worth.

The methodology of my research fits into the category of both formative and summative evaluation. It can be considered as a formative evaluation since the data gathered may have value for future assessment practice if it is found that the examination does or does not assess what is required by industry and Curriculum 2005. It is also a summative evaluation since it is undertaken on examinations, which are already in existence in order to make judgements on their merit or worth in relation to the needs of industry. A public examination (like the Senior Certificate examination) is a summative assessment of the knowledge of a school leaver (Calder, 1994). This research will therefore be a formative and summative evaluation of a summative assessment.

Scriven (in Worthen and Sanders, 1987) has described characteristics of summative evaluation, some of which relate to this research evaluation. They are:

a) The purpose of the evaluation is that of certifying program utility. If the data collected is positive regarding the utility of the Senior Certificate examination for Industry and Curriculum 2005, then it could be continued in its present form.

b) Summative evaluation has a potential consumer i.e. the audience towards whom the evaluation is directed. In this study, the potential consumers are the educational authorities in Gauteng and other provinces, learners, teachers, parents and others with an interest in current and future assessment practices.

c) The questions posed in a summative evaluation are essentially about the program. The questions asked in this research are concerned with the Senior Certificate science examination and its usefulness in employer practices.

d) The design constraints of such an evaluation are limited by the claims which are to be made as a result of the evaluation. In this research the intention is to make claims as to the advantages and disadvantages of the Senior Certificate examination as an "assessment tool". The design is constrained to questions which relate to the needs of industry regarding knowledge, skills and values, and the outcomes of Curriculum 2005.

Part of this research could also be described as a needs assessment. Stufflebeam et al (1985, p.21) have defined a needs assessment as "a process that includes gathering and using information for making decisions about the direction or worth of a program or practice" and its future direction. A needs assessment therefore may be considered as part of a formative evaluation. Stufflebeam has however distinguished a needs assessment, from a formative evaluation, which he says is usually concerned with the present or the past and which is not usually future directed, and therefore a needs assessment is not formative.

This research asks questions regarding the present needs and perceptions of industry with reference to the science Senior Certificate Examination. The research provides data, which may be useful for future decision-making regarding a Grade 12 school leaving assessment, which will serve the aims of Curriculum 2005. Stufflebeam et al. (1986) have described four different approaches to needs assessment, two of which relate to this research:

a) An analytical view: This is driven by a need to systematically investigate the direction to be taken in order for improvements to take place. This research takes an analytical view in order to investigate the current examination with a view to the actual needs of industry. It analyses which aspects of the examination could be of use in future assessment developments alongside Curriculum 2005.
b) A discrepancy view: The gap between the perceptions of desired performance and actual performance is investigated as a need. Is there a gap between the perceived needs of industry regarding the Senior Certificate Examination and the knowledge and skills tested in the examination?

On the basis of these approaches, I can characterise my methodology as research, which will be undertaken through a process of summative and formative evaluation, (or needs analysis) from an analytical and a discrepancy viewpoint. It will be an evaluation of the summative Senior Certificate science examination.

3.3 Data Collection from Industry.

3.3.1 *Instrument for Data Collection.*

A questionnaire (Appendix 1) was used to collect data regarding the skills, knowledge and values required by Engineering companies from their prospective employees with science as a matriculation subject. The perceptions of industry, as regards the "currency" which science as a subject holds and the Senior Certificate as a tool for selection is explored.

The questionnaire is divided into three sections:

Section A- Company profile.

1. Questions relating to identification data on the company.
2. Open ended questions relating to qualitative data on the employment practices of the company and the value placed on the matriculation examination.

A request was made for the company to specify one job for which they would require or would prefer a prospective employee to have science as a Senior Certificate subject. This was in order to facilitate the answering of the questions relating to knowledge considered to be important for that job.

Section B- Needs Assessment of Scientific Knowledge.

1. Quantitative data has been collected using closed questions. Table grids were given to facilitate replies and analyses (Appendix 1). The content of the examination considered to be of value required a cross in the appropriate block The areas chosen to be rated were those which are examined in the science Senior Certificate examination. The sections are taken from Fisichem (Jordaan, 1998). These sections were chosen to facilitate a comparison between the responses of industry and the analysis of the examination papers.
2. Open ended questions were included requesting information relating to any further knowledge which would be useful for the job specified. The open ended questions were hoped to elicit further thoughts and response from employers.

Section C- Needs Assessment of Intellectual skills.

This section consists of three tables. The first consists of skills considered important for learning according to Blooms taxonomy (Crossley, 1980, Eggleston and Kerr, 1969) and upon which the mark allocation for the Senior Certificate examination is based. The second table consists of the critical and specific outcomes as compiled for the Natural Sciences in Curriculum 2005, in order for industry to specify which of these are important for their prospective employees. The critical and specific outcomes were combined since there is some overlap of these outcomes. The third table contains job-related skills, which, upon personal reflection and general reading and discussion I considered to be of value. The inclusion of these is substantiated by comments expressed by some companies on their value.

The questions have been carefully worded in order to ensure validity (Brown and Dowling, 1998). Validity refers to the face value of the questions in that they should relate clearly to the area of investigation i.e. they access what is being investigated. Care was taken, to guard against repetition and dummy items (Worthen and Sanders, 1987) and to ensure that all questions relate clearly to the needs of industry regarding the Senior Certificate examination.

Cohen and Manion (1994) have queried the validity of postal questionnaires since respondents who fail to return their questionnaires, for various reasons, may have given very different answers from those who did, and therefore alter the distribution of the data. In my study telephonic contact was established with the appropriate human resources person at each company, in order to elicit agreement to their participation, before sending out the questionnaires. Further follow-up calls were undertaken to avoid 'no responses' as much as possible. Many problems arose during this process and these will be discussed later.

3.3.2 *Pilot Study.*

The questionnaire was piloted with a Mining and Metallurgical Engineering company and a Mechanical Engineering company. Both gave telephonic feedback which proved valuable to the final structure of the questionnaire. This went a long way in ensuring that the questions were clear, unambiguous and produced the required data.

Statisticians were consulted to obtain advice on the data collection and form of collation to ensure that they could be statistically analysed.

3.3.3 *Sample.*

Data was collected by theoretical sampling (Brown and Dowling, 1998) from one sector of industry, that of Engineering. The rationale behind this choice was the assumption that a school leaver with science as one of their subjects would consider strongly the Engineering fields for employment and that this sector would employ school leavers with science as one of their subjects. Four branches of engineering in Gauteng were sampled; mining, chemical, mechanical and electrical engineering.
The sample was restricted to Gauteng to enable telephonic and if necessary, personal contact.

In order to obtain a representative sample of employers from the four sub sections of engineering in Gauteng, a list of companies from each of these sectors was sourced through AS and TS (Associated Scientific and Technical Society) which is an umbrella organisation for various member organisations in this field. The following member organisations were contacted for a list of their members: Institute of Mining and Metallurgy, Institute of Mechanical and Mining Engineers, Institute of Chemical Engineers, and Institute of Electrical Engineering. It was intended to have a sample of 35 companies from each membership list (the number was chosen with the advise of statisticians in order to produce statistically significant results) i.e. a total of 140 companies from which to draw data.

a) Mining and Metallurgy

The Mines and Quarries Africa Yearbook, 1998-1999 was obtained from the Institute of Mining and Metallurgy. The yearbook was used to draw up a list of all mines and quarries in Gauteng. A total of 72 companies was compiled, and from this a random sample of 35 was generated using the table of random numbers.

These 35 companies were telephoned and the Human Resource (HR) department was contacted. If there was no HR department then the person most closely involved with employment was contacted. Once the appropriate person was reached, a brief description of the purpose of the research was given and then permission obtained to fax or post or hand deliver (whichever was most appropriate) the questionnaire, on the understanding that it would be completed and returned.

Only 23 companies from this sector of the Engineering field agreed to receive the questionnaire, a disappointing number. The reasons for this were varied. Three companies were no longer taking on new staff, one voiced no interest, four were in the process of closing down and four on the list were non-existent. There were thus 12 casualties before even beginning to attempt to get the questionnaires returned, which proved to be a formidable task as will be discussed in section 3.3.4.

b) Electrical Engineering

A list of electrical engineers was obtained from the SA Institute of Electrical Engineers. This list only contained 37 members. From this list 35 companies were chosen by random sampling. These were contacted by telephone as described above.

A similar pattern to that experienced with Mining and Metallurgy followed, four companies were non existent, two were not prepared to complete anything, three turned out to be duplicates of previously listed companies but listed separately under different names. From the initial telephone contacts 26 questionnaires were faxed to companies prepared to be involved with the research.

c) Chemical Engineering

The third sample list was compiled from the Institute of Chemical Engineers and supplemented by the list of Chemical Engineers listed in the South African Association of Consulting Engineers, as the original list contained too few members from which to sample. A random sample of 35 companies was compiled from a list of 42 companies. The same process was followed and 31 questionnaires were sent out.

d) Miscellaneous Engineering

The fourth group was intended to be Mechanical Engineers drawn from the SAACE (South African Association of Consulting Engineers). From a list of 45 companies, 35 were selected by random sampling. The same procedure as with the other sectors was followed. However this time the first ten phone calls indicated that it appeared that most Mechanical Engineers function as consultants (which was not the case with the other lists of engineers) and therefore only employed graduates.

It was then decided that this sample was not suitable and a random sample of 45 General Engineers was compiled from the 1999 Yellow Pages. The number in the sample was increased with the realisation of the large numbers of casualties in the previous studies. Again however, on personal contact, only 21 of these were willing or suitable to complete the questionnaire. The reasons for this were varied and are discussed in section 3.3.4.

The reasons for the disappointing responses will now be discussed.

3.3.4 *Difficulties in Data Collection.*

In addition to the problems already mentioned, the data collection proved to be difficult for many reasons.

The first group, the Mining and Metallurgy Engineers, were contacted in the first week of September. After the initial telephone contacts eleven questionnaires were faxed, seven posted, and five hand delivered by me. Four responses were received from companies within a week with no further follow up. Over the next three months after repeated phone calls, a further two companies had closed down and were unable to be contacted, two refused to complete the questionnaire, one only employed labourers and one only employed tertiary trained staff and office staff, therefore were not suitable candidates for the research. Finally only six could be used in this study.

Those companies who declined to participate were mostly those which do not employ school leavers, employing only tertiary qualified people, or labourers who do not require Senior Certificates.

The interaction with the Electrical Engineering companies had similar problems. Only five questionnaires were returned without further prompting. With follow up calls a further five companies found it was not applicable to them as they only employed tertiary graduates and office staff, one employed only labour and two felt they did not have the time to complete the questionnaire. After three months of follow up, nine questionnaires were returned, two of which could not be used, as one was filled in for job descriptions of qualified engineers and one did not relate to the science as part of the job specifications. Finally only seven questionnaires from this group could be used.

Collection of data from the group of Chemical Engineering companies proved similarly problematic. Of the 31 questionnaires sent out, three companies on reflection could not complete the questionnaire as they only employed graduates, one proved to be a duplicate company. With no further follow up calls, eight were returned. When follow up calls were made 11, replied that they employed only tertiary educated staff (despite the initial telephone conversations). One company felt that they were too small to complete the questionnaire and one replied that they did not have a data bank and therefore could not complete the questionnaire. After three months of many follow up calls, eight questionnaires were completed and returned, two of which could not be used.

The Miscellaneous Engineering group produced poor results as above for many reasons. From the initial telephone contact with each of the 45 companies on the list, only 21 agreed to receive the questionnaire. The reasons for this were varied. For example, it was found that seven companies only took on labourers, four refused and were not interested in participating, and twelve were in the process of, or had already closed down. A further two casualties were a company owned by an Israeli who did not understand all that much of our education system, and one company admitted to only employing Zimbabweans and therefore the Senior Certificate was not a consideration as they had A level certificates as a measure of ability. From the 21 questionnaires faxed two responses were received with no further prompting. When follow up calls were made three companies refused to complete the questionnaire, one only employed graduates and therefore could not contribute and one employed only labourers and therefore the Senior Certificate and science as a subject was not a consideration for them. The rest did not respond even after repeated calls. After the three months, five were returned, two of which could not be used since they were incomplete, only three questionnaires could be used.

As described above, the process of getting the information returned has been difficult. Many of the HR people contacted seemed to have no time to do any work outside of their work responsibility. There was also a turnover of staff during the three months of data collection and hence continuity was disrupted. Many mislaid the original questionnaire and many of the questionnaires had to be faxed again, and in some cases two or three times after the first fax.

I have discussed the above difficulties in detail in order to be able to reflect on the problems of doing this kind of research. In a time of rapid change, with instability and insecurity, there are many closures of businesses. Staff turnover is a problem, of the contacts made there were five changes in the HR positions contacted (one of which was a death on a highway as a result of what was attributed to "road rage" after an argument). It would seem that very large samples would need to be taken if one wanted to receive enough data in order to be able to generalise findings to a situation or field. The data collected in this study therefore can only suggest conclusions which hopefully will stimulate further research.

3.4 Data Collection from the Examinations.

The Senior Certificate examination is a summative assessment which takes place at the end of Grade 12, the final year of formal schooling in South Africa. It is intended as an indication of competence in knowledge, skills and values learned during the school years. From the grades obtained, further decisions are made regarding job opportunity and future tertiary study. There are two examination boards which function in Gauteng, the Gauteng Department of Education (GDE) and the Independent Examinations Board (IEB) and therefore both were chosen for the study. They are further separated into a Higher Grade (HG) level and a Standard Grade (SG) level, a pupil choosing which is to be written, based on their performance during the final two years. A HG pass is necessary in science if a career in the sciences is to be followed at a University.

3.4.1 *Sample.*

Examination papers to be evaluated have been restricted to the GDE and the IEB since these are the two examinations in Gauteng which prospective employees would be writing at the end of Grade 12. I have analysed both the HG and SG examinations from 1996-1999. By analysing four consecutive years, it has been possible to establish if there is any trend towards a change in the assessment in preparation for the outcomes based Curriculum 2005.

The purpose of this part of the investigation was to analyse the HG and SG Senior Certificate examinations as to the knowledge skills and values which are assessed. This will enable comparisons to be made as to the "match or mismatch" of the perceptions and needs of industry as regards the Senior Certificate science examination as a tool for selection of job applicants.

The Senior Certificate examination is a test. A test is a collection of items developed and collated in order to measure a set of knowledge and skills. Each item in the test has the stated problem, a record of the examinee's response and the way in which the response is scored (Worthen and Sanders, 1987). The science examinations in South Africa have been guided by Blooms Taxonomy as to the allocation of marks to each intellectual skill, as specified in the letter on decisions and recommendations relevant to teachers of Grade 12 science pupils (Gauteng Department of Information, JCE meeting, February, 1996). It has been mentioned to me that the Senior Certificate examiners have been briefed to attempt to test the critical outcomes as approved by SAQA, in the test items in 1999 (Meg Pahad, personal communication). This is in line with the intended outcomes based education, which proposes a change from norm-referenced testing (NRT) to criterion-referenced testing (CRT).

3.4.2 *Instrument for Examination Analysis (Appendix 2 and 3).*

The format followed by the Senior Certificate science examination papers is that of two separate two-hour examinations, one in physics and one in chemistry. Each paper is divided into two sections; the first is a section of multiple choice questions; and the second consists of various short and long questions on the curriculum content. The mark allocation for each section is indicated in Table 3.1 below:

Table 3.1

Mark Allocations

Examination paper	**Multiple choice**	**Free format questions**	**Total**
HG GDE physics	20 questions X 3 = 60	140	200
HG GDE chemistry	20 " X 3 = 60	140	200
HG IEB physics	15 " X 4 = 60	140	200
HG IEB chemistry	15 " X 4 = 60	140	200
SG GDE physics	15 " X 3 = 45	105	150
SG GDE chemistry	15 " X 3 = 45	105	150
SG IEB physics	10 " X 4 = 40	110	150
SG IEB chemistry	10 " X 4 = 40	110	150

The proportion of marks allocated to the multiple choice questions would ensure that at least a little less than a third of the paper has total reliability. Wiliam (1998) has stated that multiple choice questions enable greater reliability than more interpretive, free format questions, and especially those requiring verbal explanation of understanding.

The tool for analysing the Senior Certificate science paper (Appendix 2 and 3) consisted of two parts. The first (Appendix 2) contained a list of the physics and chemistry content examined in the papers as described by Physichem (Jordaan, 1997, 1998, and 1999). The questions relating to each topic was obtained from the Physichem for the 1996, 1997, and 1998 examinations and the question numbers entered against the topic listed in the grid. The mark allocation for each question is also derived from the examination papers in the Physichem and entered in the second part of the grid. The mark totals for each topic were calculated in order to check the total for each paper, in order that no questions were omitted in error. For the 1999 examinations as there was no Physichem available for those papers at the time of this study the above mark allocation was done independently by myself.

The second tool (Appendix 3) consisted of a table in three sections. The first section was drawn up to collate the mark allocation in each paper to the categories drawn from Blooms taxonomy (Crossley, 1980; Eggleston and Kerr, 1969). The second and third sections were for the allocation of marks according to the critical and specific outcomes of Curiculum 2005 (Government Gazette, 1997) for the natural sciences.
I drew on the assessment criteria and range statements from the Government Gazette to inform my criteria for analysis and the understanding thereof. Each category and outcome was allocated a code, which corresponded to the codes used in the industy questionnaire, in order to facilitated comparisons.

Separate sheets were collated for each examination - a total of 16 analyses. This consisted of four Higher Grade GDE and IEB papers, and four GDE and IEB standard grade papers. The procedure for data collection is described in Chapter 4. The data collected was then entered onto a computer spread-sheet and graphs drawn in order to facilitate comparison and comment on the trends found in these examination papers.

In order to establish whether the analysis would be reliable (Wiliam, 1998), and that there was some consistency in the analyses, a pilot study was undertaken.

3.4.3 *Pilot Study.*

A pilot study with three different "scorers" was undertaken to establish whether my instrument would give a reliable analysis. The purpose of the pilot was to establish clarity on my own interpretation of the criteria in order to ensure some consistency in the analyses.

The pilot study was carried out on the Western Cape SG, physics and chemistry, examination papers. The mark allocation was 10 multiple choice questions for three marks each and the balance of the questions made up 120 marks to make a total of 150.

The pilot study was c[illegible] by myself, and two other qualified teachers, each analysing the e[illegible]dependently. The results will be referred to as my own result or "pilo[illegible] 2". The results of the analyses are shown in Table 3.2. A discussion on the results obtained and the variations shown will follow.

Table 3.2

Results of Pilot Run Analysis of Cape SG 98 Science Examination.

3.2.1 Mark allocation for abilities (as in Blooms Taxonomy):

Category	Chemistry Own	Chemistry Pilot 1	Chemistry Pilot 2	Physics Own	Physics Pilot 1	Physics Pilot 2
3.1 Knowledge recognition and re call.	86	73	62	18	20	17
3.2 Comprehension- 3.2.1- understanding the meaning of symbols and equations/facts	6	5	4	13	13	10
3.2.2- verbal presentation of understanding of knowledge	8	4	9	16	26	6
3.2.3- selecting data computations, problem solving in familiar situations	41	27	56	93	73	31
3.2 Application of knowledge to new/novel problem situations			17			67
3.3 Analysis-ability to recognise Parts as a whole	6	10	6			8
3.4 Synthesis-to produce a solution from parts of information						5
3.5 Evaluation-making value judgements and decisions based on results						3

3.2.2 Critical Outcomes – Curriculum 2005:

Outcome	Chemistry Own	Chemistry Pilot 1	Chemistry Pilot 2	Physics Own	Physics Pilot 1	Physics Pilot 2
4.1 Problem solving using critical and creative thinking/decision making						12
4.2 Team group work						
4.3 Manage themselves/activities						
4.4 Collect/analyse/organise/ evaluate information, a process.		34	8		73	37
4.5 Communicate using visual/language skills, i.e. verbal explanation.	8	4	11	18	16	12
4.6 Use science/technology with regard to environment						20
4.7 Demonstrate understanding of interconnectedness of all problem solving situations.						

3.2.3 Specific outcomes for natural sciences- Curriculum 2005:

Outcome	Chemistry Own	Chemistry Pilot 1	Chemistry Pilot 2	Physics Own	Physics Pilot 1	Physics Pilot 2
5.1.Evidence of Independent investigation- process skills						
5.2.Demonstration of understanding of principles of nat. sciences.	42	31	24	19	21	40
5.3.Identification of problems and use of knowledge in problem solving- taken to mean calculations.	61		24	109	76	92
5.4.Awareness of knowledge related to social, economic and political issues						4
5.5.Decision making skills using data given.			72			
5.6.Relationship between science and culture.						
5.7.Knowledge of changes in past and possible future changes of scientific knowledge.						
5.8.Awareness of ethical bias and iniquities						
5.9.Knowledge of interaction of sciences and its importance for economic development.						

Table 3.2.1 shows an overall consensus that most of the mark allocation is attributed to knowledge recognition and recall in the chemistry paper. Fewer marks were allocated to understanding of symbols and facts, a few to verbal presentation of understanding, and a third or less than a third of the marks (41,27 and 56) to problem solving. Very few marks were allocated by any of the 'scorers' to analysis in the chemistry paper, and none to synthesis or evaluation. Similarly in the physics paper the consensus was that most of the mark allocation is to problem solving in familiar situations.

However Pilot 2 allocated 17 marks to new or novel problem solving in the chemistry paper and 67 in the physics paper, which the other two analyses did not. This indicates a different interpretation of what is new or novel. Question 4.2 in the physics paper for example is about two ice-hockey players who collide and the questions follow regarding velocity changes. If one considers the application to ice-hockey as new then the question may be considered novel. However this question is similar in principle to many other questions seen before, such as questions on ice-skaters, and is therefore in my opinion not new. Herein lies the first indication of the difficulties in achieving consistency in the interpretation of the categories. What does "new" imply? According to the South African Pocket dictionary (19870 one of the meanings is "changed or different from the previous" i.e. a question which is changed or different. No question in the examination paper is exactly the same as any question previously encountered by a student. In this light every question could be considered new. For my purposes questions were not considered as "new" if the knowledge base, principles and thought processes were the same.

The analysis of outcomes proves to be more complicated (Tables 3.2.2 and 3.2.3) and it is here that the interpretations become vital if there is to be reliability.

Table 3.2.2 shows that Pilot 2 allocated 12 of the physics marks to critical problem solving whilst the other two recognised no critical thinking in the paper. The category of problem solving using critical and creative thinking and decision making needs careful definition. "Critical" involves a sequence of stages in a complex thought process, which if to be creative needs to have an element of independent imaginative thought.

A similar problem in the interpretation of outcome 4.4 (Table 3.2.2) is noted, with the understanding of what is collecting, analysing or organising. My interpretation based on the Government Gazette (1997) is that it is data collected by students through a process of investigation as in a practical task or assignment, of which an examination is clearly not an example, and therefore I had not allocated any marks to this area.

There was however, consensus between analyses on verbal explanation (outcome 4.5) since this is a far less interpretative category and most questions which required language use were allocated to this category.

A difference is seen in terms of what is considered the use of science and technology with regard to the environment (outcome 4.6). Is a question regarding a rowing boat on a river considered as using science as regards the environment (which is where the allocation of 20 marks to 4.6 came from), or merely a problem regarding the principles of forces? My understanding of the use of science and technology in the management of the environment involves the management of natural resources such as use of power from natural resources as an example, and the scientific principles contained therein.

Similar comment applies to the analysis of the examinations according to the specific outcomes in Table 3.2.3. The pilot analysis showed similar allocation of marks for outcomes 5.2 and 5.3. Only one analysis (pilot 1) allocated no marks to problem solving in the chemistry paper. In this case, I returned to the definitions from the Government Gazette (1997) which requires innovative thinking (new ideas) in problem solving. This would have removed any indecision, since there is no call for any independent, new or inventive thought in the examination. One analysis (pilot 2) saw a large allocation of marks given to decision-making skills in the chemistry paper. These refer to questions relating to experimental data followed by questions of calculation and interpretation with regard to results. Most of the questions in the chemistry papers on experimental data were those with which the pupils should be familiar from the content specified in the curriculum and therefore they would be reporting on known results rather than decision making. This is again a difference as a result of interpretation.

The interpretation is of the utmost importance in order to establish reliability. Although a short explanation accompanied the request for the pilot studies, no discussion or consensus of meaning was reached before the independent analyses were done.

Neither pilot 1 nor 2 made comment regarding any cultural or gender bias in the questioning. I similarly encountered little other than to comment upon the fact that generally boys' names were used in problems. In addition to this, lack of clarity in the language of the questions could be interpreted as cultural bias in South Africa. An example of this being question 4.1 in the physics paper, with the wording a "safety rope arresting his fall". It would require well-developed English language skills to understand the meaning of the word "arresting" as "breaking" the fall.

It would have been helpful to have had a discussion with both of the teachers who took part in the pilot study to reach a consensus on their understanding of the different categories. This may have produced more consistent results. The results however do show that most marks are allocated to similar areas and therefore establishes some credibility and a measure of reliability for the analyses done on the examinations in Gauteng from 1996 to 1999. The analysis of the examinations is a subjective exercise and therefore the allocation of marks in an analysis such as this would vary from one analysis to the other, and is a limitation of this research. In order to obviate major differences in interpretation, I will give my interpretation of each category in Appendix 5. An explanation of the process followed in the allocation of marks in the analysis of the examinations follows in Chapter 4.

The main benefit of the pilot study was that it enabled me to sharpen and clarify the categories for my own analyses.

3.5 *Statistical Analysis of the Match-mismatch Between the Examinations and the Needs of the Engineering Industry.*

The data collected from the analysis of the examinations and the feedback from the Engineering industry was handed to the Statistical Department of the University of the Witwatersrand. The data was in the form of two spreadsheets. One spreadsheet contained the data collected from the 22 Engineering companies who had completed the questionnaire. The other contained detail of the mark allocations as collated from the examination papers studied. The data was analysed using the Chi square distribution in order to compare the data for the purposes of investigating the match-mismatch of the needs of the Industry versus the knowledge skills and values tested in the Senior Certificate science examinations.

The Chi Square analysis compares observed frequencies with theoretical frequencies. A value chi square is calculated to reflect the significance of these differences. A value which represents a significant difference at a level at which the hypothesis of a match is rejected (Ferguson, 1996). The value of chi square which reflects a significant difference was advised to be 0.05. Therefore any value of < 0.05 was taken to reflect a significant difference between the emphasis of the examination on a topic and the needs of Industry.

The observed frequencies in this research refer to the data collected from industry regarding the perceived importance of certain scientific topics for specific job situations. The theoretical frequency was taken as the mark allocation for the topics in the Senior Certificate examination in the GDE and IEB 1999 science examination.

It was decided to use the data from the HG and SG 1999 examinations since the data was collected from the engineering industry in that year. The two sets of data were entered into the statistical program. Since the data from industry was in the form of a yes/no response and therefore binary, the mark allocation in the examinations, if present for a topic, was taken as a yes for the purposes of the comparison.

The results of this statistical valuation together with the examination analysis and feedback from industry are reported in Chapter 4, followed by a discussion on the match–mismatch between the two.

Chapter 4

Analysis of Examination Papers and Feedback from Industry

4.1 Introduction.

In this chapter I will present my analysis of the data received from the Engineering Industry and my analysis of the examination papers. It will be seen in the analysis of data that the results of the Senior Certificate examination are used by half of the Engineering Industry as a tool for selection. In this case, the content which is examined should be in line with the skills and knowledge expected by industry. It is for the purposes of this comparison that the examinations were analysed and the results discussed here.

4.2 Analysis of Feedback from the Engineering Industry.

The feedback, from the 22 companies who returned the questionnaire, was entered onto a spread-sheet against a company code allocated during the sampling, and the response to each question entered against this code. Totals across the 22 companies for the different questions were calculated and tabulated.

The total number of staff employed by these companies is 15370. The data returned on the numbers of school leavers employed each year, whether they have science as one of their subjects and details of gender were missing in more than half of the companies as they replied that they did not keep such detail on hand for their staff. Therefore no conclusions could be drawn based on this data.

As regards the importance of the Senior Certificate examination as a tool for employment, 11 out of the 22 companies use the Certificate as a method of selection of prospective employees. Those who do use the Secondary Certificate as a tool for employment felt that it was an indication of potential and was a first step in selecting the competent for further training. Amongst these it was felt that it is important to have a standard against which one can measure potential or competence.

Of the remainder of the sample, eight did not use the Senior Certificate, one company replied yes and no, depending upon the job, and two did not complete this section of the questionnaire. It therefore appears that almost half of employers, in the sample of the Engineering Industry taken, use their own methods of selection. One company replied that the examination results did not give a true reflection of academic ability, and others use their own "in house" personality and skills based assessment techniques. Many placed much importance on personal initiative as regards what personal effort is seen in "job hunting" or extra skills obtained. Just less than half (eight out of 22) of the employers do not regard the examination as having predictive validity since they use other methods of selection to predict desired performance.

These 22 companies specified 41 job descriptions. These included artisans, technicians, analysts, electricians, machine operators, laboratory assistants etc. The topics, which were rated as important for most of the jobs were Newton's laws and electricity, followed by energy and motion. The chemistry topics were of less relevance for many of the jobs and were of value mostly to the chemical engineering field. Within the jobs specified as requiring chemistry: solutions; acids and bases; and redox reactions were considered the most important. The results of this feedback are reflected in Table 4.1 below.

Table 4.1

Results of the Feedback from the Engineering Industry.

Physics Content	1.1 vector	1.2 motio	1.3 gases	1.4 Newt	1.5 momen -tum	1.6 energ	1.7 e-field	1.8 elec		
+response	17	21	18	28	18	22	17	26		
Chemistry Content	2.1 bond	2.2 solut-ions	2.3 sulph	2.4 nitro-gen	2.5 halogen	2.6 reacts	2.7 eqilib	2.8 acid/ base	2.9 redox	2.10 org. chem
+response	8	14	6	5	6	7	4	11	8	5
Blooms Taxonomy	3.1 know	3.2.1 under stand	3.2.2 verbal	3.2.3 applic	3.3 new know	3.4 analy-sis	3.5 synth-esis	3.6 eval		
+response	34	35	28	35	25	39	30	33		
Critical Outcomes	4.1 prob solv	4.2 team work	4.3 indiv. man	4.4 organ-sing	4.5 commu nicating	4.6 envir-	4.7 inter conne			
+response	37	34	25	30	34	27	27			
.										
Specific outcomes	5.1 lab skill			6.2 creati vity	6.3 honesty	6.4 punct uality	6.5 comp uters			
	22			20	31	29	20			

The feedback from the Engineering Industry in the table- above showed that some topics are more important than others.

There was no feedback in response to the open-ended questions regarding any topics, other than those specified, which could be of assistance. There was one request for pyro-chemistry which is of import to the gold industry in South Africa. This is of relevance to outcomes based education in its critical and specific outcomes, 4.6 and 5.9 respectively. These relate to the importance of the application of scientific learning to environmental and economic issues.

The feedback on the criteria, as defined with reference to Blooms Taxonomy, shows the equal importance of knowledge, understanding, analysis, synthesis and evaluation (Table 4.1). A similar trend is seen in the feedback on the skills listed according to the outcomes for learning specified in the Government Gazette (1997). Almost all of the skills aimed for in Curriculum 2005 carry import for most of the job situations listed (Table 4.1). All of the specific outcomes were also highly rated. Laboratory skills, honesty, creativity and punctuality were some of the other skills rated as important.

The open questions asking for other desirable skills, elicited responses that the schools should enable students to manage themselves. This is listed as one of the outcomes desired in Curriculum 2005 (Code 4.3). Self-belief, self-sufficiency, self-motivation and accountability for self-development were amongst other skills listed as desirable. Other comment included the awareness that an individual must be flexible and able to manage change. There was a great deal of comment on the gap between the regurgitation of knowledge and the application thereof. Many requested more practical training in the application of knowledge and skills. One of the companies commented that the examination results reflect only the regurgitation of knowledge learned and that it had little reference to the application thereof.

Since the needs of the sample of Engineering companies contacted in this research reflect a very positive need for the skills as defined by Curriculum 2005, the results confirm the trend towards skills based learning. If this is to be successful then the assessment procedure must be changed. For the many reasons discussed in Chapter 2, if the learning program is changed but the assessment is not, teachers will continue to teach to the test and the required skills will not be explored and developed in the classroom.

The consistency of the data collected from this small sample from the Engineering Industry confirms that the skills specified for curriculum 2005 should be a part of the learning process. However the feedback suggests that knowledge cannot be sacrificed for skills. It therefore follows that any summative testing at the end of Grade 12 must in some way both test and reflect, knowledge and skills.

A discussion on what the current examination tests, based on the analyses of the examinations, follows.

4.3 Analysis of the Science Examination Papers over the Past Four Years.

After analysing the Cape paper for the purposes of the pilot study, the first HG paper of the GDE (Gauteng Department of Education) in 1996 was analysed. After one analysis it was repeated in order to clarify my understanding of the categories and to attempt to establish that I was being consistent in my interpretation and allocation of marks. This proved to be difficult until interpretations were clarified.

For the purposes of this study the classification of Blooms Taxonomy (Crossley, 1980) and the description of cognitive processes in learning (Mucheru, 1994) were expanded and combined in order to analyse the examination papers in distinct categories. The categories and the meanings ascribed to them are detailed in Appendix 4. A brief description of those categories which proved problematic follows.

The application of knowledge to new or novel problem situations (Code 3.3) was interpreted, in this analysis, to be those questions which were not encountered in the generally used text books. Questions allocated here were those which applied to novel situations encountered in the environment, and those which used scientific theory as applied to everyday situations not usually found in text books.

Analysis (Code3.4) was taken to refer to higher order cognitive skills. As such it relates to the ability to recognise parts of information as a whole, to break information down into its constituent parts and to recognise relationships between parts of learned knowledge. Synthesis (Code 3.5) was interpreted as the ability to piece together information, in an organised way, in order to produce a meaningful result. It thus involves questions, which go beyond the problem solving skills in order to come to a conclusion at the end of a problem solving exercise. Evaluation (code 3.6) was considered to involve valid judgements made on experimental results or a situation.

The interpretation of the critical and specific outcomes was followed as detailed in Appendix 5.

For each year, the physics and chemistry papers were analysed separately, beginning with the HG, as follows:

a) Appendix 2 was used to collate the questions which related to each topic in the examination. The question numbers were entered against each topic and the mark allocation for each topic totalled. The data was collected using Physichem (Jordaan, 1997, 1998 and 1999). The data collected was then entered on a computer spread-sheet and histograms constructed to display the results clearly (Appendix 6).

a) Each section of each question in the examination was read, and the procedure and thought process which would probably be followed was decided upon. Based upon this decision, the full marks of each section of the question were allocated to one of the categories in each of the sections: Blooms taxonomy; Critical Outcomes; and Specific Outcomes using Appendix 3. The results of the analyses according to Blooms taxonomy were then entered on a spread-sheet and histograms constructed reflecting the mark allocation per topic for each examination for each year (Appendix 6.3 and 6.6). The results from the analysis for the outcomes were clear and did not need to be represented in this way.

b) The total for each category was calculated and these totals for each paper entered in the Tables 4.2.3, 4.2.4, and 4.2.5 below.

Whilst carrying out the analyses, care was taken to be consistent in the allocation of marks. The analyses were done, one each day as far as was possible, so that the time between analyses would not alter the interpretation of categories, which were continually referenced.

Each question was not solved to its conclusion due to time constraints. Every question was read, the procedure to be followed decided upon and if it involved, for example, the direct application of equations in the solving of a problem, it was considered to be a problem solving skill (Code 3.2.3). Since each problem question was not solved to its conclusion there may have been a small percentage of the mark allocated which was analysis. In any event without a marking memorandum for each paper, this would be impossible. On reflection I felt that this would not change the overall result.

Table 4.2

Results of the Analysis of the Senior Certificate examinations- HG

4.2.1 Physics:

Mark allocation per learning area. (Multiple choice plus others)

Content	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
1.1Vectors	15	17	15	27	28	28	28	28
1.2 Motion	12	43	24	25	44	28	28	28
1.3 Gases	19	19	18	16				
1.4 Newton	60	33	31	29	23	16	28	24
1.5 Momentum	16	6	15	9	4	20	24	24
1.6 Energy	16	13	30	26	17	24	4	8
1.7 E-fields	17	26	24	27	32	12	28	32
1.8 Electricity	45	43	43	41	52	72	60	56

4.2.2 <u>Chemistry:</u>

Mark allocation per learning area. (Multiple choice plus others)

Content	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
2.1 Bonding			19	13	9	4	8	4
2.2 Solutions	6							
2.3 Sulphur	24	30	32	27	16	20	20	12
2.4 Nitrogen	23	19	17	18	9	6	12	
2.5 Halogens	9	20	22	30	17	8	4	20
2.6 Reaction rate	9	24	7	10	4	4	8	14
2.7 Equilibrium	40	32	31	22	21	36	33	30
2.8 Acid/base	39	25	30	27	32	35	31	34
2.9 Redox reactions	23	21	20	23	33	27	35	15
2.10 Organic chemistry	27	26	22	30	28	31	23	36
1.3 Gases		3			31	29	26	35

4.2.3 <u>Mark allocation for abilities (as in Blooms Taxonomy):</u>

Category	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
3.1 Knowledge recognition and re call	110	83	97	93	128	117	69	85
3.2.1-understanding meaning and	102	137	104	104	108	119	131	89
interpretation of symbolic	67	43	45	61	32	37	50	55
3.2.2-verbal presentation of understanding 3.2.3-selecting data and application to familiar situations	121	128	126	121	127	120	134	107
3.3 Application of knowledge to new/novel problem situations		9	8	11	4		16	54
3.4 Analysis								
3.5 Synthesis			8					
3.6 Evaluation			12			7		10

4.2.4 Critical Outcomes Curriculum 2005-for all learning areas:

Outcome	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
4.1 Problem solving using critical and creative thinking								
4.2 Team group work								
4.3 Manage themselves/activities								
4.4 Collect/analyse/organise/ evaluate information								
4.5 Communicate using visual/language skills	35	36	47	54	27	40	50	55
4.6 Use science/technology effectively and responsibly with regard to environment		3			5		24	34
4.7 Demonstrate understanding of interconnectedness of all problem solving situations.								

4.2.5 Specific outcomes for Natural Sciences:

Outcome	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
5.1 Process skills-lab skills								
5.2 Demonstration of understanding of concepts and principles in acquired knowledge	152	181	145	153	150	163	173	159
5.3 Innovative use of knowledge and skill in problem solving						-		
5.4 Awareness of knowledge related to management of natural resources			4		5		29	
5.5 Use of scientific knowledge in responsible decision making								4
5.6 Relationship between science and culture								
5.7 Knowledge of changes in past and possible future changes of scientific knowledge								
5.8 Awareness of ethical bias and iniquities as related to science								
5.9 Knowledge of interaction of sciences and its importance for economic development		3						

The same procedure was then followed for the SG papers the results of which are reflected in Table 4.3 below.

Table 4.3

Results of the Analysis of the Senior Certificate examination-SG

4.3.1 Physics:

Mark allocation per learning area. (Multiple choice plus others)

Content	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
1.1 Vectors	24	18	6	20	26		11	25
1.2 Motion	23	21	20	18	15	34	15	18
1.3 Gases	23	18	8	20				
1.4 Newton	14	16	45	17	15	30	30	10
1.5 Momentum	12	6	10	13	15	15	15	15
1.6 Energy	17	19	11	16	19	15	15	28
1.7 E-fields	17	17	6	20	19	15	19	21
1.8 Electricity	20	35	44	26	41	41	45	33

4.3.2 Chemistry:

Mark allocation per learning area. (Multiple choice plus others)

Content	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
2.1 Bonding			8	2	8	4	8	8
2.2 Solutions	3	3	7	15		4		4
2.3 Sulphur	25	23	10	19	14	8	28	6
2.4 Nitrogen	11	13	11	16	11	13		12
2.5 Halogens	15	17	19	16	4	4		7
2.6 Reaction rate	7	3	12	13	12	10		12
2.7 Equilibrium	17	30	17	16	14	12	21	13
2.8 Acid/base	29	23	26	20	31	27	23	21
2.9 Redox reactions	22	18	23	20	18	19	22	21
2.10 Organic chemistry	18	20	17	23	25	22	24	21
1.3 Gases					13	27	24	25

4.3.3 Mark allocation for abilities (as in Blooms Taxonomy):

Category	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
3.1 Knowledge recognition and re call	87	91	90	107	71	96	97	89
3.2.1-understanding meaning and interpretation of symbolic.	105	106	90	87	83	81	63	84
3.2.2-verbal presentation of understanding	26	21	27	24	43	20	21	23
3.2.3-selecting data and application to familiar situations	79	73	80	89	64	58	63	82
3.3 Application of knowledge to new/novel problem situations		5		3	19	39	49	22
3.4 Analysis								
3.5 Synthesis		6	13		6	6	7	
3.6 Evaluation								

4.3.4 Critical Outcomes Curriculum 2005-for all learning areas:

Outcome	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
4.1 Problem solving using critical and creative thinking								
4.2 Team group work								
4.3 Manage themselves/activities								
4.4 Collect/analyse/organise/ evaluate information								
4.5 Communicate using visual/language skills	14	27	30	16	39	4	21	23
4.6 Use science/technology effectively and responsibly with regard to environment		8			15		8	17
4.7 Demonstrate understanding of interconnectedness of all problem solving situations.								

4.3.5 Specific Outcomes for Natural Sciences:

Outcome	GDE 96	GDE 97	GDE 98	GDE 99	IEB 96	IEB 97	IEB 98	IEB 99
5.1 Process skills-lab skills								
5.2 Demonstration of understanding of concepts and principles in acquired knowledge	118	133	108	85	112	96	71	78
5.3 Innovative use of knowledge and skill in problem solving								
5.4 Awareness of knowledge related to management of natural resources		4			15			17
5.5 Use of scientific knowledge in responsible decision making								
5.6 Relationship between science and culture								
5.7 Knowledge of changes in past and possible future changes of scientific knowledge								
5.8 Awareness of ethical bias and iniquities as related to science								
5.9 Knowledge of interaction of sciences and its importance for economic development								

4.4 Discussion on Data Collection.

4.4.1 *Higher Grade (HG) Examination Papers.*

From Table 4.2.1 one can see that the allocation of marks in the GDE examinations was generally concentrated on electricity and Newton's laws. The allocation of marks is relatively consistent from year to year. The 1996 paper showed a deviation from the average mark distribution with a greater percentage of the marks allocated to Newton's laws. The IEB examinations concentrate mostly on electricity with the other marks fairly evenly distributed across vectors, motion, Newton's laws, momentum and electrical fields. Gases are not examined in the physics paper but are included in the chemistry paper. Graphs showing the distribution of the physics marks are presented in Appendix 6.1.

Table 4.2.2 shows that sulphur, equilibrium, acids and bases, redox reactions and organic chemistry seem to carry similar allocations of marks in the GDE and IEB examinations. Gases play a large part in the mark allocation in the IEB chemistry paper but much less in the GDE physics paper. Sulphur is examined more consistently and to a larger proportion than nitrogen and the halogens in the IEB paper. The GDE paper allocates the marks over all three of the inorganic topics in more even mark allocation. In the overall analysis the mark allocation per section is relatively consistent as in the physics paper (Appendix 6.2).

The mark allocation according to Blooms Taxonomy shows a major emphasis on knowledge recall, comprehension and the application of knowledge to problem solving. There is less emphasis on verbal ability to explain scientific ideas and concepts and very little on new/novel problem solving, analysis, synthesis or evaluation (Appendix 6.3).

In referring to Table 4.2.4 it can be seen that the only critical outcome assessed in any significant way is verbal communication of understanding, with only a few papers (only GDE 1997, IEB 1996, 1998 and 1999) showing some testing on knowledge related to the environment. Similarly the only specific outcome assessed with a significant allocation of marks is the demonstration of understanding of the concepts of science. The HG 1998 physics paper of the GDE made some attempt to relate questions to the environment and to applications relating to natural resources. This was evident in a question on aerosol cans which relates the theory of gases to environmental issues.

The IEB has attempted to relate scientific theory to the environment in that the headings used for each question relate to everyday situations, as in the 1998 HG paper. For example, the section on vectors is headed "the hiker" and not "vectors" and "photostat machine" instead of "electric fields". The appropriate questions follow. This is an attempt towards the setting of scientific theory in the everyday and practical mode as proposed by Curriculum 2005. The questions which follow, however, are mostly the standard textbook problem situations with some new challenges such as the question on the printing machine in the 1999 physics paper.

4.4.2 *Standard Grade (SG) Examination Papers.*

Table 4.3.1 shows the mark analysis for the SG Physics papers for the GDE and IEB The allocation of marks over the groups is very similar for both the GDE and IEB papers for the years 1996, 1997 and 1999. The SG paper for GDE in 1998 shows an obvious deviation from the pattern. Newton's laws and electricity dominated in all papers with all other topics having far fewer marks allocated to their assessment. The IEB examination showed a similar pattern in mark allocation through the years except for 97 where vectors were excluded from the paper. The differences in mark allocation are clearly demonstrated by the graphs in Appendix 6.4.

Table 4.3.2 shows the SG chemistry mark allocations for the GDE and IEB. The allocation of marks is fairly consistent over the years, other than a marked variation in the allocation to bonding and solutions from one year to the next. The GDE 1997 paper showed an emphasis on equilibrium. The 1998 IEB paper deviated from the pattern in that sulphur carried all of the inorganic chemistry marks with nitrogen, halogens, reaction rates and solutions not assessed at all. This seems to be an unbalanced paper for the assessment of inorganic chemistry. Equilibrium in this paper was also favoured. The balance of the paper, acids/bases, redox reactions, organic chemistry and gases follows a constant mark allocation pattern (Appendix 6.5).

Table 4.3.3 records the allocation of marks according to Blooms taxonomy for the SG papers. The GDE paper follows a similar mark pattern to the HG paper that is with the maximum marks allocated for knowledge recall, understanding of principles and application to problem solving, with fewer marks allocated to verbal demonstration of knowledge and understanding. Again, very little analysis, synthesis or evaluation is assessed, if at all. The IEB paper shows some assessment of new and novel situations in problem solving over the last three years (Appendix 6.6).

The analysis with regard to outcomes follows a similar pattern to that of the HG papers in that only the critical outcome of communication and specific outcome of understanding of principles is tested in any significant way.

There : little difference between the HG and SG papers other than differences in the mark allocation to different topics. For example there is a difference in the allocation of marks to the GDE, SG paper on electricity from year to year (the HG paper is more consistent). There is also differentiation in difficulty of problem solving, those of

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As discussed in Chapter 2, validity is also an important aspect of the examinations. The objectives of the curriculum, and therefore assessment, thus far have been to enable learners to demonstrate that they have the basic knowledge required to proceed to further study, job application or training. This study has concerned itself with those school leavers entering the job market. The examinations were analysed with regard to their validity in this respect.

The examination tests what knowledge is known by the student at the time. Since the knowledge required by the Engineering sample is tested in the examination the examination has concurrent validity (Stobart and Gipps, 1990; Wiliam, 1998).

The examination does test the knowledge required by the sample of industry taken and has construct validity in terms of knowledge expected by those entering the Engineering field. However the examination does not test any of the skills as outlined in Curriculum 2005, and perceived as important to the Engineering Industry, and therefore does not have construct validity as regards the skills required (Stobart and Gipps, 1990; Wiliam, 1998).

Content (descriptive validity) and curricular validity (Wiliam, 1998; Wood, 1991) of the examinations is debatable since it concerns knowledge and skills as specified in the curriculum for the examination. The curriculum does specify that higher order cognitive skills, such as analysis, synthesis and evaluation should be a part of the learning program. The examination analysis shows that very little if any higher order skills tested, but does test knowledge which is consistent with the curriculum prescribed at present for Grade 11 and 12. Two of the papers analysed were less valid in these two aspects than the others since they concentrated mark allocation to specific areas and were therefore not a comprehensive test of knowledge known. The SG 1998 chemistry paper for the IEB excluded all the inorganic chemistry other than sulphur. The SG 1998 physics paper for the GDE concentrated the mark allocation on Newton's laws and therefore little of the other areas of the curriculum were tested.

With the proposed introduction of Curriculum 2005 in Grades 11 and 12 the current examination will have no content or curricular validity since it assesses, at best, only two or three of the outcomes specified.

Regarding instructional validity, in reality, as things stand in South Africa today the "playing fields" are not level and students are not equally prepared for the examination. Therefore the examination does not have instructional validity for all learners. This threatens the curricular validity discussed above.

Since the examinations can be seen from the analysis to follow a very similar pattern in terms of mark allocation from year to year, teachers will be enticed to teach to the test and, from personal experience, many do. As a result the marks of certain students may well be inflated (backwash validity) (Wiliam, 1998) in our current system. This then jeopardises the predictive validity of the examination which many of the employers perceive the examination to have, as is seen by the feedback from the sample. Intrinsic (Wiliam, 1998) and convergent (Wood, 1991) validities could not be established in this study.

As mentioned in chapter 2 the different validities hold together "as strands in a rope" which determines the strength of the examination in this regard. The current examinations have validity for the knowledge based curriculum at present in Grades 11 and 12 but does not have validity for Curriculum 2005 for future Grades 11 and 12.

4.4.4 *Bias and Equity in the Examinations.*

There is no valid test without consideration of the purpose of the test (Stobart and Gipps, 1997). One of the purposes of the current Senior Certificate examination is to guide school leavers into future career choices. The opportunities available to them are determined to a large degree by the results of the examination. This is seen from the feedback from half of the sample of employers who will screen future employees through their results due to the face validity of the examination. Since the examination is only assessing at best half of what these employers expect (since it tests mostly knowledge), many of the school leavers will be biased by an examination result which does not recognise many of their skills. If employers recognise that the examination does not test skills required by them and therefore use other tests to assess these skills, then the examination has content validity (as discussed above) only for the knowledge required.

The feedback from the sample of the Engineering Industry indicated that employers who do not use the Senior Certificate results for screening of prospective employees have their own "in-house" personality and trainability testing programs. Only one of the companies mentioned the National Qualifications Framework (NQF) as a means for assessment of potential employees and therefore saw the need for alternative assessments for employment practices.

Similarly, for those prospective employees who are screened and accepted on the basis of their success in the Senior Certificate examination, the job situation may require skills which they do not possess as these are not a part of the examination. Many prospective employees may well have the skills required for a job and yet are unsuccessful since their knowledge presented in the examination may be limited for many reasons outside their control. The examination for these individuals unfairly discriminates against them in the job market.

No obvious intentional bias was found in the examination questions themselves. It could be commented upon that boys' names seem to be preferred in the questions and this could be translated as gender bias towards boys. There are few instances where a girl's name is used in the problem wording. Other than this there was no obvious gender or cultural bias and therefore there is equity in this aspect of the testing. There is also still cultural bias to a minor degree in the choice of words such as "bakkie", which although colloquial, could be construed as more easily understood by pupils from a particular social group and therefore as cultural bias.

It has also been argued that written questions favour girls and multiple choice questions favour boys (Wood, 1991). In these examinations since written questions form the bulk of the paper they should favour the girls. As mentioned in the literature review it is difficult to conceive of a test that is not biased and therefore absolutely equitable.

4.5 Chi Square Statistical Results.

The results of the statistical analysis, which was carried out to explore the match-mismatch of the needs of the Engineering Industry and the examinations as regards the examination content is reflected in Table 4.4. The figures in the table reflect the extent to which the responses from industry match the content of the examination. A figure below 0.05 shows that statistically there is a significant mismatch between the needs of industry and the content of the examination.

Table 4.4

Results of Chi Square Statistical Analysis.

Physics		GDE-HG & SG	IEB-HG & SG
	1.1 vectors	0.091	0.091
	1.2 motion	0.157	0.157
	1.3 gases	0.106	0.106
	1.4 Newton	0.306	0.306
	1.5 momentum	0.106	0.106
	1.6 energy	0.176	0.176
	1.7 E-fields	0.091	0.091
	1.8 electricity	0.260	0.260
Chemistry	2.1 bonding	0.007	0.007
	2.2 solutions	0.609	0.609
	2.3 sulphur	0.001	0.020
	2.4 nitrogen	0.011	0.011
	2.5 halogen	0.002	0.002
	2.6 reaction rate	0.004	0.004
	2.7 equilibrium	0.001	0.001
	2.8 acids/base	0.023	0.023
	2.9 redox reacts	0.007	0.007
	2.10 organic chem	0.001	0.001

The table reveals that the content of the physics examinations matches the needs specified by the Engineering Industry. From the table it can be seen that all the topics examined, have a chi square value of higher than 0.05, and therefore does not reflect any significant difference in the comparison. There is also no difference between the GDE and IEB papers in terms of their meeting the needs of industry.

The chemistry paper does reflect a significant difference between the examinations and the needs of industry since all topics have a value of less than 0.05 except for "solutions" which had a Chi Square value of 0.609. This was to be expected in the overall analysis since only nine of the jobs specified on the responses required chemical knowledge. There was no difference between the GDE and IEB in the analysis.

This confirms previous results that the knowledge required by industry is tested, particularly in the physics paper. This adds to the reliability of my research.

It was decided that a statistical analysis of the match-mismatch between the Blooms taxonomy and outcomes versus industry was not necessary due to the obvious differences.

Some discussion will follow on conclusions drawn from the results of the analyses and the feedback from the Engineering Industry and from the comparison between the examinations and the needs of industry.

4.6 Conclusions.

From the analysis of the examinations it is clear that the examination does a valid and reliable job as far as testing knowledge content required by most jobs in the sample of the Engineering Industry studied. However the emphasis from industry on higher order cognitive skills, of analysis, synthesis and evaluation and the practical skills which are specified by Curriculum 2005 is not matched by the examinations. Very little, if any at all, of the papers test higher order cognitive skills or any other skill as specified in Curriculum 2005.

Since the needs of the sample of engineering companies contacted in this research reflect a very positive need for the skills as defined by Curriculum 2005, the results confirm the trend towards skills based learning. If this is to be successful then the assessment procedure must be changed since curriculum is driven by assessment (Stobart and Gipps, 1997). For the many reasons already discussed, if the learning program is changed but the assessment is not, teachers will continue to teach to the test and the required skills will not be explored and developed in the classroom. The present knowledge based learning in Grades 11 and 12 will continue.

The data collected from this small sample from the Engineering industry suggests that there is sufficient emphasis on the need for the skills as specified for curriculum 2005 to be part of the learning process together with knowledge learned. It therefore follows that any summative testing at the end of Grade 12 must test and reflect the knowledge learned and also skills acquired.

Further discussion regarding possible new assessment procedures which would produce reliable and valid assessment which would serve the needs of the Engineering Industry and perhaps all industry (which would need to be established with surveys on a greater number of employees and industries) will be discussed in Chapter 5.

Chapter 5

Conclusions and discussion based on research data

5.1 Introduction.

The purpose of this study was to see if there is a mismatch between the needs of Industry and the Senior Certificate science examination, and if so, to address the mismatch. The data, collected from the analysis carried out on the Senior Certificate science examinations from 1996 to 1999, and the questionnaire returned by the sample of companies from the Engineering sector, were reported in the preceding chapter.

This data shows that there is an overall mismatch. There is a match between the knowledge tested in the examinations and the needs of the Engineering Industry but a mismatch between the skills and values which are not tested and are needed by the industry.

This chapter will draw on these results in order to address the mismatch and to suggest future assessme strategies. These may result in better service to Industry with a valid and reliable employment tool, as well as to school leavers by providing a valid and reliable examination result for them. A more balanced assessment might give a "fair" chance of opportunity in the job market to all school leavers. Finally my conclusions and recommendations will contribute to discussion on appropriate assessment for Curriculum 2005.

5.2 Interpretation of the Results.

The questions formulated in Chapter 1, i.e. to explore the match-mismatch of the examinations and the needs of Industry, will be used to interpret the results reported.

1. What are the skills, knowledge and values which the current Senior Certificate examination is testing?

From the results of the analysis of the examinations of the Higher Grade (HG) and the Standard Grade (SG) examinations, in the Gauteng Department of Education (GDE) and the Independent Examinations Board (IEB), it can be seen that the examinations follow a similar pattern over the years with minor variation.

At present the GDE and IEB examinations both test mostly knowledge recall, understanding with some problem solving based on the prescribed curriculum content for Grades 11 and 12 in Gauteng. The examinations have validity and reliability, as discussed in Chapter 4, for the knowledge tested as specified by the requirements of the current Curriculum for the Senior Certificate examination.

The analysis showed little assessment of higher order cognitive skills, as defined by Blooms Taxonomy, and as prescribed as outcomes for Curriculum 2005. Therefore from a skills and values perspective the examination has no construct validity.

The relevance of science with regard to the environment, industry and the economy is absent, or make up a very small component of the examination.

2. Are the skills, values and knowledge which are assessed in the examination reflective of the needs of employers with reference to the job opportunities available to school leavers at present, and is the Senior Certificate therefore a valuable tool for employers?

From the previous discussions in Chapter 4 it is clear that there is no significant difference between what is tested and what is needed by industry (Appendix 8) from a scientific knowledge point of view. Therefore, for the Engineering Industry the examinations have content validity (Stobart and Gipps, 1990, Wiliam, 1998), and the needs of industry for their prospective employees regarding knowledge and understanding of scientific principles are met by the Senior Certificate examination.

However, from feedback from the Engineering industry, all the outcomes as listed by Curriculum 2005 were considered of importance by all the companies for almost all job specifications. There is no match between the skills and values needed by industry for the jobs available to school leavers and the testing in the examinations.

The data collected from the sample of the Engineering industry shows that the Senior Certificate may well be considered as a valuable tool for employment, i.e. that it has face validity, by some employers (about 50% as shown by the data collected). In reality the examination is testing less than half of what employers require in the work place today from school leavers, with science as a subject, looking for jobs in the Engineering sector of industry.

The decision to be made on future success is, for many employers surveyed, who use the Senior Certificate examination results as criteria for employment practices, made on the examination results. Many schools will continue to "teach to the test" since critical decisions are made based on these examination results and since the examinations are seen to be are very similar from year to year. As discussed in Chapters 2 and 4, students who have been "coached to the test" have inflated marks and therefore the predictive validity of the examinations will be jeopardised. Those school leavers for whom the results reflect memory recall will be "privileged". The face validity, which certain companies ascribe to the Senior Certificate, is therefore invalid.

The Senior Certificate does not test any of the skills which are needed in the work place as reported in Chapter 4. These skills may be inherent in a school leaver for whom, as result of inferior schooling, the examination has no instructional validity (Wood,1991) and who is as a consequence denied opportunities.

Those companies from the Engineering Industry sample, who do not use the examination as an assessment tool, may recognise that the examination does not have predictive validity since no skills and values are tested. They therefore use other in-house testing which they feel better assesses the potential of a school leaver as reported in Chapter 4. For these companies, the examination does not have predictive validity nor face validity as discussed in the previous chapter.

The Senior Certificate based on the research data is not a valuable tool for employment practices although it is perceived by at least 50% of the sample to be so.

3. Does the current examination meet any of the requirements of Curriculum 2005 as an assessment tool?

The current senior certificate examination is a summative evaluation in the form of a norm referenced test. The examinations were found to test almost exclusively knowledge, the application thereof in familiar problem solving situations and some verbal ability in explanation of knowledge learned. The test contained very little high order cognitive skills nor application of knowledge to the environment, economy or importance of the sciences for everyday experiences.

Curriculum 2005 is an attempt to address the inequalities of the past and to provide learning programs which will provide equal access to opportunity for all school leavers. To do this, critical and specific outcomes have been described for learning and more specifically for this study to the "natural sciences" (Government Gazette, 1997).

These outcomes are directed towards knowledge, skills and values needed by all people, in order to take their place as worthwhile members of society. Skinner (1999, p.127) has expressed the view that

"people need to be trained to think, to solve problems, to compete, to innovate in order to attain the necessary commercial advantage on the world stage- or, as seems more likely to make a living for themselves outside of the formal economy."

Based on the data returned by the sample of the Engineering Industry there is sufficient evidence that the learning outcomes of Curriculum 2005 are valued by employers. However content cannot be ignored. The response from the sample was that content as prescribed by the current curriculum is as important as the skills and values. Mahomed (1999) has stressed that content is always important and content cannot be sacrificed for skills.

Kraak (1999, p.49) has stated that "specific learner content will not be prescribed in a national curriculum framework". If this is the case in Grades 11 and 12, any knowledge based examination on a national or provincial level will not be possible since there will be no uniformity in knowledge taught in the classrooms. Any assessment would have to be independent and teacher based. If the current proposed Curriculum 2005 is introduced until the end of Grades 11 and 12 the current assessment examinations as discussed in this paper will have no value. The value, which the current assessment has for industry in terms of testing knowledge acquired, will be lost. It would then be a change from one inadequate assessment process to another equally inadequate.

With these arguments in mind recommendations for future assessments, which will meet the needs of Curriculum 2005 and industry will now be discussed.

5.3 Conclusions and Recommendations.

Malcolm (1999, p.107) has stated that it is not so much a case of "envisaging change" since change is essential "but of defining and managing it". As a result of this study it is evident that it is not so much a debate as to whether a change in curriculum should take place but rather what a new curriculum should look like. The results of my research show that Curriculum 2005 goes a long way towards better meeting the needs of industry. The current school leaving Senior Certificate examination does not meet the requirements of Curriculum 2005 nor the Engineering Industry. New assessment practices must be introduced to ensure the success of Curriculum 2005, since curriculum is driven by assessment as discussed in the literature review.

Aside from the demands of Curriculum 2005, to reduce the ability in science to a single score, as is done now, is to do a disservice to the field of science and to the learning of science. A single norm referenced examination as in the current system, which does not include any practical experience nor skills as outlined in Curriculum 2005 in the natural sciences, is not a valid assessment of scientific competence. Some kind of practical experience to demonstrate learned skills (criterion referenced assessment) must be included.

Furthermore, if the summative assessment at the end of Grade 12 is to serve as a tool of selection for those entering the job market and those continuing into tertiary institutions, it must from both perspectives include knowledge content in its assessment.

A summative assessment in science at the end of Grade 12 must be made in order for the learner, prospective employers and tertiary institutions to make choices against certain criteria. Given the arguments in Chapter 4 and the beginning of this chapter, both knowledge and outcomes (as skills and values) must be included in the curriculum. All of these aspects must therefore be tested in any new assessments proposed.

This summative assessment should include a combination of the norm referenced, valid and reliable testing of the knowledge and understanding of scientific principles as in the present examination, and criterion referenced assessment of skills and values as outlined by Curriculum 2005.

In light of the above discussion, a more appropriate and effective system of examinations must be found for school leavers in South Africa today. The elements of criterion referenced continuous assessment as proposed for Curriculum 2005 will play an important role in the effective assessment of scientific competence, providing the aspects of knowledge and basic principles of science are not ignored. Certain recommendations will now be discussed.

Recommendation 1

A summative assessment should continue to be made at the end of Grade 12. The summative assessment should consist of two components: a formal examination on specified scientific content; and a practical component, involving continuous assessment through Grades 11 and 12 (a route which I believe the IEB hope to take beginning year 2000).

The formal examination should be a norm referenced reliable and valid assessment of the knowledge gained, in a similar format to the current examination. Examiners should be cautioned not to follow a similar format of mark allocation to topics from year to year since this encourages "teaching to the test" as discussed in the first part of this chapter and jeopardises predictive validity.

In order to free up the time necessary for the teachers to carry out practical work, with continuous criterion referenced assessment, the content to be examined should be reduced. The examination could then be reduced to one 3 hour paper (chemistry and physics) instead of the current two 3 hour papers (one each of physics and chemistry).

The choice of the content to be examined from the perspective of knowledge recall and understanding would need to be decided upon. From the current study the current curriculum content considered to be most important by the Engineering Industry in physics could be reduced to Newtons laws, electricity, energy and motion. Similarly the specified content for chemistry could be reduced to solutions, acids and bases and bonding. However other stakeholders in the final assessment procedure (tertiary institutions and other sectors of industry employing school leavers) would need to be consulted before the prescribed content is decided upon. [1]

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1. The curriculum content could be specified for all of the content. Teachers could be responsible for the choice of half of the topics to be studied for examinations. The other half is "learned" through practical tasks and continuously assessed by the teachers. Examinations would be set to give a choice to the learner for each topic depending upon which they felt more confident. Teachers would then be able to teach those topics in which they felt most confident for the formal summative examination.

The results of this formal assessment would be recorded as a mark which is norm referenced against the population of South Africa, as is currently the practice, which ensures a certain "fairness" as discussed in the literature review.

The second part of the school leaving assessment would be the practical demonstration of competence in skills and values. These would be assessed by continuous, criterion referenced assessment by teachers in the classrooms.

Deacon and Parker (1999, p.65) have expressed the opinion that statements listing outcomes have no meaning unless linked to "assessment and their practice in specific contexts". The practice of these outcomes must therefore be linked to specified curriculum content for the sciences (specifically chemistry and physics) within the curriculum for the natural sciences. Once the content to be tested in the formal examinations is specified, the remaining topics could be assessed in practical assignments, discussion and practical tasks in the classroom. All the topics currently prescribed for the Senior Certificate examination should be included in the curriculum since all have value for industry as is demonstrated by the data collected and discussed in Chapter 4.

The continuous assessment of learning outcomes related to the content prescribed would take place through Grades 11 and 12. Skills (as outcomes) could be measurable in practical class tasks and discussion, according to criteria such as poor, accomplished and excellent, or through mark allocation. Further studies would need to take place with the schools and examining bodies to develop criteria with which to assess skills. The continuous, criterion referenced assessment would then be moderated by the examining boards. These would accompany, or be combined with, the mark assessment of the examinations.

The advantage of an assessment of the kind proposed above is that it would meet the needs of industry as a tool for selection with greater predictive validity than the examination mark alone. It would also be "fairer" to learners.

A further advantage would be the reduction of the examination to one instead of two formal examinations. The cost, and the efforts involved in the management of the process, would be reduced by half. This would go some way to balance the enormous costs of further training and moderation of teachers. This would also free up many of the experts in assessment, currently involved in the process of managing the examinations, to be available for support and moderation in the schools.

Recommendation 2

The above recommendation places a high premium on teacher effectiveness. The implementation of recommendation 1 demands a teaching force which is both trained and resourceful. The processes outlined above would therefore be difficult given the poorly trained and under resourced schools which exist in South Africa today in many areas.

Given the determination of the government to balance out the inequalities of the past and the feedback form the sample of the Engineering Industry in this research, changes must be made.

The lack of resources and training must be addressed and a new curriculum and method of assessment introduced if the needs of our economy and learners are to be met. A change in assessment, which would drive the change in curriculum, provides teachers and the authorities a chance to improve all our learning in schools. It also enables teachers to "learn as much as they teach" (Deacon and Parker, 1999, p.62). Through the training of teachers for criterion referenced assessment, they would be further empowered and become more competent as teachers. This is a means of addressing the inequalities which exist in our schools. Many training programs have been instituted and will pay dividends in the future. Much support and information on Curriculum 2005) is available through the media, for example, the Sunday Times (January 30, 2000), educational magazines (The Teacher), the Internet and many new reference books. However specific training and much support in assessment is required.

A specific curriculum outline must be developed to guide learning content for Grades 11 and 12. This would provide a guideline against which the schools would be monitored regularly each year through the moderation of the internal assessments. This could take place through one-day seminars where the criterion referenced testing skills are discussed, suggestions and support provided for the Grade 11 and 12 teachers. This would also assist in answering the criticism from teachers regarding the lack of explanation and clarity on the Curriculum 2005 and outcomes based learning and assessment.

These programs could be instituted and should be ready for the current Grade 7 learners, who will be introduced to Curriculum 2005 this year, and who will reach grade 11 in 2004. The first comprehensive "summative" assessment could accompany grade 12 school leavers in 2005.

The introduction of an assessment of this nature would enable a slow introduction to the new assessment methods since only half of the assessment would be a new process. Thus society and teachers would be reassured that not all of the "old" curriculum and assessment techniques are to be disregarded since they do have merit as already discussed.

The lack of reliability in criterion referenced assessment due to bias or inexperience in assessment (Watson,1998) would be balanced by the validity produced by continuous assessment of the practical skills needed to give the assessment content, curricular, and predictive validity (as discussed in chapter 4) for Curriculum 2005. The value of the norm referenced examinations in terms of its reliability and validity for scientific knowledge and understanding of prescribed content, as discussed in the last chapter, would be retained. In this way we would not be "throwing out the baby with the bath water".

It is a question then of slow change and training of our teaching body which is essential in any event if the future of our education system is to maintain global standards.

5.4 Final Concluding Comments.

This research shows that the change to a system as outlined in Curriculum 2005 will meet many of the needs of the Engineering Industry, which are not met by the current Senior Certificate examination, and therefore by the curriculum which accompanies it. However without further definite prescription of knowledge content as well as the outcomes, education will not serve the needs of the Engineering Industry, and will struggle to maintain any national standards. Market related demands must be met in South Africa today, and hence the voice of industry must be heard, as discussed in the introduction to the literature review.

A summative assessment, which has recognised standards against which school leavers and our educational system can be judged, must continue. Continuous, criterion referenced assessment done by the teachers, is not sufficient given the difficulties with reliability (Harlen, 1994;Watson, 1998).

If the current outcomes proposed are not included in assessment in some recognised, recorded and formal way (as suggested above) the learning programs in the schools will remain results-bound based on a formal examination, and therefore knowledge bound. The current Senior Certificate examination will then remain as it is today, a stepping stone serving the needs of those continuing into academic training in tertiary institutions, a very small percentage of our society.

Any future assessment, which will inevitably drive learning programs, needs to take cognisance of the fact that there is universal evidence that increasing education levels lead to economic and social benefits to society (Mahomed, 1999). The effort and finance which we devote to education, can only enhance our fledgling democratic society in future years.

The crucial issue of the "role of the educator as designer, manager and teacher" (Harley and Parker 1999, p.198) must be addressed. In doing so they have acknowledged that it is a daunting task " to transform the identities and roles of teachers" with massive and radical retraining of competencies, values and practices (ibid, p.198). It is yet only a small part of the massive restructuring and re education of all our peoples after the Apartheid years and should be a part of bold moves forward.

It is only in this way that we will avoid the feelings of many of our school leavers expressed in these lines in an anonymous poem "You Taught Me"

Yes, you taught me many facts
-thank you, I am quite clever now-
but
Why is it that I feel I know
nothing?
Why do I feel I have to leave
School to go and learn about coping
with life

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Appendix 1
Industry Questionnaire- Investigation of the Science Senior Certificate Examination.

Section A – Company profile

1.Name of Company:
2.Contact name:
3.Physical address:
4.Postal address:
5.Phone: Fax: Email:
6. Staff profile: 6.1.Total Staff employed............. 6.2.Number of employees with matriculation certificate and NO further tertiary education........... 6.3.Number of employees with science as a matriculation subject and NO further tertiary education .....
7. School leaver profile: 7.1. How many school leavers are employed at the beginning of each year?............................ 7.2. How many of these have science as a subject?........ 7.3. How many male school leavers are employed each year?.......... 7.4. How many female school leavers are employed each year?........

Section B - Needs assessment of examination content

Instructions for completion of Table 1 below- Physics examination content.
and Table 2 below- Chemistry examination content.

1. In the first column list the job profile/s or job opportunities which are available in your company for science matriculants.
2. Against each job definition place a cross against the knowledge content/s, listed at the head of the matrix, which is applicable to that job situation.
3. A description of each content area for you reference is listed at the end of the tables on page 4.

Table 1.1.

Job description	**Vector**	**Motion**	**Gases**	**Mechanics**	**Momen-tum**	**Energy**	**Electro-Statics**	**Elec-tricity**

Table 1.2. Please list any **physics** knowledge content not listed above which would be useful in job situations:

Job description	**Physics content (not included in the above table) -useful in job specified.**

Table 2.1.

Job descrip-Tion	Atomic Bond-ing	Phases Of Matter	Sulphur	Ni[illegible]-gen	Halog-ens	Reaction Rates	Equilib	Acid-Base	Redox Reaction	Organic chem

Table 2.2 Please list any **Chemistry** knowledge/content not listed above which would be useful in job situations:

Job description	Content (not included in the above table) –useful in job specified.

Section C - Needs assessment of Intellectual Skills

Please complete Tables, 3.1, 3.2 and 3.3 below as in Section B

A description of the criteria to be rated is listed at the end of the tables on page 6.Table 3.1

Job Description	Know-ledge	Comprehension Known	New/novel	Verbal Explan.	Analysis	Synthesis	Evaluation

Table 3.2

Job description	Problem Solving	Team work	Individual Manage-ment	Organise info	Communi cation	Environm ental/inter act.	Interconn ectedness

Table 3.3.

Job description	Lab Skill	Culture /science	Knowledge/ changes	Ethics	Econ omics	Creati vity	Honesty	Punct uality	Compu ters

Table 3.4 Please list any skills/ knowledge/values not listed above which would be useful in job situations:

Job description	**Skills/knowledge/values (not included in the above table) –useful in job specified.**

7. Please comment on any issue not covered in this questionnaire which you feel is relevant to the present/future planning of examinations as an assessment tool for employment practices:

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8. Any further comments which you would care to make :

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....

THANK YOU!

…….For your precious time

…….For your part in what I hope will be a meaningful investigation of current needs of Industry for school leavers and their assessment.

Information note on the criteria headings used for evaluation in the tables.

1. Descriptions of physics and chemistry content areas:

Table 1.1 **-Physics:**

Vector: Speed and Velocity as vectors e.g. solving problems by construction and by calculation, e.g. Forces are acting at a point, calculate by construction and by calculation the resultant and equilibrant.

Motion: speed, velocity, acceleration. $V = \frac{\Delta s}{\Delta t}$ $A = \frac{\Delta s}{\Delta t}$

Gases: pressure, volume, behaviour of gases.

Mechanics: Newtons Laws of Gravitation and Motion and their formulae e.g. $F=ma$ $F\Delta t=mv-mu$ $E=mgh$

Momentum: Momentum=massxvelocity e.g. The momentum (e.g. of a truck hitting a wall or another vehicle) = its mass x velocity at which it is travelling.

Energy: Potential energy and Kinetic energy-energy of bodies at rest and energy in movement. $E=mgh$ $E = \frac{1}{2}mv$

Electrostatics: e.g. Electric fields, electromagnetic waves, radio waves, light waves etc. $E=\frac{F}{Q}=\frac{V}{d}$

Electricity: e.g. Current, Ohms Law, Resistance, Heating, Work.

$R=\frac{V}{I}$ $Q=It$ and $P=VI$

Table 2.1**-Chemistry:**

Atomic bonding: Knowledge of atomic and molecular structure of the elements and compounds.

Phases of Matter: Liquids, solids, and solutions

Sulphur: sulphates, industrial preparation of sulphuric acid.

Nitrogen: nitrates, Haber process-industrial preparation of ammonia

Halogens: chlorine, fluorine, bromine, iodine.

Reaction rates: Speed of reactions and factors determining rate of reaction.

Equilib: Equilibrium reactions, and means of shifting eqilibrium.

Acids and Bases: e.g. Acid- Base reactions.

Redox reac: Oxidation and Reduction reactions reactions.

Organics: (chemistry), the reactions of carbon compounds and their use in industry, e.g. soap and perfume manufacture etc.

2. Description of the table headings for Intellectual skills:

<u>**Table 3.1**</u>
Knowledge: refers to the recognition of knowledge learned in school and the recall thereof.
Comprehension:1. Known- comprehension of knowledge learned and the use thereof in familiar problem solving situations
2. New/ Novel-comprehension of knowledge learned and the use thereof in new/ novel problem situations.
3. Verbal explan.-verbal expression and description of problems and their solutions.
Analysis: the ability to recognise the parts of a problem.
Synthesis: the ability to construct a whole picture from parts of a situation.
Evaluation: the ability to make judgements and draw conclusions from results of experiments or data given.

<u>**Table 3.2**</u>
Problem solving: Identify and solve problems and make decisions using critical and creative thinking.
Team work: Work effectively with others as members of a team, group, organisation and community.
Individual management: Organise and manage themselves and their activities responsibly and effectively.
Organise info: Collect analyse, organise and critically evaluate information.
Communication: Communicate effectively using visual, symbolic (formulae etc.) and/or language skills in various modes.
Environmental/ inter act: Use science and technology effectively and critically showing responsibility towards the environment and health of others.
Interconnectedness: Demonstrate an understanding of the world as a set of related systems by recognis[illegible]g that problem solving contexts do not exist in isolation.

<u>**Table 3.3**</u>
Lab skill: Use processes such as laboratory equipment to carry out scientific investigations.
Culture/science: To have an understanding of the relationship of science to culture.
Knowledge/changes: Awareness of past , present and potential future changes in scientific knowledge, i.e. an awareness of the historical in the sciences.
Ethics: To have an understanding of ethical issues, bias and inequalities in the sciences.
Economics: To [illegible] nding of the relationship of science to the economy.
Creativity: [illegible] awing.
Honesty: Selt [illegible]
Punctuality:
Computers: Basic [illegible] er literacy.

Appendix 2

Tool for initial allocation of marks

Examination paper:...

Table for addition of marks for sections 3,4 and 5.

Questions: Mark Allocation: Tot

Topic																				
Vectors																				
Motion																				
Gases																				
Newton																				
Momentum																				
Energy																				
e-fields																				
Electricity																				
Bonding																				
Solutions																				
Sulphur																				
Nitrogen																				
Halogens																				
Reaction rate																				
Eqilibrium																				
Acid/base																				
Redox reactions																				
Organic chem																				

Appendix 3

Tool for exam analysis- Exam...

1 Mark allocation for abilities (as in Blooms Taxonomy):

Category	Marks	Tot
3.1 Knowledge recognition and re call.		
3.2 Comprehension- 3.2.1- understanding the meaning of symbols and equations/facts		
3.2.2 –verbal presentation of understanding of knowledge		
3.2.3 –selecting data computations, problem solving in familiar situations		
3.3 Application of knowledge to new/novel problem situations		
3.4 Analysis-ability to recognise parts as a whole		
3.5 Synthesis-to produce a solution from parts of information		
3.6 Evaluation-making value judgements and decisions based on results		

2. Critical Outcomes which form the backdrop to Curriculum 2005-for all learning areas

Outcome	Marks	Tot
4.1 Problem solving using critical and creative thinking/decision making		
4.2 Team group work		
4.3 Manage themselves/activities		
4.4 Collect/analyse/organise/ evaluate information, a process.		
4.5 Communicate using visual/language skills, ie verbal explanation.		
4.6 Use science/technology with regard to environment		
4.7 Demonstrate understanding of interconnectedness of all problem solving situations.		

3. Specific outcomes for natural sciences

Outcome	Marks	Tot
5.1.Evidence of Independent investigation- process skills		
5.2.Demonstration of understanding of principles of nat. sciences.		
5.3.Identification of problems and use innovative thought in problem solving.		
5.4. Awareness of knowledge related to social, economic and political issues		
5.5.Decision making skills using data given.		
5.6. Relationship between science and culture.		
5.7. Knowledge of changes in past and possible future changes of scientific knowledge.		
5.8.Awareness of ethical bias and iniquities		
5.9. Knowledge of interaction of sciences and its importance for economic development.		

4. Comment on any bias in questions:

Cultural bias in the questions
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

Appendix 4

Description of Categories of Analysis-Blooms taxonomy

Code. Description.

3.1 Knowledge recognition and recall- any question which was direct memory repetition of learned fact and any question which involved the direct transference of knowledge learned to the answer was allocated to 3.1.

3.2.1 Comprehension of symbols/equations/facts- this was interpreted as questions involving simple calculations, the recall of equations, interpretation of symbols, diagrams or graphs etc.

3.2.2 Verbal presentation of understanding- all questions, which required language skills, to explain knowledge acquisition and application.

3.2.3 Selecting data, problem solving in familiar problem format-this refers to all questions which were familiar typical "text book" encountered problems solved by calculation.

3.3 Application of knowledge to new/novel problem situations-these were interpreted in this analysis to be those questions which were not encountered in the general use text books. Questions allocated here were those, which applied to novel situations encountered in the environment, and those, which used the scientific theory to be applied to everyday situations. The student would have to use individual "new" thought in applying learned knowledge.

3.4 Analysis-ability to recognise parts of information as a whole to break it down into its parts and recognise relationships between parts of learned knowledge.

3.5 Synthesis- the ability to piece together, through organised thought, information, in order to produce a meaningful result.

3.6 Evaluation- pupil is expected to judge experimental results or data calculated, in order to make a valid judgement.

Page

120

Missing

4.6 Use science technology with regard to the environment-this required questions, which related to scientific theory as applicable to aspects of our environment and include aspects of every day life such as printers, toasters etc

4.7 Understanding of the connectedness of all problem situations- since the questions typically asked in the examinations relate only to the theory of science there was no evidenc of this outcome being tested.

B. Specific Outcomes for the Natural Sciences.

Code. Description.

5.4 Evidence of independent investigation-this is a project component of experimental work and research and hence cannot be examined in a test situation.

5.5 Demonstration of understanding of the principles of natural sciences-this relates to all questions which required more than just a recall of knowledge. Questions requiring the application of the principles of theory of science were placed here, whether in multiple choice or verbal explanation.

5.6 Apply scientific knowledge in problem solving in innovative ways-innovative implies new thought and individual solutions to problem solving.

5.7 Awareness of knowledge related to social/economic/political issues-this would include management of natural resources such as water and it role in power supply. Little evidence of this outcome was found. Very few questions related to these issues.

5.8 Decision making skills using data given-refers to decisions taken based on data calculated or experimental evidence given

5.9 Relationship between science and culture-if taken to mean the relationship between science and the culture which supports scientific endeavour then there was no evidence of this in the examinations.

5.10 Knowledge of changes in the past and possibilities in the future- would relate to questions involving a historical understanding of the progress of science and the possibilities oft e future. No evidence was found of this in any of the examination papers studied.

5.11 Awareness of ethical bias and iniquities- the science curriculum precludes any such questions since by its nature science is a process which develops from proven experimentation and derivation. It would therefore preclude any iniquities. It certainly does not form part of the curriculum as it stands today and was therefore not found to be part of the examinations.

5.12 Knowledge of interaction of science and its importance in economic development-questions allocate here would involve the importance of any scientific theory in the management of economic processes.

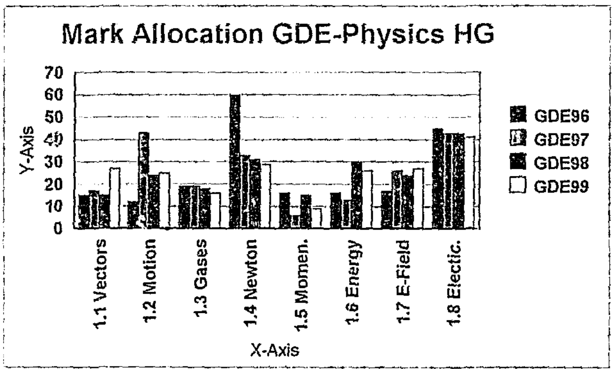
The specific outcomes 5.2, 5.3, 5.4 and 5.5 are very similar to 3.2.1 (Blooms taxonomy), 4.1, 4.6 (critical outcomes). For this reason they were not included as separate codes in the questionnaire for industry in order that the questionnaire was kept as short and concise as possible to ensure the maximum number of responses.

Appendix 6

Mark Allocations and Analysis

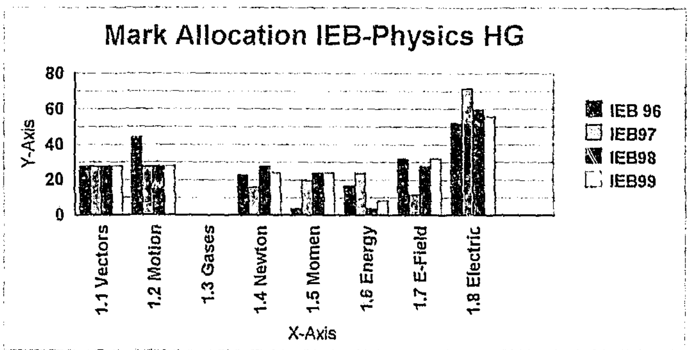
Mark Allocation GDE-Physics HG

	GDE96	GDE97	GDE98	GDE99
1.1 Vectors	15	17	15	27
1.2 Motion	12	43	24	25
1.3 Gases	19	19	18	16
1.4 Newton	60	33	31	29
1.5 Momen.	16	6	15	9
1.6 Energy	16	13	30	26
1.7 E-Field	17	26	24	27
1.8 Electic.	45	43	43	41



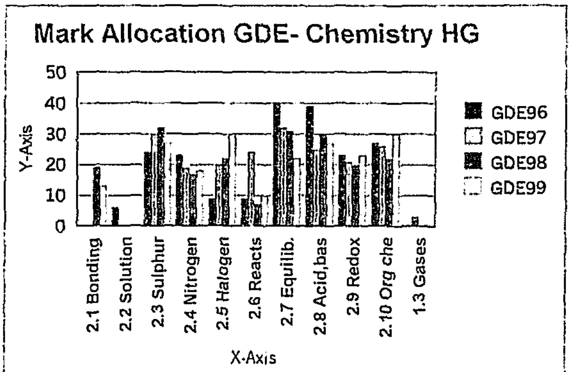
Mark Allocation IEB-Physics HG

	IEB 96	IEB97	IEB98	IEB99
1.1 Vectors	28	28	28	28
1.2 Motion	44	28	28	28
1.3 Gases				
1.4 Newton	23	16	28	24
1.5 Momen	4	20	24	24
1.6 Energy	17	24	4	8
1.7 E-Field	32	12	28	32
1.8 Electric	52	72	60	56



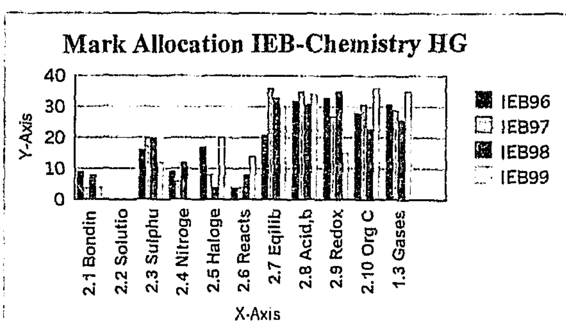
Mark Allocation GDE- Chemistry HG

	GDE96	GDE97	GDE98	GDE99
2.1 Bonding			19	13
2.2 Solution	6			
2.3 Sulphur	24	30	32	27
2.4 Nitrogen	23	19	17	18
2.5 Halogen	9	20	22	30
2.6 Reacts	9	24	7	10
2.7 Equilib.	40	32	31	22
2.8 Acid,base	39	25	30	27
2.9 Redox	23	21	20	23
2.10 Org chem	27	26	22	30
1.3 Gases		3		



Mark Allocation IEB-Chenistry HG

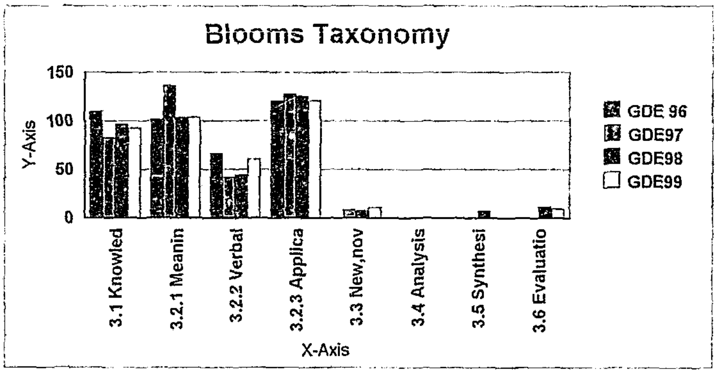
	IEB96	IEB97	IEB98	IEB99
2.1 Bonding	9	4	8	4
2.2 Solution				
2.3 Sulphur	16	20	20	12
2.4 Nitrogen	9	6	12	
2.5 Halogen	17	8	4	20
2.6 Reacts	4	4	8	14
2.7 Eqilib	21	36	33	30
2.8 Acid,base	32	35	31	34
2.9 Redox	33	27	35	15
2.10 Org Chem	28	31	23	36
1.3 Gases	31	29	26	35



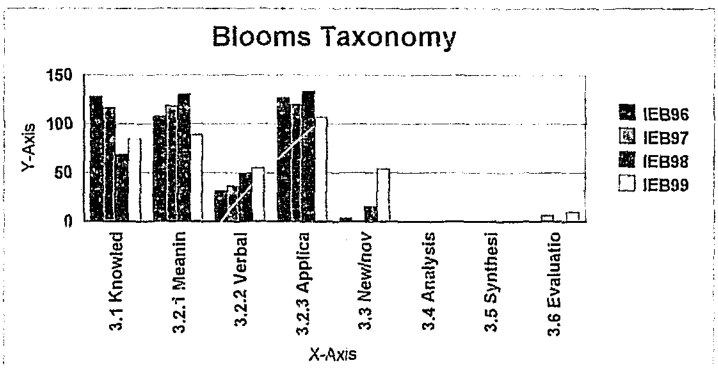
HG

Mark Allocation According to Blooms taxonomy

	GDE 96	GDE97	GDE98	GDE99
3.1 Knowledge	110	83	97	93
3.2.1 Meaning	102	137	104	104
3.2.2 Verbal	67	43	45	61
3.2.3 Applicat	121	128	126	121
3.3 New,novel		9	8	11
3.4 Analysis				
3.5 Synthesis			8	
3.6 Evaluation			12	10

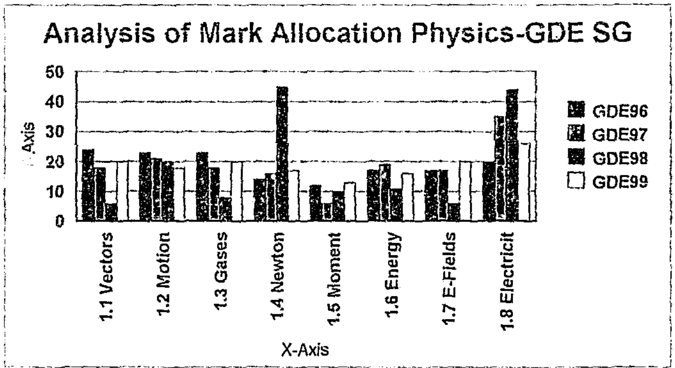


	IEB96	IEB97	IEB98	IEB99
3.1 Knowledge	128	117	69	85
3.2.1 Meaning	108	119	131	89
3.2.2 Verbal	32	37	50	55
3.2.3 Application	127	120	134	107
3.3 New/novel	4		16	54
3.4 Analysis				
3.5 Synthesis				
3.6 Evaluation		7		10



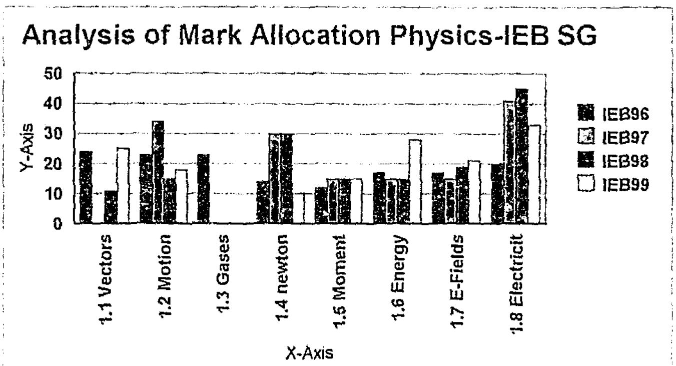
Analysis of Mark Allocation Physics-GDE SG

	GDE96	GDE97	GDE98	GDE99
1.1 Vectors	24	18	6	20
1.2 Motion	23	21	20	18
1.3 Gases	23	18	8	20
1.4 Newton	14	16	45	17
1.5 Momentum	12	6	10	13
1.6 Energy	17	19	11	16
1.7 E-Fields	17	17	6	20
1.8 Electricity	20	35	44	26



Analysis of Mark Allocation Physics-IEB SG

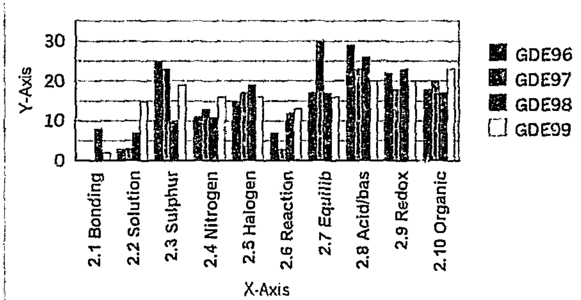
	IEB96	IEB97	IEB98	IEB99
1.1 Vectors	24		11	25
1.2 Motion	23	34	15	18
1.3 Gases	23			
1.4 newton	14	30	30	10
1.5 Momentum	12	15	15	15
1.6 Energy	17	15	15	28
1.7 E-Fields	17	15	19	21
1.8 Electricity	20	41	45	33



Analysis of Mark Allocation Chemistry-GDE SG

	GDE96	GDE97	GDE98	GDE99
2.1 Bonding			8	2
2.2 Solution	3	3	7	15
2.3 Sulphur	25	23	10	19
2.4 Nitrogen	11	13	11	16
2.5 Halogen	15	17	19	16
2.6 Reaction	7	3	12	13
2.7 *Equilib*	17	30	17	16
2.8 Acid/base	29	23	26	20
2.9 Redox	22	18	23	20
2.10 Organic	18	20	17	23

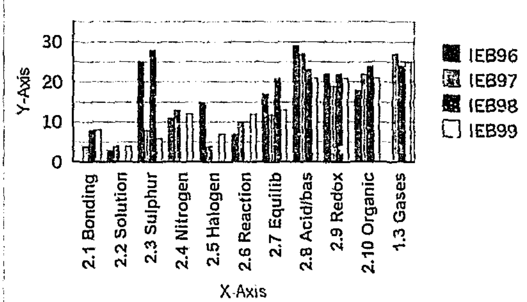
Analysis of Mark Allocation Chemistry-GDE SG



Analysis of mark Allocation Chemistry-IEB SG

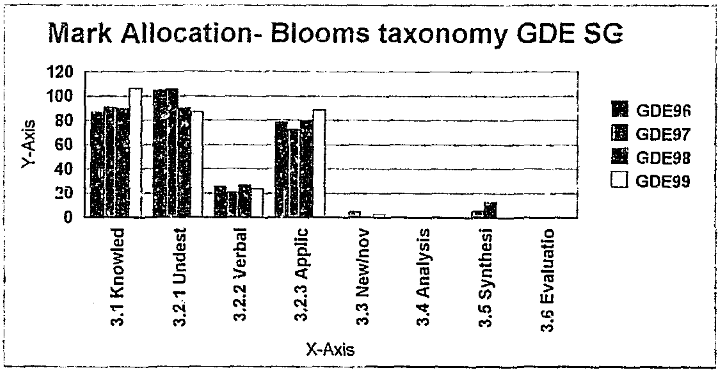
	IEB96	IEB97	IEB98	IEB99
2.1 Bonding		4	8	8
2.2 Solution	3	4		4
2.3 Sulphur	25	8	28	6
2.4 Nitrogen	11	13		12
2.5 Halogens	15	4		7
2.6 Reaction	7	10		12
2.7 Equilib	17	12	21	13
2.8 Acid/base	29	27	23	21
2.9 Redox	22	19	22	21
2.10 Organic	18	22	24	21
1.3 Gases		27	24	25

Analysis of mark Allocation Chemistry-IEB SG



Mark Allocation- Blooms taxonomy GDE SG

	GDE96	GDE97	GDE98	GDE99
3.1 Knowledge	87	91	90	107
3.2.1 Undestand	105	106	90	87
3.2.2 Verbal	26	21	27	24
3.2.3 Applic	79	73	80	89
3.3 New/novel		5		3
3.4 Analysis				
3.5 Synthesis		6	13	
3.6 Evaluation				



Mark Allocation Blooms taxonomy IEB SG

	IEB96	IEB97	IEB98	IEB99
3.1 Knowledge	87	96	97	89
3.2.1 Understand	105	81	63	84
3.2.2 Verbal	26	20	21	23
3.2.3 Applic	79	58	63	82
3.3 New/novel		39	49	22
3.4 Analysis				
3.5 Synthesis		6	7	
3.6 Evaluation