

**UNIVERSITY OF CAPE TOWN**  
**FACULTY OF EDUCATION**

Swazi college students' mastery  
of English logical connectives in science

A dissertation  
presented in partial fulfilment  
of the requirements for the degree of  
MASTER OF EDUCATION

by

**JANET MARIAN CUMMING**

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## ABSTRACT

Based on the educational theorists Gardner (1977(a)), Ehindero (1980), Mawasha (1976-1984) and Ogunniyi (1985) and extending earlier findings by McNaught (1980) in Zimbabwe, my investigation sought to answer the following questions:

1. How do the item facilities of a group of African (Swazi) college science students, on two parallel tests of logical connectives, based on Gardner's work, each consisting of the same 34 logical connectives, but different in presentation format compare?
2. Are there significant correlations between the item facilities obtained by the Swazi first year science students on the tests of logical connectives and their scores obtained in Matriculation English and Biology and college English communication and General science?
3. Is there evidence of learning of logical connectives without direct instructional intervention over a period of six months when exposed to English first language speaking lecturers?
4. In what ways are the works of Gardner and McNaught expanded, confirmed, or enriched by further investigation in a totally different culture?

Diagnostic and pre-test - post-test methods were used to gather data on the comprehension of the 34 logical connectives, and on academic achievement scores, of 65 Swazi teachers-in-training in KaNgwane, a subtropical, rural-agricultural region in Southern Africa.

The data were collected by means of modified Gap Filling and Sentence Completion items, derived from Gardner's pioneering work, by adapting and

refining certain items to be more relevant and meaningful in the local South African context. The data was processed by means of comparing Gardner's form IV pupils' item facilities with the Swazi students' item facilities on each logical connective. The differences were analysed by means of Chi square tests, Spearman's Test, McNemars' Test and a correlation matrix.

The chief findings were that Swazi students' item facilities compared favourably with those obtained by Gardner's form IV pupils on the 34 logical connectives overall. The Swazi students found 7 easier than the Australian pupils, 16 equally as difficult and 15 more difficult than the Australian pupils, but this was dependent on the format.

The thesis concludes by making recommendations to teachers, textbook writers, publishers and educational authorities on issues in science education with regard to English second language, particularly in terms of teacher training.

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## **LIST OF ABBREVIATIONS**

DET	Department of Education and Training
EL1	English first language
EL2	English second language
L1	First or vernacular language
L2	Second language
GF	Gap Filling (multiple-choice type question)
SC	Sentence Completion (multiple-choice type question)
STD	Secondary Teachers' Diploma

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**"All subject teachers need to be much more aware of the linguistic demands their specialisations make upon pupils."**

**Bullock, A. A LANGUAGE FOR LIFE (HMSO). London, 1975, p  
291.**

## **CHAPTER 1**

### **THE ORIGINS AND CONTEXT OF THE RESEARCH.**

#### **1.1 ORIGIN AND BACKGROUND OF THE PROBLEM.**

This study is a sequel to recent work in KaNgwane, Southern Africa, by the author, Cumming (1990) published in the Australasian Journal of Engineering Education (APPENDIX X), and by Cumming and Rochford (1989) published in the First Annual Convention and Conference Proceedings of the Australasian Association for Engineering Education.

In 1985 approximately 38 per cent of white South African pupils received instruction through the medium of English. Approximately 80 percent of these pupils were taught English by teachers who used English as a second language (Kitching 1985:1). On the other hand, all Black children i.e. approximately 71% of the South African school going population, receive their education in English from the fifth year onwards (South African Labour Statistics 1990:3.6). English is a second language both to these children, and to their teachers, so their understanding of the science content in their school science textbooks, written in English, may be erroneous or incomplete (Stevens 1976:55-68). One area of weakness - the focus of this study - might be their impaired interpretation and use of logical connectives in English.

Logical connectives are words or phrases which serve as links between sentences, or between propositions within a sentence or between a proposition or a concept. Several hundred different logical connectives are encountered in the English language. About two hundred of these occur with moderate to high frequency in secondary school science textbooks. (Gardner 1977(a):v)

The present cultural investigation is a recent extension, on the African continent, of Dr. Paul Gardner's work "Logical Connectives in Science", carried out on 16530 form I-IV students in secondary schools in the state of Victoria in Australia, from 1974-1977. This was a continuation of his earlier studies in the field of vocabulary difficulties among science pupils from 1971-1974 in Papua and New Guinea and the Philippines (Gardner 1971; Gardner 1976).

In particular, the present study investigates, interprets and explains difficulties which first year SiSwati-speaking College students experience when comprehending English logical connectives in the context of college science and everyday science. It is set in the broader context of the earlier follow-up language studies in Zimbabwe and in Natal, South Africa, by one of Gardner's co-workers, Mc Naught (McNaught, C. McNaught, I. and Ellis-Whitfield, D. 1980; McNaught, C. 1989). Gardner found that the difficulty was due mainly to unfamiliarity with certain logical connectives rather than to any conceptual problems with the logical relation signalled by these connectives (1977(a):80). Culturally, however, unfamiliarity as well as conceptual relationship difficulties may exist for these Swazi students who study science using English as a second language (EL2).

The chosen problem originated during a period of my ten years of lecturing and publishing in science, and science-related subjects to Black South African students in teacher training. As first language speakers and lecturing in English, the medium of instruction, many of my colleagues and I suspected that, because of their inadequate command of English, the students did not always understand instructions, and that misconceptions were common. Being a biology textbook author as well, there was also personal motivation - a real need to investigate - and a tangible, important, relevant, practical, problem to study.

Thus the need arose, as a first language speaker, to give special attention to teaching specific aspects of English as I lectured to my students in Biology, Physical and General Science and Environmental Education, in order to be understood. The idea of designing an "English for Science Students" course, as a compulsory introductory course for all science students was discussed favourably by my colleagues in the Department of Mathematics and Natural Sciences, and the current research study should be seen in this context.

The present African study thus focuses culturally on one aspect of English across the curriculum for English second language speakers (EL2), in contradistinction to Gardner's main study which was essentially a diagnostic or status study among English first language (EL1) speaking pupils. However, the current investigation is concerned particularly with young adults (Swazi student teachers-in-training), not with school pupils.

## **1.2 PURPOSE OF THE INVESTIGATION.**

The overall purposes of this study are to:

- i. investigate the international validity of Gardner's comparative findings on selected logical connectives obtained with form IV (grade 10) pupils in the state of Victoria in Australia, i.e. (a) to measure the extent to which his item facilities might be compared world-wide; and (b) to highlight individual item similarities and differences, accounting for these culturally where necessary.
- ii. culturally modify questions based on Gardner's diagnostic test items, for local English second language African (Swazi) students where necessary; and

- iii. refine the items where the original wording may be ambiguous or uncertain in local or colloquial contexts in Southern Africa.

This study may then lead to suggestions for modifications or extensions to existing theories on teaching and testing of logical connectives in second language teaching in science, in different cultures and perhaps, even across the curriculum.

### **1.3 STATEMENT OF THE PROBLEM.**

This investigation seeks to answer four main questions:

1. How proficient is a sample of 56 first year African (Swazi) college science students, as a group, on two parallel tests of logical connective, based on Gardner's work, each consisting of the same 34 logical connectives, but different in format of presentation?

More particularly:

- (a) On which items do these English second language (EL2) students as a group score appreciably above the form IV Australian item facilities (by more than 15%)? What explanations might be offered to account for these achievements?
- (b) On which items do these Swazi students as a group score appreciably below the form IV Australian item facilities (by more than 15%)? What cultural explanations might be offered to account for these deficits?
- (c) On which items do these Swazi students as a group offer feasible alternative answers which are acceptable locally (in South Africa) for second language students?

(d) Which logical connectives are:

- i. very easy for both Australian first language science pupils and African (Swazi) second language speaking college science students; or
- ii. very difficult for both Australian first language speaking pupils and African (Swazi) second language speaking college science students?

(e) Regarding the relative difficulties of individual items in the two parallel versions of the Diagnostic test, Gap Filling (GF) and Sentence Completion (SC), do the scores of the Australian and African science students follow similar trends? For example, if Australian students find a particular GF item appreciably easier than its SC equivalent, will the African students do likewise or vice versa?

2. Are there significant correlations between the scores obtained by the African (Swazi) first year science students on the test of selected logical connectives and their scores obtained in :

- i. Matriculation Biology and/or Physical Science?
- ii. Matriculation English?
- iii. College General Science (First year final examination)?
- iv. College English Communication (First year final examination)?

3. Is there evidence of learning of logical connectives without direct instructional intervention? i.e. simply by exposure to English-speaking European teachers (lecturers) for the first time in most cases? More particularly, does the performance of the first year Swazi college science students on logical connectives improve or change significantly when they are re-tested after six months, without conscious or intentional instructional intervention in logical connectives?
4. In what ways are the pioneering works of Gardner and Ellis-Whitfield, McNaught & McNaught expanded, confirmed or enriched by further investigation in a totally different culture?

#### **1.4 THE SAMPLE.**

This study is restricted to African SiSwati-speaking first year college students at a College of Higher Education in 1988 in KaNgwane (FIGURE 1.1 - p.7). All these students studied General Science as a first year course, and in their second and third year of high school teacher training they specialized in both Biology and Physical Science, or in one of the two combined with either Mathematics, Agricultural Science or Geography. Thus they specialized in two high school teaching subjects. Although they have received their high school education and part of their primary education through the medium of English as a second language (EL2), their overall level of English proficiency tended to be utilitarian rather than sophisticated. At college level they receive all their lectures in English. The SiSwati lectures for students specializing in this subject obviously are in SiSwati.

Ninety five per cent of the students were resident in the college hostels, although they came from nearby regions, 50-100km away. The students' ages ranged from 18 to 27 years.

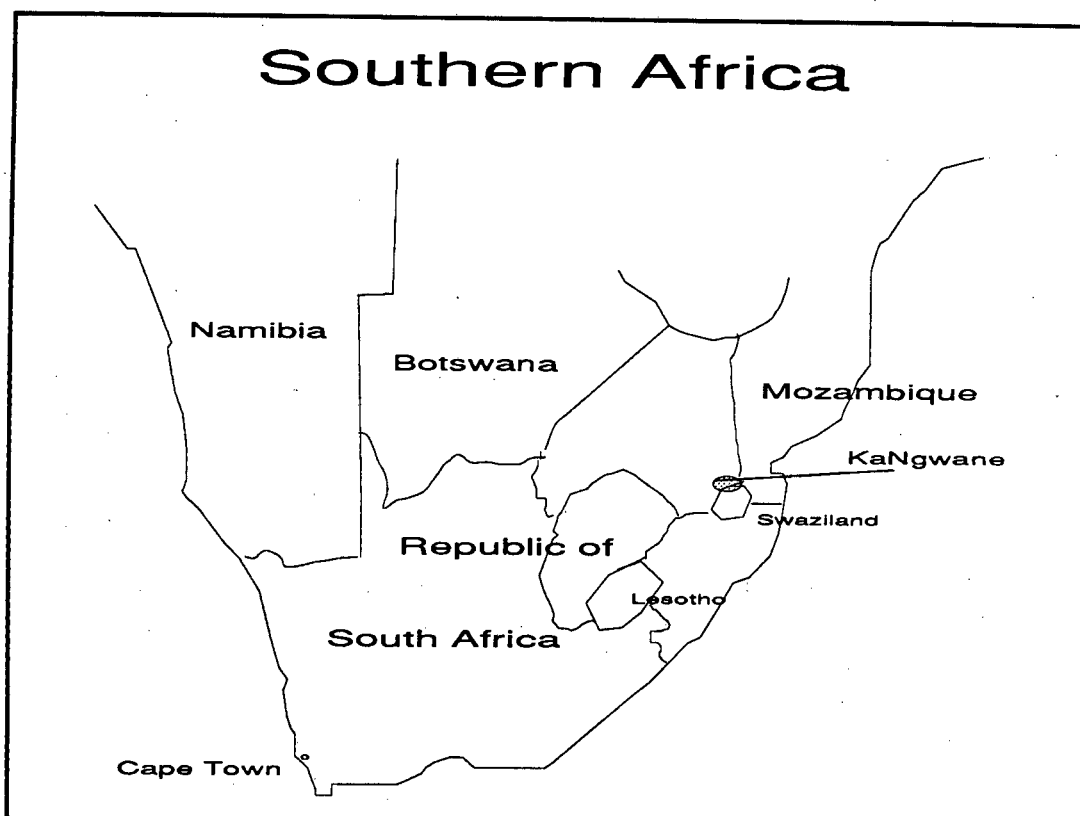


FIGURE 1.1 Map of Southern Africa highlighting the location of KaNgwane.

## 1.5 CLARIFICATION OF CONCEPTS AND TERMS.

### LOGICAL CONNECTIVES.

Logical connectives are words or phrases which serve to link sentences, or which occur between prepositions within sentences, or between a preposition and a concept (Gardner 1977(a)). These terms indicate the nature of the relationship which exists between the parts of a passage of text and frequently indicate the degree of explicitness of that relationship as well (Snow 1980:153). They also indicate function as transition words which contribute to the smooth flow of thoughts in written sentences (Gardner 1977b;3).

Gardner (1977(a)) identified approximately 830 logical connectives in the English language, of which about 200 occur relatively frequently in secondary school science textbooks. Examples are *viz.*, *therefore*, *if...then*, *furthermore*, *whereas*, and so on. (Throughout this thesis, logical connectives are italicised.)

In Gardner's (1977(a):3) study on logical connectives reference is made to other labels used by different authors to describe these linking words. Among them we find *Logical Connectives* (Youniss and Firth 1964, 1967; Suppes and Feldman 1971; Roberge 1975), *Conjunctives* (Robertson 1966; Katz and Brent 1968), *Logical Connectors* (Quirk, Greenbaum, Leech and Svartvik 1972), *Logico-grammatical Items* (Stevens 1972), *Language Connectives* (Paris 1973), *Discourse Markers* (Mackay 1974), *Linkers* (Pritchard and Chamberlain 1974) and *Sequence Signals* (Ton San Yee 1975).

#### COLLEGE SCIENCE / SCIENCE.

This term refers to General Science, and includes concepts from the Physical Sciences (Physics and Chemistry), and the Biological Sciences (Botany, Zoology, Ecology).

General Science is prescribed nationally as a first year subject in Black Teacher Training Colleges. Its syllabus is laid down by the national body, the Department of Education and Training. This General Science course focuses on concepts in the standard 6 and 7 secondary school syllabi in particular, and the methods of teaching them.

## SISWATI.

This is the official African language spoken by Swazi people, the largest ethnic group, living in KaNgwane (FIGURE 1.1 - p.7) and is one of 15 different African languages spoken by the various population groups in South Africa. Nine of these languages (African languages) are recognised officially in government, law and education, viz. Zulu, Xhosa, Southern Sotho, Northern Sotho, Tswana, Tsonga, Venda, Swazi and Southern Ndebele (Prof. S.C. Satyo, Dept. African Languages and Literatures, University of Cape Town - Personal Communication 1991).

## QUESTION FORMAT.

### GAP FILLING (GF).

The gap filling format presents the student with a pair of propositions, and requires the student to select from the list of distractors in the multiple choice question, the most appropriate linking term (logical connective).

#### EXAMPLE.

The class of animals known as Insecta contains the largest number of animals \_\_\_\_\_ many pests of Agricultural crops.

- A. according to
- B. known as
- C. depending on
- D. including
- E. in terms of.

### SENTENCE COMPLETION (SC).

The sentence completion format requires the student, after encountering a particular logical connective, to select a proposition from those listed (distractors) in the multiple choice question, as the most consistent with the logical force of the given connective to complete the stem.

**EXAMPLE:**

The experiment was easy to do apart from

- A. being interested in the work.
- B. having no difficulties with the experiment.
- C. having to keep the thermometer at exactly 5°C.
- D. having done the experiment many times before.

**1.6 AIMS.**

This study aims to investigate whether any appreciable differences will occur, for cultural and other reasons, among the item facilities of the 34 logical connective obtained with Form IV Australian science pupils compared with those item facilities obtained by the freshman Swazi college science students.

It also aims to investigate whether similarities will exist among the item facilities obtained by Australian pupils and the students in KaNgwane on each of the two formats (GF and SC) of the 34 selected logical connectives.

Finally the study aims to investigate whether appreciable relationships may also occur between the scores of the first year college science students on the several tests of logical connectives and their college academic examination scores in English, Biology and General Science, and seeks to establish this in one way or another.

## **1.7 EXPERIMENTAL PROCEDURE.**

### **PHASE I.**

In a related investigation in the Cape Province, Kitching (1984) established that the average first-year English Second Language (EL2) Afrikaans-speaking college student (age 18 years) had an overall communicative competence equivalent to that of an average Standard 5 (grade 7) English-speaking pupil (EL1) (age 12-13 years). However, in the first part of this present investigation the performances of 56 SiSwati-speaking first year college science students on two particular versions of a test of understanding logical connectives in English are measured. The item facilities of these students on the items are compared with the item facilities derived for English first language speaking form IV (grade 10) science pupils in Australia, and explanations are offered to account for any significant deviations on particular items. The purpose of phase I is the development, adaptation, and validation of an instrument for use as a local measure.

### **PHASE II.**

The SiSwati-speaking science students are re-tested six months later without receiving a programme of instruction in the use of logical connectives in science, and changes in item performances are recorded, together with possible explanations.

### **PHASE III.**

The students' achievements on the tests of logical connectives are related to their examination results in Matriculation Biology and/ or Physical Science, Matriculation English, College General Science and College English Communication skills.

Phase III of this investigation is an association of the instrument scores with the achievement of local academic content.

In an attempt to account for differences emerging in Phase I between the Australian pupils and the African (Swazi) students, insights will be drawn from the African cultural theorists Ehindero (1980:283-288) Mawasha (1976-1984) and Ogunniyi (1986:111-122).

### **1.8 IMPORTANCE AND SIGNIFICANCE OF THE STUDY.**

Dove (1986:29), Hartshorne (1985:149), Schoeman (1981:72) and van den Berg (1981:72) all stress the fact that learning in a second language (EL2) - in this case English as medium of instruction, as occurs in almost all African countries from about the age of 10 or 11 years (grade 4 or 5) - is laborious and places limitations on pupils' understanding. This study seeks to identify some logical connectives which African students understand less well than others, compared with Australian pupils.

Dove (1986:29) and Ingle and Turner (1981:366) claim that the adoption of a foreign language tends to cause duality of thought patterns because pupils must modify existing cultural norms and construct new ones based on values developed by other people with different cultural and linguistic ideals.

Most science teachers and lecturers in South Africa instructing second language learners are concerned about student underachievement. They consider some of the causes to be related to learning science through the medium of a second language in which the students are not proficient, and to cultural differences. This problem is important for the following reasons:-

1. By consensus of their lecturers, most of the college students in this study appear to lack linguistic coping skills in English as a second language. The low mean scores (of the order of 30%-40%) obtained by the students (in general) in Matriculation English and in the College English Communication course support this concern.
2. Some aspects of the prescribed content of college and school science are devoid of cultural meaning for these students (Bajah 1985:577-582; Brophy 1984:44; Ehindero 1980:284; Ingle and Turner 1981:358-362; Hartshorne 1985:148; Sibanda 1984:73; Sizulu 1987:11; van den Berg 1980:99;). The topics of radio-activity and laser beams, for example, are not yet relevant to the rural African setting (Ogunniyi 1986:119) and cannot be integrated conceptually into traditional African thought, linguistic and cultural patterns. This tends to be associated with reduced student motivation.
3. It seems desirable that editors, textbook writers and teachers be informed when particular logical connectives in English are culturally interpreted, or when they are too difficult for most local African students to understand.

## **1.9 CHAPTER SUMMARY.**

This study is a cultural extension and exploration of Gardner's work, not with first language speakers (EL1), but with African second language speakers of English (EL2) and how the presence of logical connectives might affect their understanding of aspects of science in a third world context. The origin, importance and purpose of the investigation have been described, and the experimental procedure introduced. The study has been set against a background of the work of leading African cultural theorists with special reference to linguistic structures, meanings and interpretations, and now this important context will be presented in more detail in the following chapter.

## **CHAPTER 2**

### **REVIEW OF RELATED LITERATURE**

This chapter is divided into three sections. Firstly a summary is presented of the findings of important, relevant empirical and qualitative investigations into the role of English language in science teaching. Secondly, some of the pioneering literature on logical connectives is reviewed, and thirdly the central theoretical framework for this study is presented from the literature and discussed.

#### **2.1 THE ROLE OF ENGLISH LANGUAGE IN SCIENCE LEARNING**

Although a large body of work exists on the use of English as a medium of instruction in science for second language learners, the findings of several of the most important studies relevant to this investigation may be summarised as follows:

In a paper on the problems of learning and teaching science through a foreign language Strevens (1976:55-68) claims that two unstated assumptions exist in most studies on the philosophy and practice of science education. These are that the learner is a member of the same culture and is accustomed to the same general education system, values and procedures, as those in which the studies of science education were prepared; and that the teacher and learner have as their common mother tongue the language in which the science is taught. For the vast majority of science learners in developing countries, as well as for immigrants in technologically developed countries, this is not true. In most cases English is the mother tongue of neither the learner nor the science educator.

Stevens identifies a number of problems which may be broadly classified as linguistic or socio-linguistic in nature. Among them we find:

- Language differences between teachers and learners leading to difficulties of mutual comprehension in spoken English.
- Degree of adaptation for science in the learner's language such as (a) absence in the learner's mother tongue of words or expressions equivalent to ones in English e.g. "electricity", "octagonal" (b) absence in the learner's mother tongue or culture of certain concepts e.g. "gravity", "infinity". Many languages do not possess and have not yet developed terms, words, expressions, relationships, operations and ways of communicating about science. Because these are not part of the learner's culture or language, learning through English also causes further difficulties in cognition and understanding.
- Word order difficulties, i.e. word order sequences from their mother tongue being transposed into their spoken and written English.
- Lack of familiarity with common everyday roots from Greek or Latin which occur in scientific vocabulary e.g. "geo-", "zoo-", "kilo-", "anti-".
- Lack of precision in the use of English e.g. indifferent use of logical operators (logical connectives) such as *if*, *when*, *whenever*, *as a result of*.

Seddon and Waweru (1987) acknowledge the fact that scientific concepts which emanate primarily from Western cultures, and which are not part of traditional African cultures in many developing countries, are difficult if not impossible to translate and teach or test in the vernacular language. However, they were able to demonstrate that transfer can be affected from English to both Swahili and Kikuyu, and between both Swahili and Kikuyu (in Kenya). They also showed that

for the three languages of teaching, the resulting performance in both the vernacular languages was indistinguishable from that in English (1987:247). This suggests that there may be methods to overcome the barriers which inhibit transfer to these vernacular languages in developing countries.

"That there should be a close relationship between language and concept learning seems clear enough. On one level, a child who experiences difficulties in the use of spoken or written language is likely to have additional difficulties in understanding and using the rather specialised vocabulary of the sciences. On a deeper level, language plays a crucial role in the child's ability to construct meaning..." (Curtis and Millar 1988:62)

Curtis and Millar (1988) in a study comparing language and conceptual understanding in science between English and Asian speaking children found that fluency with language, in this case English, and familiarity with science considerably affected the children's performance. They also found that Asian children who had stayed in England for a longer period tended to experience fewer problems and that the problems that these Asian children experienced were unlikely to be specific to science. They suggest increased classroom and homework tasks involving the use of written and spoken language to reinforce concept learning and encourage familiarity with new terminology and ideas (Curtis 1988:72).

In a study on the language of science and high school students Lynch, Chipman and Pachaury (1985) looked at the gap between a child's language and scientific language and the linguistic and cognitive level of argument in most science textbooks which appear to be too demanding for the average pupil. The persistence of this formal language of science over a century leads them to wonder if they were not dealing with a feature of science communication that constitutes a pragmatic and linguistic necessity (1985:676). This study involved testing a group of Hindi pupils in Hindi, and a group of Tasmanian pupils in English, on key

science concept words such as atom, solid, volume and element using multiple choice questions. They concluded that only in specific cases do the Hindi terms act as facilitators and that, where relative ease or difficulty was experienced by the Hindi pupils, this reflected cognitive or cultural variables as well as educational ones.

Ehindero (1980) investigated the influence of two languages of instruction on Yoruba primary school pupils' levels of cognitive development and achievement in science. The purpose of this investigation was to determine whether instruction in science through one's own mother tongue resulted in higher performance on science achievement tests than instruction in a foreign language. The foreign language in this case was English. This investigation was based on Piaget's view of the importance of mother tongue learning and development, Vygotsky's view of language being a cultural mediator employed in social intercourse, developed to relate to reality and regulating an individual's higher cognitive functions and the UNESCO monograph of 1953 on the use of vernacular languages in education. The study did not attempt to negate the instrumental value of, nor the necessity for teaching and learning science in a second language, although the study results showed that the pupils instructed and tested in Yoruba achieved considerably higher grades on higher order questions, classified according to Bloom, than the group that had been instructed and tested in English.

Turning to Southern Africa:-

"Many African children, especially those in the rural areas, very rarely find opportunity to learn and to use English in practical social situations involving native speakers of English. Indeed many children rely almost entirely (at least while they are still in the same rural environment) on what the teacher provides." (Mawasha 1976:44)

Mawasha (1976, 1979, 1984, 1984) studied common errors made in written English by North Sotho speaking South Africans. He lists one of the major reasons for these problems, the fact that when children learn a second language (L2), they need a receptive competence of two language varieties - that of the target language and that of their vernacular - while they have a production competence in only one, viz. the vernacular. He claims that it is largely as a result of this problem that pupils often tend to fall back on their vernacular (L1) language structure in an attempt to cope with the target language, which manifests itself as the phenomenon of interference in second language learning (1976:42).

Although Mawasha's research on the teaching of English as a second language (EL2) is not only in terms of teaching science in English, his findings indicate even more clearly the problem when talking about teaching of science in English by English second language (EL2) speakers. Research findings on a sample of English second language teachers showed that 70% of those sampled for the study were inadequately qualified to be teaching English as a second language (Mawasha 1979:46). For this reason it is thus obvious that the black pupils "do not always receive the advantage of instruction based on adequate academic background..." (1983:55).

Rangaka (1982) supports this and says that as vital and beautiful as African languages are, English is essential as an access language to meet the needs of modern industry, technology, commerce and international contact. He goes on to say that even though the English teacher may lack competence in English...

"Alone, the English master has to do battle against linguistic distortion and, in some cases, complete ineptitude. In all this he is unaided, the teachers of other subjects (English-mediated) continuing their use of broken English with callous indifference. Products of the mother-tongue syndrome themselves, they may perhaps be pardoned. But this does not alter the fact that they commit murder every period."  
(1982:28)

Wilkinson, Reuter and Kriel (1987:50) in a study on the problems associated with teaching and learning Physical Science in number of dependent and independent states in South Africa, identified: (i) "pupils experiencing difficulties expressing themselves in English" as one of the most important problems associated with teaching Physical Science and

(ii) "pupils' difficulty in coping with scientific language" as one of the most significant reasons why pupils do not take Physical Science as a subject.

They point out that the pupils are taught important scientific concepts in the early grades when they do not have a complete command of the English language. This, they say, makes conceptualizing of later important Physical Science concepts very difficult, and the reason for struggling with scientific terminology. This is aggravated by the fact that their teachers have a poor command of English and because they rarely, if ever, communicate in English after school hours (1987:51).

For most Black South Africans it is more appropriate to call English a target language rather than a second language because, for most of them, their second language is another black language and not English. For this reason Gamaroff (1987:20) says of prospective Tswana-speaking teachers of English, they have inherited erroneous patterns from their secondary and tertiary education, because their teachers had an inadequate command of the language. Africans living in townships near cities live in heterolingual societies. They are confronted with three or four different African languages as well as different slang languages such as "scamato" spoken by the "mapantsola" or "fly-taal" or "tsotsitaal", a type of universal Afrikaans, and never utter a word of English out of the classroom (Rangaka 1982:29).

The teaching of science in any third world language as against English, is fraught with problems (Stevens 1976). This is because of the lack of equivalent technical terminology, the level of development of the language and its cultural basis, and the usage of adopted curricula. The argument as to whether science should be taught in English or in the mother tongue is thus a matter still open to a lot of debate.

"That employers and university lecturers alike seriously question the competence of many entrants to their worlds and actively institute bridging courses in language for such entrants points directly at serious deficiencies in the schooling process" (Young 1986:34).

The application of such research includes the bridging courses run in the Academic Support Programmes at the Universities of Cape Town (Garraway, Gennrich and Hartley, 1988) and the Witwatersrand (Rutherford 1990 - personal communication).

The students at the University of Cape Town in the English for Academic Purposes (EAP) course, while relatively competent using everyday English "seemed to have failed to crack the code of Scientific Academic English" (Garraway 1988:3). For this reason a course was designed on the basis of requests from the Science Faculty to provide the students with sufficient experience in English to cope with Science. In a section of this course students learn to use "linking markers" (logical connectives) correctly in order to link steps, statements and processes together in write-ups in a logical sequence (Garraway 1988:8).

## 2.2 PIONEERING LITERATURE ON LOGICAL CONNECTIVES.

Logical connectives and their effect on learning have been studied in a wide variety of contexts, from experimental cognitive psychology (Bruner, Goodnow, and Austin, 1965) and genetic epistemology (Piaget 1924) to socio-linguistics (Stubbs, 1976; Bernstein 1971) and linguistics and comprehension (Dik, 1968; Bever, 1970; Clark, 1970; Ferreira and Sinclair, 1971) (cited in Gardner 1977(a)).

Robertson (1968) also investigated primary school children's understanding of a small number of common logical connectives using sentence completion type multiple choice questions.

From the large pool of logical connectives identified in school science textbooks, Gardner's (1977(a)) team designed items to measure students' comprehension of English, as well as to determine the students' abilities and difficulties with those logical connectives which occur most commonly in science.

Gardner's work with science pupils is an extension of Robertson's (1968) form of research (multiple choice questions) and is primarily psychometric. The correlations in his study between frequency and facility, he claims, suggest that in many cases, difficulty is simply due to unfamiliarity, and not due to any conceptual problems with the logical relation signalled by the connective (1977(a):80).

Gardner's decision to use sentence completion and gap-filling type multiple-choice questions was for ease of administration and scoring and because it was the most commonly employed type in research on reading (1977(a):34).

### **2.3 CENTRAL THEORETICAL FRAMEWORK FOR THE STUDY.**

This study is based on the definitive work of Paul Gardner between 1974-1977 called LOGICAL CONNECTIVES IN SCIENCE. This was an investigation of the abilities and difficulties in comprehending logical connectives in both scientific and everyday contexts among junior secondary school students in Victoria, Australia. Gardner set out to identify the more commonly used logical connectives in science, and then to measure difficulties experienced by junior secondary school pupils' in comprehending these connectives (1977(a):v). The objectives set for the project were:

1. to compile a comprehensive list of logical connectives in the English language;
2. to determine the frequency of occurrence of these terms in scientific materials;
3. to develop a set of objective test items to measure secondary school students' difficulties with the more common terms; and
4. to investigate possible relationships between the ability to comprehend logical connectives and other variables of interest in education (Gardner 1975:173).

The scope of Gardner's work was comprehensive in comparison to other researchers in this field who did intensive studies on a small number of connectives, or who enumerated various classes into which logical connectives could be classified, listing a few examples of each class (Gardner 1977(a):4). Approximately 800 terms, which serve as logical connectives in the English language, were identified. Two hundred of the most frequently occurring ones were then selected for his investigation. A thousand test items were developed and divided into 25 tests of 40 items (20 Gap Filling and 20 Sentence Completion) each and these formed the final versions of the instruments that he used in the research. These were administered to a random sample of Form I, II, III and IV

pupils in Victorian secondary schools. The total sample consisted of 16530 pupils (approximately 165 per test per form level) (1977"(a):v).

Gardner's work focuses on the use of logical connectives in scientific discourse. The stance of this work was primarily psychometric in that the list of logical connectives served as a pool around which test items were designed to measure pupil's comprehension of these terms. His work was not primarily concerned with linguistic analysis of the ways in which connectives are incorporated into syntactical structures of the English language, neither was it concerned with psycho-linguistic explanations of how young children learn to use and transform such structures (1977(a):4).

Gardner's tests may be regarded as criterion-referenced in that they set out to measure the attainment of specified objectives. They were not norm-referenced tests because Gardner was not trying to make comparisons among individual students based on their total scores. His interest was in the individual item facility values and how these indicate pupils' comprehension of and the ability to use particular logical connectives rather than in individual pupils' total test score performances (McNaught 1980:32). Gardner's findings from the pilot (one test of 50 test items - 25 GF and 25 SC) and major study (25 tests each of 40 items - 20 GF and 20 SC) showed that:

- The test displayed high internal consistency, i.e. the comprehension of logical connectives is a fairly unidimensional construct which can be measured reliably;

- There was a moderate product-moment correlation ( $r = 0.49$ ) for the total pilot sample between the item facilities of SC items and GF items. Because the item type and item context differed, similarities in item difficulty must have been associated with specific difficulties due to the logical connective being tested;
- Many of the items proved to be moderately or extremely difficult;
- There was a steady growth in comprehension of logical connectives between Form I and IV, although connectives which presented difficulties at the form I level presented similar difficulties at the form IV level;
- The standard deviations of the tests were high, approximately 7 or 8 at the lower form levels and 6 to 7 at the higher form levels over the 25 tests. These large values indicated the presence of a wide range of individual scores. The scores of the tests covered the full range between the minimum score and the maximum possible score of 40;
- The Cronbach reliability coefficients (ranging from 0.97 to 1.00 ) were high, suggesting that the items in the test bank were consistent indicators of the absence or presence and the extent of the pupils' ability in coping with logical connectives;
- The difficulty experienced by the pupils was more often due simply to their unfamiliarity with the connective than to any conceptual problem with the logical relation signalled by the connective. Frequency however not the sole determinant of difficulty experienced with certain logical connectives;
- Connectives indicating inference proved difficult, as were those involved in generalisations and terms in apposition. Certain logical connectives showed lack of familiarity with additive terms;

- Three terms, *conversely*, *if* and *moreover*, proved to be extremely difficult.

Gardner claims the difficulty with *conversely* is because the word is frequently misused; the difficulty with *if* is because it is used in logical reasoning and that although junior pupils understand the word they cannot use it in logical reasoning; and the difficulty with *moreover* is due to infrequent use of the word in spoken discourse or in text books.

Logical connectives can be classified on the basis of their grammatical properties, and also according to their logical properties, i.e. according to the nature of the semantic relationship between the propositions being linked. The **grammatical** classes include those listed in TABLE 2.1.

i. Coordinators	<i>and, or, but</i>
ii. Correlative pairs	<i>neither...nor, not only...but also,</i>
iii. Subordinators	<i>as, because, if, since, when</i>
iv. Adverbials	<i>furthermore, similarly, hence</i>

TABLE 2.1 Grammatical classes of Logical Connectives.

According to their **semantic** functions logical connectives may be classified (Gardner 1977(a):15) as presented in TABLE 2.2.

<u>CATEGORY</u>	<u>EXAMPLE</u>
additive (equating) (reinforcing)	<i>similarly</i> <i>and, furthermore, in addition</i>
apposition	<i>namely, in other words, for example</i>
causal	<i>because, since</i>
conditional	<i>if, in case, suppose, provided that</i>
contrastive (adversitive) (antithetic)  (concessive) (reformulatory) (replative)	<i>nevertheless, but</i> <i>conversely, in contrast, instead</i> <i>although, however, yet</i> <i>or, in other words</i> <i>alternatively, on the other hand</i>
disjunctive	<i>or, alternatively</i>
enumerative	<i>firstly, secondly...finally</i>
illative	<i>consequently, hence, as a result</i>
inferential	<i>otherwise, in that case</i>
purposive	<i>so that, in order to</i>
summative	<i>in conclusion</i>
time (frequency) (transitional) (when)	<i>generally, occasionally, often</i> <i>meanwhile</i> <i>before, next, recently, then,</i> <i>now</i>
transitional	<i>now, as to</i>

TABLE 2.2 Categories of logical connectives classified according to semantic function.

In standard school science textbooks, many passages may contain lengthy explanations with a logical argument, followed by a conclusion. Linking all the sentences and propositions in the argument to produce a smooth discourse, are

terms known as logical connectives (Gardner, 1977(a)). Thirteen logical connectives are italicised in the following example taken from a South African Matriculation Biology textbook:

**EXAMPLE:**

*Only about 20% of starch in plants consists of soluble amylose while 80% consists of insoluble amylopectin. The large amylopectin molecules therefore constitute the greater part of starch. Thus starch, as such, is practically insoluble in water, and as a result, cannot be transported from cell to cell. However, with the help of enzymes, starch is hydrolysed easily by the living organism into smaller molecules which are more soluble in water. These smaller molecules can be a more soluble polysaccharide, dextrin, which is hydrolysed further into the soluble disaccharide molecule maltose and further into glucose. In this soluble form it can be transported easily in the living organism. Many plants produce starch during photosynthesis. The starch which is formed in this way accumulates initially as starch grains inside the chloroplasts, but during the night the starch is converted into soluble sugar which can be transported to other parts of the plant where it is needed. Here it can be converted again into starch which is stored in parts of the plant like tubers or bulbs or it can be used for other purposes; for example, as a source of chemical potential energy for respiration processes.*

(Senior Secondary Biology - Std 10. Smit, Fox, van Dijk, Hennessy, Nel, van Antwerpen, 1987) (My Italics)

## 2.4 CONCLUSION

Researchers such as Youniss and Firth (1964, 1967), Robertson (1966) and Gardner (1977(a)) have long been aware of the importance of logical connectives in language learning in areas such as linguistic construction, comprehension in young children developing competence with language and second language learning. On the other hand problems inherent in teaching subject matter in a second language and second language learning across the curriculum in addition to the above mentioned areas are of particular relevance to South Africa and its

diversity of languages and cultures. (Mac Donald.1990 - personal communication; Young 1986:33-56).

In this chapter research on problems caused by logical connectives in learning and understanding have been examined and also the effect of learning in a second language, more particularly when that second language is English in the Science classroom in an African environment.

The problem now at hand is to investigate how the earlier work links up with the specific linguistic competencies of Swazi college science students, and it is to this particular problem that the current work addresses itself in the next chapter.

"Acquisition and learning are both based on prior understanding of the language, particularly at L2 (second language) level. For effective L2 learning to occur the INPUT must be understood and at the same time go a bit beyond the current level of competence of the learner..."  
(Young 1987:3 - based on Krashen's second language learning and second language acquisition ideas.)

## **CHAPTER 3**

### **EXPERIMENTAL DESIGN, PROCEDURE AND CRITERION.**

#### **3.1 THE SETTING FOR THE INVESTIGATION.**

Elijah Mango College of Higher Education is a tertiary institute, specializing in secondary teacher training. The college is situated in Kabokweni, a semi-industrial township in KaNgwane. KaNgwane is the national state for the Swazi people (population nearly one million) of South Africa and is located in the south eastern corner of the Eastern Transvaal Lowveld near Nelspruit and White River (FIGURE 3.1-close up of FIGURE 1.1). This college is the second in the region, and was established in 1986. The Secondary Teachers' Diploma (STD) is a three year diploma course offered by the Department of Education and Training (DET) of South Africa, and is implemented by all of the colleges of Education under its jurisdiction in South Africa, as well as by most the colleges in the National and Independent States.

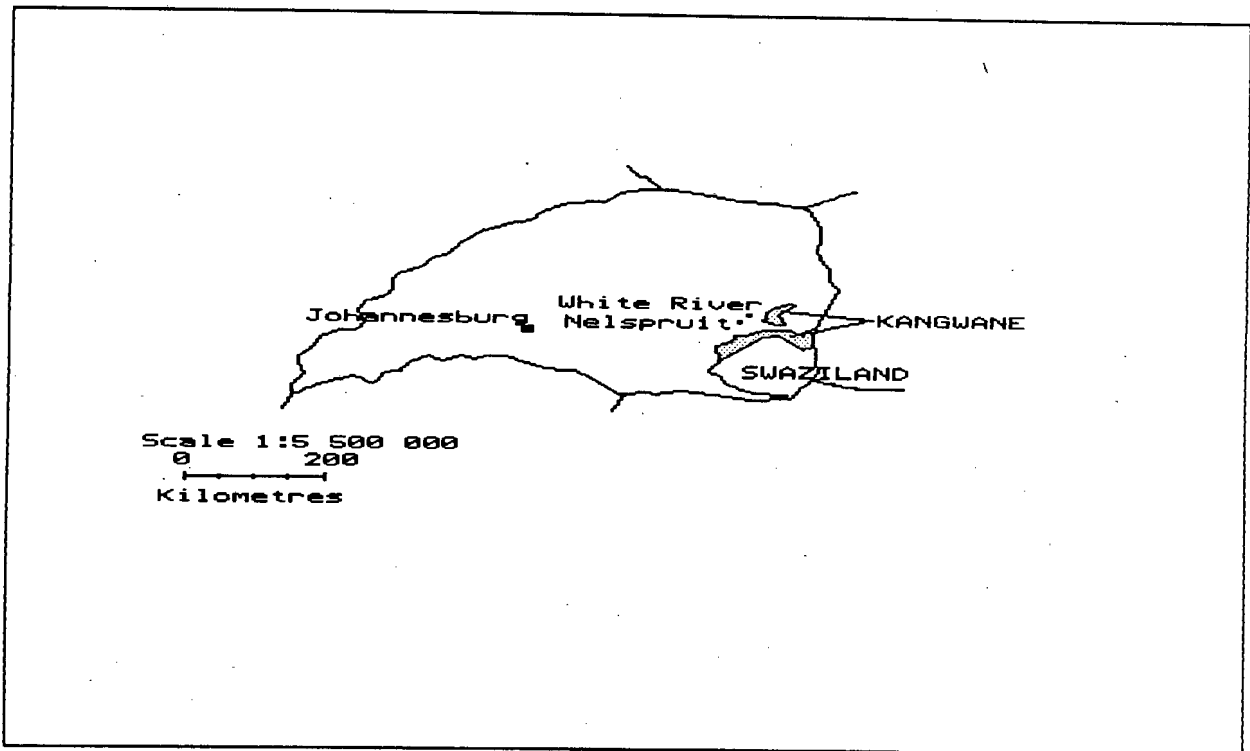


FIGURE 3.1 Location of KaNgwane.

### 3.2 THE POPULATION AND SAMPLE.

The full-time student population are all young black SiSwati-speaking, South African students, between 18 and 27 years in age, who have attained matriculation averages of between 45% and 60%. (SiSwati is not necessarily the mother tongue of all these students, but because they were able to speak this language they are accepted at this college which is specifically for students from this region).

English is not their mother tongue and neither was it necessarily their second language, but it is the language (target language) in which they were instructed.

The purpose of the STD is to equip the students with the skills and academic knowledge which will enable them, on qualifying, to teach the two subjects in which they have specialized, up to matriculation level.

The college was designed to accommodate between 600 and 800 students. The residences on the campus accommodate approximately 75% of the students, while the other 25% live in Kabokweni, or nearby villages. The students are able to specialize in one of the following fields;

#### ARTS AND LANGUAGES:

SiSwati, English, Afrikaans, History, Geography, Biblical Studies, Mathematics.

#### COMMERCIAL SUBJECTS:

Accounting, Economics, Business Economics and Typing

#### SCIENCES:

Mathematics, Physical Science, Biology, Agricultural Science and Geography.

The college also runs a University Academic Support Programme for students registered at university but studying by correspondence i.e. University of South Africa students. In 1990 the college linked with the University of the Witwatersrand and now also offers degree courses in the specialization subjects, so that students may gain certain credits towards a degree, on obtaining a 4-year Secondary Teachers' Diploma.

The sample selected was the college first year General Science group in 1988. These students had studied either Biology and/or Physical Science as Matriculation subjects. In their second year at college in 1989 they elected to major either in both Biology and Physical Science or in one of them, combined with either Mathematics, Geography or Agricultural Science.

The initial sample for the pilot test consisted of 65 students, but the final group for the second test was reduced to 56 due to students leaving the College, changing courses and student absence from the second tests during 1988.

The initial group consisted of 12 female and 53 male students, and the final group of 9 female and 47 male students. The sample may be considered to be an opportunistic sample. This first year group was selected randomly without set criteria, since it was the largest group, and thus the most convenient from which to gather the required data.

### **3.3 SELECTION AND MODIFICATION OF DIAGNOSTIC TESTS.**

After studying Gardner's work, thirty four logical connectives were selected for the Diagnostic tests (Version A and Version B). These thirty four logical connectives were the ones that:-

- occurred most frequently in a representative sample of local South African school science textbooks (Appendix I) and/or
- were rated by Gardner to be difficult, very difficult or extremely difficult (Appendix II); and/or
- occur in the language SiSwati; and/or
- had common, and basic curriculum content; and/or
- in certain cases were also covered in the Academic Support Program (ASP) at the University of Cape Town for Science students.

The logical connectives selected initially are listed in TABLE 3.1 :-

LOGICAL CONNECTIVE SISWATI EQUIVALENT		
After	Emuva (kwekuba)	conjunction
*Also	Futsi	conjunction
*Apart from	Ngephandle kwekutsi	adverb
As	Ngobe / ngekutsi	conj and adv
Because	Ngobe	conjunction
But	Koje/kodvwa/kodwana	conjunction
*Clearly	Ngalokukhanyako	adverb
* <u>CONVERSELY</u>	Ngalokunye	adverb
Due to	Ngobana	conjunction
For example	Ngekulinganisa / ngekubonisa	noun verb
*From	Kusukela	verb
* <u>FURTHER</u>	Futsi	conjunction
*Hence	Ngakoke/ngaleyondlela	adverb
However	Kodvwa	conj and adv
If...then	Nangabe...bese	conjunction
*In other words	Ngalamanye emagama	adverb
*In turn (similarly)	Bese...	conj and adv
*Including	Ngenisa	verb
Instead	Endzaweni/esikhundleni	adverb
Just as	Njengobe	conjunction
* <u>MOREOVER</u>	Futsi	conjunction
*Much like	Cishe	adverb
*Now (at this time)	Manje	conjunction
Obviously	Vele	adverb
* <u>RESPECTIVELY</u>	Ngekulandzelana	adverb
* <u>SIMILARLY</u>	Ngalokufanako	adverb
Since	Njengobe	adverb
Such as	Njenga	adjective
* <u>THAT IS</u>	Kuba	conjunction
*Therefore (logical)	Ngako-ke	conjunction
* <u>VIZ.</u>	Khona/njengekutsi	adverb
Where	Lapha	conj and adj
Whether	Nobe	conjunction
Yet	Kube	conjunction

(\* = difficult according to Gardner)

TABLE 3.1 Thirty four logical connectives used in the initial investigation.

The degree of difficulty is based on Table 3.2.1 DIFFICULT LOGICAL CONNECTIVES in Gardner (1977(a):57) (Appendix II). Gardner included connectives in this list if their mean facility level at Form 4 level was less than 70%, averaged across the various items testing that specific connective. Only the connectives preceded by an asterisk (\*) listed above, are included in Gardner's list

of difficult logical connectives. Connectives listed as very difficult (CAPITAL LETTERS) had a mean item facility of less than 50% and connectives listed as extremely difficult (UNDERLINED CAPITALS) had a mean item facility of less than 30%.

Eighteen of the 34 selected logical connectives also occur as conjunctions in SiSwati. Of these, three are conjunctions and adverbs and one is a conjunction and adjective. The other seventeen occur as adverbs, adjectives, nouns or verbs.

Note that the word "futsi" in SiSwati is used for *also*, *further* and *moreover* and that "ngobe" is used for both *as* and *because*.

The 68 suitable multiple choice questions were selected from Gardner's one thousand examples. These were based on the 34 logical connectives that had been selected. Each logical connective was tested by a Gap Filling question and by a Sentence Completion question. The items selected were related to science content, but a few covered everyday concepts. Thus there were 34 Gap Filling questions and 34 Sentence Completion questions each testing the same 34 logical connectives. Certain items were modified slightly to fit the local conditions, i.e. use of Christian names, towns, countries and animal species.

EXAMPLE: *Ostrich* replaces *emu*.

These 68 items (questions) which formed the pilot tests were tested on staff members in the Department of Mathematics and Natural Science at the college. The staff members included mother tongue speakers of English, Afrikaans, SiSwati, and Swazi (a staff member from Swaziland) as well as a staff member from Ghana and a South African Indian. They all approved of the standard and content of the test items although they did not all attain 100%.

### 3.4 NULL HYPOTHESES.

Four null hypotheses were tested in the current investigation. As this investigation is based on Gardner's work, the tests are mostly criterion referenced and not norm referenced, as the focus is on difficulties caused by specific logical connectives and not on achievement by individual students.

**H<sub>0</sub> 1.** There will be no statistically significant correlations between the item facilities obtained by the Swazi students on the 34 Gap Filling Items and 34 Sentence Completion Items extracted from Versions A and B of the Diagnostic Test of logical connectives, using the Spearman test.

**H<sub>0</sub> 2.** The Form IV Australian pupils' item facilities on the 34 selected logical connectives will not be significantly different from the Swazi students' item facilities on the same 34 logical connective items.

**H<sub>0</sub> 3.** After an intervening period of six months there will be no statistically significant increase in each of the facility indices of 18 specifically selected logical connectives by the Swazi students.

**H<sub>0</sub> 4.** There will be no statistically significant correlations between the first year college students' scores on tests of logical connectives and their academic scores obtained in Matriculation Biology, Matriculation English, College General Science and College English Communication.

### 3.5 EXPERIMENTAL DESIGN AND PROCEDURE PROGRAM.

**FIGURE 3.2** summarises and depicts the diagnosis and collection of the data, using Version A, Version B, Version C and Version D of the test instruments. The time sequence for the several phases of testing are also presented.

# PHASE 1

March 1988

Diagnostic tests of purified 34 logical connectives on 65 first year general science second language college students	
Version A 34 logical connectives 19 GF and 15 SC	Version B 34 logical connectives 15 GF and 19 SC
$n_a = 30$	$n_b = 35$

# PHASE 2

Early August 1988

Version C - 18 logical connectives all GF $n_c = 56$
---

Late August 1988

Version D - 18 logical connectives all SC $n_d = 56$
---

# PHASE 3

Correlation Matrix

Comparison of marks from Versions C and D, Matric English, Matric Biology, College English Communication, and College General Science.

	ME	MB	CE	CGS	TC	TD	Total GS
ME							
MB							
CE							
CGS							
TC							
TD							
Total GS							

Figure 3.2 Experimental design

### **3.6 DATA COLLECTION AND VARIABLES.**

The data collected in this study were to serve two main purposes.

Firstly, evidence was sought of unusual interpretations of English logical connectives by students of non-western origin (Swazis) i.e. items in which a high number of the Swazi students selected a specific alternate response.

Secondly, evidence was sought as to whether the scores of these students in their use of logical connectives were significantly associated with their academic scores in selected subjects.

Accordingly, the data gathered in this investigation consisted of the following:

#### **3.6.1 INDEPENDENT VARIABLES AND THEIR INSTRUMENTS**

The independent variables examined in this study were the four instruments used to collect data. These were:

Version A (19 GF and 15 SC items)  
 Version B (15 GF and 19 SC items)  
 Version C (18 GF items)  
 Version D (18 SC items)

#### **3.6.2 DEPENDENT VARIABLES AND THEIR INSTRUMENTS**

In order to test the hypotheses listed in section 3.4, the following data were also collected:-

- English Scores obtained by the Swazi students in the National Matriculation Examination.
- Biology/Physical Science Scores obtained by the Swazi students in the National Matriculation Examination.

- English Communication Scores obtained by the Swazi students in the College First Year Examination.
- General Science Scores obtained by the Swazi students in the College First Year Examinations.

The details of the Matriculation results and the college examination scores were obtained from the college students' personal files.

### **3.7 DEVELOPMENT AND REFINEMENT OF THE INSTRUMENTS.**

- Two sets of Diagnostic Test Scores were obtained based on a modified Gardner instrument. In its pilot phase this consisted of 68 experimental parallel items (34 logical connectives - tested as pairs of 34 Gap Filling and 34 Sentence Completion items). In these first two trial diagnostic tests (Version A and Version B), the 68 items were divided into two parallel diagnostic test forms, each containing 34 items. To maintain the interest of the students through variety of item presentation, Diagnostic Test Version A, written by half the class, consisted of 19 Gap Filling and 15 Sentence Completion items while Diagnostic Test Version B, written by the other half of the class, consisted of 15 Gap Filling and 19 Sentence Completion items, being the pairs of Version A but in opposite format. Alternating the two test formats also eliminated any form of copying between students at neighbouring desks. The pilot phase of the investigation was thus exploratory in nature, to assess the suitability of various items for Swazi students.

A brief motivational talk was given prior to the administration of the diagnostic tests, relating to the problems caused by a second language in teaching science,

briefly mentioning the understanding and use of logical connectives as the focus of the tests. These motivational talks were received positively by the students, who responded enthusiastically and conscientiously.

The test responses were evaluated and the item facilities were compared with the item facilities obtained by the form IV Australian pupils. After studying the indices of difficulty of the original 34 logical connectives, 18 were selected for further study because of their unusual degree of difficulty or ease with the Swazi group as a whole. Because the Swazi students' item facilities on the other 16 logical connectives were almost identical to those of the form IV Australian pupils, it was decided that they had served their purpose at this point in the investigation and so they were dropped. These 16 discarded, or culturally less interesting logical connectives are listed in TABLE 3.2.

In the case of the other 18 trial logical connective items, the Swazi students' item facilities were at least 15% above or below the form IV Australian pupils' item facilities (perhaps for esoteric, cultural or academic reasons in South Africa).

These 18 culturally more interesting logical connectives, chosen on the basis of a comparative item analysis, are also listed in TABLE 3.2.

Hence two delayed tests of logical connectives based on the original pilot test versions were developed known as:

- Version C - (18 GF items) and
- Version D - (18 SC items).

The research thus narrowed to using two versions of 18 selected logical connectives as additional independent variables. These deviant local responses have generated a study with both quantitative (rigorous) and interesting qualitative (interpretive) aspects.

EASIER FOR THE SWAZI STUDENTS	MORE DIFFICULT FOR THE SWAZI STUDENTS	SAME FOR THE SWAZI STUDENTS AND THE AUSTRALIAN PUPILS.
<p>conversely (SC) for example (SC) further (GF) obviously (SC) respectively (GF) that is (GF,SC) viz. (GF,SC)</p>	<p>apart from (GF,SC) because (GF) but (SC) conversely (GF) further (SC) however (GF,SC) if...then (GF) in turn (GF) instead (GF,SC) moreover (GF,SC) obviously (GF) respectively (SC) since (SC) where (SC) yet (GF,SC)</p>	<p>after also as clearly due to from hence in other words including just as much like now similarly such as therefore whether</p>
<p>18 logical connectives selected for use in test versions C and D, that are academically and culturally interesting.</p>		<p>16 academically common logical connectives.</p>

TABLE 3.2 Comparison of the relative difficulties in different formats of the 34 logical connectives amongst form IV Australian pupils and the Swazi students (See Appendix Va).

### **3.8 SELECTION OF CRITERION SCORES.**

The scores that the college students obtained in their Matriculation English and Biology examinations, as well as the scores obtained at the end of their first year in their English Communication and General Science College examinations, were taken as criterion scores. These were compared with their item facilities in Version C and Version D on the 18 logical connectives. The scores from the Matriculation and College examinations were thus taken as academic scores with which the item facilities can be compared.

### **3.9 SUMMARY.**

In this chapter the experimental design and procedure has been discussed. The investigation has been divided into three phases.

#### **PHASE I.**

Thirty four logical connectives (68 items; 34 Gap Filling and 34 Sentence Completion) were selected from Gardner's comprehensive list. These were modified to suit local conditions and used in the pilot study. Two tests, Versions A and B were used in this pilot study, half the sample writing the one test and the other half the other test.

#### **PHASE II.**

The Swazi students' item facilities on the pilot tests were compared with Gardner's form IV students' item facilities and 18 logical connectives were selected for a second series of tests, Test Versions C and D. These two tests were administered six months later. Each of these tests were written by the whole sample.

### PHASE III.

The item facilities from these tests, as well as the students' academic scores on English and Biology at Matriculation level and college level, were compared as set out in four hypotheses.

The results of this investigation are discussed in chapter 4.

## **CHAPTER 4.**

### **PRESENTATION OF RESULTS AND ANALYSIS OF DATA.**

In this chapter the results of the investigation are presented and analysed. The results are summarised as each hypothesis is discussed in turn. Other results of cultural interest are also presented in this chapter. A discussion of the emerging significant differences will occur in chapter 5, including possible explanations for these findings.

#### **4.1 ANALYSIS AND VALIDATION OF THE SCORES.**

If two different forms of a test are validly measuring the same single construct, then a predictive validity coefficient of 0.50 is considered acceptable when using scores obtained by individuals in Educational and Psychological studies (Ebel 1972:301), with a range of 0.30 to 0.70. In chapter 2 Gardner reported  $r = 0.49$  (in his pilot test) for the topic under investigation, but this was not obtained by correlating scores; instead it was from correlating Gap filling and Sentence completion item facilities - an unusual technique which does not establish construct validity as such.

Sixty five students wrote the original pilot tests. The item facilities, which were compared with Gardner's item facilities, were based on this opportunistic sample of 65 students in order to select the 18 logical connectives used in the second series of tests i.e. Versions C and D. Only 56 of the original 65 students wrote the second series of tests. For the purpose of continuity, the item facilities of only

these 56 students are considered in the hypotheses and in any comparisons between Versions A and B and Versions C and D.

### H<sub>0</sub> 1. - THE SIGNIFICANCE OF ITEM FORMAT.

That there will be no statistically significant correlations between the Swazi students' item facilities on the 34 Gap Filling Items and on the 34 Sentence Completion Items extracted from Versions A and B of the Diagnostic Test of logical connectives, using the Spearman test.

Using the item facilities from Versions A and B, but separating them into Gap Filling and Sentence Completion items and subjecting these 34 pairs of item facilities to a Spearman rank-order test, a correlation coefficient of  $r = .50$ , was obtained ( $n=34$ ,  $df=32$ ,  $p<0.01$ )(See Appendix VIII). The null hypothesis is thus rejected.

Gardner reports a similar correlation coefficient on his pilot test (50 items, 25 GF and 25 SC) across forms I-IV of  $r = 0.49$ , between the Gap Filling and Sentence Completion Tests.

### INTERPRETATION.

The evidence suggests that the Tests A and B are measuring item facilities with regard to logical connectives equally as well as Gardner's Tests. Because the correlation obtained is not perfect, i.e 1.00, the 34 Sentence Completion items are not measuring exactly the same thing as the 34 Gap Filling items. In other words,

although they may be substantially measuring understanding of the same 34 logical connectives, they are also measuring, among other things, ability to handle different test formats. In this case the validity coefficient obtained is 0.50. While this is both strong and significant, it is not clear cut, suggesting that something other than logical connectives have been measured by the test items, most probably reaction to the different item formats and structures.

#### H<sub>0</sub> 2. - INTERNATIONAL CORRELATIONS ON THE SAME ITEMS.

That the Form IV Australian pupils' item facilities on 34 selected logical connectives will not correlate significantly with the Swazi students' item facilities on the same 34 logical connective items.

The correlation coefficient for Test A comprising 34 items versus an equivalently constructed test using Gardner's pupils' item facilities gives  $r = 0.57$  items, while the correlation coefficient for Test B versus an equivalent Test using Gardner's pupils' scores gives  $r = 0.70$  (See Appendix VIII). The null hypothesis is thus rejected.

#### INTERPRETATION.

These correlations are satisfactory, approaching 0.70 which is very good, and is an international corroboration of a sample of Gardner's work which is producing substantially acceptable results. Thus Gardner's work is being validated on the African continent i.e. logical connectives appear to be substantially measuring universal English language ability and proficiency by pupils, but with local

variations. The local value of  $r = 0.70$  substantiates Gardner's construct or notion of a logical connective in a world context.

H<sub>0</sub> 3. - PERFORMANCE INCREASE WITH TIME.

That after an intervening period of six months, there will be no statistically significant increase in each of the facility indices of the 18 selected logical connectives by the Swazi students.

McNemar's test for the significance of change is particularly applicable to those "before and after" designs in which each person is used as his own control and in which measurement is in the strength of either a nominal or an ordinal scale (Siegel 1956:63). The McNemar test in this case was applied to each of the 18 logical connectives on a "before and after" basis for each of the 56 students (24 and 32 in each group respectively). The values in TABLE 4.1 are found in Appendix Va (A+B)<sup>2</sup> and C+D.

To test for the significance of any observed changes using the McNemar test a fourfold table of frequencies is set up to represent the first and second sets of responses from the same individual.

A	B
0,0	0,1
1,0	1,1
C	D

Where 0,0 & 1,1 represent no change and 1,0 & 0,1 represent a change in the individuals' responses (0 = wrong answer, 1 = right answer).

We are only interested in those cells which show change i.e. B and C. The Chi-square value is calculated using:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where E represents expected frequency and O represents observed frequency.

or 
$$\chi^2 = \frac{(B - C)^2}{B + C}$$

Where B represents expected frequency and C represents observed frequency as shown in the fourfold table of frequencies shown above.

In my calculations I used the following formula which includes Yates' correlation for continuity (Siegel 1956:64):

$$\chi^2 = \frac{(|B - C| - 1)^2}{B + C} \quad df = 1$$

Where B and C have the same meaning as above.

Of the 36 (18 logical connectives) items tested 11 show a significant change.

Although this is significant educationally it is not statistically significant and thus the null hypothesis is not rejected.

LOGICAL CONNECTIVE	GAP FILLING			SENTENCE COMPLETION		
	Item Facility Mar 1988	Item Facility Aug 1988	Chi Square Value	Item Facility Mar 1988	Item facility Aug 1988	Chi Square Value
Apart from	22	53	5.87*	33	38	0.00
Because	63	78	1.45	79	88	0.60
But	91	84	2.25	58	100	8.10*
Conversely	9	25	2.88	17	50	4.08*
For example	69	91	4.00*	83	96	0.80
Further	38	41	0.00	29	88	12.07*
However	47	72	6.10*	50	67	1.50
If...then	35	50	1.45	58	71	0.36
Instead	54	38	2.50	66	78	1.13
In turn	71	83	2.00	91	84	1.50
Moreover	8	46	7.11*	47	56	0.31
Obviously	50	50	0.17	88	97	0.80
Respectively	58	50	2.25	22	34	0.75
Since	79	75	0.57	47	66	1.78
That is	71	96	4.16*	91	91	0.00
Viz.	83	96	0.57	86	94	4.16*
Where	83	92	0.17	56	78	4.00*
Yet	54	67	0.57	75	94	4.16*

TABLE 4.1 The 18 selected Logical Connectives subjected to the McNemar test. (Chi square of 3.84 at  $p = 0.05$ , \* denotes all values greater than Chi square at  $p = 0.05$ .)

All the values in TABLE 4.1 marked with an asterisk indicate higher values than the minimum Chi-square value of 3.84 for  $p = 0.05$ . *Apart from*, *for example*, *however*, *moreover* and *that is* used in the Gap Filling format show significant performance change, as do *but*, *conversely*, *further*, *viz.*, *where* and *yet* in the Sentence Completion format.

#### INTERPRETATION.

Learning may have occurred "spontaneously" during the intervening six months. This is detected sometimes by the Gap filling items alone and sometimes by the Sentence completion alone in TABLE 4.1 above.

H<sub>0</sub> 4 - CORRELATIONS WITH ACADEMIC SUBJECTS.

There will be no statistically significant correlations between the first year college students' scores on tests of logical connectives and their academic scores obtained in Matriculation Biology, Matriculation English, College General Science and College English Communication.

	ME	MB	CE	GS	TC	TD	CD
ME	1.0000 (56) .0000	.1608 (56) .2366	.4348 (56) .0008	.3927 (56) .0028	.3251 (56) .0145	.3622 (56) .0061	.3676 (56) .0053
MB	.1608 (56) .2366	1.0000 (56) .0000	.2482 (56) .0651	.3131 (56) .0188	.1153 (56) .3973	.2523 (56) .0607	.1878 (56) .1657
CE	.4348 (56) .0008	.2482 (56) .0651	1.0000 (56) .0000	.5876 (56) .0000	.5769 (56) .0000	.5483 (56) .0000	.6158 (56) .0000
GS	.3927 (56) .0028	.3131 (56) .0188	.5876 (56) .0000	1.0000 (56) .0000	.4899 (56) .0001	.4515 (56) .0005	.5115 (56) .0001
TC	.3251 (56) .0145	.1153 (56) .3973	.5769 (56) .0000	.4899 (56) .0001	1.0000 (56) .0000	.6616 (56) .0000	.9341 (56) .0000
TD	.3622 (56) .0061	.2523 (56) .0607	.5483 (56) .0000	.4515 (56) .0005	.6616 (56) .0000	1.0000 (56) .0000	.8853 (56) .0000
CD	.3676 (56) .0053	.1878 (56) .1657	.6158 (56) .0000	.5115 (56) .0001	.9341 (56) .0000	.8853 (56) .0000	1.0000 (56) .0000
Key to Table:	ME Matric English						
	MB Matric Biology						
Coefficient	CE College English						
(sample size)	GS College General Science						
significance level	TC Test C						
	TD Test D						
	CD Test C and Test D						

TABLE 4.2 Matrix of academic scores

The matrix in TABLE 4.2 records the correlations of students' scores obtained among Version C and Version D and their four sets of academic scores.

Moderate to high correlation trends occur among all the variables with the exception of Matriculation Biology. This may be due to chance or to the way in which the Matriculation Biology examination is structured. The understanding of logical connectives appears to be significantly related to success in academic college and matriculation examinations. The null hypothesis is thus refuted for most correlations.

#### INTERPRETATION.

As mentioned earlier, this investigation - as well as Gardner's original work on which this investigation is based - is concerned with how well students comprehend the use of certain logical connectives at various stages of their education. It has been established in the literature that Cloze procedures provide a good index of comprehension (Gould, 1977:250; Wegerhoff, 1981:38; Wright, 1982:4), and Sentence Completion is almost synonymous with the Cloze procedure.

In TABLE 4.2 (page 50), the highest correlation with academic scores, 0.62, occurs between College English and the combined score of Gap Filling and Sentence Completion. College English is taught as a communication skill with the emphasis on comprehension. The correlation matrix also concerns comprehension. The correlation between Gap Filling and Sentence Completion is 0.66. This approaches the strong theoretical validity coefficient of 0.70. In other words, it provides substantial support for the construct validity of both versions of the test. The fact that the teaching of English at the college is aimed at

comprehension, the correlation between College English and Total Test (Gap Filling and Sentence Completion) appears to be important.

The correlation between Total Test (Gap Filling and Sentence Completion) and College Science of 0.51 is consistent, as is the correlation between College English and College Science of 0.59.

The lower correlations with the Matriculation examination scores indicate that something other than English comprehension was being measured in them.

## **4.2 DIAGNOSIS.**

### **4.2.1 TEST VERSIONS A AND B.**

Diagnostic test Version A and Version B were analysed and the item facilities of difficulty for each of the logical connective items were calculated (Appendix V a)

In collaboration with the supervisor of this investigation, the item facilities obtained by the college students were compared with Gardner's item facilities (Appendix V a). Where inspection revealed appreciable over- or under-achievement of the order of 15% in the college students' item facilities, possible explanations were suggested for each item deviation. Ambiguity, cultural factors, lack of laboratory experience, acceptable alternative answers, or combinations of these factors were considered as possible reasons for the deviations from Gardner's pattern of responses.

A list of these deviating items, (Appendix IV) as well as the proffered reasons, were given to the SiSwati Language Board to scrutinise and they considered these suggestions as acceptable. (Copy of letter from SiSwati Language Board - Appendix III)

In this evaluation of the 34 logical connectives used in Version A and B in the original pilot study with 65 students, 19 logical connectives stood out from Gardner's item facilities. Of these, 18 were selected and used in the second series of Achievement Tests, Test C (18 Gap Filling Items) and Test D (18 Sentence Completion Items). *Much like* was not included as it is not commonly used in SiSwati.

The item facilities on the logical connectives in Diagnostic Test Version A and in Diagnostic Test Version B were ranked (Appendix V b and V c). From these rank tables it is clear that there is a degree of similarity in positions of certain logical connectives at the top and bottom in both formats of presentation (Gap Filling and Sentence Completion), indicating that certain logical connectives appear to be consistently more difficult while others are consistently easier. Spearman rank correlations give a coefficient of 0.50 for the Swazi students and 0.70 for Gardner's pupils (Appendix VIII).

Rank order scores of Test C and Test D are also presented (Appendix V d and V e). When compared with the rankings of the equivalent items in the Diagnostic Test Versions A and B similar trends are visible with respect to logical connectives that are consistently difficult or easy.

#### 4.2.2 TEST VERSIONS C AND D.

The item facilities for each item in the second series of tests (Versions C and D), written six months later, were compared with the item facilities for the equivalent items in the first tests (Versions A and B). An overall improvement was noted. Of the 36 items tested - 18 Gap Filling and 18 Sentence Completion (based on the same logical connective) 31 showed higher item facilities and 5 lower item

facilities. Certain improvements were noteworthy (15% and more), as presented in TABLE 4.3

LOGICAL CONNECTIVE	TYPE	CHANGE IN ITEM FACILITY VALUE	INCREASE OVER SIX MONTHS
Further	(SC)	29% to 78%	49%
But	(SC)	58% to 97%	39%
Conversely	(SC)	17% to 55%	38%
However	(GF)	47% to 81%	34%
Apart from	(GF)	22% to 52%	30%
Moreover	(GF)	8% to 38%	30%
Where	(SC)	56% to 83%	27%
Respectively	(SC)	22% to 48%	26%
Since	(SC)	47% to 72%	25%
However	(SC)	50% to 72%	22%
Because	(GF)	63% to 84%	21%
For example	(GF)	69% to 90%	21%
Conversely	(GF)	9% to 28%	19%
Further	(GF)	38% to 57%	19%
Yet	(SC)	75% to 93%	18%
Instead	(SC)	66% to 83%	17%

TABLE 4.3 Logical connectives which showed improvement in item facility.

The fact that there appears to be improvement on more Sentence Completion items may be due to the fact that this test (Test D) was written three weeks after the Gap Filling item test (Test C) and a certain amount of intervening or spontaneous learning may have occurred. The overall improvement may be due to greater exposure to English first language speakers at the college and continuing use of English on a daily basis. TABLE 4.4 records the cases in which the mean scores dropped, but not by a large margin:

LOGICAL CONNECTIVE	TYPE	CHANGE IN ITEM FACILITY VALUE	DECREASE OVER SIX MONTHS
Since	(GF)	79% to 78%	1%
But	(GF)	91% to 84%	7%
In turn	(SC)	91% to 83%	8%
Respectively	(GF)	58% to 47%	11%
Instead	(GF)	54% to 41%	13%

TABLE 4.4 Logical connectives on which the item facilities dropped.

The decrease in item facilities recorded in the five cases listed above are attributable to random variation, except, perhaps in the cases of *respectively* and *instead*. What is interesting to note overall is that the item facilities dropped mainly in the Gap Filling items and rose mainly in the Sentence Completion items.

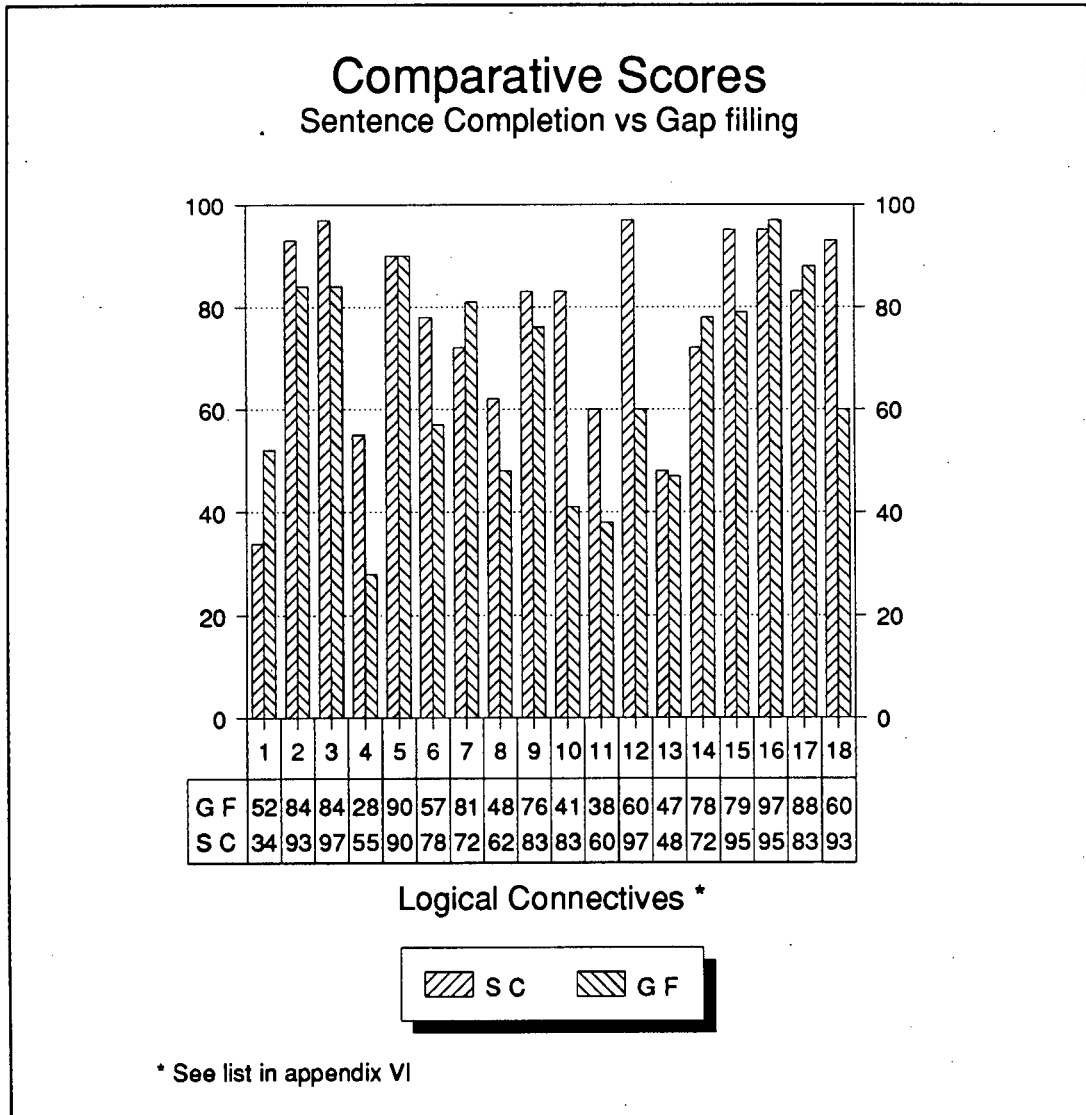


FIGURE 4.1 Achievement - gap filling versus sentence completion (Tests C and D)

From FIGURE 4.1 it appears that the students cope better on Sentence Completion than on Gap Filling although not significantly. On comparing the overall achievement of Gap Filling and Sentence Completion using the Wilcoxon Test,

the difference ( $Z = 0.74$ ) was not significant (Appendix V f). Gardner also found that there was no significant difference between the Gap Filling and Sentence Completion items (using the sign test), and that in general, the item type is unrelated to the item difficulty (Gardner 1977(a):77).

Nevertheless, in his major study Gardner found that at Form I level, everyday-Gap Filling items appeared a few percent easier. However the purpose of the present investigation was not to determine if students coped better on Gap Filling or Sentence Completion items.

The remarkable improvement after six months on the second series of test item facilities (Versions C and D) may be explained by suggesting that the students had learnt partly from the first series of tests (Versions A and B). When the second test series was run the students did say "M'am we've done this test already". This was partially true because they had tackled some of the items previously and were familiar with the format and content of the questions.

The first series of tests had not been handed back to the students, and neither had there been remediation or discussion on the items in the original tests. The question papers were collected after the first series of tests, so neither learning nor revision of the questions was possible; and neither were the students warned about the second series of tests.

Students were more familiar with sentence completion as a didactic form of imparting information. It is the standard format for multiple choice type questions as well as for verbal questioning in African classes. The slightly better achievement on this format may thus be related to the cultural aspects of teaching to which they are exposed and accustomed.

Because some of these changes are appreciable and noteworthy, and because a number of the item facilities are now above the item facilities determined by Gardner, the following suggestions are made to account for the improved competencies:-

- Greater continuous and extensive exposure to first language English (EL1) speakers i.e. lecturers, especially in first year at an African college with English as the official medium of instruction;
- Increased reading and research in English for college assignments in all subjects using reference materials for secondary and tertiary levels;
- Greater exposure to a variety of media, both audio and visual, using English as medium of instruction;
- Having to cope in English at a higher academic level (more academic than at school) in all college subjects; and
- Having to communicate competently, at least 60% of the time, in English.  
When problems are encountered at school level pupils and teachers lapse into mother tongue frequently because their command of English is inadequate.

Looking at isolated results (Appendix VII - Frequency Tables) reveals the problems experienced with the use of specific logical connectives as well as general language problems:-

APART FROM: the inadequate use of *apart from* in Sentence Completion format seems to indicate a problem with the scientific concept of keeping the temperature constant during an experiment, while the use in Gap Filling format shows that *apart from* as a connective is problematic because *by way of* and *rather than* are selected in preference to *apart from*.

CONVERSELY (classified by Gardner as extremely difficult): The Swazi students also experienced problems. In the Sentence Completion format, the correct option was not the one selected most frequently because the connective is not understood by the students. In the Gap Filling format *for example, in contrast, often, and on the other hand* were more popular as correct answers.

ALSO: The use of *also* to start a sentence in the Sentence Completion format proved problematic. In South Africa *also* is more commonly used within a sentence than to start it.

In chapter 3 it was noted that in SiSwati "futsi" is used for *also, further* and *moreover* and that "ngobe" is used for *as* and *because*. Looking at the students' choices of options on *also, further* and *moreover* in both Gap Filling and Sentence completion formats in the Frequency tables (Appendix VII), some form of confusion or uncertainty exists. All three concepts exist in SiSwati but are covered by one word. Possibly because of this use of one word, the distinction is not clear and so leads to problems of comprehension.

The use of "ngobe" for *as* and *because* does not create as great a problem. These logical connectives are not considered to be difficult ones, and from the responses, which are inverted in the two formats, it appears that it might be the content/concepts in the items that are more problematic.

#### **4.3 REMEDIATION.**

No supplementary instruction was planned in this investigation or purposefully conducted after the first series of tests. The only form of learning that may have occurred during the six months between the two series of tests, would have been

through incidental teaching of concepts and syllabus content common with some of the test items. No portion of the syllabus relating to any of the concepts in the tests was purposefully selected during this period. Teaching was done according to the work programme planned independently, and was in no way related to the tests.

#### 4.4 OUTCOMES OF STUDY.

At the start of this investigation, one of the expectations was that similarities would exist between the item facilities obtained by the college students and those of the Form IV Australian pupils on the 34 selected logical connectives.

This is supported to a large extent by their performance on Diagnostic Test Version A where their item facilities range from 8-100 as compared with Gardner's item facilities range of 17-98 and by a range of 17-100 for the Swazi students and 8-95 for Gardner's pupils on Diagnostic Test Version B (Appendix V g).

Verification of the assumption that local African cultural nuances and contexts would affect students' understanding of, and performance on, certain English logical connectives received corroboration in respect of the following 10 logical connectives of the initial 34 selected:- *apart from, for example, further, however, instead, obviously, that is, since, viz. and yet.*

Another aim of the study was to show that appreciable relationships existed between the students' scores on the tests on logical connectives and their academic examination scores on English, Biology and General Science. This was supported by the findings as set out in TABLE 4.2.

## **CHAPTER 5**

### **SUMMARY, IMPLICATIONS AND RECOMMENDATIONS.**

In this chapter the results of the investigations are discussed and possible implications and recommendations flowing from these findings are set out.

#### **5.1 CONCLUSIONS.**

In this investigation a group of Swazi students' item facilities on 34 logical connectives were compared with those obtained by a group of Form IV Australian pupils on the equivalent 34 logical connectives, in both Gap Filling and Sentence Completion format.

The Swazi students' item facilities on a pilot test were also compared with a second test administered six months later to determine if any change occurred over this period.

1. Sixteen of the logical connectives were found to be equally easy or equally difficult for both groups based on the pilot study findings.
2. Fifteen of the logical connectives appeared to be more difficult for the Swazi students either in GF or SC format, or both, and seven logical connectives appeared to be more difficult for the Australian pupils either in GF or SC format, or both, based on the pilot study findings.
3. Improvement of the Swazi students' item facilities over the six month period was pronounced on sixteen items although mild performance regression was recorded on two logical connectives.

4. The logical connectives *conversely* and *moreover* - considered to be extremely difficult - and *further, respectively* and *similarly* - considered as very difficult by Gardner (1977(a):57) - proved to be very problematic for the Swazi students as well. The Swazi students coped well with *viz.* listed as extremely difficult by Gardner, but this is possibly due to the fact that it occurs relatively frequently in South African Science textbooks.

## 5.2 DISCUSSION AND RECOMMENDATIONS

1. If most of the Science textbooks used by the EL2 pupils and students (as well as those used by EL1 pupils) contain very terse English, technical and difficult vocabulary (Barrass 1979), complex sentences (Carrick 1978:113, Wright 1982:3) and tend to be overloaded with logical connectives, it would be advisable to examine these texts. Publishers and textbook authors of South African science textbooks should take note that certain logical connectives appear to be problematic and should use them with discretion, and consider carefully the language they use in school textbooks. As Young (1986:51) says, the language of textbooks is a topic for extensive research, and writers and publishers could place much greater stress on concept formation, sounding of words and use of tenses, eg. past tense and subjunctive forms for history.
2. This study confirms the view of Mawasha that greater exposure to English and to EL1 speakers improves the students' proficiency in the use of English and also their comprehension of English. Mawasha (1979:50, 1983:55-56, 1984:13) suggests that most Black EL2 teachers should do more training in English at College or University to increase their competency and to raise the general level in English. There would seem to be an implication that in the

case of science teachers, English proficiency should be a criterion for appointment, particularly at secondary school level.

3. Attention must be given to the language used when teaching science. All teachers are language teachers (Ashworth 1985:6, Rice 1982:53, Venter 1985:14) - a recommendation from the Bullock Report of 1975. In order to understand the language of science, pupils must understand the language of instruction i.e. English, in both spoken English by the teacher and the language used in textbooks (Barrass 197: 191, Carrick 1978:121 Gould 1977:248) . Teacher training curricula need to be restructured to place greater emphasis on English and how it is used in science. Aspects like logical connectives, tenses, reporting, reading with understanding, use of Latin and Greek and degrees of comparison could be included.
4. There is an indication that Education structures should allow greater exposure of EL2 speakers to EL1 speakers. Continuous exposure to EL1 speakers was associated with improvement in the Swazi students' ability on logical connectives and coping skills in English.
5. Many teachers could work together on improving English proficiency using common themes across the curriculum, improving English usage in their given subject at the same time.

"All teachers, regardless of subject, need to be made aware that *all* teachers are language teachers . . . One of the major priorities of a language policy is to heighten teachers' awareness of the complexities and subtleties of language and the particular demands that their subjects make on the language skills of pupils and students." (Rice 1982:53)

6. Science and technology need a clear understanding and use of English particularly, in the scientific world. If third world countries are to catch up with first world science and technology (Ogunniyi 1986:119), there is a need to understand and use scientific and technological terminology competently. Basic English has to improve, eg. a telecommunications technician must be able to understand terminology and concepts, and how to link these logically and cope with abstraction. Logical connectives such as *if ... then, conversely, respectively* and *consequently* would be important in such situations.

### 5.3 IMPLICATIONS FOR FURTHER RESEARCH

The findings revealed by this investigation suggest the following for teaching science to EL2 learners:

1. This investigation could be extended to other local EL2 speakers, i.e other ethnic groups eg. Zulu, Sotho and Afrikaans, and at high school and tertiary levels for both EL1 and EL2 groups in South Africa.
2. A study of this nature could be conducted on a sample similar to the one used in this investigation, but attention could be placed on low and high achievers and how their proficiencies change when retested six months later to see if significant changes occur among the groups.
3. Would exposure of EL2 pupils to EL1 children of their own age group from primary school not improve their English? Would open schools not improve the Swazi pupils' English and, at the same time, improve the English pupils' mastery of Swazi or other second language?

4. Readability tests could be carried out on local science textbooks using a Cloze procedure on logical connectives.

#### **5.4 EVALUATION OF THE EXPERIMENTAL DESIGN**

No data gathering method is without weakness or error. In the case of the current investigation, the population was restricted by student unrest in the area and the study could have benefitted from a larger sample.

In addition it may have been beneficial for the study to include everyday as well as scientific items for each logical connective tested.

#### **5.5 ISSUES RAISED BY THIS STUDY NOT FOUND IN THE AUSTRALIAN STUDY**

A large number of Black African pupils are restricted in an impoverished Education system. There is a lack of suitable facilities and adequately qualified teachers. Most of the teaching is done by EL2 teachers to EL2 learners, with little or no chance for improvement in English proficiency unless English at teacher training level is drastically improved. What type of "role model lecturer" is needed? Do the students want impeccable European EL1 lecturers for the sake of language purity, or Swazi EL2 lecturers for the sake of cultural priorities? Answers to these questions will continue to evolve as the new South Africa of the 1990's emerges in a spirit of hope and optimism.

## 5.6 CONCLUDING REMARKS

What then of mother tongue education? In certain studies in Africa it was found that primary children studying science, cope equally well whether they are taught in English or in their mother tongue, and sometimes even better when taught in their mother tongue (Ehinder 1980:287). As the language level becomes more complex, and as science concepts become more abstract at high school level, the African mother tongue has limitations due to the absence of technical and scientific terminology to cope with concepts foreign to the language and culture. The terminology problems can be overcome if consensus on terms can be reached, but the costs of translation and printing in the many different vernacular forms mitigate against this. It thus seems natural that science and other high school subjects be taught through the medium of English.

However, this is not without its problems, as can be seen from the findings of this study. Looking at one aspect of English, Gardner found that first language learners experienced problems in the use and understanding of certain logical connectives in their studies in science. In this study Gardner's findings were corroborated in English second language. Swazi students in KaNgwane, South Africa, experienced similar difficulties, but their problem is compounded because English is not their mother tongue, nor is it the mother tongue of most of their teachers.

Nevertheless, the findings presented in this African study indicate the attainment of relatively high levels of understanding and achievement using one quite demanding linguistic "yardstick" from Australia, suggesting that a good measure of overall optimism and confidence for the future might not be entirely out of place, and might indeed be both appropriate and well merited under the current challenging circumstances of Southern Africa.

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While Eeore frets  
and piglet hesitates  
and Owl pontificates  
... Pooh just is.

**LIST OF SOUTH AFRICAN SCHOOL SCIENCE  
TEXTBOOKS ANALYSED.**

Exploring General Science - Standard 6

Fourie.D.I, Kaske.C.E.M.E, Wessels.B.J, van Huyssteen.J.A.  
Via Afrika Ltd. Goodwood, Cape Town. 1985.

Junior Secondary General Science - Standard 6

Walters, S.W, Fox.H.E, Schreuder.B.K, Voster,P.W.  
Maskew Miller Longman, Cape Town. 1983.

Understanding Science - Standard 6

Jansen.E and Dekker.J  
Maskew Miller Longman, Cape Town. 1985.

Modern General Science - Standard 7

Heyns.G.F, Cronje.N.S, de Villiers.G, Gibbon.D.B, Olmesdahl.A.B, du P du  
Toit.J.J, Botha. J, de Kock.D, du Toit.J.H, Ziervogel.A  
Nasau Ltd. Parrow, Cape Town. 1984.

Successful Science - Standard 7

Clarke.A, Clarke.A, Hurst.R, Thoka.I.B.M, le Roux.P, van Stormbroek.B.K  
Oxford University Press. Cape Town. 1985.

Discovering Biology - Standard 8

Thienel.A, Pellew.V, Green-Thompson.A.L, Ayerst.P.W  
Shuter and Shooter, Pietermaritzburg. 1985.

Living Biology - Standard 8

Kaske.C.E.M.E, Van Wyk.A.P, Clark.A, Cumming.J.M, Van Huyssteen.J.A.  
Via Afrika Ltd, Goodwood, Cape Town. 1986.

New Modern Biology - Standard 9

Botha.N.P.J, Van Dyk.J.J  
Educum Publishers, Johannesburg. 1986.

Senior Biology - Standard 9

Du Toit.J.J, van Rensburg. A.G, du Toit.J.H, Botha.J, Volschenk.B, van der  
Westhuizen.H.C, de Kock.D, Nienuhr.G.A  
Nasou Ltd. Goodwood, Cape Town. 1986.

Discovering Biology - Standard 10

Ayerst, Green-Thompson, Pellew, Thienel  
Shuter and Shooter, Pietermaritzburg. 1987.

Senior Biology - Standard 10

Du Toit.J.J, van Rensburg. A.G, du Toit.J.H, Botha.J, Volschenk.B, van der  
Westhuizen.H.C, de Kock.D, Nienuhr.G.A, Baird.D  
Nasou Ltd. Goodwood, Cape Town. 1986.

Senior Secondary Biology - Standard 10

Smit.A.L, Fox.H.E, van Dijk.D.E, Hennessy.E.F, Nel.D, Voster.P.W.  
Maskew Miller Longman, Cape Town. 1987.

TABLE 3.2.1  
DIFFICULT LOGICAL CONNECTIVES

again (furthermore)	FURTHER	notice that
also	furthermore	NOW (consider that)
alternatively	generally	now (instead)
and so	hence	occasionally
apart from	here	often
as (like)	i.e.	on the basis of
as much as	<u>IF</u> (LR items)	only if (LR item)
as though	in addition	RESPECTIVELY
AS TO	in contrast	say
at the same time	in fact	similar to
at this/that stage	in general	SIMILARLY
besides	in other word	simultaneously
by way of	IN PRACTICE	so also
clearly	in terms of	so far
commonly	in that	so to speak
consequently	in these examples	such that
<u>CONVERSELY</u>	in turn (in this order)	suppose/then
ESSENTIALLY	in turn (similarly)	THAT IS
first, second,,finally (CS item)	in (...) ways	the fact that
firstly, secondly, thirdly (CS item)	including	therefore (it follows logically)
for instance	indeed	thus (it follows logically)
for the same reason	IT FOLLOWS THAT	unlike
frequently	<u>MOREOVER</u>	VIZ.
from	much like	where (meaning of symbols being)
from (his/this) point of view	namely	whereby
	neither/nor	while (as long as)
	nevertheless	

A connective was included in this list if the mean facility at Form 4 level, averaged across the various items testing that connective, was less than 70%. CAPITAL LETTERS indicate a very difficult term (mean item facility less than 50%), UNDERLINED CAPITALS indicate extreme difficulty (mean item facility less than 30%).

LITIKO LETEMFUNDVO NEMASIKO  
DEPARTMENT OF EDUCATION AND CULTURE  
DEPARTEMENT VAN ONDERWYS EN KULTUUR

SISWATI LANGUAGE BOARD  
HULUMENDE WAKANGWANE  
KANGWANE GOVERNMENT  
KANGWANE REGERING



Sakaposi  
Private Bag X 1002  
Privaatsak  
LOUW'S CREEK  
1302

**KANGWANE**

3 November 1989

ayela:  
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erw. No.

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Miss J Cumming  
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1. Your letters dated respectively 30 March 1989 and 27/9/89 refer .
2. I am sorry that it took such a long time to respond especially to your first letter which intended you would have the Board's response after their meeting at which the assignment would have been submitted.
3. The assignment, because of other commitments the Board had to attend to in line with their agenda, was not presented to them. I then, inadvertently or even stupidly, stored it away, as, from the initial glance, it looked quite beyond my reach to grasp what it was all about.
4. After your second letter I took the assignment again and looked it closer. For the symbols "GF" and Sc" I still am not quite sure of what they all are about. I smatteringly guess from your comments what the G stands for namely 'Gardener' but for the Sc I only guess that it relates to the Scores as related to the Gardner scores.
  - 4.1 My closer scrutiny made me attempt to reply to your enquiry as follows:
    - (a) Your observations with respect the causes for good or fair and poor performance in the use of the connectives involved, are correct in all the cases.
    - (b) We have some of the connectives , e.g. But , Because, Instead, however, in high frequency in the native language. The language difficulty as you observe in some of the others, is aptly relevant. Misunderstanding and cultural background

are pertinent in the probable causes of poor performance in the cases you observed. The field within the context of which the connectives were used indeed also played a part in the quality of the scores of your students. Some of the connectives are not easily rendered in the native language and request proficiency in both English and SiSwati to be used correctly.

5. In conclusion I submit that, in my opinion, you have done your homework well and I sincerely believe you know your thing. You have to reach much down to find me that I have really dared to even have a little to say to an M A student.

I wish you well in your academic effort.

Yours sincerely

SECRETARY

**Summary of interpretation of results on logical connective tests given to SiSwati Language Board.**

NOTE: MUST BE READ WITH SUMMARY OF RESULTS SHEET, TEST A AND TEST B QUESTIONNAIRES AND FREQUENCY TABLES.

**1. Swazi student's item facilities UP on Gardner's item facilities**

**THAT IS:** Carbon dioxide formula

- Drill and repetition method of teaching at school
- Basic course content
- Improvement due to exposure to EL1 speakers.

**VIZ.:** Protein structure

- Drill and repetition teaching vs inquiry, invitation to learn methods.
- Common in South African textbooks.
- Note imbalance on Gardner's scores.

**2. Swazi students' item facilities DOWN on Gardners' item facilities**

**BECAUSE:** Potassium stored under paraffin

- Cultural background - potassium uncommon
- Lack of equipment, laboratories, practical experience.
- Improvement due to experience with potassium during test period, and contact with EL1 lecturers.
- Note balance on Gardner's scores

**BUT:** Snails for aquarium

- Cultural discrepancies - aquarium and petshop are foreign concepts
- Note imbalance on question format - Gardner's scores are better
- Improvement due to exposure to EL1 speakers and practical ecology.

**HOWEVER:** Camping trip

- Low on both formats of question - language, misunderstanding of question and inability to use "however"
- Cultural discrepancy - camping not part of culture
- Improvement due to exposure to EL1 speakers.

**IN TURN:** Food chain

- Structure of GF question poor - better on SC format
- Improvement possibly due to greater emphasis on practical ecology.

**SINCE:** Distilled water for batteries

- Distilled water and car batteries foreign to culture - cultural and concept problem
- Biology students not familiar with course content of Physical Science syllabus
- Use of "since" in SC format problematic

**WHERE:** Saliva in digestion

- Concept that tends to cause problems in teaching - chemistry
- Question format - GF easier to cope with language

**YET:** Flightless bird - ostrich

- Logical connective not common
- Language usage - not common to start a sentence with "yet"
- Although an ostrich is a South African bird not all children have seen one - do not occur in KaNgwané - culture

**3. Alternate forms acceptable**

Options other than those suggested as correct by Gardner selected by students. I consider these acceptable or correct due to local language usage and cultural bias.

**APART FROM:** Experiment was easy

- Alternate forms acceptable due to structure of question - restructure
- Problem with use of logical connective "apart from" - still problematic after six months exposure to EL1 speakers.

**FURTHER:** Tadpoles - characteristics of frogs

- Wide spread of options selected. Logical connective considered very difficult and this is evident.
- Structure of item difficult. Not common to start a sentence with "further".
- Marked improvement - due possibly to more reading in English and exposure to EL1 speakers.

**IF...THEN:** Iron in soil

- Alternate forms acceptable - "even if ...then", "if...then" difficult to use and not much improvement over six months
- Gardners' pupils scores very average, thus also have problems with "if...then"

**INSTEAD:** Chemicals used by farmers

- Question format problematic
- Alternate logical connective acceptable locally - "also", "too"
- SC improves over six months but GF worsens

**OBVIOUSLY:** Body 80% water

- Alternate form acceptable - "on the other hand" suitable in GF item
- GF more problematic than SC
- Overall improvement - exposure to EL1 speakers

**RESPECTIVELY:** Lithium, sodium, potassium

- These metals not common culturally, foreign concept although part of science syllabus, not studied practically in most schools due to lack of laboratories
- Alternative form acceptable particularly SC item, and "accordingly" also acceptable locally
- Question format problematic
- Improve on SC item, regress on GF item ? Gardners' scores also on low side

#### **4. Universal Problems**

Both the Australian and the Swazi students experience problems comprehending these logical connectives. A slight improvement is noted on these item facilities but in general they indicate a problem area.

**CONVERSELY:** Setting of the sun.

- Universal language, comprehension and usage problem - see correlation with Gardner's profile scores. All scores are low.
- Not commonly encountered in textbooks except mathematics books.
- Improvement due to greater personal use of English in studies and through exposure to EL1 speakers. Use of "conversely" not used commonly in daily speech, but also possibly better comprehension of English and not necessarily of logical connective.
- Reason for improvement in SC format not known.
- Alternate logical connective acceptable in GF format - "in contrast". Spread of answers in second set of test not so diffuse.

**MOREOVER:** Use of DDT

- Universal language problem, academic term, not frequently used
  - "Futsi" used for "also", "further" and "moreover"... problematic association.
- Alternate logical connectives/options acceptable.

**TABLE OF ITEM FACILITIES.**

CONNECTIVE	FORMAT	GARDNER	A+B(1)	A+B(2)	C+D
after	gf	97	83	81	
	sc	93	90	92	
also	gf	53	54	50	
	sc	49	53	46	
apart from	gf	80	26	22	53
	sc	76	40	33	38
as	gf	78	74	72	
	sc	50	46	50	
because	gf	82	66	63	78
	sc	82	80	79	88
but	gf	93	87	91	84
	sc	89	60	58	100
clearly	gf	51	40	38	
	sc	91	90	88	
conversely	gf	38	14	9	25
	sc	8	17	17	50
due to	gf	92	83	81	
	sc	95	97	100	
for example	gf	71	71	69	91
	sc	41	80	83	96
from	gf	69	63	59	
	sc	57	47	46	
further	gf	29	40	38	41
	sc	55	37	29	88
hence	gf	67	69	66	
	sc	61	53	54	
however	gf	95	49	47	72
	sc	92	53	50	67

CONNECTIVE	FORMAT	GARDNER	A+B(1)	A+B(2)	C+D
if then	gf	63	31	35	50
	sc	52	53	58	71
in other words	gf	45	57	58	
	sc	71	63	59	
in turn	gf	79	63	71	83
	sc	91	91	91	84
including	gf	70	73	75	
	sc	51	60	56	
instead	gf	80	57	54	38
	sc	92	69	66	78
just as	gf	98	80	79	
	sc	92	89	88	
moreover	gf	17	7	8	46
	sc	54	43	47	56
much like	gf	74	53	58	
	sc	34	43	38	
now	gf	92	87	83	
	sc	86	63	63	
obviously	gf	72	50	50	50
	sc	78	89	88	97
respectively	gf	44	60	58	50
	sc	49	23	22	34
similarly	gf	44	47	46	
	sc	39	37	38	
since	gf	82	80	79	75
	sc	68	49	47	66
such as	gf	84	77	71	
	sc	72	60	63	
that is	gf	50	73	71	96
	sc	91	78	91	91
therefore	gf	87	83	83	
	sc	85	89	88	

CONNECTIVE	FORMAT	GARDNER	A+B(1)	A+B(2)	C+D
viz	gf	24	87	83	96
	sc	72	89	86	94
where	gf	82	87	83	92
	sc	78	60	56	78
whether	gf	98	100	100	
	sc	89	86	84	
yet	gf	85	63	54	67
	sc	94	77	75	94

GARDNER = Item facilities - Australian form IV pupils. (n = 3608)

A+B(1) = Item facilities - Pilot Study. (n = 65)

A+B(2) = Item facilities - Pilot Study (n = 56) Population changed to compare with C+D

C+D = Item facilities - Second series of tests (n = 56)

**TEST A**

Rank	Logical connective	correct	type
1	whether	100	gf
2	due_to	97	sc
3	after	90	sc
4	clearly	90	sc
5	now	87	gf
6	viz	87	gf
7	where	87	gf
8	therefore	83	gf
9	because	80	sc
10	for_example	80	sc
11	just_as	80	gf
12	since	80	gf
13	such_as	77	gf
14	including	73	gf
15	that_is	73	gf
16	in_turn	63	gf
17	yet	63	gf
18	but	60	sc
19	respectively	60	gf
20	in_other_words	57	gf
21	instead	57	gf
22	also	53	sc
23	hence	53	sc
24	however	53	sc
25	if_then	53	sc
26	much_like	53	gf
27	obviously	50	gf
28	as	47	sc
29	from	47	sc
30	similarly	47	gf
31	apart_from	40	sc
32	further	37	sc
33	conversely	17	sc
34	moreover	7	gf

(n = 65)

Item facilities Test A ranked

**TEST B**

Rank	Logical connective	correct	type
1	in_turn	91	sc
2	that_is	91	sc
3	but	89	gf
4	just_as	89	sc
5	obviously	89	sc
6	therefore	89	sc
7	viz	89	sc
8	whether	86	sc
9	after	83	gf
10	due_to	83	gf
11	yet	77	sc
12	as	74	gf
13	for_example	71	gf
14	hence	69	gf
15	instead	69	sc
16	because	66	gf
17	such_as	66	sc
18	from	63	gf
19	in_other_words	63	sc
20	now	63	sc
21	including	60	sc
22	where	60	sc
23	also	54	gf
24	however	49	gf
25	since	48	sc
26	moreover	43	sc
27	much_like	43	sc
28	clearly	40	gf
29	further	40	gf
30	similarly	37	sc
31	if_then	31	gf
32	apart_from	26	gf
33	respectively	23	sc
34	conversely	14	gf

(n = 65)

Item facilities Test B ranked.

**TEST C**

Rank	Logical connective	correct
1	viz	96
2	that_is	96
3	where	92
4	for_example	91
5	but	84
6	in_turn	83
7	because	78
8	since	75
9	however	72
10	yet	67
11	apart_from	53
12	if_then	50
13	obviously	50
14	respectively	50
15	moreover	46
16	further	41
17	instead	38
18	conversely	25

(n = 56)

GF Item facilities ranked - Test C.

**TEST D**

Rank	Logical connective	correct
1	but	100
2	obviously	97
3	for_example	96
4	viz	94
5	yet	94
6	that_is	91
7	because	88
8	further	88
9	in_turn	84
10	instead	78
11	where	78
12	if_then	71
13	however	67
14	since	66
15	moreover	56
16	conversely	50
17	apart_from	38
18	respectively	34

(n = 56)

SC Item facilities ranked - Test D.

**COMPARISON OF TESTS A AND B**  
**USING THE WILCOXON MATCHED-PAIRS**  
**SIGNED-RANKS**

Sample 1: TEST A

Sample 2: TEST B

Test based on: Ranks

Number of positive differences = 15 with average rank = 18.8

Number of negative differences = 19 with average rank = 16.4737

Large sample test statistic  $Z = 0.256448$

Two-tailed probability of equaling or exceeding  $Z = 0.797601$

NOTE: 34 total pairs. 0 tied pairs ignored.

**SUMMARY STATISTICS**

<u>Variable:</u>	<u>Test A</u>	<u>Test B</u>	<u>Test C</u>
Sample size	34	34	18
Average	61.3235	62.6176	66
Median	64.5	58.5	68
Mode	83	88	84
Geometric mean	54.9302	57.9195	62.5678
Variance	487.013	509.94	423.176
Standard deviation	22.0684	22.5819	20.5713
Standard error	3.7847	3.87276	4.84869
Minimum	8	17	28
Maximum	100	100	97
Range	92	83	9
Lower quartile	50	47	8
Upper quartile	79	86	84
Interquartile range	29	39	36
Skewness	-0.753652	-0.145175	-0.264682
Standardized skewness	-1.79405	-0.345585	-0.458443
Kurtosis	0.331229	-0.972984	-1.18656
Standardized kurtosis	0.394242	-1.15808	-1.02759

<u>Variable:</u>	<u>Test D</u>	<u>Gardner A</u>	<u>Gardner B</u>
Sample size	18	34	34
Average	77.2222	69.5588	69.5294
Median	83	76	74
Mode	83	82	92
Geometric mean	74.5859	64.7604	64.4612
Variance	351.477	504.133	463.166
Standard deviation	18.7477	22.4529	21.5213
Standard error	4.41888	3.85064	3.69087
Minimum	34	17	8
Maximum	97	98	95
Range	63	81	87
Lower quartile	62	51	52
Upper quartile	93	85	89
Interquartile range	31	34	37
Skewness	-0.887425	-0.752627	-0.808911
Standardized skewness	-1.53706	-1.79161	-1.92559
Kurtosis	-0.0393499	-0.346579	0.271214
Standardized kurtosis	-0.034078	-0.412511	0.322809

**TEST A.**

1. Anna made herself a cup of black tea with lemon. She noticed that the colour of the tea became lighter after
  - A. she usually drank tea with milk.
  - B. lemon juice gives a tangy taste to tea.
  - C. she added lemon to it.
  - D. she usually added two spoons of sugar.
  
2. Mammals have a number of special features. Their babies develop inside the mother. After they are born, their mothers feed them with milk. Also,
  - A. human beings, horses, cows and whales are all mammals.
  - B. the whale, which feeds its young with milk, is a mammal.
  - C. reptiles have none of these features.
  - D. mammals have a four-chambered heart and a body covered with hair.
  
3. The experiment was easy to do, apart from
  - A. being interested in the work.
  - B. having no difficulties with the experiment.
  - C. having to keep the temperature at exactly 5° C.
  - D. having done the experiment many times before.
  
4. Cellulose must be the most commonly occurring substance made by living things as
  - A. soil bacteria can break down the cellulose in dead plant cells.
  - B. cellulose is made of a chain of sugar molecules.
  - C. cows can digest cellulose, but humans cannot.
  - D. cotton fibres are almost pure cellulose.
  - E. trees, shrubs and grasses are largely made of cellulose.
  
5. Metals which react with air are stored under paraffin. Potassium metal is stored under paraffin because
  - A. paraffin is not used in the storage of many substances.
  - B. some other metals do not react with air.
  - C. copper is not stored under paraffin.
  - D. it reacts with air.

6. Adrian went to the pet shop on Saturday to buy water snails for his aquarium but
- A. he wanted the water snails to keep his aquarium clean.
  - B. they are very easy to handle.
  - C. they feed on green plants.
  - D. the shop did not have any.
7. Mrs. Mason forgot to water her indoor cactus plant for over a month, but it stayed alive and healthy. Clearly,
- A. she remembered to water it.
  - B. she forgot to water it for a year.
  - C. the plant doesn't need much water.
  - D. her husband asked her to water it.
  - E. the plant needs to be given fertilizer as well as water.
8. Whenever the sun is rising, it is in the eastern part of the sky. Conversely,
- A. it is daytime in South Africa when it is night time in America.
  - B. whenever the sun is setting, it is in the western part of the sky.
  - C. the moon and stars also rise in the eastern part of the sky.
  - D. whenever the sun is in the eastern part of the sky, it is rising.
  - E. the direction of sunrise is slightly different in summer and winter.
9. There was a violent explosion in the chemistry laboratory due to
- A. several students being injured.
  - B. the chemicals being over-heated.
  - C. the teacher's very clear warning
  - D. the fire brigade's arrival five minutes later.
10. Enzymes are substances which speed up chemical reactions in living things. For example
- A. there are thousands of different enzymes in the human body.
  - B. pepsin, produced in the stomach, speeds up the digestion of proteins.
  - C. enzymes are easily destroyed by high temperatures.
  - D. enzymes are produced inside living cells.
  - E. the reaction would be slow if the enzyme was not there.

11. Helen measured the time for objects of different weight to fall from the same height to the floor. From these measurements
- A. she concluded that the time taken was the same for the different objects.
  - B. she had used objects made of steel.
  - C. she had done the experiment six times.
  - D. she had used a stop watch to measure these times.
  - E. she also did the experiment using objects of the same weight but different size.
12. Tadpoles (baby frogs) are different from adult frogs in several ways. Frogs have legs, but young tadpoles do not. Tadpoles have a tail but frogs do not. Further,
- A. tadpoles live in water, but frogs live out of water.
  - B. tadpoles take several weeks to grow into frogs.
  - C. frog's eggs hatch into tadpoles.
  - D. the frog belongs to a class of animals called amphibians.
13. Aircraft arriving in South Africa from overseas sometimes carry insect pests that could cause animal diseases or damage to plants. Hence
- A. planes are sprayed with insecticide on arrival.
  - B. some travellers are quite careless and bring in material that might contain some insects.
  - C. malarial mosquitoes, fruit flies and wood borers are three examples.
  - D. most international flights land at Jan Smuts airport in Johannesburg.
14. The weather during the school camp was mostly fine. However,
- A. it rained on the day of the hike.
  - B. some children swam in the pool.
  - C. there was one fine day.
  - D. we did not enjoy doing all the dishes.
15. Without sufficient iron from the soil, plants become yellowish in colour. Lime (calcium carbonate) combines with iron in the soil, so that plants cannot use the iron. If a farmer adds too much lime to the soil, then
- A. the plants must have looked as though they needed more lime.
  - B. other farmers should follow his lead.
  - C. the plants will die from having too much iron.
  - D. the plants will be yellowish instead of green.

16. Enzymes are substances which speed up chemical reactions in living things. \_\_\_\_\_ many reactions in living things would take slowly if an enzyme are not present.
- A. For example                      B. However                      C. Nevertheless  
D. In other words                      E. In contrast.
17. Living things usually feed on other living things. Sometimes there is a long food chain. (Animal 1 eats animal 2, 2 eats 3, 3 eats 4...). Some birds eat frogs. The frogs eat spiders. \_\_\_\_\_, the spiders eat flies.
- A. In theory                      B. In turn                      C. In short  
D. In practice                      E. In contrast.
18. The class of animals known as insecta contains the largest number of animals \_\_\_\_\_ many pests of agricultural crops.
- A. according to                      B. known as                      C. depending on  
D. including                      E. in terms of.
19. Many of the chemicals used by farmers to kill insect pests are rather dangerous. Some scientists are trying to find other methods that can be used \_\_\_\_\_.
- A. too                      B. instead                      C. accordingly  
D. indeed                      E. also.
20. The whale is a mammal. A female whale feeds her babies with milk \_\_\_\_\_ a cow feeds her calves.
- A. just as                      B. but                      C. moreover  
D. because                      E. while.
21. For many years DDT has been widely used by farmers to kill insect pests. Many people now think that it should not be used so much, because it can harm birds, fish and other animals. \_\_\_\_\_ some types of insects have become resistant to it, so that it doesn't kill them any more.
- A. Similarly                      B. Conversely                      C. Even so  
D. Moreover                      E. For example.
22. Some kinds of fish lay their eggs in a sticky net to keep them together, \_\_\_\_\_ birds that keep their eggs in a nest.
- A. according to                      B. despite                      C. much like  
D. consistent with                      E. in addition to

23. Twenty years ago, penicillin was made from mould. \_\_\_\_\_ it can be made from chemicals.

- A. Finally                      B. Now                                      C. Conversely  
D. Similar                      E. Indeed.

24. About 80 percent of the human body is water and a large amount of this water is lost from the body each day. \_\_\_\_\_ an intake of water is necessary for life.

- A. On the other hand  
B. Alternatively                      C. Eventually  
D. Obviously                      E. Otherwise.

25.

METAL                      ATOMIC NUMBER

Lithium	3
Sodium	11
Potassium	19

Lithium, sodium and potassium have atomic numbers 3, 11 and 19

- \_\_\_\_\_.
- A. accordingly                      B. too                                      C. respectively  
D. alternatively                      E. coincidentally.

26. The force of gravity on an object becomes weaker as the object moves further away from the earth. \_\_\_\_\_, the electrical force of attraction between a proton and an electron in an atom becomes weaker as they move further apart.

- A. Despite this                      B. Indeed                                      C. Consequently  
D. Simultaneously                      E. Similarly.

27. Distilled water and not tap water, should be used to top up car batteries \_\_\_\_\_ tap water contains salts which damage the battery.

- A. unless                                      B. but                                      C. since  
D. although                                      E. so that.

28. Various methods for preserving orange juice are available, \_\_\_\_\_ canning, freezing or evaporating the water to form a powder.

- A. despite                                      B. such as                                      C. due to  
D. just as                                      E. regardless of.

29. The formula of carbon dioxide is  $\text{CO}_2$ , \_\_\_\_\_ a carbon dioxide molecule contains one carbon atom and two oxygen atoms.
- A. that is                      B. but                              C. even though  
D. yet                              E. for example.
30. All the members of the Mgwenya Wildlife Club are going to the Botanical Gardens today. Siphos is a member of the club. \_\_\_\_\_ he will be going to the Botanical Gardens.
- A. Similarly                      B. In addition                      C. Therefore  
D. However                      E. Nevertheless.
31. There are many kinds of protein molecules, but they always contain atoms of four particular elements, \_\_\_\_\_ carbon, hydrogen, nitrogen and oxygen atoms.
- A. viz.                              B. just as                              C. etc.  
D. in term of
32. When you chew your food it is mixed with saliva in your mouth. The food then travels down to your stomach, \_\_\_\_\_ sugar is digested and moves to the blood stream.
- A. because                      B. if                                      C. unless  
D. where                      E. in that.
33. Thandi had a high temperature and a swollen chin. Her doctor did a blood test to find out \_\_\_\_\_ she had glandular fever or not.
- A. because                      B. so                                      C. when  
D. whether                      E. how.
34. Most birds can fly. An ostrich is a bird. \_\_\_\_\_ it cannot fly.
- A. besides                      B. also                                      C. thus  
D. so                                      E. yet.

**TEST B**

1. Anna made herself a cup of black tea with lemon. She noticed that the colour of the tea became lighter \_\_\_\_\_ she added the lemon to it.  
A. as if                                      B. after                                      C. unless  
D. whereas
  
2. Mammals have a number of special features. Their babies develop inside the mother. After they are born, their mothers feed them with milk. \_\_\_\_\_, mammals have a four-chambered heart and a body covered with hair.  
A. Clearly                                      B. Consequently                                      C. However  
D. Also                                      E. In fact
  
3. The experiment was easy to do, \_\_\_\_\_ having to keep the temperature at exactly 5°C.  
A. by way of                                      B. apart from                                      C. instead of  
D. rather than
  
4. Cellulose must be the most commonly occurring substance made by living things \_\_\_\_\_ trees, shrubs and grasses are largely made up of cellulose.  
A. unless                                      B. even if                                      C. except that  
D. so that                                      E. as
  
5. Metals which react with air are stored under paraffin. Potassium metal is stored under paraffin \_\_\_\_\_ it reacts with air.  
A. although                                      B. so that                                      C. until  
D. because                                      E. unless.
  
6. Adrian went to the pet shop on Saturday to buy water snails for his aquarium \_\_\_\_\_ the shop did not have any.  
A. because                                      B. or                                      C. so  
D. likewise                                      E. but

7. Mrs. Mason forgot to water her indoor cactus plant for over a month, but it stayed alive and healthy. \_\_\_\_\_, the plant doesn't need very much water.
- A. Thereupon                      B. Unfortunately                      C. Clearly  
D. Respectively                      E. Instead.
8. There are many kinds of protein molecules, but they always contain atoms of four particular elements, viz.
- A. carbon, hydrogen, nitrogen and oxygen atoms.  
B. carbohydrate and fats are other types of molecules in living things.  
C. cheese, milk, meat and fish contain protein.  
D. sulphur atoms are present in some protein molecules.
9. When you chew your food it is mixed with saliva in your mouth. The food then travels down to your stomach, where
- A. the saliva is produced by the salivary glands in the mouth.  
B. it is in the middle of your body.  
C. the stomach is like a large bag.  
D. sugar is digested and moves to the blood stream.
10. Thandi had a high temperature and a swollen chin. Her doctor did a blood test to find whether
- A. he gave her some tablets to take three times a day.  
B. she was feeling rather ill.  
C. she had been home from school for three days.  
D. she had glandular fever or not.
11. Most birds can fly. An ostrich is a bird, yet
- A. it has feathers.  
B. it can run very quickly.  
C. the female lays large cream coloured eggs.  
D. many insects fly.  
E. it cannot fly.
12. The force of gravity on an object becomes weaker as the object moves further away from the earth. Similarly,
- A. the force of gravity causes a ball thrown upwards to return to the earth.  
B. objects dropped from a great height hit the ground at a great speed.  
C. the force of gravity on an object is commonly called "weight".  
D. the sun is much further away from the earth than the moon.  
E. the electrical force of attraction between a proton and an electron in an atom becomes weaker as they move further apart.

13. Distilled water and not tap water, should be used to top up car batteries since
- A. all modern cars are fitted with batteries to run their electrical systems.
  - B. the chemical reaction in the battery uses up water.
  - C. tap water contains salts which damage the battery.
  - D. most cars have 12 volt batteries.
14. Various methods of preserving orange juice are available, such as
- A. keeping orange juice fresh for a long time.
  - B. canning, freezing or evaporating the water to form a powder.
  - C. there are various methods for preserving other kinds of food.
  - D. in the old days, orange juice quickly went bad.
15. The formula of carbon dioxide is  $\text{CO}_2$ , that is,
- A. it is a colourless, odourless gas.
  - B. it dissolves in water to form carbonic acid.
  - C. a carbon dioxide molecule contains one carbon atom and two oxygen atoms.
  - D. it is used by plants to make sugar during photosynthesis.
16. All the members of the Mgwenya Wildlife Club are going to the Botanical Gardens today. Siphso is a member of the club. Therefore
- A. he will not be going because his mother won't let him.
  - B. the club is hiring a bus to take every one there.
  - C. he will be going to the Botanical Gardens.
  - D. entrance to the Gardens is free.
17. For many years DDT has been widely used by farmers to kill insect pests. Many people now think that it should not be used so much, because it can harm birds, fish and other animals. Moreover
- A. DDT has saved many lives by killing malarial mosquitoes in tropical countries.
  - B. DDT is the abbreviation for dichloro-diphenyl-trichloroethane.
  - C. DDT was discovered by Muller in Switzerland in 1939.
  - D. some types of insects have become resistant to it, so that it doesn't kill them any more.

18. Some kinds of fish lay their eggs in a sticky net to keep them together, much like

- A. spiders which catch their food in a sticky web.
- B. the net which protects the fish eggs until they hatch.
- C. birds that keep their eggs in a nest.
- D. most fish which lay their eggs in the sand.
- E. ants which lay their eggs in ant hills.

19. Twenty years ago, penicillin was made from mould. Now

- A. it prevents the growth of certain bacteria.
- B. it can be made from chemicals.
- C. it was the first antibiotic to be mass produced.
- D. it was discovered by Alexander Fleming.

20. About 80 percent of the human body is water and a large amount of this water is lost from the body each day. Obviously

- A. some of the substances in the body, e.g. proteins consist of very large molecules.
- B. water has the formula  $H_2O$ .
- C. only small amounts of vitamins and minerals are needed in the body.
- D. an intake of water is necessary.

21.

<u>Group 1</u>	<u>Atomic</u>	<u>Group 2</u>	<u>Atomic</u>
<u>Metals</u>	<u>Number</u>	<u>Metals</u>	<u>Number.</u>

Lithium	3	Beryllium	4
Sodium	11	Magnesium	12
Potassium	19	Calcium	20

Lithium, sodium and potassium respectively

- A. have different atomic numbers.
- B. are metals.
- C. have atomic numbers 3,11 and 19.
- D. belong to a different group to beryllium, magnesium and calcium.

22. Without sufficient iron from the soil, plants become yellowish in colour. Lime (calcium carbonate) combines with iron in the soil, so that plants cannot use the iron. \_\_\_\_\_ a farmer adds too much lime to the soil, \_\_\_\_\_ the plants will be yellowish instead of green.

- A. Although...nevertheless
- B. If...yet
- C. Even if...then
- D. If...then.

23. Enzymes are substances which speed up chemical reactions in living things. In other words
- A. pepsin, produced in the stomach, speeds up the digestion of proteins.
  - B. there are thousands of different enzymes in the human body.
  - C. enzymes are easily destroyed by high temperatures.
  - D. many reactions in living things would take place slowly if an enzyme were not present.
24. Living things usually feed on other living things. Sometimes there is a long food chain. (Animal 1 eats animal 2, 2 eats 3, 3 eats 4...). Some birds eat frogs. The frogs eat spiders. In turn,
- A. the spiders try to escape from the frogs.
  - B. not all frogs eat spiders.
  - C. the spiders eat flies.
  - D. frogs are formed from baby tadpoles.
25. The class of animals known as insecta contains the largest number of animals including
- A. other animals that are not in the class insecta.
  - B. many crops are eaten by insects.
  - C. the fact that many are killed by insecticides.
  - D. many pests of agricultural crops.
26. Many of the chemicals used by farmers to kill insect pests are rather dangerous. \_\_\_\_\_ instead.
- A. Dieldrin, endrin and aldrin are very dangerous chemicals
  - B. Some scientists are trying to find other methods that can be used
  - C. A century ago, farmers used no chemicals at all on their crops
  - D. During the twentieth century, insecticides have reduced disease and increased food supply
27. The whale is a mammal. A female whale feeds her babies with milk just as
- A. a cow feeds her calves.
  - B. the whale is not a fish.
  - C. the adult whale eats tiny plants and fish.
  - D. the whale is a mammal.
28. Whenever the sun is rising, it is in the eastern part of the sky. \_\_\_\_\_, whenever the sun is in the eastern part of the sky, it is rising.
- A. For example
  - B. In contrast
  - C. Often
  - D. Conversely
  - E. On the other hand

29. There was a violent explosion in the chemistry laboratory \_\_\_\_\_ the chemicals being over-heated.
- A. in spite of                      B. due to                                      C. in terms of  
D. as an example                  E. according to.
30. Enzymes are substances which speed up chemical reactions in living things. \_\_\_\_\_ pepsin, produced in the stomach, speeds up the digestion of proteins.
- A. In other words                  B. For example                              C. However  
D. In short                              E. Furthermore.
31. Helen measured the time for objects of different weight to fall from the same height to the floor. \_\_\_\_\_ these measurements she concluded that the time taken was the same for different objects.
- A. Just like                              B. Together with                              C. As to  
D. From                                      E. Rather than.
32. Tadpoles (baby frogs) are different from adult frogs in several ways. Frogs have legs, but young tadpoles do not. Tadpoles have a tail but frogs do not. \_\_\_\_\_, tadpoles live in water, but frogs live out of water.
- A. Further                              B. Alternatively                              C. Instead  
D. Meanwhile                              E. Nevertheless.
33. Aircraft arriving in South Africa from overseas sometimes carry insect pests that could cause animal diseases or damage to plants. \_\_\_\_\_ planes are sprayed with insecticides on arrival.
- A. Hence                                      B. Respectively                              C. Instead  
D. For example                              E. In contrast.
34. The weather during the school camp was mostly fine. \_\_\_\_\_, it rained on the day of the hike.
- A. However                                      B. Consequently                              C. In effect  
D. Similarly                                      E. Accordingly.

**TEST C.**

1. Metals which react with air are stored under paraffin. Potassium metal is stored under paraffin \_\_\_\_\_ it reacts with air.  
A. although                      B. so that                      C. until  
D. because                      E. unless.
  
2. Whenever the sun is rising, it is in the eastern part of the sky. \_\_\_\_\_, whenever the sun is in the eastern part of the sky, it is rising.  
A. For example                      B. In contrast                      C. Often  
D. Conversely                      E. On the other hand
  
3. The experiment was easy to do, \_\_\_\_\_ having to keep the temperature at exactly 5°C.  
A. by way of                      B. apart from                      C. instead of  
D. rather than
  
4. Many of the chemicals used by farmers to kill insect pests are rather dangerous. Some scientists are trying to find other methods that can be used \_\_\_\_\_.  
A. too                      B. instead                      C. accordingly  
D. indeed                      E. also.
  
5. The formula of carbon dioxide is CO<sub>2</sub>, \_\_\_\_\_ a carbon dioxide molecule contains one carbon atom and two oxygen atoms.  
A. that is                      B. but                      C. even though  
D. yet                      E. for example.
  
6. Distilled water and not tap water, should be used to top up car batteries \_\_\_\_\_ tap water contains salts which damage the battery.  
A. unless                      B. but                      C. since  
D. although                      E. so that.

7. Without sufficient iron from the soil, plants become yellowish in colour. Lime (calcium carbonate) combines with iron in the soil, so that plants cannot use the iron. \_\_\_\_\_ a farmer adds too much lime to the soil, \_\_\_\_\_ the plants will be yellowish instead of green.
- A. Although...nevertheless  
B. If...yet                      C. Even if...then                      D. If...then.
8. The weather during the school camp was mostly fine. \_\_\_\_\_, it rained on the day of the hike.
- A. However                      B. Consequently                      C. In effect  
D. Similarly                      E. Accordingly.
9. Living things usually feed on other living things. Sometimes there is a long food chain. (Animal 1 eats animal 2, 2 eats 3, 3 eats 4...). Some birds eat frogs. The frogs eat spiders. \_\_\_\_\_, the spiders eat flies.
- A. In theory                      B. In turn                      C. In short  
D. In practice                      E. In contrast.
10. Enzymes are substances which speed up chemical reactions in living things. \_\_\_\_\_ pepsin, produced in the stomach, speeds up the digestion of proteins.
- A. In other words                      B. For example                      C. However  
D. In short                      E. Furthermore.
11. Tadpoles (baby frogs) are different from adult frogs in several ways. Frogs have legs, but young tadpoles do not. Tadpoles have a tail but frogs do not. \_\_\_\_\_, tadpoles live in water, but frogs live out of water.
- A. Further                      B. Alternatively                      C. Instead  
D. Meanwhile                      E. Nevertheless.
12. Adrian went to the pet shop on Saturday to buy water snails for his aquarium \_\_\_\_\_ the shop did not have any.
- A. because                      B. or                      C. so  
D. likewise                      E. but

13. When you chew your food it is mixed with saliva in your mouth. The food then travels down to your stomach, \_\_\_\_\_ sugar is digested and moves to the blood stream.
- A. because                      B. if                                      C. unless  
D. where                          E. in that.
14. There are many kinds of protein molecules, but they always contain atoms of four particular elements, \_\_\_\_\_ carbon, hydrogen, nitrogen and oxygen atoms.
- A. viz.                              B. just as                              C. etc.  
D. in term of
15. For many years DDT has been widely used by farmers to kill insect pests. Many people now think that it should not be used so much, because it can harm birds, fish and other animals. \_\_\_\_\_ some types of insects have become resistant to it, so that it doesn't kill them any more.
- A. Similarly                      B. Conversely                      C. Even so  
D. Moreover                      E. For example.
16. Most birds can fly. An ostrich is a bird. \_\_\_\_\_ it cannot fly.
- A. besides                      B. also                                      C. thus  
D. so                                  E. yet.
17. About 80 percent of the human body is water and a large amount of this water is lost from the body each day. \_\_\_\_\_ an intake of water is necessary for life.
- A. On the other hand      B. Alternatively                      C. Eventually  
D. Obviously                      E. Otherwise.

18.

METAL                      ATOMIC NUMBER

Lithium	3
Sodium	11
Potassium	19

Lithium, sodium and potassium have atomic numbers 3, 11 and 19 \_\_\_\_\_.

- A. accordingly                      B. too                                      C. respectively  
D. alternatively                      E. coincidentally.

**TEST D.**

1. Metals which react with air are stored under paraffin. Potassium metal is stored under paraffin because
  - A. paraffin is not used in the storage of many substances.
  - B. some other metals do not react with air.
  - C. copper is not stored under paraffin.
  - D. it reacts with air.
  
2. Whenever the sun is rising, it is in the eastern part of the sky. Conversely,
  - A. it is daytime in South Africa when it is night time in America.
  - B. whenever the sun is setting, it is in the western part of the sky.
  - C. the moon and stars also rise in the eastern part of the sky.
  - D. whenever the sun is in the eastern part of the sky, it is rising.
  - E. the direction of sunrise is slightly different in summer and winter.
  
3. The experiment was easy to do, apart from
  - A. being interested in the work.
  - B. having no difficulties with the experiment.
  - C. having to keep the temperature at exactly 5°C.
  - D. having done the experiment many times before.
  
4. Many of the chemicals used by farmers to kill insect pests are rather dangerous. \_\_\_\_\_ instead.
  - A. Dieldrin, endrin and aldrin are very dangerous chemicals
  - B. Some scientists are trying to find other methods that can be used
  - C. A century ago, farmers used no chemicals at all on their crops
  - D. During the twentieth century, insecticides have reduced disease and increased food supply
  
5. The formula of carbon dioxide is CO<sub>2</sub>, that is,
  - A. it is a colourless, odourless gas.
  - B. it dissolves in water to form carbonic acid.
  - C. a carbon dioxide molecule contains one carbon atom and two oxygen atoms.
  - D. it is used by plants to make sugar during photosynthesis.

6. Distilled water and not tap water, should be used to top up car batteries since
- A. all modern cars are fitted with batteries to run their electrical systems.
  - B. the chemical reaction in the battery uses up water.
  - C. tap water contains salts which damage the battery.
  - D. most cars have 12 volt batteries.
7. Without sufficient iron from the soil, plants become yellowish in colour. Lime (calcium carbonate) combines with iron in the soil, so that plants cannot use the iron. If a farmer adds too much lime to the soil, then
- A. the plants must have looked as though they needed more lime.
  - B. other farmers should follow his lead.
  - C. the plants will die from having too much iron.
  - D. the plants will be yellowish instead of green.
8. The weather during the school camp was mostly fine. However,
- A. it rained on the day of the hike.
  - B. some children swam in the pool.
  - C. there was one fine day.
  - D. we did not enjoy doing all the dishes.
9. Living things usually feed on other living things. Sometimes there is a long food chain. (Animal 1 eats animal 2, 2 eats 3, 3 eats 4...). Some birds eat frogs. The frogs eat spiders. In turn,
- A. the spiders try to escape from the frogs.
  - B. not all frogs eat spiders.
  - C. the spiders eat flies.
  - D. frogs are formed from baby tadpoles.
10. Enzymes are substances which speed up chemical reactions in living things. For example
- A. there are thousands of different enzymes in the human body.
  - B. pepsin, produced in the stomach, speeds up the digestion of proteins.
  - C. enzymes are easily destroyed by high temperatures.
  - D. enzymes are produced inside living cells.
  - E. the reaction would be slow if the enzyme was not there.
11. Tadpoles (baby frogs) are different from adult frogs in several ways. Frogs have legs, but young tadpoles do not. Tadpoles have a tail but frogs do not. Further,
- A. tadpoles live in water, but frogs live out of water.
  - B. tadpoles take several weeks to grow into frogs.
  - C. frog's eggs hatch into tadpoles.
  - D. the frog belongs to a class of animals called amphibians.

12. Adrian went to the pet shop on Saturday to buy water snails for his aquarium but
- A. he wanted the water snails to keep his aquarium clean.
  - B. they are very easy to handle.
  - C. they feed on green plants.
  - D. the shop did not have any.
13. When you chew your food it is mixed with saliva in your mouth. The food then travels down to your stomach, where
- A. the saliva is produced by the salivary glands in the mouth.
  - B. it is in the middle of your body.
  - C. the stomach is like a large bag.
  - D. sugar is digested and moves to the blood stream.
14. There are many kinds of protein molecules, but they always contain atoms of four particular elements, viz.
- A. carbon, hydrogen, nitrogen and oxygen atoms.
  - B. carbohydrate and fats are other types of molecules in living things.
  - C. cheese, milk, meat and fish contain protein.
  - D. sulphur atoms are present in some protein molecules.
15. For many years DDT has been widely used by farmers to kill insect pests. Many people now think that it should not be used so much, because it can harm birds, fish and other animals. Moreover
- A. DDT has saved many lives by killing malarial mosquitoes in tropical countries.
  - B. DDT is the abbreviation for dichloro-diphenyl- trichloroethane.
  - C. DDT was discovered by Muller in Switzerland in 1939.
  - D. some types of insects have become resistant to it, so that it doesn't kill them any more.
16. Most birds can fly. An ostrich is a bird, yet
- A. it has feathers.
  - B. it can run very quickly.
  - C. the female lays large cream coloured eggs.
  - D. many insects fly.
  - E. it cannot fly.

17.

<u>Group 1</u> <u>Metals</u>	<u>Atomic</u> <u>Number</u>	<u>Group 2</u> <u>Metals</u>	<u>Atomic</u> <u>Number.</u>
Lithium	3	Beryllium	4
Sodium	11	Magnesium	12
Potassium	19	Calcium	20

Lithium, sodium and potassium respectively

- A. have different atomic numbers.
  - B. are metals.
  - C. have atomic numbers 3,11 and 19.
  - D. belong to a different group to beryllium, magnesium and calcium.
18. About 80 percent of the human body is water and a large amount of this water is lost from the body each day. Obviously
- A. some of the substances in the body, e.g. proteins consist of very large molecules.
  - B. water has the formula  $H_2O$ .
  - C. only small amounts of vitamins and minerals are needed in the body.
  - D. an intake of water is necessary.

## FREQUENCY TABLES - PILOT TEST

### TEST A: SENTENCE COMPLETION / SC AND GAP FILL / GF

SC	AFTER	Frequency	Percent
correct	A	2	6.7
	B	0	0.0
	C	27	90.0
	D	0	0.0
	E	0	0.0
	X	1	3.3

SC	ALSO	Frequency	Percent
correct	A	11	36.7
	B	2	6.7
	C	1	3.3
	D	16	53.3
	E	0	0.0
	X	0	0.0

SC	APART FROM	Frequency	Percent
correct	A	4	13.3
	B	4	13.3
	C	12	40.0
	D	10	33.3
	E	0	0.0
	X	0	0.0

SC	AS	Frequency	Percent
correct	A	5	16.7
	B	9	30.0
	C	0	0.0
	D	2	6.7
	E	14	46.7
	X	0	0.0

SC	BECAUSE	Frequency	Percent
	A	2	6.7
	B	4	13.3
	C	0	0.0
correct	D	24	80.0
	E	0	0.0
	X	0	0.0

SC	BUT	Frequency	Percent
	A	5	16.7
	B	2	6.7
	C	5	16.7
correct	D	18	60.0
	E	0	0.0
	X	0	0.0

SC	CLEARLY	Frequency	Percent
	A	2	6.7
	B	0	0.0
correct	C	27	90.0
	D	0	0.0
	E	1	3.3
	X	0	0.0

SC	CONVERSELY	Frequency	Percent
	A	4	13.3
	B	12	40.0
	C	0	0.0
correct	D	5	16.7
	E	9	30.0
	X	0	0.0

SC	DUE TO	Frequency	Percent
	A	0	0.0
correct	B	29	96.7
	C	0	0.0
	D	1	3.3
	E	0	0.0
	X	0	0.0

SC	FOR EXAMPLE	Frequency	Percent
correct	A	2	6.7
	B	24	80.0
	C	0	0.0
	D	0	0.0
	E	4	13.3
	X	0	0.0

SC	FROM	Frequency	Percent
correct	A	14	46.7
	B	0	0.0
	C	0	0.0
	D	9	30.0
	E	7	23.3
	X	0	0.0

SC	FURTHER	Frequency	Percent
correct	A	11	36.7
	B	6	20.0
	C	1	3.3
	D	12	40.0
	E	0	0.0
	X	0	0.0

SC	HENCE	Frequency	Percent
correct	A	16	53.3
	B	4	13.3
	C	7	23.3
	D	3	10.0
	E	0	0.0
	X	0	0.0

SC	HOWEVER	Frequency	Percent
correct	A	16	53.3
	B	7	23.3
	C	3	10.0
	D	4	13.3
	E	0	0.0
	X	0	0.0

SC	IF...THEN	Frequency	Percent
	A	2	6.7
	B	1	3.3
	C	11	36.7
correct	D	16	53.3
	E	0	0.0
	X	0	0.0

GF IN OTHER WORDS		Frequency	Percent
	A	6	20.0
	B	4	13.3
	C	2	6.7
correct	D	17	56.7
	E	1	3.3
	X	0	0.0

GF	IN TURN	Frequency	Percent
	A	2	6.7
correct	B	19	63.3
	C	1	3.3
	D	2	6.7
	E	6	20.0
	X	0	0.0

GF	INCLUDING	Frequency	Percent
	A	3	10.0
	B	2	6.7
	C	1	6.7
correct	D	22	73.3
	E	1	3.3
	X	0	0.0

GF	INSTEAD	Frequency	Percent
	A	4	13.3
correct	B	17	56.7
	C	9	30.0
	D	0	0.0
	E	0	0.0
	X	0	0.0

GF	JUST AS	Frequency	Percent
correct	A	24	80.0
	B	2	6.7
	C	0	0.0
	D	0	0.0
	E	3	10.0
	X	1	3.3

GF	MOREOVER	Frequency	Percent
correct	A	5	16.7
	B	7	23.3
	C	12	40.0
	D	2	6.7
	E	4	13.3
	X	0	0.0

GF	MUCH LIKE	Frequency	Percent
correct	A	0	0.0
	B	10	33.3
	C	16	53.3
	D	2	6.7
	E	2	6.7
	X	0	0.0

GF	NOW	Frequency	Percent
correct	A	1	3.3
	B	26	86.7
	C	1	3.3
	D	2	6.7
	E	0	0.0
	X	0	0.0

GF	OBVIOUSLY	Frequency	Percent
correct	A	10	33.3
	B	2	6.7
	C	3	10.0
	D	15	50.0
	E	0	0.0
	X	0	0.0

GF	RESPECTIVELY	Frequency	Percent
correct	A	6	20.0
	B	5	16.7
	C	18	60.0
	D	1	3.3
	E	0	0.0
	X	0	0.0

GF	SIMILARLY	Frequency	Percent
correct	A	4	13.3
	B	0	0.0
	C	6	20.0
	D	5	20.0
	E	14	46.7
	X	0	0.0

GF	SINCE	Frequency	Percent
correct	A	0	0.0
	B	3	10.0
	C	24	80.0
	D	3	10.0
	E	0	0.0
	X	0	0.0

GF	SUCH AS	Frequency	Percent
correct	A	2	6.7
	B	23	76.7
	C	2	6.7
	D	3	10.0
	E	0	0.0
	X	0	0.0

GF	THAT IS	Frequency	Percent
correct	A	22	73.3
	B	0	0.0
	C	3	10.0
	D	2	6.7
	E	3	10.0
	X	0	0.0

GF	THEREFORE	Frequency	Percent
	A	3	10.0
	B	1	3.3
correct	C	25	83.3
	D	1	3.3
	E	0	0.0
	X	0	0.0

GF	VIZ.	Frequency	Percent
correct	A	26	86.7
	B	2	6.7
	C	1	3.3
	D	1	3.3
	E	0	0.0
	X	0	0.0

GF	WHERE	Frequency	Percent
	A	1	3.3
	B	0	0.0
	C	0	0.0
correct	D	26	86.7
	E	3	10.0
	X	0	0.0

GF	WHETHER	Frequency	Percent
	A	0	0.0
	B	0	0.0
	C	0	0.0
correct	D	30	100.0
	E	0	0.0
	X	0	0.0

GF	YET	Frequency	Percent
	A	6	20.0
	B	1	3.3
	C	2	6.7
	D	2	6.7
correct	E	19	63.3
	X	0	0.0

## TEST B: GAP FILL / GF AND SENTNCE COMPLETION / SC

GF	AFTER	Frequency	Percent
correct	A	5	14.3
	B	29	82.9
	C	0	0.0
	D	1	2.9
	E	0	0.0
	X	0	0.0

GF	ALSO	Frequency	Percent
correct	A	0	0.0
	B	2	5.7
	C	5	14.3
	D	19	54.3
	E	9	25.7
	X	0	0.0

GF	APART FROM	Frequency	Percent
correct	A	11	31.4
	B	9	25.7
	C	9	25.7
	D	6	17.1
	E	0	0.0
	X	0	0.0

GF	AS	Frequency	Percent
correct	A	0	0.0
	B	5	14.3
	C	3	8.6
	D	1	2.9
	E	26	74.3
	X	0	0.0

GF	BECAUSE	Frequency	Percent
correct	A	1	2.9
	B	7	20.0
	C	3	8.6
	D	23	65.7
	E	1	2.9
	X	0	0.0

GF	BUT	Frequency	Percent
	A	2	5.7
	B	0	0.0
	C	0	0.0
	D	2	5.7
correct	E	31	88.6
	X	0	0.0

GF	CLEARLY	Frequency	Percent
	A	5	14.3
	B	8	22.9
correct	C	14	40.0
	D	5	14.3
	E	3	8.6
	X	0	0.0

GF	CONVERSELY	Frequency	Percent
	A	7	20.0
	B	9	25.7
	C	7	20.0
correct	D	5	14.3
	E	7	20.0
	X	0	0.0

GF	DUE TO	Frequency	Percent
	A	2	5.7
correct	B	29	82.9
	C	0	0.0
	D	1	2.9
	E	2	5.7
	X	1	2.9

GF	FOR EXAMPLE	Frequency	Percent
	A	9	25.7
correct	B	25	71.4
	C	0	0.0
	D	1	2.9
	E	0	0.0
	X	0	0.0

GF	FROM	Frequency	Percent
correct	A	2	5.7
	B	10	28.6
	C	0	0.0
	D	22	62.9
	E	1	2.9
	X	0	0.0

GF	FURTHER	Frequency	Percent
correct	A	14	40.0
	B	7	20.0
	C	3	8.6
	D	7	20.0
	E	4	11.4
	X	0	0.0

GF	HENCE	Frequency	Percent
correct	A	24	68.6
	B	3	8.6
	C	3	8.6
	D	1	2.9
	E	4	11.4
	X	0	0.0

GF	HOWEVER	Frequency	Percent
correct	A	17	48.6
	B	6	17.1
	C	8	22.9
	D	4	11.4
	E	0	0.0
	X	0	0.0

GF	IF...THEN	Frequency	Percent
correct	A	6	17.1
	B	5	14.3
	C	12	34.3
	D	11	31.4
	E	0	0.0
	X	1	2.9

SC IN OTHER WORDS		Frequency	Percent
	A	11	31.4
	B	1	2.9
	C	1	2.9
correct	D	22	62.9
	E	0	0.0
	X	0	0.0

SC	IN TURN	Frequency	Percent
	A	0	0.0
	B	3	8.6
correct	C	32	91.4
	D	0	0.0
	E	0	0.0
	X	0	0.0

SC	INCLUDING	Frequency	Percent
	A	6	17.1
	B	4	11.4
	C	4	11.4
correct	D	21	60.0
	E	0	0.0
	X	0	0.0

SC	INSTEAD	Frequency	Percent
	A	4	11.4
correct	B	24	68.6
	C	2	5.7
	D	5	14.3
	E	0	0.0
	X	0	0.0

SC	JUST AS	Frequency	Percent
correct	A	31	88.6
	B	0	0.0
	C	2	5.7
	D	2	5.7
	E	0	0.0
	X	0	0.0

SC	MOREOVER	Frequency	Percent
	A	15	42.9
	B	5	14.3
	C	0	0.0
correct	D	15	42.9
	E	0	0.0
	X	0	0.0

SC	MUCH LIKE	Frequency	Percent
	A	6	17.1
	B	7	20.0
correct	C	15	42.9
	D	2	5.7
	E	5	14.3
	X	0	0.0

SC	NOW	Frequency	Percent
	A	8	22.9
correct	B	22	62.9
	C	4	11.4
	D	1	2.9
	E	0	0.0
	X	0	0.0

SC	OBVIOUSLY	Frequency	Percent
	A	1	2.9
	B	1	2.9
	C	1	2.9
correct	D	31	88.6
	E	0	0.0
	X	1	2.9

SC	RESPECTIVELY	Frequency	Percent
	A	12	34.3
	B	7	20.0
correct	C	8	22.9
	D	8	22.9
	E	0	0.0
	X	0	0.0

SC	SIMILARLY	Frequency	Percent
	A	7	20.0
	B	10	28.6
	C	3	8.6
	D	1	2.9
correct	E	13	37.1
	X	1	2.9

SC	SINCE	Frequency	Percent
	A	3	8.6
	B	13	37.1
correct	C	17	48.6
	D	2	5.7
	E	0	0.0
	X	0	0.0

SC	SUCH AS	Frequency	Percent
	A	9	25.7
correct	B	23	65.7
	C	2	5.7
	D	1	2.9
	E	0	0.0
	X	0	0.0

SC	THAT IS	Frequency	Percent
	A	1	2.9
	B	0	0.0
correct	C	32	91.4
	D	2	5.7
	E	0	0.0
	X	0	0.0

SC	THEREFORE	Frequency	Percent
	A	1	2.9
	B	3	8.6
correct	C	31	88.6
	D	0	0.0
	E	0	0.0
	X	0	0.0

SC	VIZ.	Frequency	Percent
correct	A	31	88.6
	B	4	11.4
	C	0	0.0
	D	0	0.0
	E	0	0.0
	X	0	0.0

SC	WHERE	Frequency	Percent
correct	A	6	17.1
	B	2	5.7
	C	6	17.1
	D	21	60.0
	E	0	0.0
	X	0	0.0

SC	WHETHER	Frequency	Percent
correct	A	0	0.0
	B	5	14.3
	C	0	0.0
	D	30	85.7
	E	0	0.0
	X	0	0.0

SC	YET	Frequency	Percent
correct	A	3	8.6
	B	4	11.4
	C	1	2.9
	D	0	0.0
	E	27	77.1
	X	0	0.0

**SPEARMAN RANK CORRELATIONS****TEST VERSION A VS TEST VERSION B**

Test_A	Test A 1.0000 ( 34) 1.0000	Test B .4983 ( 34) .0042
Test_B	.4983 ( 34) .0042	1.0000 ( 34) 1.0000

---

**GARDNER A VS GARDNER B**

Gardner_A	Gardner A 1.0000 ( 34) 1.0000	Gardner B .6923 ( 34) .0001
Gardner_B	.6923 ( 34) .0001	1.0000 ( 34) 1.0000

---

Key -                      Coefficient  
                                 (sample size)  
                                 significance level

**SPEARMAN RANK CORRELATIONS****TEST VERSION A VS GARDNER A**

	Test A	Gardner A
Test A	1.0000 ( 34) 1.0000	.5758 ( 34) .0009
Gardner A	.57581 ( 34) .00091	.0000 ( 34) .0000

---

Key    Coefficient  
       (sample size)  
       significance level

**TEST VERSION B VS GARDNER B**

	Test B	Gardner B
Test B	1.0000 ( 34) 1.0000	.7099 ( 34) .0000
Gardner B	.70991 ( 34) .00001	.0000 ( 34) .0000

---

Key    Coefficient  
       (sample size)  
       significance level

## SUMMARY CORRELATION MATRIX

Variable:	meng	mbio	ceng
Sample size	56	56	56
Average	46.6071	51.0714	57.5
Median	45	45	57.5
Mode	45	45	63
Geometric mean	45.6918	50.5438	56.4852
Variance	90.0974	60.6494	116.982
Standard deviation	9.49197	7.78777	10.8158
Standard error	1.26842	1.04068	1.44532
Minimum	35	45	38
Maximum	75	75	83
Range	40	30	45
Lower quartile	35	45	50
Upper quartile	55	55	65
Interquartile range	20	10	15
Skewness	0.592546	1.30576	0.114182
Standardized skewness	1.81026	3.98915	0.348831
Kurtosis	0.176713	1.52483	-0.745323
Standardized kurtosis	0.269933	2.32922	-1.1385

Variable:	csci	gf	sc
Sample size	56	56	56
Average	48.3036	66.2679	77.0893
Median	48.5	67	78
Mode	45	67	83
Geometric mean	47.561	64.3373	76.1
Variance	70.6153	248.636	146.919
Standard deviation	8.40329	15.7682	12.121
Standard error	1.12294	2.10711	1.61974
Minimum	29	33	50
Maximum	65	100	100
Range	36	67	50
Lower quartile	42	56	72
Upper quartile	54.5	78	83
Interquartile range	12.5	22	11
Skewness	-9.52085E-3	0.0719626	-0.230029
Standardized skewness	-0.0290867	0.219849	-0.702751
Kurtosis	-0.392396	-0.536186	0.0413924
Standardized kurtosis	-0.599395	-0.819038	0.0632279

# Technical/Industrial Education Planning for a Developing Region of Southern Africa

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This paper suggests a blueprint for the planning of education in the area of science/industry/agriculture/mining/technology in the 1990's for KaNgwane — a developing third world national state of nearly one million SiSwati-speaking people of Southern Africa. It begins by analyzing reasons for the general malfunction of science education systems in developing countries in recent decades, then indicates possible solutions for KaNgwane, avoiding pitfalls by anticipating likely problem areas. Recommendations are made by adapting a synthesis of the Thai model (1981), Russell's policies (1979) and Hamilton's proposals (1987) to the special needs and context of KaNgwane itself.

## INTRODUCTION

The goals of this paper are to:

- Identify elements commonly encountered in third world education planning and development that have tended to contribute to the malfunction of science and technological education policies in recent decades;
- Identify from these elements key aspects that must be borne in mind when undertaking engineering education planning in a third world context;
- Describe some of the needs and characteristic features of one local developing region (KaNgwane) in Southern Africa which acts as a contextual focus for this paper;
- Examine recent models/proposals for planning science and technological education in developing countries for their possible relevance and applicability to KaNgwane;
- Formulate a relevant set of proposals that might be incorporated into a science and engineering education policy for KaNgwane.

## ELEMENTS IN THIRD WORLD EDUCATION PLANNING THAT HAVE CONTRIBUTED TO THE MALFUNCTION OF SCIENCE EDUCATION SYSTEMS IN RECENT DECADES

For the purposes of this paper, the terms Third World or developing countries will refer chiefly to Africa. Developing countries are defined as countries attempting to extend and upgrade their education systems. They are characterised by a rapid population growth (more than 2% per annum), high illiteracy and urgent educational needs. Although a large proportion (up to 25%) of the national budget is devoted to education, the planning, management and administrative structures are weak, and a large proportion of the teachers are professionally underqualified. African third world countries are further identified by unexploited natural resources, low levels of industrialization and human resource development, relatively low national incomes and a dependence on external aid for education and development [1][2].

In this first section nine major elements that tend to contribute to a malfunction of the science education systems in third world situations have been identified. These serve as signposts / indi-

ators for what could also happen in developing regions of Southern Africa.

## PROBLEM NO. 1

The Industrial Revolution (which incorporates the scientific and technological revolution) required 200 years to evolve in Western Europe, and consequently is difficult to accelerate in Africa.

Through their use and control of science and technology, industrialised nations have developed the potential to enhance the human environment, increase production and improve the standard of living [3] while, at the same time, Africa has been little affected by the agricultural and industrial revolution [4]. Although there has been considerable progress in developing countries during the past three decades, a huge gap still exists between the technologically advanced western countries and third world countries. This gap is more than just economic - it is a knowledge and power gap [5]. Africa must now try to catch up and adapt to the rapidly changing circumstances brought about by the knowledge industry, and develop ways to take advantage of scientific and technological developments as quickly as possible with a minimum of cultural disruption.

## POSSIBLE SOLUTION

It has been argued that the use of alternative technology, such as self-instructional programmes, or sophisticated radio, television-satellite or computer-assisted programmes would reduce the need for teachers, who are costly to train and difficult to manage. Though some of these systems have been successful, none has proved to be the panacea anticipated for the inadequacies of conventional classroom teaching and learning. The element of human interaction between teacher and pupils is essential for motivation in learning [1]. Thus teachers are indispensable and technology is essential. Technology is here to stay and, if utilized effectively, can complement the role of the teacher by reducing instructional work load.

## PROBLEM NO. 2

**African education systems do not meet the culturally unique aspirations of African countries.**

D'Aeth [6] in the African context and Schoeman [7] in the South African context both mention that the Western European type of education used in schools is largely unsuitable for Africa. It is a bookish schooling, unsuited to predominantly agricultural societies, which ignores their language, traditions and culture [8][9][10].

In his policy directive Education for Self-Reliance Nyerere [11] maintained that the education being provided in Tanzania in 1982 was basically an elitist education designed to meet the needs and interests of a very small proportion of those who entered the school system, and that it was divorcing the participants from the society it was supposed to be preparing them for.

## POSSIBLE SOLUTION

Ghosh [5], Hartshorne [12], Ogunniyi [13], Sibanda [14], Sizulu [15] and Woolnough [16] all stress the need for the relevance of the education system to reflect the needs of African students and society as a whole, and a linkage of science and technology with the real-life needs of the society. This implies the development of science and technical curricula that will meet the needs of the rural and the urban people and provide opportunities for social and economic advancement. Brophy [17] suggests that a solution to this problem would be for curriculum developers to identify scientific concepts and content which are both relevant to local communities and are also seen to be important and valuable by the communities for pupils to learn. Examples would be the technical and fundamental skills and concepts required for entry into industrial and agricultural training [18] to assist the local communities in coping with ecological balance, drinkable water, sanitation, crop production and other essential aspects of daily life [13].

## PROBLEM NO. 3

**The number of jobs available in Africa does not match the number of young people leaving school.**

One of the major differences between developed and developing countries is their population trends. Most developed countries have a zero or negative population growth while developing

countries are experiencing growth rates that may double by the end of the century. If this trend continues unchecked, the governments of these countries will not be able to feed, control or even educate their people adequately [2].

As set out in the United Nations Charter, free primary or basic schooling for all children is a basic human right, a way of overcoming ignorance and a necessary means to improving the quality of life. Political leaders in newly independent countries in Africa have been under pressure to provide this free education [6] but economic and industrial progress has not been as rapid. Educational planning has not been based on manpower needs, and thus has arisen the problem of educated people (certificated) and no job market [19][20]. This raises the question of what types of science should be taught in schools and technikons if few jobs in science are available.

## POSSIBLE SOLUTION

Addressing the Transvaal Teachers' Association at their 1981 National Conference, Dr. Viljoen, the Minister of National Education in South Africa, said:

*an over supply of purely academically, as opposed to vocationally, educated candidates serves neither the needs of the country nor those of the individuals concerned. Irrelevant preparation is not only frustrating but wasteful; more so in a time when effectiveness and productivity are watch-words [21].*

## PROBLEM NO. 4

**Western style education leads African pupils to have unrealistic employment expectations after obtaining their school leaving certificate.**

Barber [22] and Sadie [23] claim that one of the major problems caused by the Western style of education is that it has led pupils to expect certain types of jobs when they leave school, particularly skilled or white collar jobs, and especially in the cities.

This leads to another problem, namely that technically skilled and educated people tend to leave rural areas where they are most needed [24]. Coupled with this expectation from their education, pupils also place unrealistic value on their school leaving certificate. It is regarded as a status symbol, entitling the holder to the privileges of the group he has now joined.

*Educational attainments are interpreted in socio-political rather than economic terms [7].*

## POSSIBLE SOLUTION

African students need to be equipped with the scientific knowledge, skills and attitudes necessary to prepare them adequately for careers in science and technology.

*Poor planning and implementation as well as the lack of clear cut policies have been the most agonizing problems bedevilling the realizing of science education objectives in Africa [13].*

Ogunniyi [13] also says that, irrespective of the lack of facilities, the low status of scientists and science teachers has led to the point where science has to fight for its survival. The pure science being taught has not been preparing pupils adequately to enter the few existing careers in science. By the end of the school career pupils should have been exposed to 10-12 years of applied science and its processes, and thus some pupils may have begun to learn how to make decisions, reason, think clearly and confidently, solve problems and use various manual and technical skills [25]. This is strongly backed by one of the decisions made at the OAU Conference in Lagos [26]:—

*The importance of scientific and technical skills and know-how for modern development cannot be over-emphasised. It is in this area that Member States are over-dependent on imported technical and scientific manpower. It is therefore cardinal, and in accordance with the principle of self-reliance, that Member States should give special priority to the development of scientific and technical manpower at all levels, including the training of science and technical teachers and instructors (p.37).*

Thus the need for training in specialized skills, and the development of human resources to increase bargaining power with industrial nations, all point to the necessity of exploiting modern information technology in education and development. Ghosh [5] says indigenous technology is a must in order to reduce the dependence on industrialized nations.

Dove [1] though, claims that there is evidence today that when young people perceive that they have no chance of entering salaried

white-collar occupations, and that entrepreneurial and craft skills can generate an income, they start to value teachers with technical skills and not only those with academic qualifications.

## PROBLEM NO. 5

Government implementation of far-reaching changes in curricula tends to occur without cognizance of professional opinion.

An important element that appears to be missing in the development of science and technological education in Africa is the conspicuous absence of active involvement of the professional bodies of the local scientific community and of the local teachers and lecturers themselves [1][13][27]. Coupled with this oversight by the governments, the absence of any co-ordination of the many science and technical education programmes being run and organized by outside (foreign) organizations in various regions of the countries concerned. Garbers [4] mentions approximately \$500,000,000,000 in foreign aid and loans for third world countries for eradication of poverty and economic development being wasted in this way annually.

In the past the purpose of education in developing countries has been to produce the skilled manpower for economic growth. Science and technology were seen to be the miracle works in the education system paving the road to economic development and providing the manpower in the form of scientists, engineers and technologists. The role of science education was thus to provide a science elite, using irrelevant science curricula. By the 1970's it was clear that the target economic development had not been achieved and that science education had failed to produce the scientists and technologists required. This was partly due to insufficient and underqualified teachers, but more importantly to the adoption of school science curricula designed for use in America and the United Kingdom, such as the Nuffield Physics and Chemistry projects. These were adopted in Africa with superficial adaptations only. Unfortunately at the time of implementation these curricula had not been fully evaluated in their countries of origin, and neither had they been designed for developing countries [17]. As Ingle [8] says *the end product can all too easily become a cultural mis-*

Science and engineering curriculum reforms also failed because policy targets were too ambi-

tious, time scales too short, allocated resources inadequate, and the vital stages in the development of the curricula such as situational analysis, monitoring and evaluation were neglected. Another major reason for the failure was that teachers were neither involved in the curriculum developments nor trained to use them, and so continued using the methods to which they were accustomed [1].

## POSSIBLE SOLUTION

Probably no solution is available because comprehensive, thorough and valid science curriculum development evaluation is particularly expensive.

## PROBLEM NO. 6

Parents prefer to send their children to urban schools, believing that they will get a better education.

A view commonly held by African parents is that the Secondary School Leaving Certificate is the *Great Escape* from poverty and the rural areas [1][7][20][22][28]. The extended family structure [29] has also led to the migration of pupils to urban areas, causing crowding in schools and slum formation. The fact that most parents are illiterate and uneducated also leads to their being unable to encourage and assist their children in their learning tasks, let alone in science [9]. Parents are usually justified in believing that their children will get a better education in the cities as city schools are better equipped and staffed. However, curricula are often geared for urban conditions with little scope for adaptations to the culture and actual conditions in the remote country areas [1].

## POSSIBLE SOLUTION

To meet the needs of the nation, science and technological education programmes and curricula should be designed for both the contemporary and emergent needs of the diverse societies within that nation [10][13][20]. Thus the development of various science curricula with emphasis on different areas, or a modular system with a *core plus options* basis which incorporates the different regions and their needs, is a possible solution. As Ogunniyi [13] says:—

*topics that relate to mechanised farming, control of malaria and many tropical diseases, ecological balance, provision of good*

drinkable water, production of food, development of good roads, drought, and small agro-based industries etc. are more relevant to the African setting than topics such as computers in the school, computer assisted learning, laser beams, radio-activity and many other topics that have featured in the science curricula of industrial societies.

## PROBLEM NO. 7

Shortage of qualified science teachers, lack of equipment and overcrowded classrooms are ever present.

Rapid population growth and poor planning and management in education in developing countries, has led to overcrowded classrooms and laboratories, lack of facilities, textbooks, equipment and teaching of science in schools [7][8][10][12][13][14]. The major constraint in the development of science and technology in these countries is the lack of suitably qualified teachers, so advances in science and technology cannot occur [12].

One of the anomalies in third world teacher training (which is a sub-system of the education system) is the fact that changes in schools tend to precede those in teacher training, and that it is not unusual for lecturers in remote teacher training colleges to remain unaware of changes in curricula and textbooks [1].

## POSSIBLE SOLUTION

In a number of countries, e.g. Lesotho, Tanzania and Zimbabwe, have resorted to sandwich or accelerated teacher training to alleviate teacher shortages and to reduce the cost of teacher training [2].

## PROBLEM NO. 8

Difficulties related to cultural background, second language and superstition are prevalent.

schooling in a second language, as occurs in all African countries from about the age of 10 or 11 years, is laborious. It places limitations on pupils' understanding, since adopting a foreign language tends to cause a duality of thought patterns [1][8]. The pupils must modify existing cultural norms and construct new ones based on values developed by other people with different cultural ideals [7][8][9][12]. Hence it can be

strongly argued that African languages should be developed scientifically and technically so that all school instruction can be carried out in the mother tongue [9]. In certain countries (India, Sri Lanka, Malaysia and Tanzania) foreign language has already been abandoned in favour of the indigenous language [2]. Coupled with this language problem is the problem of superstition, mysticism and fatalism [8][25] and the African's monistic world-view which Odhiambo [27] says has been an impediment to the African becoming a natural scientist.

*As for the African, his monism has deprived him of the choice between either science or mysticism; instead he has concentrated his intellectual powers in devising a vastly intricate social and communalistic system ...*

## POSSIBLE SOLUTION

If it is desirable that the African embrace science and engineering, rather than mere technology, then teachers and lecturers must reach the root of the problem — the African's monistic world-view — and try to modify it in a manner in which he can begin to regard nature apart from himself or other beings. Science syllabuses should be formulated to achieve this from junior school level upwards.

## PROBLEM NO. 9

Absence of career guidance occurs at school level.

Career (vocational) guidance does not feature at all on formal school timetables in African schools. Teachers are not qualified to teach guidance and, as such, tend to be unaware of specific opportunities available in the fields of science and technology. Pupils do need such career guidance [22] but this is lacking.

## POSSIBLE SOLUTION

Given the correct training, science teachers and career guidance officers/teachers could integrate visits to industries and research institutes with normal classes, as well as invite scientists and technologists from the region to lecture at the school, and so introduce the children to the variety of careers available [14]. Being aware of accessible careers will aid pupils when selecting subjects for matriculation, further study and work opportunities [1].

The nine major problems identified above are by no means the only ones that have led to a malfunction of science and engineering education in the third world. There are others. In the rest of this paper suggestions will be made for addressing these problems in the 1990's in KaNgwane.

## QUESTIONS TO ASSIST IN THE FORMULATION OF A THEORY OF EDUCATIONAL PLANNING FOR KANGWANE

The following questions in Coombs [30] reflect succinctly some of the issues raised in the previous section. These questions have to be addressed when formulating an educational plan with particular reference to the form of third world science and technological education existing in the schools and colleges in KaNgwane:—

- Is the present local educational system meeting the scientific needs and goals of its pupils, students and society? In other words, what are their needs, aspirations and prospects?
- Is the present local science education plan based on a long range view encompassing perspectives which are short range (1-2 years), medium range (4-5 years) and long range (10-15 years)?
- Is the local system of science and engineering educational planning comprehensive? i.e. does it embrace the whole educational system, formal and non-formal education and training, ensuring a harmonious evolution of all the parts?
- Is it integrated with the economic and social development and planning of this region?
- Is local educational management an integral part of the science and industrial education planning for this region?
- Does the science and engineering educational planning of this region concern itself with qualitative as well as quantitative expansion of the students?
- What should be the global priority areas of the science education system of this region?
- What are the best alternative ways of pursuing these objectives and functions? (i.e. alternative educational technology, relative costs, time, feasibility, educational effectiveness).

- What proportion of the region's national resources should be devoted to science and industrial education at the expense of other sectors, and how should the total resources available be allocated among the various components and levels of the education system?
- Who should pay, and how should the burden of educational costs and sacrifices be distributed?

## KANGWANE'S GOVERNMENT POLICIES

Government policies have been formulated in the key areas of education, agriculture, economics, public service development, and health and welfare.

In an attempt to meet some of the basic needs of these policies, the Technical College/Technikon provides one year National Certificates in seven different fields such as electricity, motor body repair work, and building skills, as well as an intensive commercial course.

KaNgwane is relatively well supplied with rivers, and several dams and irrigation schemes exist. However, more dams must be built in the near future to cope with increasing demands, with attendant demands in engineering and technical skills.

## ECONOMIC DEVELOPMENT POLICY

The Economic Development Corporation was established to stimulate the region's growth by establishing and/or financing agricultural, industrial and economic ventures. This body investigates the development of material and human resources and their ability to produce local employment capacity. Labour intensive industries are favoured for creating employment opportunities to improve the quality of life of the inhabitants of the region. The Corporation concentrates on three areas:—

Firstly, rural development is a major concern, and the Corporation aims at alleviating the stress of unemployment by providing basic services such as safe water supplies and sewage.

Secondly, one of the larger towns has been selected as an industrial centre, and two industrial parks have been established. The following types of concerns exist at present: a sawmill and other timber concerns (roof treccils), furniture, game skin tanning, musical instruments, food, clothing and gem factories.

Thirdly, two mines (anthracite and asbestos) are in production and a further three anthracite mines are due to commence operations. Other minerals occur in the region, but are of limited economic value (barite, lithium, gold, iron, nickel, tungsten, antimony, copper and tin).

Proposed development in the economic sector includes extensive housing development programmes in all the larger towns for different income brackets, construction of office buildings and shopping complexes, industrial and business premises, central markets, community centres, bus shelters, civic centres, fire and police stations, post office facilities, sport and other recreational facilities, old age homes and libraries where they are most needed.

The Department of Works is responsible for construction and maintenance of roads and bridges, water supply and purification and electrical supply and maintenance. Electricity is supplied by ESKOM (South Africa).

Proposed developments include tarring all the roads and providing stormwater provisions in the streets in the major towns, supplying reticulated electricity, water and sewage to all new suburbs to be developed, and upgrading the existing facilities. To meet these engineering and industrial needs, science education must provide a more technical/vocational course [20][31].

## AN EVALUATION OF POSSIBLE MODELS/ PROPOSALS OF SCIENCE AND ENGINEERING EDUCATION FOR IMPLEMENTATION IN DEVELOPING COUNTRIES

In an attempt to derive possible solutions applicable to KaNgwane the process of reform in science and technological education in Thailand [32], and a proposal for Third World Science Education by Russell [20] will be examined.

### Science Education Reform: The Thai Example

In 1971 the Institute for the Promotion of Teaching Science and Technology in Thailand (IPST) was given a broad spectrum of responsibilities, and an enabling act laying down certain objectives to promote and execute as follows:—

- the study and research of curricula, teaching techniques and evaluation,
- training programmes for teachers, instructors, lecturers, pupils and students,

- research development and production of science equipment and materials,
- the preparation of texts, exercises, references, supplementary materials and teachers' guides [32].

A **systems approach** was utilized to synchronize the major outputs and required inputs and timing and sequencing of the total operation. Curriculum development was seen to be a continuous process beginning with the definition of goals and objectives followed by decisions on themes, content, skills and attitudes to be developed.

The criteria used for selection of content activities, attitudes and skills were determined by design teams composed of local teachers, teacher training instructors, university education specialists and other specialist educators. The materials were then written, tested, rewritten, trials were conducted, the curriculum revised, published, teachers were trained and, finally, the curriculum was distributed and implemented throughout the country and school follow-up systems were established.

The whole process was viewed as continuous over a period of six years (1971–1977). After implementation (1977) an overall evaluation of the curriculum occurred, followed by further revision and modifications to the goals and objectives of the new Physics, Chemistry and Biology in the schools in the Kingdom of Thailand. In the development of the science reform programme four areas were tackled concurrently:—

- The writing and publishing of student texts and teachers' guides. These set the pace and determined the schedules that evaluation, teacher training and equipment development had to meet;
- The area of examinations and testing, including university entrance examinations. The IPST evaluation teams designed tests and pre-tested attitudes, understanding and science process skills by questionnaires and tests. The aim was to avoid the old type of examination-oriented learning;
- Teacher training began in the first year of curriculum development. Thirty-six colleges began to use the IPST curricula, equipment and approach in their teacher training programmes in 1976. Teachers were also employed to test experiments, to assess their suitability and to evaluate the text drafts.

Some of the teachers used in the initial trial programmes were then used to train about 90% of all the other teachers in private and public schools in 2–3 week workshops;

- Low cost school science equipment to meet the needs of the designed programmes were produced by IPST, and 32 teachers' colleges in the distant provinces established equipment repair centres to assist the secondary schools.

The curriculum was reformulated to help pupils acquire scientific knowledge which could be applied to their daily lives, to show the value of conservation of natural resources and habitats, and to teach them to observe their local environment in terms of their own lives. The scientific skills thus gained were used to assist pupils with problems in their own lives, as well as for the social welfare of the community as a whole. The value of this science education reform process in Thailand was that it was based on clear goals of science education, rationally linked to a national purpose and understood and accepted by all.

The success of the programme was also due to correct timing for decision and sequential implementation, strong leadership and sustained professional and financial support. It is important to note that the Thai model was initiated at the tertiary level. From there it went to secondary schools and only after the first evaluation was the reform extended into primary education.

### Russell's proposal for science education in a third world country

Different from the Thai model, the proposal by Russell for Third World science education development was described towards the end of the 1970's in Zimbabwe (then Rhodesia).

In reply to the question *What sort of Education is required to accelerate development in Third World countries?* Russell [20] offered the following suggestions:

- There must be progress towards employment or self-employment for the whole working population; progress towards eliminating poverty, and progress towards reduction of glaring inequalities and a re-distribution of income;
- Comprehensive educational planning must be firmly grounded in manpower studies which consider present needs for specific jobs at all levels of employment, and self-employment in the urban and rural sectors;

- Curriculum design must draw on the local environment, must relate to the acquisition of transferable skills, abilities and aptitudes, and must aim at the integration of all levels of education, including various aspects of development in science, engineering and technology;
- Both formal and non-formal education and training should be interspersed with work throughout life, i.e. recurrent education must feature strongly. This implies a good basic education from 6–16 years of age, and thereafter a flexible post-basic transferable vocational element of training. At 16, pupils should take aptitude tests (not conventional academic examinations) for occupational recruitment, while further academic studies can occur for a minority;
- This proposal is similar to the system that is followed in West Germany. Children are kept at school until the age of 18, but at the age of 16 they are split into two streams; those that continue with general education and those that follow a technical and vocational course and apprenticeship schemes. Those youngsters (16–18 year olds) following a technical vocational stream are thus learning a career in the workplace while attending school one day a week [31][33];
- Adult education thus becomes a dominant component in the system and recurrent education encourages life-long concern for the productive integration of work and studies. Education thus becomes learning-on-the-job, recurrent inservice and in-career, with built-in educational leave for full-time studies at universities based on learner controlled systems (a modular approach). This should help to eliminate the negative attitude towards vocational training and vocational institutes, eliminate unemployment and meet the middle level manpower needs. This idea is also very similar to Nyerere's life education for liberation and development in Tanzania [34];
- Estimates indicate that non-formal education constitutes roughly half the effort spent on education in Zimbabwe but that it rarely receives concerted planning efforts [20]. It is also more directly and immediately related to development and careers. Non-formal education also covers a wide field of skills for local community needs. Successful systems that could give guidelines to non-formal educational planning are:—

- The Village Polytechnic Self-help Movement developed in Kenya
- The Brigade System of Vocational Training in Botswana
- The low-cost Vocational Improvement Centres in Nigeria
- The National Apprenticeship Service Scheme (SENA) used in Columbia, South America
- Agricultural Extension Programmes and Minimum Package Deals as used in Zimbabwe.

All these schemes start with the identification of *felt needs* or *wants* in the local community.

- Non-formal education for development must thus be utilitarian, firmly related to the world of work of the adult in the community and integrated with the development effort at all levels of society.

## PROPOSALS TO BE INCORPORATED IN AN ENGINEERING/TECHNOLOGY EDUCATION POLICY FOR KANGWANE

A synthesis of the above models and proposals which would be most appropriate to the special context of KaNgwane is as follows:—

Firstly an in-depth, carefully co-ordinated manpower survey in all Departments should be carried out to determine the present available manpower, as well as the manpower needs, particularly in scientific and technological areas, for the next decade. Hard data is needed on which to make decisions.

This survey will then serve as a policy on which educational planning for all levels can be based, following the Thai Model.

Then major curriculum in science-related fields should be implemented as soon as possible to include application of topics related to community and individual health needs, disease control, mining, agriculture, forestry, ecology and industry, also following Ketudat's Thai Model.

The educational needs in the medical, dental and medical technology, veterinary, agricultural, commercial and industrial areas must then be negotiated with educational institutions in South Africa, so that the necessary manpower can be educated where this region does not have the facilities, and where these facilities would not be a feasible investment.

Then planning for additional course structures at the Technical College / Technikon and proposed University College can occur, based on the manpower survey needs, following Russell's Proposal.

Finally the design of a comprehensive curriculum up to age 16 must occur, with vocational specialization for the last 2-3 years of high school, based on the manpower survey and scientific and technological needs of the region (Russell's Proposal [20]).

The implementation of the new science/technology curricula, designed to meet the needs identified, would be based on that of the Thai Model, starting with teacher training. This implies a top-down approach, introducing the new curricula to teachers-in-training (pre-service) as part of their course, as well as to lecturers and teachers in the field (in-service) through workshops in different regions.

## CONCLUSIONS

KaNgwane's science and technological education system requires major restructuring to meet the needs of the region, based possibly on the Thai Model [32], while including aspects of the West German, technical vocational stream (Hamilton [31]), as well as linkage with non-formal education (Russell's Proposal [20]) by means of integration with the other Government Departments. Science and the required technology based on the manpower needs survey must be carefully integrated into the curricula to serve as the basis of development. A comprehensive manpower study is essential to determine vocational needs, and thus the planning of the education system.

At present 20% of KaNgwane's annual budget is spent on education. This may appear to be extravagant but in a developing region it is essential if the development sought is to be achieved within the next decade.

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