This is to certify that the

dissertation entitled

TEACHER EDUCATION AND A-LEVEL BIOLOGY TEACHING:
A DESCRIPTION AND EVALUATION OF
THE ZIMBABWE SCIENCE TEACHER TRAINING
(ZIMSTT) PROGRAM

presented by

Josephine Karuvunika P. Zesaguli

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of the requirements for

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TEACHER EDUCATION AND A-LEVEL BIOLOGY TEACHING: A DESCRIPTION AND EVALUATION OF THE ZIMBABWE SCIENCE TEACHER TRAINING (ZIMSTT) PROGRAM.

VOLUME I

By

Josephine Karuvunika P. Zesaguli

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

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Department of Teacher Education

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ABSTRACT

TEACHER EDUCATION AND A-LEVEL BIOLOGY TEACHING:
A DESCRIPTION AND EVALUATION OF THE
ZIMBABWE SCIENCE TEACHER TRAINING
(ZIMSTT) PROGRAM

By

Josephine Karuvunika P. Zesaguli

This study was carried out, firstly, to find out how the upgrading in-service ZIMSTT program has evolved, as a stop-gap measure of meeting the shortage of science teachers at A-Level. This was achieved by teaching more subject matter content knowledge to qualified and experienced O-Level science teachers. Secondly, the study was done to evaluate the program's impact on its Biology graduates, in terms of how well they were coping with teaching A-Level classes, their prevailing teaching practices, and their impact on their students.

The study was done in four stages. The first stage was a survey of all the 80 ZIMSTT Biology graduates from the beginning of the program to the present (1986-1992). Only 9 of these 80 were teaching A-Level classes. The second stage was the intensive classroom observations of 2 of these 9 teachers, in an urban school setting, teaching the same unit/topic (DNA, RNA, and Protein

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Synthesis), from the beginning to the end. This was followed by classroom observations of the remaining 7 A-Level Biology teachers, teaching in Government and Private (Mission) urban and rural secondary schools. These were observed teaching a variety of topics, in a lesson or two, because of very stringent time constraints. The fourth stage was a follow up of those ZIMSTT graduates who were not teaching A-Level Biology. Data were collected and triangulated from a variety of sources including, survey questionnaires, observation field notes, interview transcripts, documentary analyses, students' clinical interview transcripts, and pencil and paper tests.

The findings were that very few of the ZIMSTT graduates had been promoted to become either A-Level Biology teachers, Headmasters, Teacher Educators, or Education Officers. They had all experienced some problems initially but were then coping in these posts. The A-Level Biology teachers were, on the whole, having a positive impact on their students' cognitive and affective achievements, as indicated on different measures. However, they still need more professional assistance.

DEDICATION

This dissertation is dedicated to the current General of the Salvation Army, GENERAL EVE BURROWS and the late MRS. S. MUTSVAIRO for opening the first door, and to my late parents, MR. & MRS. K. PONDAYI, for their immense love and care.

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ACKNOWLEDGMENTS

First and foremost, I would like to express my deeply felt gratitude to The Rockefeller Foundation for making this undertaking possible. Without their most generous financial support, I would not have accomplished what I did.

I greatly appreciated the visit by Professor Gallagher, my academic advisor and dissertation committee chairman, which was also sponsored by the Rockefeller Foundation. It took place at the most opportune time. He helped me re-direct my study in light of the data which I had collected to date and the problems which I had experienced with the Ministry of Education in getting started.

Secondly, I would like to thank Michigan State University and the Fulbright Scholarship program for sponsoring my doctoral study in the U.S. This opened the door and the subsequent opportunities, which enabled me to have various valuable learning experiences. I also appreciate the approval of my study leave granted to me by the University of Zimbabwe.

Thirdly, I am most grateful to my dissertation committee: Dr. J. J. Gallagher (chairperson), Dr. D. Campbell, Dr. E. Smith, and Dr. P. Shepherd, who have been most supportive and patient. I greatly appreciate the time they gave me from their busy and tight

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Fourthly, I would like to thank my dissertation supervisors - Professor J. J. Gallagher and Professor N. Atkinson for their much needed advice; Professor and Assistant Dean J. R. Schwille and Ms. A. Schneller for their patient encouragement of the M. S. U. African Educational Research Group; and the support given by the Chairpersons of the Department of Teacher Education at M. S. U., the Department of Foundations and the Department of Science and Mathematics Education at the University of Zimbabwe, respectively.

I also much appreciated the enthusiasm, which the Ministry of Education, Zimbabwe, through the Secretary of Education, Mr. I. M. Sibanda, showed in my research study, and the very warm welcome which I was given in the regions by the Regional Directors and the Headmasters/ Headmistresses of the different schools, in which the study was carried out. I also thank the Chief Education Officer and his Deputy and the Officers at the Examination Branch of the Ministry of Education and Culture, for making the A-Level Biology syllabus, the Final Examination papers, and the results available for me.

To the ZIMSTT graduate teachers of A-Level Biology classes and their students, with whom and for whom the study was done, I would like to express my gratitude for the time they gave me, the excitement they impacted, the stimulation I received, the new vision and skills I developed about science teaching and learning, and the hope for the future which I now entertain. It was both a great joy

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and a pleasure working with all of you. I sincerely hope that my interactions with you were of mutual benefit.

Last but not least, are my grandmother, Ambuya Maud Mutambara; my children: Connie Hazvineyi, Mike Farayi, Kenny Muchatenda and Cindy Avril Zvamwaida; and my grandchildren: Yeukai Mwakapaani, Batsirayi Victor and Kenny (Jr.) Tafadzwa, I appreciated their patience and understanding for those moments "when at times sometimes" I was physically there and yet be mentally engaged with my research data. "HAMBAYI, NZIRA YAKAREBA"

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ABBREVIATIONS' KEY

ZIMSTT - Zimbabwe Science Teacher Training program.

TQ - First wave Survey Questionnaire.

2TQ - Second wave Survey Questionnaire.

C - Current ZIMSTT student candidates.

E.O. - Education Officer for Science.

R.EOI - Interview with Education Officer(Mr. Russell).

N.ZSI - Noel a ZIMSTT STAFF member's Interview.

CFI - **Teacher named** Christopher's FINAL **INTERVIEW**. Similar abbreviations for the rest of the other observed teachers:

BFI (Mrs. Bell)	**DFI** (Mr. David)
GFI (Mrs. Gregory)	**MFI** (Mrs. Morris)
MiFI (Mrs. Michael)	**NFI** (Mr. Norman)
PFI (Mr. Peter)	**VFI** (Mr. Victor).

Corresponding to these teachers' initials are the references for their **STUDENTS' INTERVIEWS**, that is, **BSI** - Mrs Bell's Students' interview response and **BSQ # 2** - Mrs. Bell's Student # 2's **QUESTIONNAIRE RESPONSE**.

Tr. - Teacher.

St. - Student.

J.HI - Interview with Headmistress Mrs, Jones.
Similarly, for the other Headmasters: **S.HI, Mu.HI & R.HI**, that is, Mr. Simon, Mr. Mudson & Mr. Russell, respectively.

RDI - Regional Director Interview.

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CHAPTER I

INTRODUCTION

OVERVIEW

This is a national follow-up study of qualified and experienced O-Level science teachers, who were up-graded to teach Biology up to A-Level. This up-grading was accomplished by the teachers enrolling in the Zimbabwe Science Teacher Training (ZIMSTT) Program. Data were collected in nine High Schools and six Teacher Training Colleges, which are located in seven of the nine regions of the Ministry of Education and Culture; in the Department of Science and Mathematics Education, at the University of Zimbabwe; and at the Head Office of the Ministry of Education and Culture.

This follow-up study concentrated on the ZIMSTT A-Level Biology teachers' beliefs, conceptions and thinking processes, their academic and professional experiential backgrounds, their A-Level students' prior knowledge, attitudes and inquiry skills, the school and science laboratory contexts, the A-level Biology syllabus and final examinations, the ZIMSTT in-service training program, and professional assistance. The ZIMSTT graduates who had been promoted to other posts of responsibility, such as Teacher Educators, Heads of Schools, and Education Officers, were also followed up in order to fir

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BACKGROUND OF THE STUDY

Nowhere is the need for quality in education more pressing than in developing countries, particularly in the wake of their post-independence, massive increases in enrolment at all levels. Zimbabwe is one such country.

Zimbabwe's education system is centralized and based on the British system. The sequence of schooling is seven years of Primary Education leading to four years of Secondary Education. Students get an O-Level Certificate on completion, which is equivalent to the American High School's Grade 12. But unlike the latter, O-Level does not lead to the university. Instead there is an extra two years of Higher Secondary Schooling, which is referred to as the Advanced Secondary Level (A-Level). This is the pre-requisite for admission into a 3-year University for undergraduate studies. After O-Level or A-Level, students can go for a three-years of professional training at either a Primary or a Secondary Teacher Education College and be certified to teach at those respective levels. On the other hand, University Graduates can teach up to A-Level with or without a Post-Graduate Certificate in Education.

Before Independence (1980), the A-Level students themselves were a special breed of students in that not only were they very highly motivated but they also had superior academic abilities, evidenced by the extent to which they had excelled in the competit

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Table 1

Total Numb
Enrollment

Primary School	
Primary Enroll	
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Second Enroll	
TOTAL SCHOOLS	
TOTAL ENROLL	7

competitive and selective system of education. These students had a positive attitude to O-Level science.

After Zimbabwe gained its Independence (1980), an egalitarian system of education was instituted, resulting in massive increases in enrollments at all levels of schooling. This intensified the already existing dire shortage of qualified teachers at all levels. Statistics which are presented in the Tables 1, 2, and 3, below, are a summary of the total numbers of both the primary and secondary schools and their respective enrollments and the numbers of their trained and untrained teachers:

Table 1

Total Numbers of Primary and Secondary Schools and Their Student Enrollments

	1970	1975	1980	1985	1990
Primary School	3,408	3,446	3,161	4,234	4,539
Primary Enroll	711,182	850,521	1,235,994	2,216,878	2,119,865
Second School	180	203	197	1,215	1,512
Second Enroll	49,550	66,910	74,321	482,000	672,653
TOTAL SCHOOLS	3,588	3,649	3,358	5,449	6,051
TOTAL ENROLL	760,730	917,431	1,310,315	2,698,878	2,792,518

Table 2
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Table 2
Total Numbers of Trained and Untrained Teachers and Student Enrollments in the Primary Schools

Teacher Qualifications	1981	1985	1990
Untrained	15,119	26,610	25,047
Trained	22,654	30,081	35,839
TOTAL NUMBER TEACHERS	37,773	56,691	60,886
TOTAL PRIMARY SCHOOL ENROLLMENT	1,715,169	2,216,878	2,119,865
TOTAL NUMBER PRIMARY SCHOOLS	3,698	4,234	4,539

Table 3

Total Numbers of Trained and Untrained Teachers and Student Enrollments in the Secondary Schools

Teacher Qualifications	1981	1985	1990
Untrained	266	5,551	11,892
Trained	4,608	11,764	15,440
TOTAL NUMBER TEACHERS	4,874	17,315	27,332
TOTAL SECONDARY SCHOOL ENROLL	148,690	482,000	672,653
TOTAL NUMBER SECONDARY SCHOOLS	694	1,215	1,512

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These data were extracted from the Secretaries' Annual Reports of the Ministry of Education and Culture (Makura, 1981, Table 4, p. 31; Chanakira, 1985, Table 4, p. 48; Sibanda, 1990, Table 1 c & d, p. 35).

Between 1970 and 1975 there was a slight increase in the number of schools and their enrollments both in the primary and secondary schools. Between 1975 and 1980 there was a drop in the number of primary and secondary schools and yet there was an increase in the enrollment especially at the primary level. This decrease in the number of schools was primarily due to the armed struggle for Independence, which was at its peak then. Moreover, at Independence, one of the Government's policies was to declare that education was to be a right for all primary school age children. Hence, there was a massive increase at the primary level which carried over into the secondary levels. This accounts for the enrollment increases at the secondary level, which are reflected in the 1985 column. These increases seem not yet to have leveled off. A decrease in enrollment at the primary level may be due to the fact that a policy of parents paying school fees and school levies has been re-introduced. Some parents cannot afford to pay these and are either not sending their children to school or are withdrawing their children who are already in school.

Three very disturbing features emerge from the statistics above. First, a comparison of the total enrollments at primary and at secondary schools shows that not all primary students move on to the secondary level. What happens to those that do not make it?

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Second, there is a high ratio of the number of students to teachers. How are teachers coping with such large classes? Lastly, there are large numbers of untrained teachers at both the primary and the secondary levels. What sort of support is given to these untrained teachers? The teacher education institutions seem to be failing to catch up in their production of trained teachers. The shortage of teachers, at both the primary and the secondary school levels, was also compounded by the exodus of some of the qualified teachers to posts in the private sector, which had hitherto not been opened for them, before independence, where the pay was higher than in the teaching field. This shortage was particularly felt in rural schools from which teachers were resigning "in most cases because of poor accommodation, water supplies and other facilities ..." (Chanakira, 1986, p. 8). Four years later, the situation had not improved. As reported by the Secretary of Education,

> The teaching service continued to be plagued by resignations, occasioned by the unfavorable living conditions in the remote rural schools. While there was a 21% drop in the number of new primary school teachers, the secondary schools sector experienced a 33% increase (Sibanda, 1990, p. 1).

Moreover, the majority of the graduates from the Faculty of Science do not opt to enroll into the Post-Graduate Certificate in Education program. They only opt to teach after failing to secure a job in industry. They do not show any commitment to teaching because, as soon as a better paying job comes their way, they quit teaching. This has aggravated the acute shortage of qualified teachers, particularly at A-Level, and especially in science subjects (Sibanda, 1990, pp. 51-52). On the other hand, the O-Level

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Science teachers, who were applying for the pre-1986 B.Ed. program, had at least demonstrated their commitment by desiring this opportunity for further professional development.

To ameliorate the shortage of Science teachers at A-level, the Ministry of Education instituted the Zimbabwe Science Teacher Training (ZIMSTT) Project (1986).

THE ZIMSTT PROJECT DESCRIPTION

The Zimbabwe Science Teacher Training (ZIMSTT) Project was set up in 1985 as a joint venture between the Ministry of Education, the University of Zimbabwe, and the Free University of Amsterdam. It has the following two aims:

> . . . preparing non graduate trained secondary school teachers so that they can teach their subject to all levels of the secondary school systems, i.e., up to A-Levels.
>
> . . . producing manpower for Curriculum Development, to teach in Teacher Training Colleges and to service other divisions of the Ministry of Education (ZIMSTT, 1988, p. 1).

Note that "teaching at least one subject to all levels of the secondary school system" meant teaching up to A-Level, where an acute shortage of qualified teachers was being felt throughout the country. This was accomplished by up-grading the O-Level certified and experienced Science teachers by giving them advanced subject matter content knowledge in either Biology, Chemistry, Physics, or Mathematics, leading to a B.Ed. (Science) degree.

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> Starting from 1986, 20 Certificated O-Level teachers in two subjects Biology and Physics were enrolled. Thereafter, Chemistry and Mathematics were also offered. Phase 1, which was taught by 8 Lecturers (4 from U.Z. and 4 from F.U.A.) ended in 1988, with 3 groups of Biology and Physics and 2 groups of Chemistry and Mathematics having graduated from the one year full-time course. The project continued as Phase II, with the course having been extended to two years full-time and being taught by 99% U.Z. lecturers . . . (Jaji & Hodzi, 1992, p. viii).

The ZIMSTT Biology program starts off with the students taking Biology Teaching Subject Pre-requisites (Chemistry and Statistics). This is followed by a series of Biology Teaching Subject Courses in Plant kingdom and Animal Kingdom, Genetics and Evolution, Plant Physiology, Animal Physiology and Ecology; Professional courses in Science Education, Science Curriculum Theory and Science A-Level Methods I & II; and a Project.

Phase II of this ZIMSTT program started January 1989 and ended December 1992. After 1992 it will be incorporated as a regular University of Zimbabwe, Faculty of Education program.

The entry requirements have since been raised to include an A-level pass in the subject the teachers wanted to enroll in, plus passing an entrance examination, which "assesses" applicants' standard knowledge in the teaching subject and ability to apply that knowledge. This examination was designed and marked by the ZIMSTT staff. Hence, selection has become more rigorous and demanding.

The B.Ed. Science Curriculum being offered in Phase II has been modified slightly after the review of Phase I. In responding to how the B.Ed. Science Curriculum had evolved, the former Department

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Chairman, who was also a member of the ZIMSTT Project Board from the beginning of the program to the present, explained that,

> . . . before the evaluation, the program consisted of 6 content areas in each discipline, 1 Curriculum Theory (Education) Course and 1 Project. The latter had more weighting, counting as two courses, as a hangover from the old professional B.Ed. which was in place before this project. After the extension of the program to two years, the curriculum was enhanced. There was an addition of the teaching subject prerequisite, which in the case of Biology includes Chemistry and Statistics. It now consists of content courses in each area of specialization (i.e., Mathematics, Biology, Chemistry and Biology); an A-Level Methodology Course, in which students go over the stipulated A-Level syllabus of their area of specialization, making certain that they themselves understand and interpret its content accurately and can improvise materials for the required practical activities. Visits to observe A-Level teachers and a mini-project, which is directed to teaching, are included in this course. The Curriculum Theory course had an added assessment emphasis (Psychometrics). The project was retained to give students opportunities to pursue an area based on personal interest of the students. This enables students to undergo personal growth in an area in which they feel compelled to know more. Hence, the B.Ed. Curriculum was based on the needs and requirements of the A-Level syllabus demands and not of Industry [Tape N.ZSI (6/3/92)] (See **KEY**, above, for the abbreviations of the data sources of the quotes).

It seems that such a program will inculcate a feeling of competence, control, and confidence in the B.Ed. students to tackle the demands of A-Level teaching.

The facilities and space used for lectures and laboratory activities were provided in the Faculty of Science. But the lecturers were only two per discipline, i.e., a Science Teacher Educator from the Faculty of Education, University of Zimbabwe and a Science Lecturer from the Free University of Amsterdam.

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The program funding was contributed jointly by the three parties involved.

> The University of Zimbabwe was responsible for the financing of the local staff, physical facilities, equipment and accommodation for the foreign staff. The Ministry of Education (Zimbabwe) paid the salaries of the students, who had been granted study leave with full pay. The Free University of Amsterdam under the auspices of NUFFIC provided for the expatriate staff, equipment, and 12 AT computers in 1989 [Tape N.ZSI (6/3/92)].

Assessment of the B.Ed. students was done continuously and on the basis of examinations which were set by the ZIMSTT program staff. The assessment weighting is 80% for Teaching and Professional Courses, each of which has a three-hours final written examination and 20% for the Project. The examinations and the project were evaluated by the corresponding Faculty of Science Department and their External Examiner.

An evaluation of the project was done during the project's third year of implementation.

> This evaluation revealed that the ZIMSTT graduates of the one-year crash course were not coping with A-Level teaching requirements. Explanations which were put forward included the fact that the pace was too fast. There was not enough time for students to reflect and digest what had been learned. Content coverage was not deep enough due to the time constraints. With the low academic level of the students on entry, they failed to gain meaningfully from the program that was offered at that fast pace. These findings led to the implementation of the recommendation that the program be extended to two years full-time (Tape N.ZSI, op. cit.).

Beyond extending the program from a one-year to a two-year full-time program, the A-Level Method Course was also added.

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Two follow-up studies have been done. One was a Tracer Study by Jaji and Hodzi (1992), whose objectives were,

1. To determine the contribution of the B.Ed. full-time program to the quality of teaching science at the secondary level.

2. To determine the contribution of the B.Ed. full-time program to the quality of teaching science at the tertiary level (teacher training colleges and polytechniques).

3. To determine what weakness the program has and how to improve it (p. 14).

The other study was an Evaluation of Phase II of the program which was done by Boeren and Kuchocha (1990). These studies had not been completed by the time the present study's proposal was submitted for funding consideration. Hence, some of the aspects which this study examines were also reviewed by either one or both of the follow-up studies. However, in the Jaji and Hodzi (1992) report, there were only two ZIMSTT Biology graduates among their total sample (N = 24) who had taken the Biology Option, whereas, the present study's findings represent feedback from a greater number of ZIMSTT Biology graduates (N=27), nine of whom are now A-Level Biology teachers. This particular follow-up study was done in order to find out how the ZIMSTT Biology training, specifically, has impacted on the nature and extent of the teaching and learning of science at A-level.

To sum up then, the ZIMSTT project was implemented as a stop-gap measure to increase the numbers of A-Level Science and Mathematics Teachers. This was done by up-grading certified O-Level Science Teachers by giving them an intensive content course in the subject

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subject, which they would teach at A-Level respectively. The project was initially a one year full-time crash program. After an evaluation, this was extended to two years.

STATEMENT OF THE PROBLEM AND STUDY OBJECTIVES

The key element in all teaching and learning situations is the effectiveness of the teachers. It is their classroom actions and behaviors that form the critical bridge between the curriculum and their students' learning. How they cope makes a difference in the quality of their lessons. The **problem** is that not much is known of, not only, how well the ZIMSTT graduates are coping, faced with a new challenge and responsibility of teaching Biology at A-level, after years of O-level science teaching; but also, how well and in what way the ZIMSTT program met the expectations of its graduates.

Therefore, this study was conducted to find out how these up-graded O-Level science teachers were coping with the demands of A-Level Biology teaching; to give both a broad and an in-depth portrayal of the patterns of teachers' thinking, teaching practices, and classroom discourse in the A-level Biology classes, taught by the ZIMSTT graduates, as perceived by their science supervisors and by the researcher; and to evaluate the impact of these practices in terms of what the students carry away from the instruction, along three dimensions (See Objective #5 below).

More specifically, this research study was carried out to try and accomplish the following **objectives**:

1. To give an overview of how **the ZIMSTT program** was conceived, developed, and implemented.

2. To describe **the ZIMSTT graduates'** academic and experiential backgrounds, why they enrolled in the program, their expectations, their perceptions of the program, what they think they got out of the program, how the program is/is not helping them in their present teaching.

3. To describe the ZIMSTT graduates' **beliefs** and **thinking processes**, i.e., **judgments** and **decisions** they make with regards to their teaching, students and their learning, the Biology subject matter and the milieu and how these impact on their observed classroom practices.

4. To describe **the teaching practices** of these ZIMSTT graduates perceived by the teachers themselves, their students, their supervisors (the Headmaster, the Head of Science Department and the Regional Science Education Officer) and by the researcher.

5. To evaluate **the effectiveness of the ZIMSTT graduates' teaching practices** along four dimensions of their present A-level biology students' acquired cognitive and manipulative skills and attitudes to science and technology:

   i. the <u>cognitive development</u> of the students of the ZIMSTT teachers, i.e., the extent to which they undergo conceptual change and come to achieve meaningful understanding of the content taught. By conceptual understanding I mean the shift from personal understandings that are idiosyncratic to understandings that are widely shared in the scientific community. The latter will be evidenced by the students being able to apply the concepts learned on pencil and paper tasks designed by the researcher which will require them to describe, explain, predict and control natural phenomena;

   ii. the <u>practical know-how</u> of the students of the ZIMSTT teachers, as demonstrated, first, by their facility to design experiments, follow written instructions and procedures, and manipulate laboratory apparatus during their practical lessons; secondly, by the nature of the questions which they ask which indirectly reflect their capacity to explore; and, thirdly, by the completeness of their responses and explanations which they give during classroom discussions;

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iii. the <u>attitudes to Science and Technology</u> of the students of the ZIMSTT teachers, as expressed on a questionnaire designed by the researcher; and

iv. the <u>overall performance(s)</u> on the public A-level Biology exam of the previous biology students of these ZIMSTT teachers. Data for this will be secured from the Examination Branch, Ministry of Education.

MAIN RESEARCH QUESTIONS

In order to achieve the objectives stated above, the study was guided by the following research questions:

1. What aspects of the **ZIMSTT program** were either over- or under-emphasized, given the teachers' experiences, levels of expertise and perceived needs?

2. Considering the norms, ideals and requirements of the **A-level Biology syllabus**, what is the nature of the teachers' beliefs and conceptions about teaching, learning, the subject matter knowledge, their students, the school and science laboratory context?

3. What sort of **teaching practices** are prevailing during the ZIMSTT graduates' A-Level Biology lessons?

4. What **prior conceptions, skills and attitudes** do the students bring from their O-level science exposure on the topic to be taught? How are these addressed by their teachers? What is the nature and quality of **practical work (laboratory life), explanations, metaphors, and illustrations** given in the ZIMSTT graduates A-Level Biology lessons?

5. What **choices** are made and how do these teachers make them (before, during and after instruction) in relation to the sequencing of the observed topic's concepts, depth of treatment, appropriate representations of the subject matter, and the implemented teaching approaches and strategies?

6. What picture of practice emerges of the ZIMSTT graduates' teaching practices? How are these practices impacting on their students' learning?

CONCEPTUAL FRAMEWORK

Teaching is so complex that it cannot be reduced to one parsimonious conceptual model. For this study, an eclectic conceptual framework was adopted because of the nature of the study being undertaken. That is, use was made of complementary theories, models, and taxonomies. Examples of theories include, first, **The Constructivist Theory** (Driver, 1981; Driver, et al., 1985; etc.) which states that people construct meanings and knowledge as they interact with their environment. The latter includes things, ideas and other people. **The Conceptual Change** Theory (Hewson, 1981; Posner, et al., 1982; Resnick, 1983; etc.) is the second theory. This theory states that in a learning situation students can be helped to undergo conceptual shift from their prior naive understandings to adopting more sophisticated scientific conceptions. If this is not achieved, then the result is that the students will have compartmentalized knowledge, that is, the school knowledge on the one hand, and their personal idiosyncratic knowledge on the other hand, which remain separate.

Examples of models are **The Decision Making Model** (Borko, et al., 1979; Shavelson, 1976; Shavelson & Stern, 1981; Sutcliffe & Whitfield, 1979); and **The Planning Models** (Yinger, 1977; Zahorik, 1975; Peterson, et al., 1978; etc.). These were used and applied in studying aspects of the teachers' thinking during their planning and reflect

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reflective phases of their teaching practice. The Conceptual Change Teaching Model (Anderson & Smith, 1987) was used in analyzing the nature of classroom interaction taking place.

Examples of taxonomies include those of decisions (Eggleston, 1979), planning (Yinger, 1977), and of lesson plans (Clark & Yinger, 1979). These served to guide the shaping of research questions and to organize data analysis and interpretation. Other research findings from the literature reviewed to date about classrooms, teaching, teacher coping mechanisms also influenced this study.

THE RATIONALE OF THE STUDY

In my roles as science teacher, the head of a science department, science education officer (supervisor), curriculum developer, and a teacher educator of prospective science teachers, I have always been looking for ways of improving science education. But pressed for time as we were with the demands of the ZIMSTT Biology program, I personally was very frustrated by the lack of communication between the ZIMSTT Staff and our graduates after they got back to their schools. Now that I was a full-time student and free from normal teaching responsibilities, I could devote full attention to this follow-up study, which was timely in that a knowledge base exists on teacher thinking, decision making and students' learning in science.

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SIGNIFICANCE OF THE STUDY

The study has both international and national significance. **For the ZIMSTT Program implementers** it will enable them to modify and improve their training program so that their ZIMSTT graduates will be better prepared to teach A-Level Biology. **For the participating science teachers**, it is hoped that they will acquire and maintain the ability of "reflection-in-action", which will enhance their teaching practice. **For the Science Education Officers**, findings from the study will enable them to organize relevant, staff development, in-service seminars and workshops for the A-Level biology teachers. **For the Curriculum Development Unit**, indications will be given of the extent to which the O-Level Science Syllabus (Nos. 5006/7, Zimbabwe) is really a sound preparatory basis for A-Level Science study as claimed in the syllabus document. Hence, the study has critical significance **for the Ministry of Education policy makers** in that specific guidelines will be given, for further improving and revitalizing science education and it will form **a baseline** for future inquiries about science teaching and learning.

Nationally, the study will provide much needed feedback for planners and decision makers. **Internationally**, for cognitive science researchers and researchers on teacher thinking and teaching, this study will add to what they presently know of teachers' cognition, by providing data for cross-cultural comparisons to see how generalizable the results are.

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ORGANIZATION OF THE DISSERTATION

The dissertation has been organized into eleven chapters in which different aspects of the data are described. In Chapter II the reviewed literature is summarized. In Chapter III a description of the research methodology is given. The context of the study is described in Chapter IV. The ZIMSTT graduates' academic and professional experiential backgrounds are described in Chapter V and their beliefs and conceptions are described in Chapter VI. The characterization of the A-level Biology students is given in Chapter VII, from the perspectives of both the students themselves and their teachers. In Chapter VIII, the teachers' decision making processes and prevailing teaching practices are described from the perspectives of the teachers themselves, their students, their Heads of Schools, and their Education Officers.

The impact made by the ZIMSTT program on the Ministry of Education and by the ZIMSTT Biology graduates on their A-Level Biology students is described in Chapter IX. The observed effective strategies and approaches are discussed in Chapter X. Lastly, the summary of the findings, conclusions and the recommendations of the study are given in Chapter XI.

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CHAPTER II

LITERATURE REVIEW

The literature, which is reviewed below, has provided useful conceptual frameworks and models. It has served both as heuristic for the present study, to generate research questions, which have guided the data collection and also as organization systems, which have facilitated the data interpretation.

COGNITIVE SCIENCE RESEARCH

Among the cognitive science research which is being done includes the research on how students learn. The findings of this line of research is summarized below.

Students' learning science. Research has indicated that students bring to a learning situation persistent prior conceptions and naïve theories which they have developed from their previous experiences. These prior conceptions may not be scientific but they play a critical role in students' learning science, in that they may interfere with how the students make sense of the concepts being taught. A mismatch then exists between what teachers say and do and what their students learn from their instruction. Hence, it is impera

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imperative that teachers should confront their students' misconceptions by using discrepant events, whose results are not what one expects to happen, in order to make the students become dissatisfied with their naive explanations, if learning, i.e., conceptual change, is to take place. This confrontation is an element of the conceptual change teaching model which has proved to be effective in assisting science students to learn with such meaningful understanding that they will be able to describe, explain, predict and control the natural phenomena. The model has four essential steps of posing a problem using a discrepant case, modeling, coaching, fading and maintenance (Driver & Easley, 1978; Osborne & Gilbert, 1980; Resnick, 1983 & 1987; Roth, et al., 1983; Hewson & Hewson, 1984; Hewson, 1981; Driver, et al., 1985; Berkheimer, et al., 1988; Anderson & Smith, 1987; Pines & West, 1986).

Besides this strategy, the teacher should also develop a repertoire of a variety of representations of the science content to match his students' individual cognitive frameworks (Wilson, et al., 1987). Hence, a significant portion of the teaching task consists of teachers making various professional decisions and judgments about their students' current state of knowledge, what they have learned, should learn and are learning and what instructional activities are appropriate (Koehler, 1983).

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RESEARCH ON TEACHER THINKING

Some of the research on teacher thinking has focussed on teacher decision making. Every decision is based on a judgement having been made. Lipman (1991) has drawn up a very comprehensive taxonomy for categorizing the various judgements which people make as they interact with ideas and phenomena.

Teacher decision making. It was pointed out by Clark and Peterson (1986) that the thinking, planning and decision making of teachers constitute a large part of the psychological context of teaching. It is within this context that curriculum is interpreted and acted upon, that is, where teachers teach and students learn. Shavelson (1973) hypothesized that one of the basic teaching skills is decision making. But this decision making has proved to be very difficult for teachers because of the "complexity of the classroom situations" (Doyle, 1977), with their "uniqueness" and "uncertainties" (Lortie, 1975; Jackson, 1986; Floden and Clark, 1987; Cohen, 1988), which are compounded by "value conflict" (Schon, 1983) and planning and teaching "practical dilemmas" (Lampert, 1985). Teachers have developed coping strategies "to try and reduce this complexity and thus increase their flexibility and effectiveness" (Yinger, 1977, p. 160).

Decision making models indicate that the process of making decisions and judgements is cyclical. That is the consequences of one decision cycle feeds into the next future planning decision cycle (Borko, et al., 1979; Sutcliffe & Whitfield, 1979; Shavelson

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& Stern, 1981; Shavelson, 1976). Decision making depends on one's perception which involves making sense of the situation, which in itself is an active construction of meaning of the observed phenomena (Marx, 1978).

Decisions can be classified according to four dichotomies as being either immediate or reflective; with or without teacher's conscious awareness; resulting in action or none (null); and singular or composite (Eggleston, 1979).

Teacher planning. Planning is defined as "a basic psychological process in which a person visualizes the future, inventories means and ends, and constructs a framework to guide his or her future action" (Clark, 1983, p. 7)

Research has found that when teachers are planning, they either concentrate on objectives (Tyler, 1950), or on content (Taylor, 1970; supported by Zahorik, 1970 & 1975; Peterson, et al., 1978; and Morine-Dershimer & Vallance, 1976), or on procedures and activities' potential appeal or management problems the planned work might have for the students (Clark & Yinger, 1979). A different planning model was proposed by Yinger (1977) as a three-stage design creative process of problem-finding or conception, problem formulation and solution, and the plan implementation stage. But these problems are not given. One must look for them. To be a problem-finder, "one must feel that there is a challenge needing resolution in the environment . . . [and] . . . attempt to devise appropriate methods of solving the problem" (Yinger, 1977, p. 234). This is similar in essence to the "r

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the "reflective conversation" which the practitioner should have with his situation during "reflection-in-action" (Schon, 1987).

The teachers' written plans have been categorized as being either "incremental" or "comprehensive" (Clark, 1983, p. 11) depending on the scope and level of abstractness. Comprehensive plans are produced by teachers with higher conceptual levels who focus more on the learner and the instructional process rather than on the objectives and the factual subject matter as in the case of incremental planners (Peterson, et al., 1978). Teachers perceive these written plans as serving different functions which were grouped into four categories: to meet personal and instructional needs; to guide instruction; and to meet administrative requirements (Clark & Yinger, 1979).

Although planning has been reported to be influenced by the curricular materials which the science teacher uses, Smith and Sendelbach (1979) found that there is a discrepancy between the intended and the enacted curricula because teachers added or subtracted or simply modified some aspects of the curriculum, depending on their levels of interpreting the curricular materials. The latter depended on the teachers' conceptual backgrounds and teaching experiences. Moreover, what the students actually learned was different from the enacted curricula because of the interference of the students' prior misconceptions which were not confronted during instruction.

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Instructional decisions. Instructional decisions are made by the teachers when they interact with their students during the teaching and learning activities. During these activities, the teachers' personal beliefs, opinions, theories and expectations surface to influence their actions and behaviors. But McNair (1978-79) reports that teachers were surprised, during stimulated recall, at some of their behavior and classroom events which they had failed to notice while they were teaching. This is understandable considering the complexity of their situation. Hence the value of having a professional colleague coming in to observe one teach and give feedback.

The teachers have their own "personal constructs" which they use to judge their students. But Marx (1978) notes a discrepancy between the teachers' stated policies and their enacted ones. The situation-specific teaching experiences and the demands of the teaching tasks influence teachers' planning and interactive decisions, regardless of whether teachers focus on content or are more sensitive to the students' ideas and experiences (Zahorik, 1970; Peterson, et al., 1978).

Lastly, Shavelson and Stern (1981) note that teachers, during instruction, are pre-occupied with maintaining the "activity-flow" of the lesson. The teachers monitor and attend to only those indicators that the activity is not going as planned and not to the immediate learning needs of their students. Individuals are monitored in terms of attentiveness and participation.

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What I have noted with student teachers is that, they evaluate a lesson as having gone well because they did not have any disciplinary problems. Their thoughts focus on students' interest and participation only. They never comment on what the students have actually learned!

Inevitably, the teachers' planning decisions influence their instruction, which in turn, will influence their students' cognitive, affective, and social achievements and behaviors.

TEACHING AND LEARNING STRATEGIES

Additional literature review was based specifically on the observations that were made during the study, regarding the nature and pedagogic implications of the variety of the teaching and learning strategies which were observed being implemented to enhance student understanding and intended development. These strategies included the use of illustrations and pictures, models, modeling, analogies, questions and answer sessions, practical work, explanations, discussions, wait-time, and the deliberate pacing of the lessons. What the literature says about each of them is summarized below and also in Chapter X.

Illustrations, charts, and pictures.

Waddill and McDaniel (1988) distinguished between detail and relational illustrations. Their research focused on the students' encoding and recall of text information depending on the accompanying type of text (narrative and relational). Their results confirmed the supplemental effects

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and the other benefits of illustrations, when processing instructions were given. They found out that "In addition to enhancing details, both kinds of pictures significantly increased the recall of non-target information in the fairy tale" (p. 462). The question raised has to do with the nature of processing instructions that the teachers give as they refer students to particular diagrams, illustrations and pictures.

Another positive aspect about illustrations is not only their economic presentation of information (Larkin & Simon, 1987), but also the way illustrations help readers to re-organize the information into useful mental models (Mayer, 1989 & Gentner & Genter, 1983). Mayer (1989) used four groups with different illustrations of how scientific devices work, that is, (i) static with labels for parts; (ii) static with labels of major action (steps); (iii) dynamic showing on and off states of the device and labels of parts and major action (parts- and- steps); and (iv) text with no illustration. He reported that the illustration group (iii) outperformed the other groups on problem solving transfer but not verbatim retention.

Mayer and Gallini (1990) demonstrated the positive effects of illustrations showing system topology and component behavior, as measured by an increase of conceptual information and creative problem-solving with students with lower prior knowledge than with students with higher prior knowledge of the scientific device.

In this same article five functions of text illustration were cited as

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> . . .<u>decoration</u> with no relevance to text ...; <u>representation</u> . . . help reader visualize a particular event, person, place or thing . . .; <u>transformation</u> . . help reader remember key information in a text . . .; <u>organization</u> . . . help reader organize information into a coherent structure . . .; <u>interpretation</u> . . . help reader understand the text . . . (Mayer & Gallini, 1990, p. 715)

If illustrations are to serve such functions, then the teachers need to think about the nature and quality of the sketches that they draw on the blackboard as they teach.

<u>Models and Modeling</u>. Ost (1987) distinguished the model as the tool and modeling as a process. He noted the importance of differentiating between a given model and the reality it depicts. Four basic kinds of models were described, that is, the representative model, the theoretical model, the logical model, and the analogue model (pp. 363-366). He also pointed out that the pedagogical power of models and modeling lies in their potential

> . . . to develop skills of explanation, interpretation and also prediction and analysis . . . conceptual simplification. As a tool in science, modeling can foster the creative process. If modeling is considered as only a methodology it can fossilize the intellect. . . . Modeling in particular provides students with experiences in hypothesis formulation and the design of investigation . . . and as an ideal way to introduce decision making as it is used in Science, Technology and Society (STS) issues (pp. 367-369).

Hence, when models are used effectively, they can enhance the development of process skills which a scientist needs to do science.

<u>Analogies</u>. Analogies are one of the effective tools in science instruction (Simons, 1984). An analogy is a phenomenon with some

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attributes and or behavior which have correspondence to a large extent with an otherwise different and unrelated phenomenon. For example, the lock and key analogy is often used to explain the enzyme-substrate interaction. Duit (1991) categorized different types of analogies as being either verbal, pictorial, personal, bridging and multiple analogies.

Donnelly and McDaniel (1993) concluded from their study that "the differences (in effectiveness) between analogical and literal representations were chiefly restricted to learners who had minimal background knowledge of the scientific concepts that were taught" (p. 981). This was also one of the conditions in the use of illustrations. The rest of their conclusions were that

> . . . Analogical representations may serve an especially good introductory function to learning new concepts . . .
>
> . . . Analogies create a bridge between two areas of studies . . .
>
> . . . Benefit of analogies lies in their ability to foster meaningful understanding and more accurate inferential thinking about the studied phenomenon than memory for specific basic details (p. 983).

And yet both inferential and recognition skills should be developed in science teaching and learning. The cognitive process involved is thinking about the similarities and differences between "the analog" and "the target," in order to either understand the target better or solve the target problem. This is called "analogical reasoning" (Vosniadou, 1989). This mental process involves structural mapping, which was illustrated by Gick and Holyoak (1980). They described how the analogy of the analog

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"Attack-Dispersion Story" had facilitated the formulation of an analogous dispersion solution, for the cancer tumor radiation problem. "Schema induction" is also involved in this process of analogical reasoning (Novick & Holyoak, 1991). This involves a formation of a new hybrid mental schema from consideration of the structural relations, which are similar in the two domains of the target and the analog phenomena.

Even young children can be trained in analogical reasoning (Lipman, 1993, 1991, 1988, 1984; Lipman et al., 1986 & 1980; Matthews, 1984 & 1980; and Pritchard, 1985).

A different approach of using analogies in teaching was taken by Wong (1993 b). He studied the facility with which students could generate, apply and modify their own analogies in an effort to construct, evaluate and modify their own explanations of a particular scientific phenomenon. The usefulness of this process, as a means and as an end, lies in the way in which it facilitates a student's self-conscious conceptual growth. This is so because generative analogies

> . . . foster evolving meaningful problems . . .; enable problem-solving from a base of understanding . . .; trigger associated memories . . .; provide a different perspective . . .; stimulate carry over from source to target domain . . .; are dynamic tools rather than static representations for understanding. Different analogies were used to explain the same concepts . . . the same analogy results in different understandings by different individuals . . . and the necessity of multiple analogies (pp. 1265-1270).

Besides these effects, the process of generating their own analogies enabled the participants to enrich their understanding of scientific concepts by facilitating "the construction of new explana

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explanations . . . and the emergence of important questions" (pp. 1264-1265).

Laboratory work. Tamir (1989) emphasized the need for teachers to stress laboratory work that emphasizes hypothesizing, predicting, developing concepts, model building, and developing positive attitudes towards science. Hence, the laboratory practical work can be a powerful tool in science teaching and learning.
However, teachers need to be cautioned against the danger of overdoing laboratory work. This may be in the form of a variety of activities being assigned as a solution to management problems, that is, just to keep the students busy.

To ensure a successful laboratory session, one has to consider five elements, that is, the purpose, relevance, the degree of structure imposed by the teacher, methods of recording and reporting data, and management (George & Lawrence, 1982, pp. 77-84). In this same article, it was pointed out that "the most successful teachers are those that spend less time controlling their students and more time instructing them and giving them opportunities to learn on their own" (p. 82). A similar finding was reported in the study by Fraser and Tobin (1987).

Explanations. Classroom interaction involves mostly the processes of describing and explaining natural phenomena. To be able to explain is one of the indications that one understands (Anderson & Smith, 1987). What counts as an explanation differs in different con

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contexts. The kind of questions which are asked in these contexts influence the type of the response that is given by participants of different cultural backgrounds. The teachers must model the habit of giving clear explanations for their students (Dagher & Cossman, 1992). They must also insist, as an assessment for their students' levels of understanding, on students giving full explanations. What may be problematic is how one can tell a good explanation from the rest. Wagner (1979) gave three features of a clear explanation i.e., logical consistency, semantic clarity, and comprehensiveness. Lipman, et al., (1980) distinguished between "explanations by causes" and "explanations by purposes" (pp. 33-34). Other explanations may be categorized as being descriptive or procedural; scientific or "everyday explanations."

Discussions. Science is both a product and a process which involves a community of scholars. As a process, this human endeavor is guided by the existing "paradigms," which are the "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (Kuhn, 1970, p. viii). Discussions take place not only among these communities of scholars, who are governed to a great extent by some accepted norms, values and principles, but also they take place everywhere about any topic. The Kuhnian concept of a "community of scholars" is similar to that of the "community of inquiry" as it is understood in the "Philosophy for Children Program" (Lipman, 1993; & Lipman, et al., 1980). Within such communities the students learn the skills of

constructive criticism, argumentation and conflict, which are critical for creative inquiry to proceed. In these communities, the students are provided with opportunities

> . . . to learn both as a group and in a group in which the students were seeing themselves as active participants in the discovery, analysis, and justification of claims of knowledge (Benjamin & Escheverria, 1992, p. 74).

Class discussions provide a forum in which students can develop as a "community of learners." In leading class discussions, teachers need to ensure that rules about turn taking, every one in the group being given an equal chance to express their opinion, listening to each other, accepting different opinions and everyone participating etc. are understood and strictly observed by the students. Lipman et al., (1980) indicated that a good discussion does not necessarily take place just because many participants are engaged in verbalization. People who are silent may be thoroughly involved as they listen to others talking.

During class discussions, teachers need to probe further their students' questions and answers seriously. Reasons behind these responses should be explored together with the students. Teachers should devise more situations in which to engage the students in fruitful discussions, model question-asking, and invite questions from the students, in order to provide students the opportunities to express themselves.

Teachers ought to be able to judge the quality of their class discussions. Lipman, et al., (1980) distinguished between "a mere discussion" and "a good discussion." He wrote the following.

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> A good discussion occurs in any subject when the net result or outcome of the discussion is discerned as marking a definite progress as contrasted with the conditions that existed when the episode began. Perhaps it is a progress in understanding . . . in arriving at some kind of consensus . . . in the sense of formulating the problem - but in any case, there is a sense of forward movement having taken place. Something has been accomplished; a group product has been achieved.
>
> In contrast, a mere discussion may evoke comments from various individuals present (one hesitates to call them "participants") but without achieving a "meeting of the minds." . . . In a good discussion something emerges and yet nothing builds in a mere discussion (pp. 111-113).

One other thing that a good discussion has the potential to develop is the skill of making good judgements, bearing in mind that every act or statement that we make entails a judgement of one kind or another.

Lipman (1991) has described different types and orders of judgements which he integrated in "The Wheel of Judgement" (p. 170). He cautioned the following.

> Merely to encourage differences of opinion in open discussion, and debate will not provide a comfortable escalator to higher order thinking. This will happen only if students are given access to tools of inquiry, the methods and principles of reasoning, practice in concept analysis, experience in critical reading and writing, opportunities for creative description and narration; as well as in the formulation of arguments and explanations; and a community setting in which ideas and intellectual contexts can be fluently and openly exchanged. These are educational conditions that provide an infra-structure upon which a sound super-structure of good judgement can be erected (p. 172).

These conditions will be used as criteria for assessing the quality of the discourse or verbal interactions that were taking pl

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place in the observed lessons, from the lesson transcripts, as a follow-up of this study.

CHAPTER III

METHODOLOGY

NEGOTIATION OF ACCESS INTO THE SCHOOLS

The first thing I had to do was to get permission, from the Ministry of Education and Culture, to carry out the research study in the Regions and in the schools. While this was being considered and processed, the list of the names of all the ZIMSTT Biology graduates was secured from the Department of Science and Mathematics Education, at the University of Zimbabwe.

The second thing that I did was to locate where these ZIMSTT Biology graduates had been deployed by the Ministry of Education and Culture's Staffing Unit. Getting this list took surprisingly and frustratingly a very long time. A number of these ZIMSTT graduates could not be located by the time the deployment list was made available to me.

RESEARCH METHODS AND DATA COLLECTION

Research design and methodology. Both quantitative and qualitative methods were used, with the latter greatly relied upon, because they yielded critically analyzed rich descriptions of the teachers' thinking and teaching processes. Qualitative methods were used more despite the fact that quantitative methods would have allowed a survey of a wider range of teachers' thinking and experiences. Qualitative methods were preferred over the quantitative methods, because the former are the most appropriate for studying the science teachers' and their students' thinking, because of their being naturalistic, flexible, inductive, process-oriented, multi-stranded etc. (Erickson, 1986; Hammersley & Atkinson, 1983; Bogdan & Biklen, 1982; Borman, et al., 1986). That is, these methods are less intrusive and disruptive of the natural setting and the processes which are going on. They also allow the kind of in-depth portrayal that is necessary to understand the complexity of the teachers' experiences in trying to implement what was learned in their ZIMSTT Biology B.Ed. program. I was trying to understand how as well as what the teachers and their students think about science. Surveys allow us to gauge how people respond to researcher's idea about science but tell us little about how people actually think about science. Hence, qualitative methods were the most appropriate for this study. Participants' perspectives were elicited within their own "microculture", which reflects the relationships among the context, the roles, and the program, which will be central in explaining the revealed patterns of the teachers' teaching practices and in the evolvement of some "grounded theory" (Glaser & Strauss, 1965; 1967).

The survey questionnaire. My intention was to collect questionnaire data from all the 80 (1986-1988, 1989-90, 1991-92)

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ZIMSTT graduates. As it turned out, the survey questionnaire (Appendix #1) had to be mailed in three waves, since the 25% return from the first wave was low. I was faced with the dilemma of not knowing whether those ZIMSTT Graduates who had not responded had not done so because they just could not be bothered, or because they had not received the survey questionnaire due to change of address, which may not have been updated in the Ministry of Education records. A second wave of questionnaires was sent, as suggested by my supervisor. This second questionnaire was modified, on the basis of the responses collected from the first wave of questionnaires, in particular those items (#s 14 b, 15, 16 & 23), which were left blank by the respondents of the first questionnaire. These four items were rephrased. The second questionnaire was addressed to the Headmasters, with "two networking tracer letters" attached, one for the Headmaster and the other for the ZIMSTT graduate, in an effort to locate those ZIMSTT graduates who had transferred to other schools (Appendix #2).

The percentage of returned responses improved with the original twenty first wave respondents plus an additional seven "new" respondents. However, from the questionnaire responses, I got (a) data which enabled me to address my research questions, and (b) better information as to what had become of the ZIMSTT graduates. Only nine out of the eighty ZIMSTT graduates (1986-1991) were teaching A-level Biology; four had been promoted to be Deputy Headmasters and Headmasters; eight had become Lecturers at either Primary or Secondary Teacher Training Colleges or at the

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Polytechnical Colleges; one had become an Education Officer (E.O. for Statistics) at the Head Office of the Ministry of Education; one became a Sanitation Officer and the rest, as far as could be ascertained, went back to teach O-Level Science.

The intensive study. As soon as the first wave questionnaires were returned, they were analyzed in order to identify the ZIMSTT graduates who were teaching A-Level Biology classes. From this analysis, two teachers were selected whose schools were both conveniently located in Harare, one a co-educational high school and the other an all boys' high school. When these teachers were followed up, they both agreed to participate and be "shadowed" for an extensive period of four weeks. Each week had 10-12 periods of 45 minutes each for the A-Level Biology lessons. During these two intensive classroom studies, the teachers were observed teaching the same topics, i.e., DNA, RNA, and PROTEIN SYNTHESIS, from the beginning of each topic to its end. Their time tables dove-tailed into each other perfectly without any overlaps. But sometimes there was no time for an immediate post-observation conference, if I had to make it on time for the other teacher's next lesson. Hence, in a single day I was forced to visit these two schools twice, in order to talk about the observed lessons, while they were still fresh in the teachers' minds. Most of the lessons were video-taped for the teachers' stimulated-recall conferences.

However, my intensive study with these two teachers came to an abrupt end when the teachers were required to go for training as

Census Enumerators, during the last week of the second school term. Hence, I lost six double periods of lesson observations with each teacher. The final interviews, to tie up the intensive study, were held at the beginning of the third school term.

Classroom observations. After the intensive study of these two teachers, I visited the remaining seven ZIMSTT A-Level Biology teachers, who were located in five of the nine regions of the Ministry of Education and Culture. These teachers were also observed teaching a variety of topics, for one or two or more lessons depending on their other teaching commitments. Interviews were held with each teacher and a sample of his/her A-Level Biology students. These classroom observations provided insights into the teachers' thinking about their practice; their students; their teaching styles; and the students' learning styles and attitudes towards their learning A-Level Biology.

During these classroom visits, I administered a student questionnaire (Appendix #3) to all the students in the nine observed A-Level Biology classes, in order to elicit students' perceptions of themselves, of their teachers, class, and the school. A corresponding questionnaire (Appendix #4) was administered to the observed A-Level Biology teachers. Both Lower Sixth (L6) and Upper Sixth (U6) Biology classes were observed, since the ZIMSTT graduates were teaching both. Out of the nine observed classes, four were L6 and the remaining five were U6 classes. An analysis of these classes by gender shows that one was a girls' school; two were boys' schools; and the remaining six were co-educational schools.

Interviews. Interviews were held in each school to substantiate and validate data from observations and field notes. On average, these interviews lasted about an hour. Different interview protocols (Appendices #s 5.1 - 5.5) were used, depending on the category of the participants being interviewed, to elicit the varied data, which enabled me to answer my research questions. The following categories of participants were interviewed.

1. The nine observed ZIMSTT A-Level Biology teachers, five of whom were teaching Upper Sixth (U6) or Form 6 classes and four of whom were teaching Lower Sixth (L6) classes. These teachers were also the Heads of the Science Departments. All the teachers were interviewed before each lesson, in order to elicit their beliefs and conceptions about teaching, learning, students, the school milieu, knowledge, and their experiences teaching A-Level Biology classes; and, specifically, to find out how the lessons had been planned. After the lessons, the teachers were interviewed in order to get an insight into what the teacher was thinking during the lesson about the subject matter, the students, the teaching and the learning processes that had gone on. In addition to this group of teachers, the following other participants were also interviewed.

2. A sample of the teachers' students (in groups of two, three, or four) (N=36) (Table 4 in Appendix 6) were asked about their teacher's teaching style and their reactions to it, what it means to be an A-Level student, what they knew before and after being taught the observed lessons' concepts, etc.

3. The Headmasters or their Deputies (N=4) and (iv) the Regional Science Education Officers (N=7) were asked about the nature and frequency of their supervising the A-Level Biology classes taught by

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the ZIMSTT graduates in their schools and the nature of the teaching practices prevailing in these classes.

4. The available ZIMSTT Lecturers at the University of Zimbabwe (N=4) were asked about the evolution of the ZIMSTT program, the nature and performance of the candidates and the nature of the follow-up done to date. Only two of the original 8 ZIMSTT lecturers and one recently appointed substitute were available for the interviews.

5. ZIMSTT graduates who are now Lecturers at the Primary and Secondary Teacher Training Colleges in Zimbabwe (N=8) were asked how they had got to where they were and how the ZIMSTT program was impacting on their present posts.

Follow-up interviews. Follow-up interviews were also held with those ZIMSTT graduates who were not teaching A-Level Biology classes but had become Teacher Training College Lecturers (N=8) and Headmasters (N=4). These graduates were asked for their reasons as to why they had opted to teach Biology at the Teacher Training Colleges and not A-Level classes and also how what they had done during the ZIMSTT B.Ed. program influences what they are now doing in their present posts. Hence, altogether twenty two ZIMSTT graduates were physically located and interviewed. The rest of the ZIMSTT graduates went back to teach O-Level Science classes. These graduates were not included in this study.

Documentary analyses. Documentary analyses were done at various levels to get data which enabled me to answer my research questions. The documents analyzed included:

> . . . the University of Zimbabwe ZIMSTT program documents, focussing on the nature of the program courses and the evaluations done to date;

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> . . . the teachers' schemes of work, focussing on the conceptual development of the topics and records of work;
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> . . . the students' written exercises, focussing on the quantity and quality of the assigned work and the nature of the teachers' feedback on the students' performance;
>
> . . . the Ministry of Education Examination Branch's records, focussing on the Cambridge Final Examination papers for the A-Level Biology syllabuses, the 1992 Upper Sixth (U6) final achievement scores, and the Chief Biology Examiner's Reports on the A-Level students' performances.

Data collection and analysis. I was the key instrument as a participant observer. Data were triangulated from a variety of different sources including: the ZIMSTT graduates' survey questionnaire responses; transcripts of interviews with the Examination Branch Education Officers, the Standards Control Unit, the ZIMSTT staff, Science Education Officers, Headmasters, the ZIMSTT A-level Biology teachers; and the targeted students; clinical interview transcripts (Pines, et, al., 1978; Nussbaum & Novak, 1976; Posner et al., 1982); science lessons' observation field notes, video, and audio transcripts; documentary analyses at the Ministry of Education, at the University of Zimbabwe, and the observed science teachers' and their students' written records of work; and the classes' pre- and post-tests on the topic taught.

All verbal interactions were audio-taped. All the nine A- Level Biology teachers were video-taped at least once for the stimulated-recall post-observation conference. The entire set of nter

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interviews and classroom interaction data is recorded on 84 audio-tapes and 20 video-tapes.

The observation field notes, relevant documents, the subjects' questionnaire responses, interview transcripts, audio- and video-tape transcripts were analyzed for themes, patterns and regularities (Goetz & LeCompte, 1984). They enabled the teachers' voices to be heard and they also provided very useful information on the research variables. All these tapes are now a rich source of material for future science teachers' pre- and in-service seminars and workshops.

The dissertation findings. The findings from the analyzed data led to the formulation of a number of assertions, many of which have substantial evidence supporting them and a few are speculative at this point (e.g., #s 2, 11, 15, 20, 24, & 33). The latter will be probed deeper in subsequent follow-up studies. There are seven encompassing themes that form major categories or major ideas into which these assertions can be placed. These categories are given as sub-headings for the assertions which are listed below. The pages in brackets, after each assertion, indicate the location of the supportive data for each assertion within the dissertation.

THE CONTEXT OF THE STUDY

1. The nature and quality of the schools' teaching and learning resources seemed to lie on a continuum ranging from being

adequately equipped to being poorly equipped and they seemed to be influencing the nature of teaching and learning taking place in the A-Level Biology classes of the ZIMSTT graduates (pp. 53-72).

2. In most of the visited schools, the staff and the students appeared to be trying to live up to their school motto, which seemed to reflect the ethos within each school quite closely (pp. 72-76).

THE TEACHERS' BELIEFS, CONCEPTIONS AND THINKING PROCESSES

3. A majority of the A-Level Biology teachers seemed to perceive knowledge in terms of its static content and very few perceived it in terms of its process and tentative content (pp. 97-104).
4. The A-Level Biology teachers' perception of learning can be placed on a continuum with passive knowledge acquisition at one end and active knowledge acquisition and sense-making at the other end (pp. 104-109).
5. Teaching seemed to be conceived, on the one hand, as "giving information", and on the other hand, as facilitating, guiding, and leading the students, not only to discover and apply knowledge, but also to change their behaviors and attitudes and, to develop learning skills (pp. 114-125).
6. An ideal A-Level Biology teacher seemed to be conceived differently by the teachers, by the Headmasters and the Headmistress, and by the Education Officers (pp. 125-128, 264-267, 268-270, 247, and 276-287).

7. The teachers seemed to conceive A-Level Biology in terms of its cognitive demands and career prospects (pp. 128-135).
8. The A-Level Biology teachers, at times, seemed to be deepening their own conceptual understanding, and at times realized their own uncertainty about some of the concepts and processes (pp. 128-135).
9. The A-Level Biology teachers and their supervisors seemed to be in agreement that a teacher needs more than subject matter content knowledge, in order to teach A-Level Biology (pp. 141-150).
10. The A-Level Biology teachers' intentions for their students seem to be centered around developing their students' understanding, appreciation and application of scientific knowledge, processes and skills, and developing a positive attitude to science (pp. 161-164).
11. The majority of teachers seemed to perceive the O-Level Core and Extended Science syllabi as not adequately preparing the students for the A-Level Biology study (pp. 183-187).
12. The ZIMSTT graduates seem to be in agreement with all their interviewed students in describing the A-Level Biology syllabus as being more demanding than the O-Level Science syllabi (pp. 204-209, 247-252).

THE PREVAILING TEACHING PRACTICES

13. The nature of the classroom discourse, in the classes of the observed A-Level Biology teachers, seemed to lie on a

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continuum, with one-way communication at one end, and interactive dialogues, between the teacher and the students and among the students alone, at the other end of the continuum (pp. 104-125, 135-141, and 150-160).

14. The observed teachers' teaching styles seemed to lie on a continuum, with a didactic style, which is characterized by knowledge transmission, at one end, and a heuristic style, which is more interactive, at the other end (pp. 109-114, 135-141, and 150-160).

15. Disregarding the individual differences among the students, on the surface, a heuristic teaching style seemed to engender more meaningful learning, which resulted in longer retention by the students, than did a didactic teaching style (pp. 114-125).

16. The images which were given by the teachers and their students seemed to correspond closely with the prevailing practices in their Biology classes (pp. 150-160).

17. The teachers seemed to use a variety of activities, approaches, and techniques to try and increase their A-Level Biology students' intended learning and development (pp. 163-171).

18. The teachers seem to be using a variety of means in trying to help their students to learn, understand, and apply what is being taught (pp. 171-183).

19. The intensive study of the two randomly selected teachers seemed to reflect the range of teaching and learning practices that were prevailing in the A-Level Biology classes of the

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remaining ZIMSTT graduates who were teaching A-Level Biology classes (pp. 212-231).

20. The teachers seemed to be pre-occupied with "covering the syllabus" and their teaching seemed to be examination driven (p. 71).

21. The ZIMSTT graduates seemed to have experienced a number of "teething problems" during their first year of teaching the A-Level Biology classes (pp. 231-238).

22. The ZIMSTT graduates seemed to have problems with organizing and managing practical lessons and asking questions and teaching the Option Topics from the A-Level Biology Syllabus (pp. 231-238).

23. The ZIMSTT graduates seemed to have developed coping strategies, in order to facilitate smoother transitions for them, as they moved from teaching O-Level Science to teaching A-Level Biology classes (pp. 238-252).

24. Only two teachers seemed to use scientific articles from sources other than the prescribed text books (pp. 60, 174-175, 218, 250-252, and 255).

25. The teachers' judgements and decisions seemed to be based on pragmatic and pedagogic considerations and concerns (pp. 252-263).

26. On the whole, pedagogically sound teaching practices, which can still be made more effective, seemed to be implemented by the ZIMSTT graduates, who were teaching A- Level Biology classes (pp. 267-268, 271-276, 279-287, and 327-348).

A-LEVEL STUDENTS' ABILITIES

27. The A-Level Biology students' incoming O-Level Science grades of "A"s and "B"s did not seem to reflect their actual cognitive calibre (pp. 183-187).

28. The teachers seemed to perceive the A-level Biology students' cognitive abilities as being mediocre, and their attitudes to learning Biology as being positive in the majority of cases (pp. 183-195 and 203-209).

29. The students seemed to be having problems with a number of learning skills (pp. 195-203).

30. The students seemed to perceive themselves as active and passive learners and as having developed both a positive attitude because of a variety of factors, and only a few of the students had developed a negative attitude to learning Biology (pp. 203-211).

31. The students seemed to need practice writing comprehensive explanations and drawing accurately labelled illustrations (p. 295).

32. The A-Level Biology teachers' and their students' perceptions seem not to be in agreement with regards to the students' mediocre cognitive abilities, attitudes to learning Biology and their manipulative skills (pp. 183-211).

33. The students learning styles seemed to be either based on recall or meaningful sense-making (pp.209-211).

SUPERVISION AND EVALUATION OF TEACHING PRACTICES

34. The prevailing teaching practices seemed to be perceived, by the Headmasters, the Headmistress and the Education Officers, as being either unsatisfactory or satisfactory, and in one case, as being excellent and exemplary (pp. 276-287).

35. The A-Level Biology teachers seem not to be getting enough supervision internally from their Headmasters and externally from their Regional Science Education Officers (pp. 287-292).

IMPACT OF ZIMSTT GRADUATES ON A-LEVEL STUDENTS' PERFORMANCE AND ACHIEVEMENTS

36. The quality of the students' responses, (i.e., explanations and illustrations) on protein synthesis seemed to vary greatly, within and across the nine observed A-Level classes (pp. 295-318).

37. The pre- and post-test scores seemed to indicate that the students appeared to have acquired a vague understanding of protein synthesis, and they seemed to be unable to apply the knowledge which they had acquired about it to solve unfamiliar problems (pp. 308-310).

38. The Examiner's comments on the performances of the A- Level Biology students, from international centers, on the 1991 final examination, seemed to indicate that the students' difficulties in understanding and developing practical skills, which were highlighted by the ZIMSTT graduates, appear to persist up to the time that they write their final examination (pp. 310-318).

39. The impact of the ZIMSTT graduates on their students' attitudes seemed to have been positive to a large extent but rather limited on their inquiry skills (pp. 321-322).

40. There seems to be no direct relationship between the teachers having taken or not taken A-Level Biology course themselves, the adequacy or inadequacy of the teaching and learning resources in the school, and the impact of the ZIMSTT graduates on their students' Final A-Level Biology Examination achievements (pp. 310-314).

IMPACT OF ZIMSTT PROGRAM ON THE EDUCATION SYSTEM

41. The ZIMSTT program appears to have had a minimal quantitative impact at the different levels within the Ministry of Education. However, the few who have been promoted, seemed to be having a qualitatively positive impact in their different posts of responsibility (pp. 322-326).

The data reflect a diversity in the subjects' perceptions and practices. The relative similarities and differences among these teachers were determined by comparing where they stood when the teachers were mapped along the continua of different aspects of the teaching and learning taking place in their A-Level Biology classes. The mapping was based on a combination of data from three different sources i.e., from the teachers' self-reports about their teaching practices; from interview reports of the teachers' School Heads, Education Officers, and students; and from what was observed by the researcher. Contradictions and tensions emerged from these comparisons. That is, sometimes there was a one-on-one correspondence and at other times the opposite prevailed. These tensions and contradictions will be used during the science in-service staff development seminars and workshops as bases for motivating discussions among the participants about their teaching practices. These aspects are described below.

CHAPTER IV

THE CONTEXT OF THE STUDY

This research study took place in Zimbabwean government and private secondary schools, which are located in both the urban and rural areas, in seven of the nine different Regions, which have been established by the Ministry of Education and Culture. Descriptions of the nature of these schools' contexts were elicited from the participants' responses on their questionnaires and during interviews with them. Their portrayals of these schools' settings were corroborated by my personal observations, made during visits to the schools.

SCHOOL LOCALITY, AUTHORITY, AND REGION

A majority (66.7%) of the high schools at which the ZIMSTT graduates who responded to the questionnaire (Items #2, 3 & 4) were located were in urban settings and a few (33.3%) were in rural settings. A majority of these schools (66.7%) were under the responsible authority of the Government, while a minority were administered either by private Church Missions (14.8%) or by the parents through the District Councils (18.5%). The regional breakdown seems to show that, of the ZIMSTT graduates who responded to the questionnaire, more were deployed in the Harare Region than in other Regions. It also appears that Matebeleland South does not seem to have any of these ZIMSTT graduates deployed in its schools. If they are there, then none of them responded to the questionnaire.

The schools from which the fourteen out of twenty of the present 1991-92 group of the ZIMSTT B.Ed. Biology candidates came from were 50% Government urban schools, 21.4% rural and private missionary schools, and 21.4% District Council rural schools. One one person did not indicate the location of his school and six out of the twenty candidates did not return the questionnaire. Of these fourteen schools only four had A-Level classes, which are all co-educational. The rest had only O-Level classes. If the trend of teachers going back to their previous schools after graduation continues, then only four A-Level Biology Teachers can be expected from this cohort. Most probably these A-Level schools will already have an adequate number of A-Level Biology teachers.

The responsible authorities build **the school facilities** and provide **the teaching and the learning resource materials**. But the teachers' salaries are the responsibility of the government, in both the private schools and the government schools. These facilities and resources constitute the contextual variables which impacted on the studied ZIMSTT A-Level Biology teachers' teaching practices in a variety of ways. The nature of these contextual variables and how they are perceived by the teachers and their students are described below.

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THE SCHOOLS' CONTEXTUAL VARIABLES

Science teaching and learning facilities and resources are a tremendous asset to any science program. The degree of adequacy of the existing facilities and resources in the nine A-Level Biology laboratories that were visited seemed to vary somewhat.

1. In all the visited schools, there was **running water, gas and electricity**. The two rural boarding schools had their own generators. In all the cases observed, the same room was used both for lectures, discussions, film showing and for practical experiments. This has the obvious advantage of minimizing student movement between different rooms and, hopefully, of forging a link in the students' mind between theory and practical. In all the laboratories, natural light permeated because of the large windows.

2. The **laboratory furniture arrangements** were of two basic plans (Appendix #8). In all cases, there was no flexibility of rearranging the rooms to suit the varied activities that might take place during the lessons, because, although the stools at the students' work tables could be moved about, the tables were all fixed to the floor. This limitation was witnessed in one class when the teacher wanted the students to discuss in small groups [Audio-tape C 6 (7/9/92) and Video-Tape CV (7/9/92)]. The size of each group mattered in this particular laboratory because the students' work tables were wide and long. Hence, if the students sat opposite each other, then they would have to speak a little louder than if they were sitting side

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by side. On the other hand, if the group has more than four members and they are sitting side by side, then the outermost individuals would have a hard time hearing and following the discussion. But then, they could always spread outside for such discussions.

3. **Storage space** was, however, adequately provided for in all the laboratories, as cupboards both under the students' work tables and the side work surfaces, or as shelves above the perimeter side work surfaces, and in a special room, i.e., a storage and/or preparation room. All the preparation rooms were located between two adjacent laboratories, except at one school at which each laboratory had its own storage and preparation room. These rooms, with or without a smaller adjacent room, also served as the **teachers' offices**.

4. **Teaching and learning materials** provided for in the different schools varied in both their quality and quantity. Hence, an assertion was formulated **that the school resources seemed to vary from school to school, across a continuum, which ranged from schools which were adequately equipped, in terms of teachers' teaching materials, chemicals, equipment, and student textbooks, to schools with very limited resources**.

An example of a school at the former extreme of this continuum is Mr. N-'s school, a non-government boarding cum day school. This teacher reported that

> . . . this school gives priority to the purchasing of text books for the nine Lower Sixth (L6) and nine Upper Sixth (U6) students. The numbers are small because science is not popular due to the low passes

> last year. . . . The science students share the basic text by Green and Stout i.e., two students per set of Book 1 and 2. Plus we have four to five extra sets for the students to borrow. In addition, for reference by the students, we have eight copies of M.B.V Roberts' Biology: A Functional Approach; five copies of Phillips and Chilton: A-level Biology; four copies of Villee's Biology and duplicated handouts on the Plant Kingdom and Plant Physiology, which we were given at the University of Zimbabwe, during our B.Ed. program (NFI, pp. 1-2).

Thus, this school has a satisfactory supply of reference materials for the students and the teacher in terms of variety, quantity and range. "But the equipment and consumables are not enough" (Ibid., p. 10).

However, all the teachers complained about there being no materials for the Option Topics of the syllabus (Cambridge Examination Board, 1992). They said that most of the references, which are indicated in the syllabus after each Option Topic, were not available in the country.

This fortunate situation of this teacher having a supportive and enthusiastic Administration and an active Parent and Teachers' Management Board (PTA) was observed and reported during the interviews with the other teachers at the other schools as well (BFI, pp. 8-9; CFI, p. 2; DFI. pp. 7-8; PFI, p. 9; MiFI, p. 10 and VFI, pp. 1-3). At Mrs. B-'s school, the parents had raised as much as Z$10,000 which went towards the building of a new library (S.HI, p.12). These are the parents who live in the neighboring high-density suburb and the majority of whom have low incomes.

On the other hand, an example of a school at the other extreme is Mrs. G-'s school, which is an urban, government former Group A school, which is located in a low-density suburb. The teacher complained about the resources in her school. She said the following.

> The laboratory situation is bad because there is virtually nothing. We lack equipment. Students are sharing 10 burners. At times that delays some students because they have to wait for so and so... For the mock exam, I only had eight prepared microscope slides of meiosis for the eighteen students ... When it comes to text books, the situation is worse. The school policy is that parents should buy textbooks and other supplies for their children. But they cannot afford it. So in this class there are less than five students with Green and Stout's Books 1 & 2. So how am I expected to make the students read and make their own notes? Hence, I give them the main points, like dictating, as the lesson progresses ... Our Administration does not emphasize notes but tests and homework, which must be given once a week but is not bothering about textbooks (GFI, pp. 6-7).

The teacher pointed out how "this requirement would not be so bad in a boarding school where one can use the evening study periods for the tests and the class time would be used for teaching" (GFI, p. 7). It seemed that there was a discrepancy between the teacher's and her Administration's priorities which was putting a toll on the amount of teaching time in the long run. Teaching and learning under such conditions was perceived as difficult and frustrating by the teachers and the students, with all this sharing. The consequence of this situation is that the teacher dictates "main points" for the students, instead of them making their own notes. Secondly, the uncooperative stance of her Administration was forcing her to borrow equipment from neighboring schools. Now, because of the frequency with which she borrows things, she reported that the other schools dreaded getting telephone calls from her. Cynically, she said, "The image our school has is of borrowers, we are a kitchen without utensils and yet they expect you to cook food in it and have your tummy full-up!" (Ibid).

A similar situation was observed in another urban, government, former Group A school as well. But the Administration's attitude to these pressures, due to the shortage of textbooks and other science teaching and learning resources, was described as ". . . sympathetic but they always respond by telling you that we are in the red . . . Hence, there is a lack of money for securing and maintaining the equipment" (MFI, p. 9).

Such financial constraints frustrated both the teachers and their students and also delayed or prevented practical work because of not having enough materials (GSI, p. 3) or "it is just skipped for good" (NFI, p. 2). These impacts are critical for the students. A postponed practical will be done out of context and the students will then fail to connect the practical with the theory which they would have learned ages ago, as was seen in two observed practical periods [GFI, p. 6 and Tape M 5 (7/9/92)]. Skipped practical work will, most likely, lead to less understanding by the students and more memorizing of facts, without really making sense of them.

In addition to all this, all the teachers reported that they had experienced great problems and a lot of frustrations when it came to putting together the final Science Practical Examination requirements for all their students. One teacher pointed out that "the suppliers that I depend on are **McDonald Scientific**, **Protea Medical**, and of late **Sci. Quip**. These suppliers are not fully

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stocked because of the limited foreign exchange allocations, which they get from the Government" (PFI, p. 9).

5. **Special facilities** like film projectors were reported to be within the school, and functional, by four of these nine A-Level Biology teachers (Mrs. Mi-, Mr. N-, Mr. V-, & Mr. D-). The rest said that they "either borrow from the AVS or from neighboring schools." Only one school had **a slide projector**, which was being effectively used. The teacher reported how ". . . sometimes the slides are not clear and so I project one good one and all the students then draw from it and it makes it easier for me to mark, because they are drawing from the same slide . . ." (BFI, p. 4).

6. **Outside scientific facilities, enterprises and resources** were also used by the ZIMSTT A-Level Biology teachers. For example, in one government, urban, former Group B school, in a high density suburb, there was **a school orchard**, to which the teacher took the class to show grafting and have students identify the "scion" and the "stalk" and predict the nature of the fruits to be borne by other various trees. This **real-life example** truly fascinated the Upper Sixth Biology students [Tape PFI (9/23/92)].

A fish pond in another similar school was also used by another ZIMSTT A-Level Biology teacher, when she had her O- Level Science Class try first to figure out the relationship between the pressure and the depth of the water, using the classical three-holed can;

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and, second, to deduce the thickness of a dam wall in relation to its depth [Tape B 1 (9/15/92)].

Mr. P- described his school's neighborhood as being

> . . . a high density suburb, with children from families whose socio-economic status is low and this has a bearing on the educational background experiences our students have e.g. TV is not seen by many; visiting to the museums, parks, the Trade Fair and even outside reading is not done by most of them. They have just the school to provide such opportunities for them. I have taken my classes each year to the local museum in the city ... Students are surprised to see these things, which up till then, they had only seen as pictures . . . (PFI, p. 8).

Thus, this teacher tries to compensate for these experiential deficiencies of his students by taking them on field trips to the local Museum of Natural History.

Besides visiting the museums the teachers reported that they also took their A-Level Biology students to research stations like the Matopos Research Station to see animal breeding taking place (DSI, p. 1); the International Crop Research Institute for Semi-Arid Tropics (ICRISAT - a Southern African Development Cooperation project) to see plant breeding (PSI, p. 4); the Lake Kariba Research Station, which is run by the University of Zimbabwe's Department of Biology, for ecological studies (CFI, p. 8); and the Forestry Industries Training Center, just outside Mutare, in the Manicaland Region (MiSQ #10 on p. 5). No-one mentioned a visit to the Botanical Gardens.

At these cited places, the students were getting real-life applications of biological principles, with their socio-economic implications demonstrated for them, by these practicing scientists.

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A very positive unintended outcome of these visits was the fact that, not only did the students get reinforcement of the subject matter principles which they had learned in their discipline, but also exposure to training and study opportunities, which provided the students with greater motivation and inspiration to pursue scientific careers. For example, one teacher reported that a couple of his students had asked him about the possibilities of having further contacts with the researchers at the ICRISAT site for information on how to secure financial assistance, in order for them to train to become crop researchers too. That is, "new horizons" (PFI, p. 9) were opened for the students.

Other outside school resources included **pharmaceutical companies**, for example, Johnson & Johnson and Protea Medical, from whom some reference materials, on the Option Topics of the A-Level syllabus, were requested [Tape Mi- 2 (10/2/92)]; **Scientific Magazines** [Tape C 14 (7/16/92); CFI, p. 2 & 7 and (CFI, p. 7); the **Audio and Visual Services (AVS)** of the Ministry of Education and Culture for films [Tapes C 22 (7/23/92) and C 23 (7/24/92)]; and

> . . . **other schools** from which I borrow equipment which is not delicate. Schools are reluctant to part with that, since it might be damaged or broken for good ... and also not the consumables because the other schools are reluctant to part with such scant resources (GFI, p. 11).

This situation, of having scant resources, has been aggravated by vandalism and now the Administration is investing into making the storerooms of the Science and the Home Economics Departments more secure.

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7. **Laboratory assistants** were a resource, which was provided for in government schools but not in private schools, because at the latter, the government will not pay for their salaries. This was brought to the researcher's attention by two teachers at the rural private boarding schools (VFI and NFI). One of them pointed out that,

> . . . as the Head of Science Department, without such assistance, it becomes difficult to fulfill my duties, which include, balancing my time between my heavy teaching load and giving professional assistance to my colleagues in the Science Department; preparing for the practical work; marking all that written work; attending to individual students' needs; and the extra-curricular duties within the boarding infrastructure (VFI, p. 9).

8. **Space** has become a premium due to the staggering increases in student enrollment (Table 1 on p. 3), especially in those schools which are located in the high-density suburbs. These schools have two sessions. That is,

> . . . there is 'hot sitting.' This means that there is one school session in the morning, for one group of students, and another session in the afternoon, for a second group of different students, with an overlap for school assembly at which the whole school can meet and interact as one. . . . Total enrollment is now over 2000 students . . . (S.HI, p.12) [Tape S.HI (9/21/92)].

According to one teacher in another school, these increased student enrollments have resulted in overcrowding in the classrooms. She pointed out that,

> . . . This was being felt most in the former Group A schools, where these larger classes are being uncomfortably accommodated in classrooms that were physically designed for smaller classes, which were

> half the present numbers. These increased numbers also reduce the extent of the interactions between the teacher and the students (MiFI, p. 11).

The consequent qualitative implications of these problems are compounded by the resultant sharing of the scant resources (GFI, p. 6); problems of supervising practical work and marking the students' written work (BFI, p. 12); organizing the practical work [Tape C 3 (7/7/93)] and (BFI, p. 1). While describing her school context and the pressures which she was operating under, Mrs. B- added, laughingly, that, the rest of the pressures are "self-created because I tend to over-plan and do more than what the syllabus demands." (BFI, p. 12) It seems then that this teacher is having adequate time which was mentioned as a constraint by the other teachers, below.

9. **Time** is a one of the most important resources in any endeavor. Virtually, all the observed teachers complained about the time constraints which they were experiencing. One Science Education Officer explained.

> The Lower Sixth (L6) classes have no first term, because their O-Level results come late and then there is the Sixth Form selection exercise. Hence, by the time the students are notified, as to which A-Level school they have been selected to attend, there's about two to three weeks to the end of Term I ... and also not counting the sixth term i.e., the Term III in their Upper Sixth Form (U6) year, because most teachers leave that for revision in preparation for the final external examinations, which take place in October-November (C.EOI, p. 8).

This was reiterated by one of the ZIMSTT A-Level Biology teachers (BFI, p.12). So what this means is that L6 and U6 have effectively four and a half terms, with twelve weeks per term each for classes. Most schools give Biology classes eight to ten periods per week. These periods are usually arranged on the time table as three double and one treble periods (=9 total) or four double periods (=8 total). Each single period lasts about 40 minutes. Hence, the total actual teaching time for L6 and U6 is, unavoidably, less than what the A-Level Biology (#9261) syllabus stipulates as adequate time to cover the Core Science syllabus (i.e., 135 hours) plus 35 hours of teaching time for each of the 3 chosen **Option Topics**. Total required teaching time is 135 hours + (3 Options x 35 hours/Option) = 240 hours (Cambridge Examination Board, 1991, pp. 44-45). Both teachers and students were constantly and acutely aware of this time constraint. During the classroom observations, an assertion was formulated **that a relationship seemed to exist between how this time constraint was perceived by both the teachers and the students and the nature and quality of the observed teaching practices and the resultant learning by the students** (See also Chapter IX). The various strategies which the teachers adopted in order to cope with this time constraint included the following:

	STRATEGIES	EXAMPLES
1.	Scheduling more than the stipulated the number of class periods suggested by the Ministry of Education.	Table 5
2.	Assigning some syllabus topics to and for the students to do the bulk of learning it on their own and to give "mini-lessons."	BFI, p. 9 & PFI, p. 2

3.	Teaching extra lessons in the evening, at the boarding schools and during the week-ends.	VFI AND NFI MiFI & PFI
4.	Lecturing and dictating notes.	DFI & GFI

One teacher said he coped by ". . . doing as much as one can, but making sure that whatever is touched on, is understood thoroughly by the students [Tape C 3 (7/7/92) & CFI, p. 9]. This latter teacher also pointed out that ". . . our students are not having enough time to study after school, because of too many sports and other extra-curricular activities" (Ibid). This teacher's observation might be pointing towards students' lack of self-discipline and inability to make effective use of their free time.

Students' reactions to their teachers' pacing of their lessons were interesting. A student in one class, in which the teacher was taking his time to ensure that his students were understanding what he was teaching them, complained saying, "if only Mr. C- would speed up because we started L6 a bit late . . . . So I want to finish the syllabus" (CSQ, #9). Another student wanted the opposite. He wrote, ". . . the only problem I have is that she (the teacher) pushes too much on speed, such that the practical work may be stopped before I finish and I cannot deduce anything" (MSQ, #13). The former student seemed to be anxious about "covering" the syllabus, while the latter student seemed to be worrying about making sense of his laboratory experiences.

The time pressure seemed to be also influencing teaching in subtle ways. For instance, it was observed on a number of occasions, that one particular teacher would ask her class a question, which she immediately proceeded to answer herself, without pausing to give her students a chance to think and try to respond to it. [e.g. Tape M 15 (7/22/92)]. This teacher's explanation was that ". . . they take too long to answer and I'll be having so much to be covered . . They should improve on speed . . ." [Tape M.POC, p. 3 (7/27/92)].

Thus, she corroborated her students' complaint about her pace of teaching.

10. **The gender of the students** was perceived by one teacher as the only pressure which he experienced. This teacher said that he did not feel the pressures, which the other teachers had mentioned, during their interviews, related to resource materials, equipment, chemicals and time. He reported that his Headmistress and PTA Management Board were very supportive, in terms of ensuring that these resources were provided for. His school is a day school which does not have any "hot-sitting," that is, classes are held in the mornings only, and the afternoons are devoted to extra- curricular activities. Hence, there is no problem of space. But being a Girls' High School, compared with a co-educational school, there seems to be a "lack of competitiveness, the desire to learn in order to produce very good results ..." (DFI, p. 7). The inference that this teacher is making is that there is more competitiveness in a mixed class of boys and girls than among the girls alone.

11. **Duplicating** problems were mentioned by three teachers (MFI, p. 10; GFI, p. 13 & NFI, p. 5), who said that the Main Office typists

were not very cooperative when teachers requested for their mock examinations to be typed. Writing objective tests on the board would take time and also one would need a very large blackboard to write all the items.

12. **THE A-LEVEL BIOLOGY SYLLABUS** (No. 9261), whose aims and assessment objectives are stated in its preamble, is the last contextual variable to be described. This syllabus (op. cit.) was designed by the University of Cambridge Local Examinations Syndicate. It is prescribed by the Ministry of Education and is offered to all A-Level Biology candidates in the country, who will have done well on the O-Level Science final examination. A comparison of the O-Level Science and the A-Level Biology syllabi reveals similarities and differences in the following aspects:

a. **Nature of the syllabi**. Since 1988, O-Level students follow a Science (5006) only or with an Extended Science Syllabus (5007) (Ministry of Education, 1992). Its aims, objectives and assessment objectives are presented in its preamble. This syllabus was designed locally and moderated by the Cambridge Examination Board. Thus, at O-Level neither Biology, Chemistry nor Physics are taught and examined as separate disciplines.

An analysis of both syllabi statements (preambles) reveals more similarities than differences. In both syllabi knowledge and understanding of biological facts is given more weighting. Both stress the socially and, technologically applied aspects of Biology.

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Both syllabi expect students to develop experimental skills, confidence in handling apparatus and materials and the ability not only to make and record observations accurately but also to interpret data.

The differences noted are in the relative weightings given to the above areas of emphases and in the depth of coverage of the same topics e.g. photosynthesis, respiration, etc. The A-Level syllabus Biology is conventional in its approach, in that it lists the concepts and principles to be learned first, before they are related to various commercial, social, and technological applications. On the other hand, the O-Level Science syllabus represents a departure from this conventional approach in that,

> . . . in this course the emphasis is on a practical study of the applications of science and technology currently used in Zimbabwe, with a view to extracting the relevant scientific concepts and principles from this study . . . (Ministry of Education, 1992, p. 2).

b. **Purposes**. Two of the A-Level syllabus aims are

> . . . to be a suitable preparation for university and polytechnic courses in Biology, Biological studies in other educational establishments and for professional courses which require students to have a knowledge of Biology when admitted ... [Cambridge Examination Board, 1991, p. 41, (f)]; and

> . . . to be complete in itself and perform a useful educational function for students not intending to study Biology at a higher level [Ibid., p. 1, (e)].

That is, the Students who intend to pursue advanced studies in Biology, and those that may not do so, are all exposed to the same subject matter content and to the same depth.

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The O-Level Science Syllabus, on the other hand,

> . . . is designed to serve the requirements of two examination subjects, namely **a Core Science subject (5006)** intended to be written by all candidates, and an optional **Extended Science subject (5007)** to be written by those candidates who intend to study a science subject or subjects after writing O-Level (Ministry of Education, 1992, p. 1).

Hence, "the difference in purposes seem to be a result of how the A-Level and the O-Level are sequenced with respect to each other" (D. Campbell, personal communication).

c. **Principles**. In terms of principles both syllabi are dealing with biological concepts and principles despite this being done at different levels of difficulty, breadth and depth.

d. **Philosophies**. In terms of philosophies, it can be inferred by studying both the O-Level Science and the A-Level Biology syllabi that they seem to be driven by the pragmatic need to satisfy the criteria of relevance, appropriateness, meaningfulness, and significance of what is learned by the students in relation to their real-life situations, job/career prospects, scientific literacy, problem solving, quality of life and scientific inquiry. Thus, the O-Level syllabus is intended to deal with the applications in which students will be involved, i.e., in the Agricultural, Industrial and Communal Sectors in the country, after completing O-Level. The A-Level syllabus deals with those topics which the University of Zimbabwe has dictated as appropriate foundational understanding, which is requisite for their first year science bo

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study. Structurally, the A-Level Biology Syllabus (No. 9261) is divided into two parts:

1. **The core syllabus** - to be studied by all candidates and to take up 135 hours of teaching time. There are five core components:

   A. Cellular Activities,

   B. Genetic Control and Inheritance

   C. Reproduction, Inherited change and Evolution,

   D. Energetics,

   E. Regulation and Control.

2. **The options**- candidates will study and be assessed in <u>three</u> of the options. . . . The options are:

   A. Diversity of organism,

   B. Applied Plant Science,

   C. Application of Genetics,

   D. Growth, development and Reproduction,

   E. Human Health and Disease,

   F. Social Issues in Contemporary Society (Cambridge Examination Board, 1991, pp. 44-45).

What was striking, during the study, was the extent to which both teachers and their students were anxious about "covering the syllabus" and leaving enough time for the revision and preparation for the A-Level Biology Final External Examinations.

All the ZIMSTT teachers felt that they had got adequate preparation by the B.Ed. Biology program, to teach the Core syllabus but not the Options in the A-Level syllabus. This inadequate preparation was compounded by the lack of reference materials on these Options in the country. These references are suggested in the syllabus, after each Option topic. Hence, teaching those Option topics has been difficult. The teachers have sought for outside assistance in order to try and alleviate this difficulty, in the form of research experts in the field, and relevant literature from "marketing houses."

The teaching demands of this syllabus include, not only the stipulated coverage and scope of Core and Option topics, but also that ". . . it is expected that practical activities will underpin the teaching of the whole syllabus . . . based on teaching time . . of a total of 260 hours" (Cambridge Examination Board, 1991, p. 45).

How the ZIMSTT A-Level Biology teachers perceived these syllabus demands is best appreciated by their contrasting of their O-Level Science teaching and their A-Level Biology teaching experiences (see Chapter VIII).

SUMMARY

Generally, teachers reported that they were operating under situations of varying degrees of difficulty. The pressures that they were facing were having a direct bearing or influence on their teaching practices. The most commonly identified pressures were of time and resources, particular laboratory apparatus, chemicals and students' textbooks. Headmasters were perceived to be saying, "We are in the red. There is no money," all the time. How these various pressures play out in the classroom, and what teachers do in their reaction to this, varied from teacher to teacher. The most negative repercussions of some of these pressures included the practices of teachers dictating notes; students not doing much outside reading; practical work either being postponed and, hence, being done out of context and/or being "talked about" i.e., not being done at all; and teachers rushing "to cover the syllabus topics" before the final examinations.

Stemming from these interviews and observations, an assertion was formulated **that the schools seem to lie on a continuum, in relation to the nature and quantity of their resources, ranging from being adequately equipped to being poorly equipped**. The observed teachers can be placed on a continuum thus:

moderate

Adequately <------------ resources ---------> Inadequately

equipped in the school equipped

(Mi-, D-, N-, & V-)<---- (C-, B-, & P-) ----> (M- & G-)

Hence, among the schools which were visited, there seems to be no relationship between the type of school and the adequacy of the teaching and learning resources in its laboratories. For example, former Group A schools, which had adequate resources for the few numbers that they served before independence, are now found along the whole continuum.

What was surprising was that a corresponding continuum emerged from the images which the students formed of their class, classroom and school [Appendix #3, Item #5 (c, d and e)]. This continuum ranged from descriptions of laboratories which were orderly, very clean, quiet, well-maintained and conducive to learning [MiSQ (f=8); DSQ (f=3); CSQ (f=5); & BSQ (f=4)], to the very opposite, characterized by uncomfortable, untidy, dusty laboratories, which were, seemingly, not being swept regularly (MSQ (f=3) and also in need of repair (GSQ (f=2). In Mrs. G-'s laboratory, the situation was so bad that some of the floor boards were either loose or completely off, leaving depressions in the floor, which nearly caused me to trip, because my eyes were on the view finder of the camcorder! In between were the rest of the schools, for which contradictory images were given by the students in the same class (PSQ #1 vs. #s 7, 12, 13, 14, & 21 ; #15 vs. #19 ; & #11 vs. #14) and (NSQ #s 1 & 2,).

THE SCHOOL MOTTOS: THE ETHOS OF THE SCHOOLS

Another lens for studying each school's contextual factors was through its school's motto. Traditionally, all schools have a school motto which represents the school's over-arching goals. Unfortunately, I realized this late into the study. This realization dawned on me at Mr. D-'s school, at which the motto was written at eye-level on the wall facing you as you approached the entrance to the Administration Offices. The motto, written in bold capital letters read, "**COURTESY, INTEGRITY & EFFORT.**"

As I discussed this motto with the Headmistress, it was clear that she and her teachers were not just concerned with the academic achievement of their girls but also with their all-round development of their personalities and characters. The Headmistress stressed how she cared for the girls and for teachers. She jokingly said that she had "an iron fist in a velvet glove and discipline is meted out with love and care" [Tape J.HI (9/16/92) p. 5]. Actually, there was peace and quiet all the time in this school, both during classes and at break. I never detected any disciplinary problem during my visits. I just loved being in this school because of its exemplary atmosphere. The girls rushed to offer me help carrying my paraphernalia (tape recorder, camcorder, and my files). They greeted me cheerfully and politely gave me way in the corridors. The school was always very clean in and out of the classrooms. There was an air of purposefulness all around.

Hence, later, when I had the great honor of being invited back to the school, to be their Guest Speaker at the school's 21st Anniversary (10/14/92), I decided to speak on **"WHAT IT MEANS TO CARE"** and to link it with the implications of their school motto. Afterwards, it was really heartwarming to hear those students, who had done well, shouting "I care!" when they were coming to receive their prizes and the parents would also shout back to their child "I do care!". We all enjoyed this. But for me, it was an indication that the message had been appreciated.

The second motto was **"VELAMFUNDO"** at Mrs. B-'s school, which literally translated is, **"Education Now Appears,"** because it was the first African secondary school to be built in the city, in a high density suburb. Its student enrollment, during the year of this study, was 2000 plus. Hence, the establishment of this school at that time was a big service to the community.

According to Mrs. M-'s Deputy-Headmaster, who was acting on behalf of his absent Headmaster, their school motto is **"Nitamur ad caelum,"** which means, **"Reach for the sky."** The school badge has a symbolic eagle soaring high into the skies. But the students in this school did not seem to be living up to their school motto, judging from their attitude and performance during the classroom observations of the intensive study. The ultimate criteria are the final Biology examinations, at which the students normally give all they have got, because of the up-coming stiff competitive selection for places at the University of Zimbabwe. An analysis of this school's A-Level Biology final examination results reflect a steady decline in the percentage pass rate. These students are not "soaring into the skies", despite their teacher's constant reminders for them to study and keep up to date with their work.

Mrs. Mi-'s school motto is **"Ex Montibus Robur,"** which she loosely translated as meaning, **"From the mountains comes our strength."** I suppose this was inspired by the scenic mountain ranges, in the school's vicinity. The school snuggles at the base of one of these mountains. The view from any window of the classrooms is really beautiful and breathtaking. The whole atmosphere in this particular school was very conducive to learning. Classrooms were tidy and there was no noise in the corridors during breaks as the students moved from class to class. The staff seemed to be very friendly with one another. The atmosphere in the staff room was really warm. I felt very welcome by everybody in this school.

Another school motto was "Deeds not words." This was explained by the Headmaster as meaning. "It is our performance in the school and the community and the results that should say it all and will be more meaningful than just 'sloganeering'" [R.HI, p. 12 and Tape R 1 (2/6/93).

That is, performance results and the outcomes of the students' and their teachers' actions should say it all. When I asked for examples of these "deeds," this Headmaster indicated how the staff members and the students were making full use of the farm land, which the school had been donated by the Mining Company that had initially built the school for its workers' children. Now the school is the responsibility of the parents and the District Council. The Parents and Teachers' Association (PTA) was reported by the Headmaster to be very supportive of the teaching and learning which is taking place in the school. The students have been working hard as shown by the end of year results, which he showed me.

Mr. V-'s school motto read "**DISCIPLINE, DIALOGUE AND LOVE.**" Mr. V- explained that being a Christian Mission Boarding School, there is strict discipline, which extends into the evening study periods, which are not only compulsory, but to which all the students attend still wearing their complete uniforms, and at which discipline is strictly observed. These evening study periods are supervised by Class Prefects and the teachers on duty. Mr. V- explained how "dialogue" is enacted as a two-way process of communication, in terms of problems and relationships, between and among the teachers, the students and the general staff members in this school. A poster which was pinned on the staff room's notice board read, "CHILDREN LEARN WHAT THEY LIVE" (Appendix #9).

Hence, to a large extent, the mottos in these schools reflected the ethos within each school quite closely. In most schools, the staff and the students were trying to live up to their school motto ideals.

CHAPTER V

THE ZIMSTT GRADUATES

Data on the ZIMSTT graduates was derived from their responses on the ZIMSTT Biology Graduates' Questionnaire (Appendix #1). The item references cited below are this particular questionnaire's items.

GENDER AND AGE DISTRIBUTION

Among the 27 ZIMSTT graduates who responded to the first wave questionnaire, fifteen were male and six were female teachers and six did not respond to this item (Item #6). The majority of these graduates (N=16) were between 31 and 35 years of age; two were between 26 and 30 years of age; two were between 36 and 40 years of age; only one person was above 41 years of age; six did not respond to this item (Item #7).

Among the 1991-92 ZIMSTT B. Ed. Biology candidates who responded to these two items (N=14), there were equal numbers of males and females. Ten of these candidates were between 26 and 30 years of age. Four were between 31 and 35 years of age. The earlier groups were older compared with the more recent intakes.

ENTRY QUALIFICATIONS

A majority of the B.Ed. graduates (81.5%) had enrolled in the ZIMSTT Biology program with an O-Level academic qualification and only 18.5% of the respondents had an A-Level academic qualification (Item #9). Professionally, 48.1% had the Certificate in Education (CE). This is the latest name, which replaced the Standard Teaching Certificate (STC), which 51.9% of those that responded had. This certificate was awarded after either a three- or a four-year teacher training course, which is taken after O- or A-Level schooling.

Among the 1991-92 B.Ed. Biology candidates, two of the respondents did not respond to this item. Of those who responded, half had an O-Level and half had an A-Level academic certificate. Professionally, 75% of the respondents had been awarded a Certificate in Education (CE) and only 16.7% of them had the Standard Teaching Certificate (STC). This also reflects how young these later intakes are at the time of their enrolment into the ZIMSTT B.Ed. program, when compared with earlier intakes. Hence, they will not have had long teaching experiences.

PROFESSIONAL EXPERIENCES

All 27 ZIMSTT B.Ed. Biology graduates who responded to the questionnaire (Item #s 8 & 9) had been secondary school O-Level science teachers, with a minimum of two years experience teaching science to Forms I-IV. The particular Science subject taught by these teachers varied depending on the school at which they were teaching. The Science subjects, which were listed, included General Science (Core and Extended), Combined Science, Biology and Chemistry. Only one of these 27 graduates had taught an A-Level Biology class before enrolling in the B.Ed. program, and none of these 1992- 93 B.Ed. candidates had done so.

Besides teaching science, some of these ZIMSTT graduates had held other posts of responsibilities before enrolling into the B.Ed. program (Item #10), which are listed in Table 6, below.

Table 6

Posts of Responsibility before the B.Ed. Program

Post	No.	% of Teachers
Head of the Science Dept.	10	37.0%
Senior Master	1	3.70%
Lecturer of Biology at a Teacher Training College	1	3.70%
Just Science Teachers	15	55.6%

That is, a majority were not holding posts of responsibility. Similarly, all the 1991-92 B.Ed. Biology candidates had also been secondary school science teachers. But only 21.4% of these candidates had been Heads of their Science Departments and one of them had been a Physical Education Lecturer at a Primary Teacher Training College.

THE B.Ed. BIOLOGY PROGRAM ENROLLED IN

All of the 1991-92 B. Ed. Biology candidates were on the two-years full-time program. They had not graduated by the time this research study was done. Among the ZIMSTT Biology graduates who responded to Item #11, 85% had taken the one-year full-time crash program; 10% had taken the two-years full-time program; and only 5% had taken the two-years part-time program.

YEAR GRADUATED

The ZIMSTT graduates who responded to the questionnaire (Item #12) indicated that they had received their B.Ed. Degrees at various times which are shown in Table 7, below.

Table 7

Questionnaire Respondents' B.Ed. Graduating Years

YEAR GRADUATED	FREQUENCY
1986	5
1987	6
1988	9
1989-1990	7

Thus, each cohort was fairly represented among survey questionnaire respondents.

WHERE THEY ARE NOW?

The various positions held after the B.Ed. program by the ZIMSTT graduates, who responded to the first and second wave questionnaires (Item #13), are indicated in Table 8, below:

Table 8

Positions Held after the B.Ed. Program

POSITION HELD	NO. OF ZIMSTT GRADUATES
Teaching A-Level Biology	9
Teaching O-Level Science	11
Acting-Headmasters	3
Deputy-Headmistress	1
Teacher Educators	8
Education Officer	1

That is, a majority went back to teaching O-Level Science classes and a few had been promoted by the time the study was carried out. The regional distribution of the nine ZIMSTT graduates, who took up A-Level Biology teaching, was as follows: two in Harare; three in Matebeleland North; two in the Midlands; one in Masvingo; and one in Manicaland. No ZIMSTT A-Level Biology teacher was located in Matebeleland South and Mashonaland (East, Central and West) Regions of the Ministry of Education and Culture.

Even outside the Ministry of Education and Culture, the ZIMSTT Biology graduates have also found their niches. One known case is employed at one of the major cities' Water Purification Plants. Unfortunately, because of time constraints, this graduate was not interviewed to find out how the ZIMSTT program was impacting on his work there.

HOW SOON A-LEVEL BIOLOGY TEACHING WAS TAKEN UP

Among the nine ZIMSTT graduates who went to teach A-Level Biology, six took it up immediately after graduating. One took it up after three terms, i.e., after a year, and another after two years. The ninth A-Level teacher did not respond to this item (#14a). Besides the few who were promoted (Item #13), the majority of the graduates never took up A-Level Biology teaching up to the time this research study was carried out. Hence, in terms of numbers, the ZIMSTT program to-date has had very little impact as far as increasing the needed A-Level Biology teachers.

REASONS FOR STILL TEACHING O-LEVEL CLASSES

Item #14b was added on the second wave questionnaire, after the first wave questionnaire revealed that only nine out of the eighty ZIMSTT Biology graduates had ventured to teach A-Level Biology classes. The reasons offered by the ZIMSTT graduates for their still teaching O-Level classes were the following.

> I don't know but I was almost given an "A" Level class at neighboring school once. It didn't materialize because they wanted an A-level Mathematics teacher. My Headmaster wanted me where I was. Later, I got promoted into a Primary Teacher Training College (2TQ #19).

[2TQ means second wave Teacher's Survey Questionnaire and the number is the designation for the respondent]

> We have only one A-level school offering Biology in the District and I found it not necessary to transfer from this school for the single purpose of teaching Biology. I am also having the responsibility of being the Head of Department and the Acting - Senior Master in the school (2TQ #18).

> I like this school and my family is well settled . . . (2TQ #12).

> No A-Level classes at present at the school I am teaching at (2TQ #17).

> Currently, I am the Acting - Deputy Headmaster at this school which has no A-Level at all (2TQ #16).

> Although I am teaching at a High School with A-Level Biology, but I prefer teaching O-Level classes because at A-Level there are more qualified and more experienced (personnel) people who can do it far much better than myself (2TQ #15).

> School has no A-level classes and this Region has no shortage of A-Level Biology teachers because there are many more than the A-Level schools (2TQ #14).

> There is not any one A-Level school in Ngezi (2TQ #13).

> Not interested to go to other schools because it is Saint Paul's which has made me what I am, I have turned down several offers (2TQ #4).

> I didn't apply to any A-Level school after completion and I am not at all interested in doing so since the remuneration of teaching A-Level classes is insignificant, it is just as good as staying with my O-Level classes (2TQ #10).

> I was promoted to Deputy Headmaster and I prefer to teach lower Forms because of the frequent interruptions from the Office (2TQ #9).

> I was seconded to Head Office as an Acting Education Officer - Computers & Statistics (2TQ #7).

> I have not been offered the place to teach A-Level Biology (2TQ #8).

The latter teacher seems to perceive the initiation of the transfer as not his prerogative. The ZIMSTT Biology graduates have not taken up A-Level Biology teaching for various reasons which included there being no A-Level classes in their school; not wanting to disrupt their families by transferring to another school with A-Level classes; waiting for the Ministry to transfer them; having been promoted to become either a Deputy Headmaster, a College Lecturer, or an Education Officer; and there being a minimal financial incentive for teaching A-Level classes.

REASONS FOR ENROLLING INTO THE PROGRAM

The ZIMSTT graduates gave various reasons, in response to the question (Item #17) "what factors influenced you to apply for enrollment into the B.Ed. Biology program?" These reasons, although expressed in different ways, are centered around the teachers' perception of the B.Ed. program as a means to advance themselves academically (f=9); professionally (f=25); financially (f=8); socially (f=6) and personally (affective/self-esteem) (f=6). It seems that the majority enrolled in order to improve their professional competence and increase their chances of promotion. This was followed by the academic-focussed reasons of the teachers wanting to learn more of the subject matter and to become a graduate.

This pattern was reversed in the responses given by the 1991-92 ZIMSTT candidates. A majority of them gave reasons which were focussed on academic advancement (f=12). This was followed by the empowerment and the enhancement of their professional competence (f=7). Two people gave the unexpected reason of having enrolled into the B.Ed. program in order to "have a break from ... teaching."

While most of the graduates were motivated to joined the B. Ed. program by the prospects of academic, financial and social gains, a few mentioned pedagogic enhancement, with specific reference to A-Level Biology teaching. For example, one teacher said that she had joined in order

> . . . to pick up ideas of how to handle the senior classes (students), i.e., the A-Level classes. My expectation was met to a large extent . . . but we did not touch all aspects of the A-Level Biology syllabus. But the basic principles had been laid down; and it is the principles that really assist one when one is planning a lesson. You cannot be told everything word for word. But as long as the ground work is there, one can fill in the rest. What was left out are sections of the syllabus like the Options . . . (MiFI, p. 1).

EXPECTATIONS FROM THE PROGRAM

There seems to be a correlation between the reasons which the ZIMSTT graduates gave for enrolling into B.Ed program and what they expected from the program (Items #s 19, 20 & 21). These expectations are summarized in Table 9, below:

Similar expectations were expressed by the 1991-92 ZIMSTT candidates. Rather surprising expectations were expressed by two candidates about whether the program's content would be easy or hard (f=2). They had also expected "to meet uncompromising tough lecturers" (C10). But they acknowledged that what they had experienced was the opposite. That is, the work had been challenging and yet they had succeeded at it (C7); and the lecturers had turned

Table 9

B.Ed. Candidates' Expectations of the Program

CANDIDATES' EXPECTATIONS	FREQUENCY
Gain subject matter knowledge	10
As a means of getting a promotion	7
Prospect of a salary increase	3
Sharpen one's practical inquiry skills	3
Acquire research skills	4
Succeeding in the program	3

out to be sensitive to the needs of the students. While the majority of the respondents indicated that their expectations had been met, through either personal hard work, and/or the way the subject matter was treated and through the lecturers' teaching styles, a small number of the respondents identified some expectations which had not been met. That is, some topics turned out to be difficult; promotion had not yet materialized; not much research was done; the timetable was packed so much that the students worked under pressure, throughout the program. The program did not produce "Educationists." No tutorials had been provided for the students. No administrative skills were developed and acquired by the graduates etc.

PERCEPTIONS OF THE PROGRAM

In response to Item #18, the ZIMSTT candidates indicated that they had perceived the B.Ed. program as having been taxing and

> . . . demanding a lot of commitment in terms of time and energy (C10).
>
> It was very rigorous and fully loaded throughout the year (19).
>
> It was killing for one year... (12).
>
> It was . . . hard work and demanding on our time . . . (15).
>
> It had too much practical work which was hurried without much understanding (C2).

One ZIMSTT graduate, describing the one-year program he went through, wrote, "This was really a crash program. The work was too much and no time to breathe . . . I was really overworked within too short a time i.e. a very short year. . . . They squeezed blood out of us . . ." (6).

This was also expressed in the Hodzi and Jaji (1991) Tracer Study. The program now stretches over two years and yet the graduates from this two-year program still felt like they were being rushed. However, despite its taxing demands, the B.Ed. program was also described in positive terms as having been ". . . exciting . . (6) . . . very rewarding . . . (9); and it was a most satisfying . . . sumptuous experience . . ." (11).

Thus, the ZIMSTT graduates seemed to have mixed feelings about the Biology program. There were aspects about the program which they liked, because they were rewarding, enjoyable and fruitful, and aspects which they did not like, because of the pressure and the challenge of the work.

WHAT THEY GOT OUT OF THE PROGRAM

Despite the high demands of the B.Ed. Biology program, the ZIMSTT graduates reported, on the first wave questionnaire (Item #18), that they had derived some positive outcomes from it, which are summarized in Table 10, below.

Table 10

ZIMSTT Program Outcomes

OUTCOMES FROM THE PROGRAM	FREQUENCY
Cognitive subject matter mastery	9
Improved professional skills	10
Positive affective impact	11
Social and cultural enrichment	2
Development of lab. practical skills	3
All round development	1

Similar positive outcomes were also reported by the ZIMSTT graduates on second wave questionnaire and by the 1992-93 ZIMSTT candidates. However, two of the 1992-93 ZIMSTT candidates highlighted the difficulties which they were experiencing during their study. One reported ". . . an acute shortage of books in the library" (C13). For the other, the difficulty of continuing to work on one's "personal research" project which was caused, according to his perception of the situation, by the "no communication, apparently between Biological Science Dept and the B. Ed. group, which has no established lecture theaters and laboratories" (C14). Actually, the latter difficulty is not due to "no communication". From my own experience of teaching part of the course from 1986-1988, the problem arose because the shared laboratories were always tied up with either a B.Sc. or a B.Ed. Biology class' practical lesson.

Despite these hassles, the ZIMSTT graduates derived substantial positive gains from their experiences in the program.

PROGRAM'S INFLUENCE ON TEACHERS' WORK

All the people who responded to Item #22 reported a positive influence by the B.Ed. program in their teaching. It seems that the B.Ed. program experiences not only enhanced the graduates' confidence in teaching (f=10), but also boosted their subject matter command (f=7), to the extent that the teachers "feel on top of the situation," and "can handle questions from students especially those requiring knowledge beyond what the textbooks can offer" (11). The program experiences also improved the graduates professionally (f=26). Some of the explanations were that

> . . . lesson preparation is now thorough (11) . . . teaching has become more practically-oriented with more pupils participating (14) . . . I gained skills to produce the best out of my students (5) . . . the

> program has taught me to work under pressure (13) . . . I am now a hard worker and . . . I research ahead of my students (22).

The graduates also reported that they had learned how to learn on their own. For example, one wrote,

> It has taught me . . . to embark on new topics in Biology. Topics which were never discussed at U.Z. I can research and understand them well enough to pass information to my students (13).

Another ZIMSTT graduate echoed that he has been influenced

> . . . to remain a student of science because new knowledge is being discovered daily ... (and so I) engage myself in research (18).

Hence, it appears that the B.Ed. program experiences were perceived to have been helpful to the teachers in their present teaching posts. But in the Jaji and Hodzi (1992) study, it was reported that

> . . . those teaching A-Level found these B.Ed. Courses useful, but those teaching O-Level Science were somewhat less positive with only 87% finding the course helpful . . . (p.24).

This discrepancy can be accounted for by the fact that the topics covered in the B.Ed. program are the same topics that are covered in the A-Level Biology syllabus, while the O-Level Science syllabus includes very few of these topics.

Lastly, the program has had an affective impact and influence on the graduates. For example, one of the graduates wrote,

> . . . since I now teach with authority, it makes me enjoy my work as a teacher, I enjoy every minute of my lessons, especially when I am answering puzzling questions from the students . . . (and I) . . . encourage my students to enjoy and 'fall in love' with science . . . (18).

Hence, the program has had a definite positive impact on the graduates' teaching practices, because of its effect on their subject matter command; attitudes to students' learning; and on the teachers' own feelings of confidence. Last but not least, was the influence on pedagogy, which was highlighted by one ZIMSTT graduate who was teaching at a Teacher Training College before and after the B.Ed. program. He said that the B.Ed. experience had developed in him two things,

> The first is being able to communicate better in terms of what you are talking about because you know more. The second thing is that I have developed patience because I appreciate the problems of understanding better. That is, you are more patient because you feel the need to explain in a manner that people really understand what the problem is about, and in developing the concepts . . . (Mu.HI, p. 1).

In response to the question of how that patience had developed from the B.Ed. course, he replied,

> . . . first of all, from the teaching point of view, the methods and the approaches used, l realized that there are many ways in which a person might understand the same thing. You may think that you are being clear, using a particular method, which might not work to a particular individual. You are looking at your style of presenting the material . . . of explaining; your need to use a variety of styles to be able to be understood by different individuals . . . (Mu.HI, pp. 1-2).

So from his B.Ed. experiences, this ZIMSTT graduate had gained knowledge which facilitated his communication skills and he had come to realize the need for possessing a repertoire of teaching techniques and styles. This is what Wilson, et al., (1987) are talking about, when they emphasize the need for a teacher to use multiple representations for putting across a given concept to pupils with different learning styles. When asked to describe how his teaching style had changed, he indicated that

> The tendency I had was to lecture to the student teachers, being adults. My teaching style was dominantly exposition, whether they understood or not. Now I get pleasure in getting students in doing things. Science is more doing. You are thinking in terms of what activities students can do. From these activities, you try to get them to deduce i.e., to come to conclusions and come to understand what you are saying. When students are involved in activities, one of the things that I think is happening is that you are raising more questions than answers. That is, if the student himself, is conscious of what he is doing, he should start to have more questions arising from the activities, so that by the time you now come to explain or expose the content, you would then be answering more questions that have arisen from the activities. So your students" learning, I think, therefore, becomes more effective (Mu.HI, pp. 2-3).

To illustrate the point of students first starting with an activity, which eventually raises questions in the students' minds, this Deputy Headmaster cited one instance, which involved a field trip to a local sewage plant. This whole activity was based on the "Primary Environmental Science Syllabus, Zimbabwe." With this example he stressed that "I believe that knowledge that comes out of a learning situation rather than a teaching situation is better understood" (Mu.HI, p. 6).

When asked to differentiate or to characterize each of these situations, he said,

> A learning situation is one where the teacher creates a situation e.g. getting access to the sewage plant, from which the learners start to interact with the environment. From that interaction you should develop learning. In a teaching situation, it remains with the teacher to develop strategies and ways of getting across what I want my students to learn. I should lead and guide so that they discover and find out as much as possible for themselves (Ibid.).

The relative prominence of the teacher in these two situations is really a moot point, because although at the sewage site, the teacher may appear to be in the background, he has his input on the work sheet which he had prepared before the trip. The important point is that in a teaching situation he might resort to the extreme of telling, i.e., lecturing and spoon-feeding. In a learning situation, students are interacting with the phenomena to try and answer their own questions. His image of a teacher was "a facilitator who stimulates students to want to do things" (Mu.HI, p. 13). His perception of teaching and learning can be summarized as: Starting with a teacher, who focuses, directs and alerts students to specific aspects of a situation or a phenomenon, depending on his objectives. That is, a teacher creates a learning situation, by providing real phenomenon for the students, who actively interact with this phenomenon. This interaction gives rise to questions. Then the students and the teacher then work towards answering the raised questions, either through verbal responses, experiments, or library searches etc. This mode of working engages the class in inquiry.

Another ZIMSTT A-Level Biology teacher, while describing his perception of teaching and learning, put it a bit differently. This teacher perceived teaching

> . . . as helping a child to grow up .... the major part being to change the intellect of the child. To do this, one has to make the students think on an issue. The teacher does this by creating a situation which makes the students to think and ask questions about a particular situation (NFI, p. 17).

For this teacher, learning involves "changing the intellect of the child." Using an example of protein synthesis, he explained that,

> . . . one starts off with a general question like 'what makes body proteins? Where does the body get the information i.e. where does the recipe come from?' Then, one breaks this broad question into smaller and more specific questions, which continue to focus on a particular aspect of protein synthesis. That is, by answering each of these short specific questions, in turn, you direct the children to focus their thinking on a particular idea or process. In the process, the teacher facilitates this by creating other situations from which the students get answers to these questions. In the end, you will have facilitated the development of the concept which you are teaching i.e. they develop something like 'the big picture' of the idea, the process, or the phenomenon (NFI, p. 17).

Considering these two perceptions of teaching, one can see that both scenarios take place in "the teaching situations" and "the learning situations." That is, there are times when one starts off with a question and then creates situations to try and answer that question. Then there are times when one starts off by presenting a situation and then asks students to explain their observations of the phenomenon in the presented situation.

The pedagogic implication of this is that, these two scenarios or approaches provide exciting and stimulating alternative ways of introducing lessons. It seems that both of these two conceptions of teaching stress the asking of questions about the experienced phenomenon. The question that arises concerns the nature and the frequency of the questions, which are being asked in the A-Level Biology classes, by the teachers and their students.

ADEQUACY OF PREPARATION BY THE PROGRAM

This item (#23) was responded to only by the nine ZIMSTT Biology graduates who have taken up A-Level Biology teaching. There seems to be a consensus among these A-Level Biology teachers, that they felt that the B.Ed. Biology program had prepared them reasonably well for teaching the previous A- Level Biology syllabus and not for teaching the Option Topics of the current syllabus. Thus, the ZIMSTT Biology graduates, who were teaching this revised syllabus had not been exposed to these new concepts. These Option Topics are now being discussed in the program [Tape E.ZSI (11/00/93)].

One graduate summed up their predicament and all these sentiments very well when he wrote extensively that,

> . . . I feel that the B.Ed. program prepared me adequately both theoretically and practically for my A-Level teaching, although, because of the current changes or restructuring in the syllabus I am finding a bit of problems here and there. When I did my B.Ed. program I was adequately prepared for the syllabus which was in schools at that time. But the syllabus has since changed. With the Core Syllabus I am Okay. It is with certain Option Topics, which have been included where I find some problems, e.g., Issues In Contemporary Society and Applications of Science. With regards to practicals, I think I was adequately prepared in so far as preparations and organizing them. The only constraint/problem is sometimes you may be forced to abandon the practicals.
>
> Lastly, I think the B.Ed. program helped me by instilling in me that attitude of wanting to do a lot of research on my own. I have little or no problems when I want to look for information i.e. where to find it? and how to find it? This I am also trying to instill into the pupils; for they should also want to do a lot of research on their own, by giving them questions of a probing nature and encouraging them to read the variety of science publications on what science has to offer today (TQ #6).

What this teacher meant by "research" is looking up information from a variety of science publications, that is, doing library searches.

SUMMARY

The ZIMSTT graduates were qualified O-Level science teachers, a majority of whom had at least two years of teaching experience. They had enrolled into the B.Ed. program for academic, professional and personal advancement. They perceived the program to have been cognitively very demanding. They reported to have worked under pressure throughout because of the B.Ed. tight schedule and shortage of library books.

After graduation, only a few of those who responded to the questionnaire (N=27) were promoted to become Teacher Educators (N=8); Headmasters (N=4); Education Officer (N=1); A-Level Biology teachers (N=9); the rest went back to teach O- Level Science classes, because of a variety of reasons. However, in these posts, the B.Ed. program was perceived by the ZIMSTT graduates as having a positive influence on their work. But the program was perceived as not having prepared the A-Level Biology teachers for the new syllabus' Option Topics.

CHAPTER VI

TEACHERS' BELIEFS, CONCEPTIONS, AND THINKING PROCESSES

This chapter describes the teachers' beliefs and conceptions. It was deemed necessary to understand the teachers' beliefs and conceptions about teaching, learning, knowledge, subject matter knowledge, an ideal A-Level teacher, and their perceptions of their A-Level teaching practices before trying to make sense of their actual teaching practices and the nature of learning taking place among their students.

CONCEPTIONS OF KNOWLEDGE

When the ZIMSTT Biology graduates were asked what their conceptions of what knowledge was, they gave very interesting responses. "Knowledge" was conceived as

> . . . a body of information from textbooks and from experiments (CFI, p. 10; GFI, p. 17 & BFI, p. 11,).

> . . . a wealth of facts, concepts and ideas to be used in practical situations to improve our standard of living, e.g., at research stations to increase meat, milk and crops yields . . . (DFI, p. 10).

> . . . as what is prescribed in the syllabus . . . (NFI, p. 18).

At first, one gets the impression that these five teachers perceive knowledge as static and unchanging. But when they were probed about where the text book writers get their information from, and how the content in the text books changes, then the teachers responded with comments on how knowledge is discovered by individual inquirers. At first none of the teachers admitted to be constructing knowledge with their students in their classes. The tentativeness of knowledge was acknowledged by only one teacher who conceived knowledge as

> . . . ideas and not like coins with specific values. Knowledge, as ideas expands, in that you may think you know something about the brain, but there is more to the brain than you think you know. There is more to almost everything about knowledge and to Biology specifically (PFI, p. 16).

What this teacher seemed to be saying was that knowledge is not like money which can be passed around without changing its currency. That is, knowledge cannot be exchanged unchanged and we cannot achieve absolute Knowledge. When asked how this plays out in the classroom, he went on to explain that

> . . . when I learn about the brain, I understand about the brain better than I knew before. It means that I can conceptualize it, not by reproducing what the teacher said about the brain, but by fitting it and rearranging my previous ideas of the brain, and thus I incorporate the new ideas, so that I can make it my personal knowledge ... which is of an acceptable standard, but is still yours in a unique way, because you are an individual and you go through different experiences. How I then describe this present experience will be different and unique (PFI, pp. 16-17).

A Piagetian thinking is reflected in this response, in which the teacher is describing in essence the processes of "assimilation" and "accommodation" (Piaget, 1952 and Inhelder & Piaget, 1958). His point was that knowledge is not out there in a completed and finished form. That is, it is not static but is changing and is relative due to our different background experiences.

Hence, every time we learn something, there is a modification of one's prior conceptions, which results in a rearrangement of one's "cognitive structure" (Ausubel, 1978 and 1963), or a modification of one's existing knowledge schema, as mental processes of assimilation and accommodation take place.

Mr. P. had another interesting conception of subject matter knowledge which surfaced when he was describing the images he had of his students as "the tourists" and of the teacher as "the guide." He perceived knowledge as ". . . the jungle itself, i.e., the content of the jungle, with all aspects of the plant and animal life, the weather, the soil, and all the conditions, which make up the whole picture" (PFI, p. 7).

This image of "the jungle" portrays the richness of knowledge out there. The teacher went on elaborate that the subject matter knowledge represents specific areas or aspects of this "jungle" because

> . . . in a jungle you don't learn everything at once. So you have to pick and choose, out of the jungle, what you are interested in. For example, in studying Biology, the specific areas we are interested in are plants and animals, i.e., their parts and functions, and their interrelationships. Syllabuses guide us as to which aspects we need to focus on, in particular grade levels. Textbooks also indicate the stipulated depth of treatment i.e., how much we need to learn at any particular stage of our education (PFI, p. 7).

This teacher's perception of a teacher was as

> . . . 'a guide' who facilitates the students' exploration or survey of 'the jungle' . . . by concentrating on one aspect of this total picture, which is the specific subject matter, in this case

> Biology, as a study of plants and animals and how they interact in and with their environment (Ibid., p. 6).

That is, the teacher who knows the specific requirements at the various grade levels, guides his students, as "a guide" does with "the tourists," and facilitates their focussing on the important aspect of the phenomenon under study. The teacher helps the students to make sense of their observations. But ultimately, the task of learning what is being focussed on by the teacher remains the student's. That is, it is the student who, in the final analysis, chooses what to take particular interest in or what to ignore.

Next, when the teachers were asked where knowledge came from, one teacher replied saying,

> . . . the knowledge is produced from research, which will have been triggered by a driving question about some striking aspect of some observed natural phenomenon. But to try and answer this big question, it has to be reduced to smaller manageable questions. To answer these more specific smaller questions, the researcher creates a situation or designs experiments to test his tentative hypotheses and explanations, which he will have to put forward as possible answers to the smaller questions. From the observed results of the experiments, he discovers new ideas, which he uses to modify his prior conceptions and derive a better understanding of that particular aspect of the phenomenon, which had puzzled him in the first place (NFI, pp. 17-19).

Thus, for this teacher the process of creating knowledge, involves the implementation of the scientific method, and the need for asking questions and answering the raised questions for oneself. This idea of creating situations in which students actively make sense of their environment was also mentioned by a third teacher [Mu.HI, p. 14 (9/29/92)].

For this teacher, scientific research, which was carried out to try and answer some driving question, produces knowledge. This reminded me of what one participant had said, at a Teaching, Learning and Curriculum (TLC) Leadership Training Workshop, held at Kellogg Center, Michigan State University (August 17-19, 1993), that **"The best scientists are question askers and pattern seekers."**

What was interesting to note was that, although all the teachers had said that knowledge came from scientific research, the majority of them were not sure whether they were creating or producing knowledge with their students in their classrooms. However, they all acknowledged that science was dynamic and that new information was coming out of on-going scientific researches and being published as books or as articles in research journals and magazines. During the study, only two teachers were observed using such articles.

The eighth teacher perceived the subject matter of Biology as "something that pervades our human life" (Mu.HI, p. 8). When asked to explain what he meant, he said the following.

> We are the center of the universe, because we have the faculties to control most of the things that take place. Our ability to control that either make us or breaks us. We see plenty of evidence of where we have been careless, I don't know whether deliberately or not (Ibid).

It was pointed out that this apparent carelessness may be because people are focussing their attention on short-term gains without looking at the long-term consequences of their activities. Then, this Deputy Headmaster went on to say the following.

> But then it is through learning Biology subject matter, that we should want to preserve ourselves ... and other living things on this planet, which are important as well ... We have taken more than our share. I think this world would be a better place without human beings (Ibid.).

It seems that for this teacher, what is at the center of the subject matter is the preservation and conservation of all living things. Man is perceived by him as the cause of the observed ills in nature because he has "taken more than his share." He continued,

> So when I look at the subject matter of Biology, one is trying slowly, as one of my goals, to develop a nation of people who have got that sympathy towards the planet earth, and who should be able to stand up and say things on behalf of the planet (Ibid., p. 9).

This teacher is stressing more on developing attitudes of "sympathy towards the planet earth." These attitudes will influence students' behavior towards nature and the judgements which they will make with regards to their uses and exploitations of the natural resources. The students will hopefully feel compelled to "stand up and say things on behalf of the planet." On this point, he cited the plight of the Rain Forest in the Amazon Region in Brazil and the poaching of rhino in the Zambezi Valley, in Zimbabwe.

This Deputy-Headmaster was not teaching A-Level Biology. He was also not observed teaching his O-Level Science classes. Hence, the relationship between his goal of developing "a nation of people who have got sympathy towards the planet earth" and his classroom teaching practices was not established.

I would also argue that for a person to be able "to stand up and say things on behalf of the planet," they must be articulate in giving sound explanations and arguments, and in posing good, searching questions. One question here to raise is, to what extent are the teachers aware of the criteria of a good scientific explanation, a good argument, and a good question?

SUMMARY

At first, the teachers gave the impression that they conceived knowledge as a body of facts found in text books; only one, a Deputy-Headmaster, was concerned about how knowledge should be used for the preservation of nature. The teachers did not give much thought to the subject matter as an aspect of their cultural heritage. Nor did the teachers conceive their subject as yet another vehicle or medium for developing critical thinking skills (characterized by inquiry, caring, creativity, and development of sound judgement, Lipman, 1993, p. 40). Only after being probed, did the teachers mention that an aspect of knowledge is the process of its discovery and validation. In the case of science, this means knowing the nature of science (Gazzard, 1993), that is, its substantive and syntactic structures (Schwab, 1966 & 1978).

Hence, an assertion was formulated **that the teachers' views about knowledge lie on a continuum with knowledge as a body of facts found in text books at one end, and as tentative and changing, as a result of scientific research, at the other end.** After probing, all the nine teachers could be placed more towards the end of the continuum with knowledge as tentative rather than at the other end with knowledge as static facts:

Body of facts <------ knowledge ------> Tentative & changing

(M-, D-, V-, P-, G-, C- P-, Mi-, B-).

Whereas, before probing their relative placements on this continuum were more to the left of the continuum:

Body of facts <------ knowledge ------> Tentative & changing

(M-, D-, V-, P-, G-, C- P-, Mi-, B-).

CONCEPTIONS OF LEARNING

Teachers gave varying conceptions of what "learning" is all about. For example, one teacher's view of learning was that ". . . the student listens, carries out tasks to find information on his own, and develops the inquisitive mind, which leads him to search for information" (PFI, p. 6).

This view of learning is consistent with this teacher's conception of a learner, whom he characterized as a "tourist" (See Section 6.8 on Images). Like "a tourist," he listens to the "guide" and does what he says. For this teacher, learning is both a passive and an active process. That is, learning is passive as "students listen" and it is active as they "search for information." For this teacher, "developing an inquisitive mind" leads to learning as one finds more information to satisfy one's curiosity. This teacher, while describing the "free learning atmosphere" in his classroom and school had said the following.

> Learning has no barrier. The free atmosphere between the teacher and the learner enables us to share knowledge. This way, the students will not take me as an owner of knowledge but as a facilitator of learning. This is achievable in a warm and free learning atmosphere (PFI, p. 14).

What is pertinent here is the concept of teaching and learning, which is being perceived as sharing of knowledge. This is in contrast to a knowledge transmission mode of teaching, in which communication is one-way, from the teacher to the students. Whereas, in this sharing mode, communication is two-way because dialogue is interactive. This was observed being enacted by this teacher, during his lessons on the Option Topic on "DRUG ABUSE" and on "TOBACCO ABUSE" [Video- tape PV (9/22/92)]. In this lesson, the teacher was observed trying to draw most of the information from the students' background knowledge, through questions and answers, and he only told them the new facts, which they were not aware of. The students seemed to have gained deeper knowledge from the shared knowledge.

A second teacher echoed the idea of learning as sharing in a different way. She said "Learning involves **getting information actively**" (BFI, p. 10). When probed as from where students "get information actively?" She thought for a while and then came up with the puzzle of "who is actually learning and from whom?" (Ibid). When asked what she meant, she explained how,

> . . . when I am the one who is explaining, the students get it from me. But when one of the students is explaining, the other students and I are learning from the student who is explaining. And then, when I expand on what was said by the explaining student, he too is also learning together with the rest of the class (BFI, p. 10).

What this teacher was implying is that everyone is learning from everyone else in the class. Hence, in this particular case, there is the sharing of understandings, and the polarity of the teacher's role and the student's role becomes blurred as the roles are interchanged. That is, at some point, the students take on the role of the teacher, while the teacher takes on the role of the learner, together with the rest of the students.

Students "getting information actively" was also observed when another teacher had assigned three of her students to prepare in order for them to come and give their individual "lecturettes" to their classmates, in her Lower Sixth Biology class. These students talked, in turns, on The Pyramids of Numbers,; Pyramid of Energy, and Pyramid of Biomass. [Video Tape BV (9/20/92)]. These three students had shared the double period for their talks. After each presentation, some students posed clarification questions to the presenting student, who then had to elaborate his/her previous explanation, and other students offered additional information.

During the post-observation conference, this teacher explained,

> . . . I sometimes choose this approach of students' 'mini- lessons' or 'lecturettes', because, during the preparations, students read more and bring more information than is in the syllabus . . . but then, they have a time limit of 5-10 minutes each and so they have to learn to be precise and concise . . . Then you summarize and note the major points (BFI, p. 9).

For this teacher, learning is students reading more, and synthesizing the read text, so that he can give a concise and precise summary, which the presenting student can give to the rest of the class, as a "mini-lesson" or "lecturette." Ideally, it seems that the value of these "lecturettes" lies in the fact that the students learn how to learn on their own because one has to understand thoroughly what one has read, before one can teach the other students about it, and they also develop the skill of being "precise and concise." The students were reported to have developed self-confidence, while their own understanding was being enhanced, both during the processes of preparing for the talk, and during the class presentation, and when answering questions from their fellow classmates. The role of the teacher in such a lesson is to keep the class discussion going and in the end to summarize and point out the major ideas.

A third teacher perceived learning

> . . . as understanding, meaning students being able to say what was in their reading text and, because they understand, they should also be able to raise questions themselves and to solve problems by applying those individual facts (DFI, p. 10).

This teacher also perceives learning in terms of what a student who has learned is able to do i.e., to paraphrase the text; to answer questions which are based on the text; to raise questions; and to solve problems by applying the learned knowledge. Another teacher also reiterated this conception of learning as understanding and application of the information (CFI, p. 10). The students of these two teachers would take on the role of teachers, as they summarized their assigned reading in front of the whole class and answered questions from the rest of the students. But the teacher would retain his role of teacher as he guided the discussions after each student's presentation and as he added any left out information.

A fourth teacher perceived learning, simply as "a change of behavior" (VFI, p. 11). He didn't explain what behaviors he was thinking of. Neither could this "change of behavior" be inferred from this teacher's perception of teaching which he said "involves giving instruction" (VFI, p. 11).

A fifth teacher perceived learning "as changing attitudes" (GFI, p. 17). What this entails was not discussed because this interview was held with the teacher after school and we had little time left for it.

A sixth teacher perceived the learner as

> . . . not completely blank, that is, he is not a 'tabula rasa' (Piaget?). He comes to a teaching-learning situation with information or ideas which are either completely wrong or shallow . . . not to the required scientific or syllabus level (NFI, p. 7).

When asked how he elicits his students' prior ideas, that is, how much the students already knew, Mr. N- replied that he gave "pre-lesson exercises." But he quickly pointed out that he rarely does this. He said, "I do it usually on topics which I am definite that they know something about from their background experiences" (Ibid.). This teacher also perceived knowledge as involving change, not of behavior, but as

> . . . changing existing knowledge to accommodate a new situation, i.e., a new experience, in a created learning situation . . . so that the students can now say 'Oh, I used to think that these things happen this way, now I have the correct thing . . .' (NFI, p. 17).

This teacher brought out another aspect about learning, that it involves modifying students' naive prior conceptions and correcting any existing misconceptions. This is in agreement with what conceptual change research says about learning (Driver, et al., 1985 and Anderson & Berkheimer, n.d.).

SUMMARY

The ZIMSTT A-Level Biology teachers perceived learning as encompassing listening; carrying out tasks; searching for information; sharing knowledge; understanding the text or what is taught; and changing of behaviors, attitudes, and prior knowledge. And yet a great majority of these teachers did not elicit their students' prior knowledge. One indication that the students would have learned or understood what was taught or read, was the nature of their questions and their ability to apply the gained knowledge and skills in solving real-life problems [Tape C 21 (7/22/92) POC, p. 15].

Hence, an assertion was formulated **that the teachers' perceptions of learning can be placed on a continuum with passive knowledge acquisition at one end and active knowledge acquisition and sense-making at the other end.** The observed teachers can be placed along this continuum thus.

Passive knowledge <---------learning ---------> Active knowledge
acquisition and   acquisition and
knowledge reproduction   Knowledge production

(M- & D-) <------ (V- & G-) -----> (P-, N-, B-, C-, Mi- & Mu).

This placement is supported by evidence from their observed A-Level Biology lessons. The passive, receptive learning was observed to a greater extent in both Mrs. M-'s and Mr. D-'s lessons. Both of these teachers displayed a didactic teaching style, which is typical of a knowledge transmission paradigm. For example, all the lessons observed, which Mr. D- taught to his L6 Biology class of only nine students, were taught by reading and dictating from his own notes [Video-tapes DV (9/15/92); (9/16/92); and (9/20/92)]. During a post-observation conference, Mr. D- rationalized this practice saying that "this dictating of notes is done occasionally, with this group, in areas or topics, in which they may not be able to select main points and summarize, in making their own notes" [D.POC, p. 2 (9/16/92)].

How he decides topics in which the students will find it difficult to select the main points was not probed for. However, his students confirmed that dictations were the norm. They said that dictating of notes was their teacher's style of teaching. When asked what they felt about dictation and how it slows the pace of the lessons, the two girls, who were interviewed were in agreement that, "It saves us time and gives us guidelines for our reading of what's in the syllabus. . . . Teacher's notes are from other text books which we don't have . . . We make our notes in addition . . ." (DSI, p. 12).

The students seemed to appreciate this practice of the teacher dictating notes to them because he will have compiled them from his "other textbooks" which they do not have. In addition, they felt that they saved time when the teacher dictated notes to them. But is this the only way that the guidelines for their reading can be given?

On the other hand, Mrs. M- did not really dictate, in the strict sense of the word. As she lectured, she frequently referred to her notes and referred the students to handouts of photocopied chapters from her own resource books [e.g. Video- tape MV with lessons M 4 (7/8/92) and M 12 (7/17/92)]. It seemed that these two teachers depend on the authority of the text heavily. Policies of the teachers on their students' note-making will be discussed below.

At the other extreme, of the learning continuum, is active making sense of knowledge and knowledge production mode of teaching and learning. This was observed being implemented in the five of the observed A-Level Biology teachers' lessons. These teachers displayed a heuristic teaching style, which was enacted to varying levels, depending on the nature of the task, around which the verbal interaction was focussed. The heuristic teaching style was observed being implemented as the ZIMSTT A-Level Biology teachers were teaching a variety of topics:

1. ECOLOGY: Trophic Levels [Video-Tape BV (9/22/92)].
2. Practical Revision [Video-Tape MiV (10/01/92)]. (Appendix #10).
3. Protein Synthesis [Video-Tape CV (7/9/92)].
4. Adaptive Features For Life On Land [Video-Tape NV (9/25/92)].
5. Tobacco Abuse [Video-Tape PV (9/22/92)].

In these other lessons, in contrast to the two passive scenarios described above, the students were actively involved in making sense of what they were learning. This was achieved, in most cases, by these teachers getting their students highly involved, by holding interactive dialogues either between the teacher and the students (see #s 1, 2, 4 & 5, above) or by the students holding interactive dialogues among themselves (#3, above). In these classes, the students were given opportunities to try and make sense out of the information at hand, before interacting with the teacher for reinforcement. That is, the students were given opportunities to acquire, integrate and apply the information on their own (Gallagher, 1989).

The dialogues were started off in many different ways. One way was by asking students to read a given topic ahead and report back to the class before that topic was taught by the teacher (MiSQ, #3). A second way was by asking students to tell the story of protein synthesis process [Tape M 9 (7/14/92)]. A third way was by asking students to say what they thought on a certain point or issue, which was being discussed [Tape C 6 (7/9/92)], for example, "Why was the cheetah getting extinct?" A fourth way was by giving students opportunities to comment on other students' responses to a question [MiSQ #3, Item #2 (b)]. A fifth way was by asking students to answer each other's questions, for example, during Mrs. B-'s lesson, in which students had taught by giving "lecturettes" on the ecological pyramids of mass, numbers and energy [Video-Tape BV (9/23/92)]. A sixth way was by having students discussing with the teacher on responses to either the teacher's and/or the pupils' raised questions, both in and out of class [MiSQ #9, Item 2(b)] and also during the question and answer sessions after viewing a film, [for example, Tape C 22 (7/23/92) and Tape C 23 (7/24/92)].

Besides the maximum teacher-to-student dialogues, described above, another striking lesson, with maximum student-to-student dialogues, was observed in Mr. C-'s L6 Biology lesson [Tape C 6 (7/9/92)]. This class had just finished being taught about the process of protein synthesis. The teacher then devoted the next lesson to the students working in pairs on a problem, which required them to rearrange statements of events, which occur during the protein synthesis process, into a logical sequence (Appendix #11). Students worked in groups of twos or threes. A high level of interaction was observed throughout these groups' discussions. The teacher, as usual, did move from group to group [Video-tape CV (7/9/92)]. During the post-observation conference, after this lesson, the teacher explained that his observed behavior, of stopping at each group, was done in order for him

> . . . to monitor how well the students were reasoning; . . . to pick problematic areas; . . . to get a general idea of the students' pace; . . . to gauge and decide when to stop the groups' discussions in order for the class to compare their decisions [Tape C.POC, p. 1 (7/9/92)].

The observed class discussion, which followed this small group discussion, was very lively and animated as each group argued and tried to justify its own particular sequence [Video-Tape CV (7/9/92)].

Of pedagogic interest about this particular lesson was not just the active individual involvement of all the students, but also the opportunity, which this particular structure and organization of the lesson, had provided for each student, to have his/her voice heard. Thus, the students' ideas were brought to the surface, exposing both what they knew and what they had not quite understood. The latter was clarified by a peer and reinforced during the class discussion.

The result was that it made the students think about what they were learning from a different perspective and it engaged the students in collaborative making sense. A lot of learning seemed to be taking place during this particular lesson. Mrs., Mrs. G- and Mr. V- had moderate interactions taking place between the teacher and the students,

Hence, an assertion was formulated **that the observed teachers' teaching styles can be placed on a continuum with a didactic style** at one end and a heuristic style at the other. The observed teachers can be placed along this continuum thus:

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A didactic       <------ teaching style ------>       A heuristic
teaching style                                       teaching style

(M- & D-) <--- (G- & V-) ---> (P-, C-, N-, B- & Mi-).
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CONCEPTIONS OF TEACHING

Four out of the nine interviewed ZIMSTT A-Level Biology teachers perceived teaching as "giving information to students" (CFI, p. 10; NFI, p. 11; PFI, p. 6 & DFI, p. 10). That is, these teachers viewed teaching from a knowledge transmission paradigm. They taught by lecturing and having the students listen and jot down some notes. But for three of these four teachers this view of teaching as "giving information" seems to contradict their observed heuristic style of teaching (Mr. P-, Mr. N- and Mr. C-). However, Mr. D-'s view of teaching was consistent with his observed teaching style. But during the interviews, Mr. D- went further to say that his idea of teaching was also "to cultivate in the students the desire to try and find out more knowledge from the text books, experiments in class and in their science club" (DFI, p. 10). This latter view of teaching was not reflected in Mr. D-'s observed teaching style; he lectured and dictated notes to his class during the whole week that he was visited [Tapes D- 9/16/92; D- 9/17/92 & D- 9/20/92].

On the other hand, an attempt "to cultivate in students the desire to . . . find out more knowledge" was seen in one class of Mrs. B-, during her lesson on "Ecology." She asked her students to read ahead the chapter on ECOLOGY. Then the lesson after that homework assignment was conducted as a question and answer session, in which the teacher filled in the gaps and clarified the problematic concepts for the students. She also said that she regarded teaching as "developing inquiry skills in students." A similar sentiment was expressed by another teacher, who said,

> I really enjoy my work and I view science teaching as involving discovery learning; relating theory to everyday life; encouraging inquiry, learning based on practical work to reinforce the theory and geared to students finding out information rather than the teacher providing everything that the students require (GFI, p. 17).

When probed about the nature of the practical work which her students are engaged in, this teacher said that they perform both investigative and verifying experiments. As an example of an inquiry practical, she cited the experiment to investigate the effect of temperature on enzyme activity which they had done on peas. But the teacher had given them the peas, the hydrogen peroxide and the instructions for the students to follow. Thus, the inquiry was instigated by the teacher and the instructions were given by the teacher. Hence, the students had not been given an opportunity, during this particular practical, to design the experiment themselves. One wonders what this teacher's conception of "inquiry" is.

An interesting diversity was reflected from the range of comments given by the teachers (Mr. V-, Mrs. B-, Mr. N-, Mrs. Mi-, & Mr. Mu-), who did not specifically express the view of teaching as "giving information to students." For example, Mr. V- took "teaching as giving instruction." He also perceived

> . . . teaching as involving attitudes, that is, as an individual, the teacher should have an input in terms of feelings towards his pupils. You really have to feel you want to help students. Otherwise, the whole thing falls away and teaching becomes a bore (VFI, p. 11).

For this teacher, the students are at the center of his teaching. What makes teaching exciting is "wanting to help students and developing an attitude of caring." This teacher went on to explain that the teacher not only develops an attitude and a feeling for his pupils, but that "he also develops an attitude towards his subject matter. What is interesting about this is how one subtly projects to the students one's own attitude towards the subject" (Ibid).

When asked to cite an example of this, the teacher described how he had regarded practical work at college as "time-fillers." Now he was perceiving his own students as having adopted the same attitude to their practical work. This has grave pedagogical implications. That is, how many students are being turned off from otherwise interesting subjects, and possible areas for their specialization, just because of their teachers' own negative attitude towards their subject matter?

The importance of the teacher loving his subject was also emphasized by one Headmistress, who said, "I expect the ideal A-Level, to be a teacher who thinks, eats, and dreams his subject, to the extent that she is planning on her way to school, she is noticing relevant resources wherever she is" [Tape J.HI, (9/16/92) p. 4].

This reminded me so much of Father Greg. Croft, Mr. Les Cross and Mr. Rob Gordon, whom I had observed using such conceived resources effectively, during their ZIMASE in-service workshops, in the Harare and Matebeleland Regions, respectively.

Another teacher, who also perceived teaching as helping the students find the knowledge on their own, gave the image of the teacher as a "guide." He said, "in the way I explain, I guide the learning in the right direction so that the students do not get lost" (PFI, pp. 6-7)

When one teacher was asked how she felt about her teaching practice, she said,

> I enjoy teaching. I love the classroom because at the end I find it rewarding when they, the students, understand, more so that I get my tests from past exam papers. I enjoy students coming back to say to me, 'I have passed Science' and also seeing them at the Varsity. I feel I am part of that progress (BFI, p. 9).

This teacher enjoys teaching and is rewarded when her students show evidence of having understood what she had taught on the tests, whose items she extracts from past final examination papers. When robed as to what teaching entails for her, she replied, "To teach is to make people know some given concepts of a particular subject matter, in our case Biology, and to make them apply this knowledge in their daily, real-life problems and situations" (BFI, p. 10).

She then cited three instances to explain how she makes them apply knowledge. First of all, by asking direct application questions, for example, "How would you make the wheels of a wheel barrow move more smoothly? What would you do to make a machine work better?" The second way of making students apply their knowledge is "through role-playing." For example, "As a village worker, what reasons would you give to a mother for breast-feeding? What diet would you recommend for this breast-feeding mother? Why?" Lastly, the teacher described how she makes her students apply their knowledge "by leading them to discover." Using the Form 4 lesson on "Pressure", which I had just observed her teaching, she indicated how she had not come up and told the class that "The deeper you go in water, the greater the pressure becomes." Continuing she said,

> Instead, I started off by asking the students to describe the thickness of a dam wall. Some of the students had never seen a dam wall. But those who had gave the correct response, that it is thicker at the bottom. Then the students were asked to explain that observation i.e., why is the dam wall thicker at the bottom than nearer the top. Various explanations and reasons were given by the students. Some were correct and others wrong. I then left them in suspense of what was the correct answer. I told them that I had a demonstration outside which should help us understand how the dam walls are built (BFI, p. 10).

Outside, at the fish pond, the teacher had asked four students to demonstrate with the classical three-holed can, filled with water, and three students closed the holes with their fingers. The fourth student poured in the water from the top. On the count of three by the teacher, the three students withdrew their fingers from the holes simultaneously. Water spouted out to varying distances. All the students observed that water from the bottom hole spouted out to a farthest point away from the can. While the water through the topmost hole fell nearest to the can.

The teacher made sure that all the students had observed this by asking direst questions about how far water from each hole had fallen. She guided them to explain these observations in terms of the water pressure. Thus, she led them to conclude that the water pressure increases with depth.

Having established this fact she went back to the original dam wall question. All the students were now able to explain that the bottom of the dam wall is thicker than the top because of the increased water pressure at the increased depth of the dam. Thus, the students were asked, first of all, to recall their own background knowledge and then they were guided to discover the relevant facts through the following stages of teaching and learning.

Real-life phenomenon (the dam wall) -----> Descriptions & Tentative explanations (Hypotheses about the dam wall thickness vis-a-vis its depth) -----> Experimental Demonstration (the three-holed-can filled with water) -----> Observations -----> Class Explanations of the demonstration results -----> Deduction/ Conclusion, i.e., Guided Discovery of the fact (water pressure increases with depth) -----> Application (e.g. Design a flood wall).

In this lesson, the teacher had elicited for her students' prior knowledge about bridges from their real-life contexts. The demonstration which she had outside was effective, because it had involved some of the students actively and it had facilitated the rest of the students to make the appropriate observations, which enabled the whole class to deduce the correct structure of dam walls and the reasons for it. That is, the students had been led to discover the fact that dam walls are thicker at the bottom than nearer the top because the water pressure is more at greater depths than nearer the surface.

This approach is in essence in agreement with another teacher's perception of "teaching as leading students to think" (NFI, p. 17). This is accomplished by this teacher by "creating situations for learning." He explained that this was accomplished by "starting the class sessions with a general question about some natural phenomenon or situation, which is answered by first answering smaller, shorter, and more specific sub-questions, which direct children to the idea or process of the big picture being taught" (NFI, pp. 17-18).

Mrs. B-'s lesson on 'water pressure' had exemplified this approach very well. The last teacher to be visited had two conceptions about teaching. In the first place, the teacher perceived teaching, "as inculcating a questioning attitude, by asking the kids directive questions which lead students to ask themselves similar questions. This is one of my long term goals" (MiFI, p. 9).

What this teacher hopes is that by modeling the habit of asking questions i.e., the what? for what? why?, how? when? what if..? etc. about whatever phenomenon or situation is being observed, eventually students will also ask similar questions. Such questions encourage **the habit of wondering** by the students. Wondering, formulating of conjectures (Bruner, 1960), and asking good questions is the basis of science. These mental skills seem to be strong during one's childhood but they seem to get stifled as one grows older. Why should this be so?

The second perception of teaching for this teacher was "as developing skills of manipulation, observation, analysis, inferences and the ability to link theory to practical" (MiFI, p. 9).

She indicated that she developed these skills through "the setting up of practical work." She cited one such practical in which her students had cut and exposed apple pieces under different conditions e.g. exposed to the atmosphere, under the water, covered with vaseline, par-boiled, etc. This particular practical lesson was not observed.

However, I had the opportunity of observing another practical lesson, in which the teacher was making the students link theory to practical, as they looked at the biostrips of the leaf, the mosquito stomach with plasmodia and the pin mold fungus (Appendix #10). What was particularly striking during this practical lesson was the high degree of student involvement, through **the one-on-one teacher-student interactive dialogues**. The teacher held these dialogues with each student, over whichever biostrip that student happened to be working on, as the teacher came by him. She did this throughout this whole revision lesson [Video-tape MiV (10/2/92)]. During the post-observation conference after this practical, she had explained why she had chosen to do the revision lesson that way, "in order to ... find out if the students have understood the work. In the process you find, misconceptions here and there and you try to correct them by filling in information in addition to what is in standard textbooks" (MiFI, p. 9).

A lot of learning took place, because gaps in understanding were identified; many misconceptions were surfaced and corrected; and new insights were gained by the students themselves, since they were made to look up the missing pieces on their own, before proceeding any further, whenever they failed to answer their teacher's questions (Appendix #10).

A knowledge transmission mode of teaching seems to be implied by her expression of "filling in information" as if the student was like an empty bucket. And yet her teaching style, as observed by the researcher and as described by her students, does not reflect this at all. She had portrayed a heuristic teaching style. Unfortunately, no more of her teaching could be observed at the time because she was just getting her students ready for their U6 final examinations due in two weeks.

When the Deputy Headmaster was asked what teaching means to him, he replied,

> There are two facets to teaching, the teacher and the student. They are interesting. The assumption is that the teacher understands better than the learner. It is the duty of the teacher to guide the learner to develop an understanding (Mu.HI, p. 6).

This Deputy Headmaster understands teaching as guiding the learners. Recalling a debate we once had during the B.Ed. Biology program's Methods Course, on "whether teaching is a science or an art," he went on to say emphatically that

> It remains with the teacher to develop strategies, methods, and ways of getting across what I want with my students. I should lead ... so that they discover and find out as much as possible for themselves. I believe in knowledge that comes out of a learning situation rather than a teaching situation is better understood (Mu.HI, p. 6).

The image of teaching as "leading" is consistent with that of teaching as "guiding." But the student in this case is not just following and learning things as given. He is being expected to "find out as much as possible for themselves" from the "learning situation," which is the responsibility of the teacher to create. The differences between "a learning situation" and "a teaching situation" were explained as

> A teaching situation is one where I am taking a leading role ...at times. A learning situation is one where the teacher creates a situation, from which the learner starts to interact with his environment. From that interaction, you should start to develop learning (Ibid.).

This Deputy Headmaster is reiterating what has been described by other teachers who regard a teacher as "a guide" and as "a leader," who "creates situations to enable the students to interact with his environment in order to acquire knowledge and understanding" (BFI, p. 9 and NFI, pp. 17-18).

SUMMARY

Thus, teaching was perceived as including "giving information;" "guiding students to find out more information;" "developing a positive attitude towards the subject;" facilitating and guiding students to develop inquiry skills; making students apply their knowledge through role-playing and by guiding them to discover; leading students to think; inculcating a questioning attitude; developing higher-order thinking skills e.g. analysis and making inferences etc. No one mentioned teaching as helping students form communities where cooperative inquiry and learning takes place; and yet some of them (Mr. C-, Mrs. B-, Mrs. Mi- & Mr. P-) were observed organizing the teaching and learning activities, in such a manner that their students were learning cooperatively.

Hence, this data supports the assertion formulated that **teaching is conceived, on the one hand,.as giving information, and on the other hand, as facilitating, guiding, and leading the students not only to discover and apply knowledge, but also to change their behaviors and attitudes and to develop learning skills.**

giving information <---- teaching ----> facilitating students' conceptual behavioral changes and skills development

The data demonstrate that the teachers' conceptions of teaching and their observed teaching styles are diverse. Consistency might be expected between a teacher's conceptions of knowledge, teaching, and learning and his or her teaching style. But the data have revealed some tensions or contradictions among the teachers' conceptions and practices. For example, one teacher who viewed knowledge as tentative was observed transmitting it by lecturing to his class (Mr. D-). Another teacher who viewed knowledge as constant was observed implementing an interactive teaching style (Mr. C-). Mr. N- viewed teaching as "giving information" and also as "leading students to think." But he was observed doing more of the latter. Hence, caution is in order in interpreting the attempt here to map the teachers along the various continua. The proposed placements are relative, not absolute, and they should be regarded as tentative and uncertain, because of the limited number of observations which were made of the nine ZIMSTT A-Level Biology teachers.

CONCEPTIONS OF AN IDEAL TEACHER

When the ZIMSTT A-Level Biology teachers were asked, what the characteristics of their ideal A-Level Biology teacher were, they had varying conceptions. For example, one teacher perceived an ideal A-Level Biology teacher as one who is

> . . . **dedicated to his job**, because, the work is far more than the little incentives we get. A-Level teachers are given 'a critical shortage area allowance' of Zim $500 per month over and above their normal salaries, which is not much, considering the demands of the job. Secondly, the teacher must **have lots of time for the job**. It may mean that one should exclude other activities, in order to have enough time to do your job properly, because of the amount of preparation required (MFI, p. 15).

This teacher is characterizing A-Level Biology teaching demands as not being balanced by the extra financial incentive allowances. These allowances are given by the Ministry of Education to the

Science and Mathematics teachers, who chose to teach A-Level classes, instead of leaving for greener pastures in the industrial and commercial sectors of Zimbabwe's economy. Hence, she characterized her ideal A-Level teacher as one who has "dedication for the job ... and time ... because of the amount of preparation required."

These same sentiments of the need for time and dedication on the part of the A-Level teacher were also mentioned by another teacher from a different Region, who is teaching at a co-educational private and boarding institution (VFI).

Mrs. M- described a third characteristic of her ideal A- Level Biology teacher. She said, "He must not be a reserved teacher, who keeps to himself. **He must be able to mix and get to know his area and community very well** so that he'll know where to find and get things for teaching (MFI, p. 15).

Here this teacher is highlighting two characteristics. The first was the importance of the teacher not being "reserved" and "keeping to himself" but mixing with his colleagues. Hopefully, this mixing, be it on the social level, or professional level, will facilitate teachers talking and sharing about their work in their classrooms. Research has shown that when that happens, the result of this practice is that "the norm of collegiality" instead of "the norm of isolation" (Bettencourt & Gallagher, 1989 & 1990) will prevail in the Science Department and in the school, with the teachers focussing on science education and not on their gripes about their students in a negative sort of way.

The second point was about the teacher knowing "his area," that is, his subject matter knowledge and "his community," that is, his school context. The latter includes both the physical and the social context, as a potential resource, "from where he will get things for teaching." When asked to give examples of these "things for teaching," this teacher cited nearby clinics, museums, research stations, forests and botanical gardens, etc., from where one can access teaching resources, including people with expertise in the various biological areas or fields.

SUMMARY

As conceived by the teachers, an ideal A-Level Biology teacher seems to be one who interacts professionally with his colleagues, has knowledge of his milieu, and who is also dedicated to his job and puts a lot of time into it.

The relationship between the teachers' conceptions of an ideal teacher and their views of learning and teaching cannot be established. This is because these three aspects were not elicited from all the teachers, during the interviews with the teachers.

But there seems to be a disjunction between Mrs. M-'s views on an ideal teacher with its focus on the teacher as a professional, and the views of teaching as 'giving information' and of learning as 'passive reception of information' which were presented in the previous sections above. Evidence that the nine teachers showed "dedication to the job," "putting in a lot of time," and "knowing their areas and community well" is reflected in the data from the interviews with the teachers and their students and from classroom observations. Teachers also took time to seek and get ideas and teaching hints from their more experienced colleagues teaching within the same school (Mrs. G-, Mr. V- & Mr. D-) or at different schools (Mrs. B- and Mr. P-). They also sought resources from outside experts at the various research stations (Mr. P-, Mr. C- & Mr. N-), teaching aids from the Audio-visual services (Mr. C-), relevant enrichment literature from marketing houses (Mrs. Mi-), and duplicating services from private companies (Mrs. M-). All the teachers reported benefiting from their interactions with other teachers during the Zimbabwe Association for Science Education (ZIMASE) workshops and seminars, which were organized by the Science Education Officers.

BELIEFS ABOUT A-LEVEL BIOLOGY

Some of the ZIMSTT A-Level Biology teachers perceived the purposes of A-Levels as "**preparing students for further studies at the University**" (DFI, p. 11; BFI, p. 13 & MFI, p. 12). One teacher conceived it as

> . . . **a window to deeper knowledge and to prepare future researchers**, who will create more knowledge, i.e. who will build on existing knowledge and make it accessible to other people for their personal use and application. At A-Level, students are to understand how and why certain processes occur in the body and what would happen if these processes were not functional (PFI, p. 17).

That is, at A-Level, the aim is to engage students with the deeper biological principles, the big ideas and their applications. Some teachers pointed out that having A-Levels now conferred "an additional advantage" (DFl, p. 11) on candidates applying for vacancies at the Teacher Training and Polytechnical Colleges. These beliefs were reiterated by the six B.Ed. Biology graduates, who are now lecturing at the Teacher Training Colleges (N=8).

Mr P-'s went on to describe A-Level Biology teaching saying,

> It is challenging, you have to keep your knowledge at your finger tips, because you are meeting with students who are mature and who are able to delve into tough questions. These students make you modify your own learning and knowledge, because they also bring in new insight into your knowledge. A-Level Biology teaching is really challenging and it makes me like it. Biology is my favorite subject (PFl, p. 21).

Here is a teacher who appreciates the reality of the demands of A-Level teaching, who has braced himself for it, and who is prepared to learn from the students. This teacher reflects a positive attitude to his subject.

A second teacher commented saying,

> . . . people tend to think that Biology is easy. But A-Level Biology requires interpretation more than mere remembering. It is quite demanding on the part of the student and it is important that students, when they come to Forms 5 and 6, should be made aware that A-Level Biology requires students being stretched more than at O-Level Biology (DFI, p. 12).

Unlike Mr P-, who perceived the challenge of the subject and its pedagogy from his perspective, Mr. D- perceived the subject matter as "quite demanding on the part of the students." But, one would expect to see a high correlation between the level of difficulty of the content matter and the number and frequency of the questions asked by the students. It would appear that Mr. D-'s students do not pose any challenging questions to their teacher, as Mr. P-'s students do. Hence, Mr. P- feels challenged by the A-Level

Biology subject matter, while Mr D- doesn't. The students in Mr. P-'s A-Level Biology class were described by their teacher as being mature and as students who delve into tough questions. These tough questions were reported by the teacher to make him think and modify his own learning and knowledge. That is, Mr. P- was experiencing conceptual changes as he tried to answer these tough questions.

Mrs. B- also felt challenged and stimulated by her A- Level students' questions. The result was the following. "I have widened my knowledge to a larger extent. Sometimes I use my B.Ed. course notes for sequencing and for additional materials and to answer students' difficult questions" (BFI, p. 16).

This teacher realizes one cannot learn the subject matter at one go. She perceives the subject matter as being vast and she has been widening her knowledge to a large extent as she looks up more information in order "to answer students' difficult questions." This experience did not discourage her at all. She said, "I would like to continue teaching A-Level Biology" (Ibid.).

When the other teachers were asked, to what extent they were experiencing such conceptual changes in themselves, they all admitted to have gained clearer understandings of the concepts, which they were teaching, as a result of the students' questions. It was when they were trying to respond to these questions, that the teachers experienced having had moments of "sudden revelations at the chalkboard" and also "uncomfortable moments" (Schulke, 1991). A descriptions of these moments is given below.

Apparently, all the teachers had gone through these moments but some had not given them much thought, and yet, these constitute an aspect of teachers' developmental process during their teaching practices.

All the interviewed teachers acknowledged having a better understanding of some concepts, about which the teachers felt that they knew well, all along. This better understanding was reported to occur as a sudden "aha" feeling, that is, as "sudden revelations." Most of the teachers could not give specific examples or instances, on the spot. However, one teacher cited an instance when a sudden insight, about the idea of the "wobbling effect of the genetic code," had emerged (NFI, p. 9). What happened was that one of his students had asked why 3-4 triplet codons could code for a particular amino acid? For example, leucine is coded by CUA, CUU, CUC, and CUG triplet codons on the mRNA. So, it was in trying to answer this question that the teacher had referred to one of his reference texts by Taggart and Starr on Biology: Unity and Diversity that he obtained this sudden insight. As an outcome of a student's questions, the teacher had learned an important concept, which he had not realized previously.

Another teacher cited how the idea of "double fertilization" became suddenly clearer (GFI, p. 16). Her own understanding of this process was enhanced while teaching about it. All the teachers were in agreement as to how these "sudden revelations" came about. They all said that they occurred after students asked questions. As one teacher said, "When I, the teacher, am trying to give a satisfactory response to a student's question, it sometimes happens that suddenly it dawns on me what this thing I have been asked about is all about" (CFI, p. 16).

The teachers' policies on questions during their lessons was elicited during the interviews with both the teachers and their students. Their responses were varied. Some teachers were observed not minding being interrupted and even encouraged the students to ask questions. One pedagogical implication of this is that students' questions must not be thwarted, by being brushed aside and/or by being responded to cursorily by the teacher. The questions should be attended to fully. This provides an opportunity for both the teacher and students as learners, not only to acquire new information but also to clarify, modify and sharpen their prior conceptions. If the experiences of "sudden revelations" represents one side of the coin, then the other side is the experience of "uncomfortable moments."

With most teachers, this experience of feeling uncomfortable during the lesson was also triggered by students' questions. Then, it suddenly dawned on the teachers, in the midst of trying to give a satisfactory explanation, that they had not fully comprehended the idea or the process themselves, and yet, all along they thought that they had. For example, one teacher cited, during a post-observation conference after his lesson on the "Nervous System: The Structure of the Brain", that he had realized that his own understanding of the "association region" was really shaky as he taught it [Tape V.POC (9/30/92), VFI, p. 8]. One student had asked the following.

> Does the association region have extra structures that enable it to interpret information? If so, does it mean

> that the larger the association region, the more intelligent the person ... How different are the brains of very bright and very dull people? (V.POC, p. 4).

The teacher had also been asked by another student that "Pepper in the eyes and mouth makes you feel the same 'hot' sensation, does it mean that the impulses from the eyes and the mouth are received by the same brain center? (V.POC, p. 3-4).

A second teacher cited two instances of such "uncomfortable moment" experiences. The first instance was during the lesson which I had just observed on The Adaptations Of Ferns, Liverworts And Flowering Plants To Life On Land [Tape N- (9/25/92)]. This teacher had not been sure of how to answer the question which was raised by one girl. "How does the pollen tube know that there's an ovule down there? . . . How does it enter into that particular ovule upwards against gravity?" (NFI, p. 13).

The second instance of an "uncomfortable moment", which this teacher cited, had happened as he taught protein synthesis. The questions raised were about "(a) the primer before replication i.e. how it functions to mark the point on DNA where the unwinding is to begin . . .? (b) Which moves mRNA or the ribosomes? and (c) What happens to the mRNA after translation?" [NFI, p. 13 (8/25/92)].

What this seems to suggest is that the teachers may themselves not be clear, as far as the finer details of some of the syllabus concepts and processes are concerned.

Reflecting on the post-observation conferences, it seems that the teachers could cite "uncomfortable moments" more readily than they did with their "sudden flashes of insight." This may be because with an "uncomfortable moment" the negative feelings one has and the internal cognitive mental struggle that one goes through in trying to come up with a satisfactory response, without showing the students one's own uncertainty, makes a more lasting impression than after getting an "aha!" experience.

Of significance was the question that arose of whether there is a relationship between the frequencies of the teachers' "uncomfortable moments" or "sudden flashes of insight," the nature and frequency of the students' questions, and also with the depth and scope of the teachers' subject matter knowledge bases? With this question in mind, the data was combed again. What was observed was that, generally, in classes where students did not ask many searching questions, the teachers reported not having had many "uncomfortable moments" (M-, D- & G-). This can also be related to these teachers' teaching styles and their conceptions of learning continua. That is, the more didactic teachers (M-, D- & G-) transmitted knowledge to receptive students who asked few searching questions. Hence, few or no "uncomfortable moments" were experienced by this group of teachers. Whereas, teachers with students who asked a lot of questions during the lessons reported having had a number of "uncomfortable moments." These are the teachers with a more dialogic interactive and heuristic teaching style who gave students opportunities to ask questions in order for them to make sense of what they were learning. Some of these questions proved to be difficult to give satisfactory responses, there and then. Hence, this other group of teachers (N-, B-, Mi-, C, P- & V-) reported to have had more incidences of "uncomfortable moments."

Hence, an assertion was formulated **that the teachers seem to conceive A-Level Biology in terms of its cognitive demands and career prospects**.

PERCEPTIONS OF THEIR OWN TEACHING STYLES

When the teachers were asked to describe how they perceived their own teaching styles, Mrs. B- said that her teaching style varied from lesson to lesson. She reported that she uses different teaching techniques like **assigning individuals with an independent reading assignment**, e.g. on sexual reproduction. She had asked her students to read and to make their own notes and then they were tested without having discussed with the teacher. She reported that her students do well on this kind of work. She stressed that "I, personally, believe that if a student sets out to find out for himself ... he retains it longer. He develops a positive self-esteem and pride that I did this by myself . . ." (BFI, pp. 4-5).

In this class, the students were observed discussing the syllabus Option Topics on "Drugs and Alcohol Abuse" [Tape B- (9/16/92)] and "Tobacco Abuse" [Tape B- (9/23/92)]. These topics had been assigned as individual reading earlier during that term. During our post-observation conference on these lessons, Mrs. B- explained that, "When I think that they have a basic knowledge on the topic, I want to get it from them first and then I expand on it ... Lecturing is rarely done. Mostly, it is **question and answer**" (BFI, p. 3).

This was also observed when she was teaching the lesson on Ecology [Tape B- (9/22/92)]. That is, she builds on what they already know, which she elicits through a "question and answer" approach to teaching. Mrs. B-'s other strategy is teaching through practical work. About this, she said,

> Rarely do I demonstrate. Mostly, it is individual work, when there are enough microscopes for each student or they work in groups of three, when dealing with limited equipment, e.g., dissection kits. Sometimes I use the slide projector when the slides are not that clear, I ask them to draw from the projected slide. This makes it easier. . . . Sometimes I use the slide projector in the course of a lesson e.g. the development of a pollen tube. This way, you know they are seeing what you want them to see. Whereas, with the microscope, you cannot be sure that they have all seen the detail, which you intend them to study (BFI, p. 4).

That is, this teacher uses audio-visual aids to clarify ideas and processes during her instruction. She also stressed that she tries, as much as possible, to have the students make their own slide preparations e.g. onion root tip for mitosis and transport system in plants etc. These practices of teacher using the slide projector and of students making their own slide preparations were not observed being enacted but they were corroborated by her students [Tape BSI (9/17/92)].

Mr. N- also reported that, basically, he used the question and answer mode of teaching (NFI, p. 8). He was also observed using this approach, when he and his students were compiling a table on the board, in order to highlight the comparative adaptive characteristics of a moss, a fern, and flowering plants, for life on dry land. [Video-tape NV (9/25/92)]. Immediately after this lesson I wrote the following.

> An interesting and lively discussion took place, with all the students actively participating. Teacher gave the students opportunities to ask questions and interesting questions were raised by the students e.g. 'How does the growing pollen tube know where the ovule is?' and 'How does it enter into the micropyle, turning up against gravity?' [Zesaguli's field notes after Mr. N-'s lesson (9/25/92)].

An analysis of the video-tape of this lesson revealed a number of pedagogically very interesting features. These features included, (i) the number of raised hands by the majority of the students, after each question was asked; (ii) the amount of time the teacher waited after posing the questions and (iii) the teacher's eye movements, scanning across all the students, before calling on one student to respond. Sometimes the teacher picked on a student, who had not raised his hand, to respond to the question or to comment on another student's response. After a number had been caught napping, for the rest of the period all the students became alert and attentive. The pacing of the lesson was just perfect. Students were not rushed to give answers to questions. They were given opportunities not only to ask questions, which the teacher, in turn, asked the other students to try and answer, but also for the students to try and add on any other information, which they might have. This was an exemplary lesson because of the enactment of all these aspects of effective teaching practices.

Mrs. G- described her teaching style as involving **"teacher-pupil and pupil-pupil interactions"** (GFI, p. 10). She explained how these interactions play out by citing the two lessons, which I had observed her teaching with her Lower Sixth (L6) Biology students and with her Form 3B1 General Science class, respectively.

In Form 3B1, three students had taken turns to present to the whole class, followed by questions from fellow students. The teacher said,

> . . . the advantage of student presentations is that every student is alert, because, the information is not really altogether new, since the reading was assigned as homework. The other technique I use is designing class activities and experiments, during which I pose questions to stimulate students to think about what it is that they are going to find out (Ibid.).

But such inquiry is initiated by the teacher and not by the students themselves. This was collaborated by the students in her Form 3B1 class. Other teachers also reported using these two techniques too and their students corroborated them, during students' interviews.

A different perspective was given by Mrs. Mi- who described her teaching style saying,

> I want students to be independent. I encourage a give a and take interactions . . . with the aim of producing individuals who can independently assess a situation scientifically, i.e., a person who can approach a problem, step by step, analyzing, suggesting, and rejecting alternatives . . . a person capable of manipulating their equipment and being able to give reasons for doing it their way . . . I allow them to participate orally, giving me feedback throughout the lesson (MiFI, p. 6).

That is, Mrs. Mi-'s teaching style is such that not only does she inculcate a scientific approach in her students, but she also encourages student involvement throughout her lesson, by allowing verbal give and take dialogues with her class. Students are mentally engaged in the justifying their responses, in "suggesting, analyzing, and rejecting alternatives." That is, she engages them in persuasive argument. This seems to suggest that Mrs. Mi- is encouraging cooperative social construction of meanings and the transformations of her classroom, from being a collection of competitive independent learners into a "community of inquiry" (Sharp, 1993). This was observed being implemented during one revision practical lesson [Video-tape MiV (10/1/92)]. In teaching for independence, she said that she stressed the development of learning and inquiry skills more than the acquisition of facts. In this particular lesson, students developed the skill of looking up the correct responses, whenever they failed to answer the teacher's questions. Students reported that this approach had taught them to learn on their own. One student reported that this approach had helped him to learn and understand what they were being taught [MiSQ #23, Item #2(a) on p. 2].

Other "give and take" opportunities were reported to be provided for through the "Biological Seminars," which Mrs. Mi- organized for all the A-Level Biology students, as an off- shoot of the A-Level Biology Association of all the A-Level schools in the Manicaland Region. These student seminars were organized for the students in order

> . . . to help students communicate their ideas . . .; to diversify their experiences . . .; and generally, to motivate them, because, if you are going to stand in front of a large group, you cannot come there blank. You have to look up the information and do a good presentation. To make sure that we pay attention to detail . . . we have the seminars directed at certain topics, on a given date. And in any given Term, we are talking about 3 Student Seminars and 3-4 meetings for the A-Level Biological Teachers [Tape Mi.POC, pp. 2-3 (10/1/92)].

It sounds as if these Biological Seminars are fruitful, for the students, in helping them to learn the material, prepare for the examinations, and gain self-confidence. Cognitive, affective, and motor skills are enhanced by their participation in the varied Biological Seminar activities. Similar effects or outcomes were reported as a consequence of the activities in "the Biology Society's students' interactions" (PSI, p. 8 and PFI, p. 2).

None of the teachers declared that they lectured or dictated notes in responding to this request to describe their own teaching styles. But, they had admitted doing so when they were describing the pressures, under which they reported that they operated, due to shortages of various resources, in their teaching milieux.

Another lens for insight into the ZIMSTT A-Level Biology teachers' teaching styles was the images which these teachers and their students had of themselves, each other, their class, classroom and school (see below).

SUMMARY

The teachers' perception of their own teaching styles represented a diversity in teaching approaches and techniques. These included activities that are teacher-dominated (lecturing); student-dominated (independent reading, giving mini-lesson/lecturettes, practical work, and answering questions for homework and on tests); and interactive (teacher-students-students discussions, questions and answers, movies, field trips, and after school Biological Seminars and Biological Society activities). The evidence of these interactive activities contradicts the view of knowledge which was expressed by most of the teachers as "a body of facts."

Hence, an assertion was formulated **that a diversity of teaching techniques and approaches are being used, by the ZIMSTT A-Level Biology teachers, in trying to get their students to actively participate, learn, and understand what is being taught.**

PERCEPTIONS OF A TEACHER'S KNOWLEDGE BASE

The ZIMSTT graduates described what they perceived as a knowledge base for teaching A-Level Biology, when they were describing the advice, which they would give to new graduates (See Section 8.4.4) who have been deployed to teach A-Level, soon after graduation from the ZIMSTT B.Ed. Biology program. All the interviewed Education Officers and Headmasters were in agreement with the interviewed teachers that an A-Level Biology teacher's knowledge base must include "first and foremost knowledge of the subject matter content and that the teacher must operate at a level above that of his A-Level students" (EOI, #5, p. 6).

Secondly, the teacher must have "**knowledge of the experiments and practical work**" (Ibid.). That is, the teacher must be familiar with a variety of practical work and experiments, to be aware of which do and which don't work, and under which circumstances. It was also pointed out that the teacher must know "when it is appropriate to assign which practical work" (BFI, p. 14).

Thirdly, knowledge of the students was identified as being critical by the subjects. One needs to "know their ability" (BFI, p. 14). One Education Officer said,

> I divide students basically into groups ... some are the high fliers, that need extra work beyond what an average student can cope with. I have to plan for them, in order to let them carry on independently, or to give the slow plodders a hand. These students need my attention. They are slow to understand ... (EOI, #5, p. 7).

That is, even among the selected A-Level students, one still gets students with different learning abilities. To be effective, the teacher needs to know where each student lies on this continuum. A second Education Officer added that the teacher, in knowing his students, must come to understand them to such an extent that,

> . . . the teacher appreciates the problems the children are facing. For example, (a) the language of science may not be making too much sense to students. . . . Take Genetics, you get many new terms thrown at students all at once, without the students knowing what they are about . . . (b) their background may have been limited in exposure to things. So if you use examples like 'hydraulic brakes', when they never experienced using them, then the students cannot relate to it. . . (EOI, #7, p. 8).

Associated with this are the students' interests. This kind of knowledge is useful for the teacher in trying to devise ways and means of motivating the certain students. Thus, a teacher, in order for him to teach more effectively, he needs to know where his students are coming from and also their aspirations.

On this point about knowledge of the students, the Manicaland Regional Director emphasizes how the teacher needs this kind of knowledge, "if he is to tap and harness the students' potentials . .

and to utilize their intellectual capacities, for the benefit of both the individual and the group" (RDI, p. 2).

An example of teachers having this knowledge of students and utilizing it was when they assigned students to give "mini-lessons," i.e., "lecturettes" and to lead the class' or their Biology Seminar's and/or Biological Society's discussions. In addition to this, the Regional Director emphasized how

> . . . knowledge of the students for the A-Level teacher should lead him to realize and appreciate the fact that he is now dealing with mature young adults, who will take offence if treated otherwise. Therefore, he should not be judgmental in his approach (Ibid.).

This perception of A-Level students as "mature young adults" was reiterated during interviews, not only by the observed ZIMSTT A-Level Biology teachers, when they were discussing differences they perceived in their teaching O-Level and A-Level classes; but also by the students themselves, when they were discussing how differently they perceived themselves then as A-Level students, compared with the time they were O-Level students.

Knowledge of the environment and resources which are available for teaching and learning was also identified as a very necessary component of the teacher's knowledge base. This knowledge "enables the teacher to know where to get this or that resource for one's teaching and learning materials" (EOI, #5, p. 7). This environment was described as reaching beyond the immediate school grounds and "to include the surrounding community, and other schools" (BFI, p. 15). How this kind of knowledge comes in handy, was demonstrated by the way the teachers reported to have sought professional assistance from other more experienced colleagues at other schools, and in the way they had collaborated with specialists in the field at Research Stations, in order to arrange field trips for their classes.

In one school, these outside "experts" happened to be two former students from the school, who were then studying Pharmacy at the University of Zimbabwe. They were invited, on two separate occasions, to come and talk about "Drugs and Alcohol Abuse" and "Tobacco Abuses," respectively. Such an invitation indicated that the teacher had kept informed about the progress, which her students were making, even after they had graduated from their school and had moved on. Things which were exchanged between schools included laboratory equipment, expertise and past examination papers.

This conception of knowledge of context that included getting acquainted with teachers in other schools was reiterated by the Manicaland Regional Director. Referring to the activities of the Manicaland A-Level Biology Teachers' Association, he pointed out how "their inter-school discussions have the potential of having a cross-pollination effect necessary for the intellectual blossoming of the mind. . . . The conditions are such that the flower can do nothing but blossom to its fullest (RDI, p. 1 (10/2/92)].

Knowledge of O-Level Science was also singled out by one Education Officer who said, "An A-Level teacher should have taught O-Level Science and Biology, from Form 1-4, to be able to link the students' previous knowledge to the new A-Level topics" (EOI, #4, p. 7).

Another Education Officer, basing his suggestion on the A-Level Chemistry teachers, whom he had supervised, said, "there seemed to be an advantage if the teacher had done A-Levels himself, compared with one without having taken A-Levels as a student" (EOI, #7, p. 6). He explained this as being perhaps due to the sense of confidence, which results from being familiar with the terrain, having gone through the A-Level content before. Secondly, it may be because one has a model of A-Level teaching from the teachers that will have taught him. Depending on the quality and level of expertise that one got exposed to, there are pitfalls associated with this source of knowledge about what teaching A-Level entails (Feiman-Nemser, 1983).

This E.O.'s comment led me to check whether or not the observed ZIMSTT graduates teaching A-Level Biology classes had taken A-Level Biology themselves, another variable that might have a bearing on their observed teaching practices. It turned out that only two had indicated that they had taken A-Level Biology and their grades were a "B" and a "D." The teacher with the latter grade turned out to be a more didactic kind of teacher compared with the former teacher.

On this point of knowing the facts of Biology, one Education officer said of the A-Level Biology teacher, "He himself must be a Biologist, who is interested in and is conversant with Biology as a subject, as a working base . . . and who does not teach by reading from his book in front of the class . . . (EOI, #3, p. 4).

Besides these kinds of knowledge, other abilities and characteristics were also identified. One was that the teacher must also have "personality and creativity which will enable him to handle things and improvise" (EOI, #3, p. 4). Again I was reminded of my three favorite science teachers, who exhibited these very characteristics and ability, to the point of their teaching being an art for them. Science teaching is an eclectic practice that entails its being a skill, a science, and an artful science (Gallagher, personal communication).

The second characteristic was that the teacher "must show initiative, be able to work independently, with little supervision on a daily basis; and be able to communicate with other A-Level teachers and specialists in the field and also create friends at other schools and positions, in order to get the help that he may need" (EOI, #4, pp. 7-8). Evidence of this being done by the observed ZIMSTT graduates appeared in one of the strategies they used when they were getting over their "teething problems" (See 8.4.1, below).

Another Education Officer, mentioned that ". . . the teacher must be conversant with the intentions of the curriculum, in order for him to be of assistance to his Headmaster, who makes the decisions, with regards to the selection of subjects to be offered in their school" (EOI, #7, p. 8).

The Heads of schools mentioned this point also. One of them said that "a teacher needs to have a very wide general knowledge, which comes from reading widely" (J.HI, p. 3). A second Headmaster expressed great concern over a teacher who lacks depth in terms of the subject matter knowledge, which is being expected of him to teach in the A-Level classes. He cited an instance that took place in his school when ". . . one student from the A-Level Chemistry group came and complained about the teacher falling short in his explanation of what the previous examination question required . . ."(S.HI, p. 11).

Here was a teacher who was being perceived by his students as not being knowledgeable enough in the details of the subject matter content. This Headmaster went on to say,

> In science, the teacher should teach Science with ease and not that he has to research on a day to day basis. He'll get tired of researching as well as teaching. But a knowledgeable teacher should be able to get into class and just teach with little reference to this or that which is irrelevant to the topic being discussed. . . . The teacher should teach and do research as a 'topping up affair' rather than a finding out, on a daily basis, of the basic knowledge. . . . Sooner or later the teacher will give up and he will not enjoy the lessons in the way he would like to (S.HI, p. 11).

What this Headmaster is stressing is in agreement with what one Education Officer, who felt that the teacher's knowledge of the subject matter must be above that of his students, in order for him "to teach with ease." But the Headmaster added the following.

> Whatever research the teacher feels he has to do, must be undertaken not to find out the basics, but to 'top-up' the basics. Otherwise, the teacher will experience a 'burn-out' soon, and he will stop to enjoy teaching. That is, teaching will become a chore instead of a practice to be done with pleasure (Ibid).

The need for a sound subject matter knowledge was also mentioned by the Manicaland Regional Director, when he commented the following.

> The teacher must feel confident in his content area, in order to stand his ground in the face of argument i.e. he must have a solid understanding of the subject matter and must keep abreast

> in his area because A-Level students are reading and they don't want the teacher to give them archaic knowledge [RDI, p. 1 (10/1/92)].

What can be inferred from this is the idea that knowledge is not static. It is constantly changing as new things are being discovered. A teacher needs "to keep abreast" of these developments so that he is not giving the students "archaic knowledge." Hence, he has to read widely; or else either burn -out from the students' challenging questions and/or "turn to dead wood" (Ibid.). The image of "dead wood" that is carried along by the water current is really an apt metaphor or analogy for describing a teacher who gets by, by teaching concepts the same way, year in and year out. So, if he has taught for 20 years, he has one year's experience, twenty times, from teaching the same way. This is in contrast to a teacher, who has tried to teach the concepts differently each year. The latter teacher is the one who can claim to have had 20 years teaching experience. He has implemented some changes in response to the new aspects he has read about the topics or in response to the kinds of questions arising with one group of students.

Knowledge of the teaching methodology (pedagogy) was stressed by both the teachers, their Headmasters, the Science Education Officers and the Regional Directors. The latter urged for ". . . an approach that is investigative including throwing the kids back to the library. The approach should be such that it makes the teacher to lead and carry students with him to reach conclusions" (RDI, p. 2).

That is, the teacher should know how to engage his students in inquiry activities as opposed to a spoon-feeding approach. To do this the teacher himself needs to be clear about a number of other issues as to what "inquiry" is all about [Zesaguli, 1992 (a) & (b)]. Some of the crucial aspects that were observed included, the teacher providing stimulating scientific phenomena and a variety of materials, which bring out the related concepts about that phenomenon; the teacher being good at asking the kind of questions that stimulate the students to ask further questions, for investigation about the phenomena at hand; the teacher being open to let the students pursue their inquiry where it leads them, productively. Teachers reported this approach to teaching to be not only time-consuming, but also very difficult to organize and run. Moreover, some of the teachers in this study, reported that they did not invite students' questions. One Science Education Officer indicated that he used, as one of his criterion, the frequency of a teacher's invitation of his students' questions "to assess the teacher's confidence in teaching his subject matter" (EOI #1, p. 5).

SUMMARY

Hence, an assertion was formulated **that the teachers and their supervisors seemed to be in agreement that a teacher needs more than subject matter content knowledge, in order to teach A-Level Biology.** It was also pointed out that a teacher needs, in addition, knowledge of teaching methodology, the students, the environment, and the curriculum. But it was not always clear, when they used the term "teaching methodology," whether the teachers were distinguishing between general pedagogy and the specific subject matter content pedagogy. When all the teachers and the Science E.O.s mentioned that a teacher needs "to be above his students," this should not be taken to mean "keeping a chapter ahead of his class." The latter has been shown not to be sufficient (McDiarmid, et al., 1988; Ball & McDiarmid, 1989; Koehler, 1983 and Ball & Wilson, 1990). In addition to this required knowledge base, are the other demands that are being made on the A-Level Biology teachers. These include the expectation or demand for them to not only put in a lot of time into preparing for their lessons; but also to work hard trying "to cover the syllabus," doing a lot of extra reading, keeping up to date, duplicating extracts from the other references for their students; being committed and dedicated to helping their students to learn with understanding; feeling a sense of accountability and responsibility to their students; and believing that all students are capable of learning, in their different ways.

IMAGES TEACHERS AND THEIR STUDENTS LIVE BY

A diversity of images were given by the ZIMSTT A-Level Biology teachers and their students, in response to the ZIMSTT Graduates' Survey Questionnaire [Appendix #1, 2TQ, Item #16 (a) & (b)], the A-Level Biology Teachers' Questionnaire [Appendix #4, Item #2 (i)], and the A-Level Biology Students' Questionnaire [Appendix #3, Item #5 (a)-(e)]. These images were tabulated (Appendices #s 14.1 & 14.2, respectively).

The reasons for including these items on the questionnaires were two-fold. First, the students' images provided yet another lens through which the prevailing teaching and learning practices could be discerned. This was essential because the classroom visits were so brief that direct observation represented only a very thin slice of each teacher's practice and may not have been representative of the total picture. The students' images provide missing pieces of the jig-saw puzzle and also serve as a cross-check of teachers' self-reports.

The second reason was to discern how teachers' images represent their "complex practically-oriented set of understanding, which the teachers use actively to shape and direct the work of teaching" (Elbaz, 1983, p. 3). In essence, this is in agreement with Connely and Clandinin (1988) who wrote that they ". . . view metaphors as important parts of our personal practical knowledge and as a central form in our language of practice. We understand teachers' actions and practices as embodied expressions of their metaphors of teaching and living" (p. 71).

Lakoff and Johnson (1980) also described how pervasive metaphors are in everyday life and that they structure the way we think, what we experience, and what we do everyday. Metaphors guide future practices. Hence, if we are to improve teaching practices, we need to understand where the teachers are coming from and where they are at, as reflected by their belief systems and images which they hold. Thus, eliciting for these images has significant value of giving an accurate and comprehensive portrayal of the nature and quality of their prevailing teaching practices. This will also enhance our insight and understanding of their students' experiences and the nature of discourses in these classrooms.

Lastly, this collection of images (Appendices #s 14.1 & 14.2) will be used during future science teachers' in-service seminars and workshops, as bases for the teachers' reflection-on-practices (Schon, 1983 & 1987) that are implied by these various images and as a window into other science classes which are beyond their reach, that is, without physically visiting the schools concerned. An analysis of these images reveals different styles of teaching and their corresponding students' learning styles.

IMAGES FORMED BY THE STUDENTS

The A-Level Biology students who are taught by the ZIMSTT Biology graduates gave a variety of images to describe how they perceive themselves as students, their teachers, class, classroom and school (Appendix #14.2). The teaching and learning styles and the nature of the classroom discourse that are implied by these images will be pointed out.

Students' images of their teachers and of themselves.

A diversity of images were used by the A-Level Biology students to describe their teachers. On the one hand, some images were given of teachers as "a driver of the ship," "a shepherd of sheep," and "a commander." These images suggest **a knowledge transmission mode of teaching** and a **passive reception learning** style by the students, who perceive themselves "as a ship" and "as sheep." The latter depend on the former to direct and control them. A one-way communication mode of classroom discourse, from teacher to students is suggested by these sets of images. On the other hand, interactive teaching styles, active sense-making by the students and a two-way communication are implied by the other students' images of their teachers as "a parent," "a friend," "a leader," "a Samaritan" etc.

These images were drawn from different areas which included animals (e.g. "a dove"), religion (e.g. "a Messiah"), other subjects (e.g. "an enzyme" and "an activating energy"), and everyday life and cultural experiences (e.g. "a driver" and "a conductor"). These images portrayed teachers as active, supportive, caring, and concerned guides, providers, directors, and leaders with skills, a good approach, dedication and determination, etc.

There seemed to be a direct relationship between students' images of the teacher formed by the students in class and that teacher's observed teaching style. Moreover, the relationship was independent of gender. For example, both Mrs. Mi- and Mrs. M- taught an all boys class. While Mrs. M- was perceived as a parent by as many as 9/16 (56.3%) of her students, Mrs. Mi- was perceived as such by only 8/31 (25.8%) of her students. In addition, students used only four different types of images to describe Mrs. M-, compared with nineteen different kinds of images used to characterize Mrs. Mi-. This variety of students' images corresponds directly with the teachers' variety of teaching strategies. Mrs. M- had a more didactic teaching style. Mrs. Mi- had a more heuristic teaching style.

The images with an asterisk* before them (Appendix # 14) have obvious pedagogical implications regarding the nature of teaching that may be taking place in those classes. By implication teaching seems to be perceived as involving knowledge transmission from the teachers, who know it all, to the students, who perceived themselves as either "an acceptor," "a follower," "a sheep," "a baby," "a son," "a child," etc. The implications then are that knowledge comes in its final form; learning is reception of this knowledge; and the student is a passive and "an empty bucket" ready to be filled with this knowledge.

A lot of other images, which the students had of themselves as students, conveyed contrasting learning styles. The student images with an asterisk * e.g., "a plant," "a tape recorder," "a computer," "a parasite," "a master" etc. imply passive students and receptive learning styles. Other images e.g., "a bee," "an ant," "Jesus' disciple," "a builder," "a captain of the ship" etc. reflect active students and interactive learning styles. This has implications for the nature of classroom discourse. In the former, one-way communication would prevail. While in the latter, a two-way communication took place. Some of the remaining images reflect either the way the student is, i.e., with a short memory as "a raven" and/or who is curious and looking for more information as "a hungry lion," and "a good gormandizer," that is, one who eats ravenously. Other images reflect how the student works, i.e., very fast as "roller coaster;" hard as "a slave;" united as "a battalion" "a legion," and "warriors" etc., which suggests that students work cooperatively as a cohesive group; and as "the wind" which moves with such force that either the things in their path are carried along, or are pushed aside. This suggests that students work hard to keep at the same pace of learning as the other students or also get left behind.

Students' images of their A-Level Biology class. The class images which were given reflected both **the nature of the learning atmosphere** (e.g. as "an arena," which suggests a place of competition, conflict, and struggle), and **the nature of relationships** among the individual members of the class (e.g. as "colonies of ants," "teams," "a swarm of bees," "an army," "engine parts," "a small society," etc. which suggests **relationships of caring, sharing and cooperation**. In contrast to these, were images of **fierce competition** which were suggested (e.g. of classes as "personal and competitive with students not even willing to share information, ideas or books" (MSQ #2, 11 & 14); "a battle field with no sharing but competition" (MSQ #4); and as "men in a jungle and only the fittest survive" (MSQ #16). What was striking was how a majority of the students, in this particular class, gave the competitive picture, whereas a majority of the other classes had described cooperative relationships among the students. This actually makes a lot of sense considering the fact that these students are the ones who were observed as not having the basic textbook.

Students' images of their A-Level biology classroom. The classrooms were described in terms of (i) the nature of the physical features (e.g. "as not being well ventilated," "well lit," "a torch chamber," "the most good looking and attractive room in the school"); (ii) the resources (e.g. "as being well equipped," "educational with pictures and specimens," "a museum," "a laboratory," "a library," "a hospital laboratory," "an incubator," etc. [see videos of these classroom settings]; (iii) what goes on in these classrooms (e.g. "a dining hall as a place where students get cooked food or tabulated data"), which suggests knowledge as pre-processed and transmitted in its final form from the teacher to the students. In contrast to this were the images given of the classroom as "a theater" where "education is bisected and analyzed" and as "an academic power-house" in which "highly explosive data is processed." Clearly, these last two images reflect a conception of knowledge as not static but as something that is taken in, broken down, and processed as one makes new sense out of it. That is, learning is here reflected as an active cognitive process. This learning is taking place in a classroom milieu which was perceived as "an incubator which provides all the materials and facilities we require to develop ourselves" and as a place where work is done (e.g. "an industry" and "as a workshop"). In contrast to these are classrooms which were perceived as being chaotic by the image of "a pub", and as a place where there is restricted freedom by the image of "a jail;" (iv) the state of cleanliness of the classroom (e.g. "a house," "a kitchen," "a library," and "an eating house"; (v) the atmosphere of quietness (e.g. "a church," "a library," "a court room," "a graveyard," etc. All these images imply atmospheres, in the majority of the classes, which are conducive to reading and learning, and where a lot of care is taken to keep things in immaculate orderliness.

Students' images of their school. Responses on this item were given by very few students. Two classes (CSQ & MSQ) did not have this item on the initial questionnaire. It was added later, after it had been mentioned in one of the teacher interviews. Like the classroom, the schools were described in terms of the state of cleanliness and maintenance; the relations among the staff "as united;" the size, i.e., "big" and "small;" the degree of freedom allowed; and the explicit rules and regulations which were reflected by such images as "a cell," "a church," "a convent," and "a small community." All in all, their images did reflect the observed ethos of these respective schools.

SUMMARY

The students' images portrayed their teachers as active, supportive, caring, and concerned guides, providers, directors, and leaders with skills, a good approach, dedication and determination etc. Teaching styles were perceived by the majority of the students as being didactic and by a minority as heuristic because teaching was perceived as predominantly involving knowledge transmission from the teachers, who know it all, to the passive students, with receptive learning styles. The implications then are that knowledge comes in its final form; learning is reception of this knowledge; and a one-way communication classroom discourse prevails during their lessons. This contradicts the majority of the teachers' perceptions of their teaching styles as heuristic (See Section 6.6 above).

On the other hand, the other images which were given reflected active students, working in groups and/or teams, with interactive learning styles, and a two-way communication classroom discourse prevailing. These students were reflected as caring, sharing and cooperative, compared to a few whose images reflected them as having individualistic and competitive working relationships. The other images reflected students' varying levels of motivation, and learning paces. Their classrooms and schools, in the majority of cases, were reflected as being well-maintained, orderly, quiet, and as having limited degrees of freedom with explicit rules and regulations, and the opposite in a few cases.

IMAGES FORMED BY THE TEACHERS

Surprisingly, few teachers responded to this item even after it had been modified on the second wave questionnaire. However, an active sense-making mode of learning is suggested by the teachers' teacher/student images of "tourist guide/tourist;"

"facilitator/clients;" "Safari guide/discoverer;" "compass needle/crew in the ship;" and "conscientiser/participant." These images imply a two-way interactive dialogue between the teacher and the students. The teachers' images of themselves reflected them as facilitators of their students' learning and as guides, who tell the students what to do. These images were corroborated by some of the students' images of these teachers described above.

SUMMARY

The teachers' and students' images and their explanations suggest contradictory aspects of the prevailing teaching and learning practices, within the same A-Level Biology classes. All in all, a great diversity was portrayed by these images. Generally, these images map on directly to the continua which were formulated regarding the prevailing teaching and learning practices and the participants' conceptions and perceptions of the various aspects of these practices. Examples of this correspondence is shown below.

```
Knowledge
     Static and unchanging <-----------------> Tentative
     e.g. "coins of money"                e.g., "cooked food"

Student
     Passive/Receptive <---------------> Active
    e.g. "An empty bucket"              "a discoverer"/a
                                         processor"
          "An acceptor"                 "a builder"/"a
                                         sense-maker"
         "sheep"/"a son"                "a bee"/"an ant"
```

<u>Teacher</u>

Knowledge transmitter	<--------------->	Facilitator
e.g. "a driver"/"a leader" "a shepherd"/"a parent" "instructor"		"a tourist guide"/ "a helper"

<u>Class relationships</u>

Competitive	<----------------->	Cooperative
Individualistic	<-------------->	Teams/Groups
e.g., "men in a jungle & the fittest survive"		"colonies of ants"

<u>Classroom discourse</u>

One-way communication	<---->	Two-way & interactive dialogues
e.g., "a compass needle"		"crew in the ship"

<u>Classroom Atmosphere</u>

Chaotic & Needing maintenance & uncomfortable	<-------------->	Quiet, orderly, conducive to learning/ with restricted freedom & well maintained
e.g. "a torch chamber" "a pub"		"a small community" & "a church"/ "a library"/"a museum"

<u>Teaching</u>

Knowledge transmission	<-->	Knowledge construction
A didactic style	<----------->	A heuristic style
Implied by "driver"		"facilitator"

<u>Learning</u>

Knowledge reproduction	<---->	Knowledge production
Passive reception	<--------->	Active sense-making
Implied by "an empty bucket"		"a bee"

These pictures of the ZIMSTT graduates' teaching practices are validated by the triangulated data from a variety of sources, which included what was reported by these teachers and their students during interviews; what was described by the science teachers' supervisors; and what was observed and noted by the researcher during the intensive study of the two ZIMSTT graduates and during her brief visits to the other seven ZIMSTT graduates' classrooms.

INTENTIONS FOR THEIR A-LEVEL CLASSES

The ZIMSTT graduates' responses to Item #15a as to what they intended their students to understand by the time they completed their science course are summarized in Table 11, below:

Table 11

A-Level Biology Teachers' Intentions for Students

TEACHERS' INTENTIONS (N=27)	FREQUENCIES
1. Developing an understanding and an appreciation of the biological facts and principles.	13
2. Respecting all life forms.	5
3. The social, economic and technological applications of he acquired knowledge.	5
4. Application of the scientific method.	3
5. Preparation for a career.	3
6. Developing skills	
- to follow instructions	1
- manipulate ideas and figures	1
- skills of observation.	1

These intentions were reiterated on the second wave questionnaire and elaborated during interviews with the observed teachers. Hence, an assertion was formulated **that the A-Level Biology teachers' intentions for their biology students seem to be centered around developing their students' understanding, appreciation and application of scientific knowledge, processes and skills, and developing a positive attitude to science**. No mention was made about helping their students to construct scientific knowledge, nor about encouraging their students to reflect on scientific knowledge, which are dimensions of scientific literacy (Michigan State Board, 1991, p. 9, Fig. 1).

HOW STUDENTS ACHIEVE THE DEVELOPMENT INTENDED

The ZIMSTT Biology graduates (N=20) indicated, on the first wave questionnaire (Item #15b), that their students learn the subject matter they are taught and achieve the development intended by the teachers in a variety of ways, which are summarized in the Table 12 below.

These means were also echoed and elaborated during the second wave survey. The observed A-Level Biology teachers mentioned two additional means, that is, by "watching films and videos . . .; by forming Science Clubs and by performing club activities such as debates, quizzes, subject fora, reports, etc." (2TQ #3); and also through "theory lessons in which students analyze and synthesize data; written essays; and explanation exercises after the analysis of data" (2TQ #4). One teacher, although he was not teaching A-Level Biology, responded at length that his students learn through "lectures . . .; discrepant events . . .; case studies . . .; question-asking . . .; observations . . .; record-keeping . . .; and pupil to pupil discussions . . ." [2TQ #10).

Hence, the ways by means of which the students learn the subject matter and achieve the development intended by the ZIMSTT graduates [in Item #15 (a) above] are varied.

Table 12

Students' Activities to Achieve Teachers' Intentions

ACTIVITIES TO ACHIEVE	FREQUENCIES
1. Practical experiments.	10
2. Listening to lectures.	5
3. Individual field work.	4
4. Demonstrations by teacher or students.	4
5. Discussions during class.	4
6. Discussions during seminars and tutorials.	2
7. Discussions over students' analyses of explanations	1
& reports on the subject.	1
8. Simulations and role playing in decision-making of solving social problems and applying biological knowledge.	1

HOW TEACHERS INCREASE STUDENTS' DEVELOPMENT

Given the ZIMSTT Biology graduates' intentions and the students' actions described above [Item #s15 (a) & (b)], the actions which the graduates (N=20) take to increase their students' learning and development (Item #15c) are summarized in Table 13 below.

These teachers' self-reported actions were corroborated by the researcher's observations; and by the students in the observed A-Level Biology classes, both in their responses to Item #2 of the Student Questionnaire (Appendix #3) (for example, CSQ, pp. 6-12; BSQ, pp. 4 & 5; DSQ, pp. 2 & 3; GSQ, pp. 1 & 2; MSQ, pp. 7-9; MiSQ,

Table 13

Strategies Used to Increase Students' Learning

TECHNIQUES & STRATEGIES	FREQUENCY
1. Regular revision assessment through assignments, tests, practical activities.	13
2. Thorough preparation and proper management techniques.	7
3. Encouraging dialogic consultations with the teacher and discussions among the students, either in class as seminars, tutorials or as clubs.	7
4. Referring students to other relevant literature and to research.	5
5. Organizing field trips.	2
6. Giving immediate and constructive feedback	1
7. Relating subject matter to real-life situations.	7
8. Inviting outside experts to come and talk about their work to the students.	1
9. Referring to and using real-life applications of biological principles (highlighting its potential for good and evil.	1

pp. 2-6; NSQ, pp. 2 & 3; and PSQ, pp. 2 & 3) and during the interviews, which the researcher held with samples of these students from each class. For example, students' responses to the question, of what their teacher did to help them to learn, understand and apply what he teaches better, included the following.

> She makes us to act out protein synthesis by assigning students the roles of the cell, nucleus, DNA, mRMA, tRNA, amino acids, ribosomes, the proteins etc. We **role-played** . . . the process of protein synthesis . . and you will not forget after that . . . (BSI, p. 1).

> When she was teaching the topics of Growth and Reproduction, she brought in the **real life specimens** of the fern's life cycle stages to show us the "Alternation of Generations" . . . which would have been difficult to imagine from the diagrams in the books (BSI, p. 8).

> He arranges for **field trips** to places. We visited the Matopos Research Station where they showed us how cross-breeding is being done between different breeds of cows and goats (DSI, p. 1).

> Compared with other teachers who tell you to read about this or that with limited sources of information, she refers us to a number of books . . . and makes a lot of **hand-outs** from her own reference books for each of us . . . (MSI, p. 4).

> She gives **counselling** on our learning problems . . . (MSI, p. 5).

This individual "counselling" was also highlighted by one Headmistress and two teachers in other schools (JHI, p. 7; DFI, p. 9; and MiFI, p. 4, respectively). For example, one student in Mrs. Mi-'s class wrote that his teacher helped him to learn and understand by the way that "She usually likes counselling students on how to answer questions on a face to face basis, that is, she gives time to individuals, with problems, to see her outside class work" (MiSQ #14, on p. 3).

What was remarkable about this teacher was the fact that she found time to hold consultations with individual students over and above her being not only the Head of the Science Department, but also the Acting-Deputy Headmistress! To ensure that, she talks with each one of her A-Level Biology students, she does not hand back the tests and the homework in class. Instead, what she does is that after marking, she calls students individually to discuss their work and

> . . . at that time, she discusses with the student about his performance and gets the student to see where and how he would have missed the point. She expects us to do all our test and homework corrections and she marks them all (MiSQ #18, on p. 2).

Seven other students in this class also mentioned that this approach was very helpful and effective for them in increasing their conceptual development and understanding. Another ZIMSTT A-Level Biology teacher held these one-on-one talks with his students as well (NSI, p. 1).

The students from the other ZIMSTT graduates' classes indicated how their own teachers helped them to learn and understand in that

> She gave us an analogy of building a wall as a model of protein, synthesis and the different colored bricks as the different amino acids, which can be exchanged and substituted for each other to build different wall patterns . . . (BSI, p. 1).

> She is the best teacher in the school. . . . She always asks questions at the beginning of a lesson. . . . This makes us revise and link what we learnt before to the new topic . . . (MiSI, p. 3).

> She invited and brought outside experts to visit our school and talk to us on the special A-Level Biology Option Topics (MiSI, p. 4).

In one class, the teacher was observed to have invited two of her former A-Level Biology students, then doing their second year in Pharmacy at the University of Zimbabwe. By sheer coincidence, one was a female. She talked on <u>Drug Abuse</u> [Tape B- (8/16/92)]. The other visitor was a male. He talked on <u>Tobacco and Alcohol</u> [Tape B-(8/23/92)].

During the post-observation discussions with the teacher and the visitors, I pointed out how the students' levels of involvement during the lessons had been very impressive. They had participated actively by the way they had posed interesting questions, offered extra information and real life examples of what they had observed at home with relatives and friends who had a high dependence on drugs and alcohol. The students had given their undivided attention both to the petit, frail-looking and soft-spoken girl and the tall and humorous former best student of his graduating class and the School Captain. These two visitors had come well prepared to lead their sessions and I, personally, gained a lot of insight from both their expositions.

The teacher responded by explaining how she prepares the students for such talks by outsiders, by giving them handouts to read ahead. The teacher felt that "This way the students come with a proper mental set, a special vocabulary and questions on the topic" [B.POC, (9/16/93)].

Besides asking visitors who are doing work in scientific specialist areas,

> . . . other Upper Sixth Biology students are invited from all the A-Level schools in the Manicaland Region to regular Biological Seminars at our school, which are organized by our teacher. We meet on Saturdays when the rest of the school is away . . . to discuss prepared questions . . . and ". . . to elucidate what we were taught" (MiSQ #18, on p. 4).

When the four students who were being interviewed were asked to explain just how valuable these "Biological Seminars" were, they all chipped in and said the following.

> It is a forum for exchanging ideas. . . . Some teachers tell us different things and this helps with coverage i.e. gaps in our own knowledge and understanding are filled in. . . . We get to know how far to answer the questions and the correct approaches of responding that pleases the examiners. . . . We have more teachers going round, checking, and encouraging us. . . . It is good for revising for the examinations because it encourages us to read widely and be prepared, so that we can be competitive in the group discussions. . . . Sometimes she gives the questions to be answered ahead for all to prepare for the seminar. . . . She identifies loop-holes in our understanding, reasoning, and arguments and then she suggests new sources of information for us to research some more (MiSI, pp. 4-5).

It sounds like the students really enjoyed these seminar sessions. Unfortunately, I did not get the chance of participating in any of these seminars because there was none scheduled during my visit to the Manicaland Region. However, it can be inferred that a lot of learning took place, from the thorough preparation which the students did, and, during the seminar group discussions and panel debates. But there seems to be a great emphasis being placed on passing the final examinations.

Besides these interactive dialogues among the students from the different A-Level schools, the teachers invited each other to come and conduct a mock practical examination for one's class. This was done ". . . so that the students get used to hearing the instructions from an unfamiliar voice . . . and it is likely that I will pick up their mistakes more easily and more objectively than their teacher" (MiFI, pp. 2-3).

This makes sense because the teacher might evaluate his students' performances with a bias stemming from knowing the students so well. Other responses were that

> He welcomes questions at any time, in and out of class . . . (NSI, p. 1).

> He gives us previous examination questions for us to revise with after each topic. . . . These questions make us to study with a certain goal like that I want to catch up with this information (topic) . . . by what would have been highlighted by the questions . . . (PSI, p. 1).

This practice of giving past final examination questions was reported by all the teachers. They did so in order to familiarize their students with the final examination requirements in terms of its format, depth and scope of coverage, and in terms of the phrasing of the questions.

> During discussions, he makes you contribute by giving you questions, e.g., to draw a graph and to extrapolate explaining your thinking. . . . The teacher tolerates constructive arguments during discussions. . . . He helps you to answer your own question. Maybe you were failing to put the things together but he helps you to do that by asking you other questions and you end up bringing up the correct points yourself (PSI, p. 12).

That is, the teacher tries not to give ready answers to students' questions. Instead, he helps the students to learn how to rely on themselves in recalling the relevant information, which is needed to answer the student's own question. He also helps the students to assemble and synthesize the information into a meaningful whole.

Another student indicated that, "At the end of a topic, sometimes he gives impromptu questions instead of a written test" (VSI, p. 6).

How this is done was explained during the interview as involving the teacher bringing to class 12 or more different questions, based on the topic he will have just finished teaching about, which he distributes randomly, one to each student. Students are given a few minutes to collect their thoughts. Then students are picked randomly to tell the class their questions and answer, after which other students ask for clarifications or contribute more relevant information on the question's answer.

When asked how they felt about these impromptu questions, the interviewed students indicated that

> . . . it is good in the sense that we won't rely on one person. If teacher came with just one question, then it's only one person who answers. . . . This way, this makes us read . . . even if you are not interested in the topic . . . it makes us to try and keep up with the work. . . . Otherwise, you'll be ashamed when you can't even answer with everybody waiting . . . (VSI, p. 6).

We have a "Biological Society (PSQ #2). When asked how this "Biological Society" functions, one student indicated that

> . . . it is for Upper Sixth (U6) Biology students only. Next year we want to include Lower Sixth students because they have been showing interest by wanting to come to our discussion meetings. What we do is that somebody is given a topic . . . to go and research on it . . . and then you present it to the group and they ask questions and contribute also. . . . For example, last Friday, I presented on plant fungal diseases e.g. <u>Phytophora</u> <u>infestans</u> (PSI, p. 8).

The philosophy of the "Biological Society" seems to be similar to that of the "Biological Seminars." The only difference is that the former is a local school-based activity and the former is a regional inter-school activity. Lastly, one student reported that his teacher "emphasizes the main points . . ." (GSI, p. 1). This was observed being implemented by all the teachers in the study at the end of their lessons.

Hence, an assertion was formulated **that the ZIMSTT graduates seem to be using a variety of approaches and techniques to try and increase their A-Level Biology students' intended learning and development.**

HOW TEACHERS HELP STUDENTS TO UNDERSTAND

The question of how the ZIMSTT graduates increase their students' learning and development was probed further during interviews, in order to check on the consistencies of the responses which were given by the teachers on their questionnaire. Again all the interviewed ZIMSTT A-Level Biology teachers acknowledged that they all tried to help their students to learn, understand, and apply what they will have taught them in a variety of ways.

All the teachers reported that they made use of **charts, diagrams, and illustrations on the board and homework exercises**, in this regard (GFI, p. 11; NFI, p. 4; BFI, p. 8; CFI, p. 8; VFI, pp. 5-6; PFI, p. 4; MFI, pp. 2-3; MiFI, p. 2 & DFI, p. 5). On the use of charts and handouts, Mr. N- said that he made charts and handouts, which his students filled in as the lesson progressed. For example, the handout may be a blank diagram without labels and then the students label each part as it is discussed. Justifying doing it this way, Mr. N- said,

> Sometimes I feel that's the only way of doing it, because if you simply discuss, drawing diagrams on the board, rubbing them, and writing something else, at the end, they cannot compile the information. Whereas, this way, I feel they have the whole set up and see the whole life cycle right there. They now move with me, stage by stage, filling in the gaps (NFI, p. 4).

This was not observed on the day his A-level Biology lesson was observed by the researcher. However, it must be noted that while there is the advantage of having the whole diagram drawn accurately before-hand, there is the problem of still having to provide opportunities for the students to develop their drawing skills.

Besides charts and handouts, Mr N- said that he uses **practical work**, in which students examine and really see the specimens and reactions for themselves, instead of just telling them and referring them to pictures in the textbooks. When asked how practical work helps one to learn and understand, one student replied,

> They quicken the reasoning capacity. That is, if you perform a practical, you have results and you have got to reason on the results and then give an inference on the tests you have been doing. Thus, you tend to understand more than just reading it from the books or copied from the teacher (VSI, p. 7).

It sounds like, for this student, practical work is more than just following instructions. It involves thinking and making inferences based on the obtained results. This active involvement results in the student understanding more. A second student added that the value of practical work is that,

> It is given to train us to be able to reason and also for us to improve our knowledge on what we have been learning. . . . Sometimes you are given a practical and you are expecting some positive results and you get a negative result. Then, you are forced to reason why you did not get the expected results (VSI, p. 8).

This student realizes that a lot of thinking does go on during their practical work, as they try to figure out why their results came out not as expected. Hence, teachers should take the students' negative results as providing further teaching and learning opportunities.

One teacher indicated that he helped his students to learn and understand what was being taught ". . . by demanding individual effort from them, for example, by asking them to read from their textbooks, on their own, and then for them to try and answer set questions on the reading" (PFI, p. 4).

This way, the teacher is giving the students opportunities of making sense of a given text on their own and of demonstrating their understanding of it by "answering the set questions on the reading."

Another teacher reiterated the practice of "demanding individual effort" which he did "by writing down instructions for the practical work for individual students to follow without any assistance from the teacher or from another student. For a theory lesson I dictate the notes" (DFI, p. 4).

This teacher's students are developing their skills in following written instructions and not in note-making, since the teacher dictates the notes that he would have made.

Another more challenging way of helping students to learn and understand what was being taught was observed being implemented in the A-Level Biology class taught by Mrs Mi-. She had asked three of her students to prepare for and give "a mini-lesson" (BFI, p. 9), lasting five minutes, to the rest of the class; then they would answer questions from their peers and, lastly, the teacher summarized and stressed the main points. In this lesson, three students gave such "mini lessons" on The Pyramid of Numbers, The

Pyramid of Mass and The Pyramid of Energy. [Tape B- (9/23/93)]. Mrs. B- explained that

> . . . this exercise makes the students to read with understanding or else they cannot give these 'mini lessons'. What I have noticed is that the students tend to over-prepare and end up bringing more information than what is specified by the syllabus and that the students enjoy learning from each other. They explain the concepts in a way that they understand each other (BFI, p. 9).

Similar effects were also reported by another teacher who referred to these "mini-lessons" as "lecturettes" (PFI, p. 2).

The students from these two A-Level classes acknowledged the immense educational value which they derived from this experience of giving these "lecturettes" (PSI, p. 8) or "mini lessons" (BSQ # 7). These "lecturettes" serve as extended dialogue opportunities among the students, which is enhanced by "the teachers, who ask their students to read ahead, hold discussions and then summarize together the main points on the board" (BSI, p. 2; and GSQ #4).

Scientific magazines' articles were observed being used effectively by Mr. C- on two occasions, to help his A-Level Biology students to learn, understand, and apply what was being taught. The first time was when he was teaching the structure of DNA [Tape C 4 (7/8/92)]. He had handed out photocopies of the article "DNA: The Blueprint for Life" to the students. As he taught, he would refer the students to a paragraph here and there, as the information from these paragraphs became pertinent at that point of the lesson. The second time, when he had referred to a magazine article during his Biology lesson, was in response to a student's question on how animals become extinct. This was during a lesson on "Types and

Causes of Variation" [Tape C 14 (7/16/92)]. The teacher had quickly retrieved an article on "The Cheetah in Genetic Peril" and read it aloud to the whole class. A very lively and interesting discussion had followed. The teacher had engaged all his students actively throughout this particular lesson.

Mr. C- and Mrs. Mi- were outstanding in the extent to which they had collected scientific magazines' articles, as a resource for teaching, a practice, which their students had acknowledged and appreciated. One of Mr. C-'s students had written, "He brings more articles from the newspapers and magazines, for us to have a clear picture or view of the particular issue" (CSQ #3).

Some teachers helped their students learn and understand what they were teaching by showing films. Only Mr. V-, Mrs. Mi-, Mr. N- and Mr. D- had a 16 mm film projector in working condition. The other projectors were out of order (Mrs. M- and Mr. C-) or not available in the school (Mrs. B-, Mr. P- and Mrs. G-). In terms of using the projectors, for Mrs. G-, it boiled down to "no projector, no films, no nothing" (GFI, p. 11). That is, she had given up the idea of showing films because, as she put it,

> If a school won't part with a test tube, how can you expect it to lend you a fragile piece of equipment like a film projector? Moreover, if anything should go wrong, my Headmistress might ask me to pay for it, like she said when I telephoned another school to ask for the visking tubing . . . (GFI, p. 11).

This highlights and underscores her perspective that her School Administration is not very sympathetic and cooperative in meeting her teaching needs. However, an exception to this instance was observed in one urban school, in the Harare Region. The teacher in this school had borrowed the projector from a school across town and was able to show films of DNA, Mitosis and Meiosis. The school had provided transport for this. Such differences in administrative policies, styles, and/or attitudes seemed to be affecting teaching practices.

This matter of projectors was followed with the audio-visual services (AVS) in Harare. I was led by the officer in charge of the unit to the workshop room, where I was shown what he referred to as a "graveyard of electrical audio-visual aids". He explained that "this whole floor of equipment is awaiting repairs, whenever the parts become available. That means never, because of foreign currency shortage."

Needless to say, this situation is very serious because not making use of audio-visual aids will have negative consequences of the students missing out on essential and critical educational experiences. Considering the students' comments, which they made after seeing the three films on: (1) <u>DNA: Molecule of Heredity</u>, (2) <u>Gene Action</u> and (3) <u>Human Heredity</u>, that the films and the discussions after each film had been, on the whole, "worthwhile and fruitful" as an aid to learning and understanding, teachers should try by all means to secure projectors and the relevant films. The fruitfulness of using audio-visual aids resulted from the students having been asked by their teacher not only to identify new ideas, which they had picked from films and the difficult ideas and concepts which they still had, but also from being asked to share with the rest of the class whatever had struck and had interested them in the films [Tape C 22 (7/23/92)].

Mrs. M- said that she helped her students understand what she taught by making sure that the sequence, language and vocabulary is well understood (MFI, p. 2).

Using the protein synthesis content, she explained how she had sequenced it by teaching RNA, DNA, and what a protein looks like before teaching the process of protein synthesis. She added that in helping the students to learn complicated subject matter on protein synthesis, she has made sure that she did not speed it up. She said the following.

> I took some time and I made sure the concept is visualized by practical work . . . e.g., what you observed in the last lesson when we used the cut-out manilla shapes, where the circle stood for the phosphate molecule, the rectangle for the base, and the pentagon for the sugar) to illustrate polypeptide [meaning polynucleotide] formation . . . I made sure that I involved them by asking them what they know about it . . . and then I gave them the new ideas . . . That is, the new material is built upon the old knowledge, what they already knew. Hence, it will be better understood (MFI, p. 3).

So, Mrs. M- helps her students to learn and understand better by first establishing where they are, before giving them new ideas, and by using "cut-out shapes" to model polynucleotide formation and by pacing the lesson, in such a way that she "did not speed it up." But one of her students did complain about her pace as being too fast.

Another teacher indicated that he helped his students to learn, understand, and apply what was taught by giving them homework exercises after teaching each topic. He reported that he used short questions from textbooks or long questions from past examination papers. In doing this, Mr. N- said that he tried to have a balance of recall, comprehension, analysis etc. questions, so that the students practice and become familiar with the final examination format (Appendix #15). What was noted in this response is that the teacher is thinking of training his students on the techniques of taking the final examinations, and at the same time, he monitors their comprehension of the topic, which he has just taught.

Another teacher mentioned how he always tried to bring in real-life problems and examples. When asked to give an example of this he cited

> . . . the ecological problem of the hyacinth weed of how to eradicate it and prevent it from choking the rivers which empty into and out of the Manyame Dam and Lake Chibero, without causing any harm to the fish and to those people in the surrounding rural areas, who use the water directly from these sources (NFI, p. 4).

An impressive collection of preserved specimens were seen at two schools (Mrs. Mi-'s & Mr. D-'s schools). That real-life situations were used to explain and illustrate concepts effectively was reported by students from another class (BSI, pp. 7-8).

Teachers also said that they helped their students learn and understand what they were being taught by using models for example, the model of the brain [Video-tape VV (9/30/92)]. Students in this and other classes acknowledged that models made things clearer by "helping us visualize the parts" (VSI, p. 9), and by making the unimaginable structure of the brain accessible.

In another class, the interviewed students mentioned how the three-dimensional models of mitosis, which were used by their teacher, had facilitated their grasping of the changes in the chromosomal behavior during each mitotic phase (BSI, p. 15).

Lastly, teachers used analogies in order to help their students to learn and understand what was being taught. During the interviews the students cited examples of analogies which their teachers had used to clarify difficult concepts and /or processes. These examples are tabulated below.

Table 14

Analogies to Clarify Concepts/Processes

	ANALOGY	CONCEPT/PROCESS TO BE CLARIFIED
1.	Lock & key	Enzyme and substrate specificity (CSQ #6 on p. 6) (VSI, pp. 14-15).
2.	Boulder getting out of a depression on top of the hill before rolling down.	Activation Energy (VSI, p. 11).
3.	A straight & twisted and wire.	Protein molecules' primary & sec. structures (BSI, pp. 1-2).
4.	2 balloons cellotaped on one side and stuck together with masking paper.	Opening and closing of the guard cells in the leaf (VSI, pp. 11-12).
5.	Hand and glove	Enzyme-substrate complex formation and change in structure (VSI, p. 14).

Mrs. B- explained that energy conversion between the trophic levels was not like chalk dust movement (BFI, p. 8) and [Tape B-(9/22/92)].

In reply to how teachers helped their students to use or apply what they have learnt, all the ZIMSTT A-Level Biology teachers said that they accomplished this, by asking their students application questions in class and as homework exercises, problems, and tests (e.g. BFI, p. 9 & DFI, p. 4)).

But one teacher thought it was not his responsibility what the students did after he had taught. He said, "My part is just to help them understand and their part is to do the learning and the application . . ." (CFI, p. 9).

He explained this sentiment by reminding me that he will not be there "when the student is faced with the problem of opening a bottle with a stuck metal cap, at his/her home. The student himself will have to apply his knowledge of metals and expansion (Ibid.). So the students are being trained to apply their knowledge through the "application questions."

This data supports the assertion **that the ZIMSTT A-Level Biology teachers seem to be using a variety of means in trying to help their students to learn, understand, and apply what is being taught**. These means included the use of diagrams; models and modeling; analogies; audio-visual aids; appropriate pacing of lessons; practical work; showing real-life specimens; giving real-life problems; students presenting "lecturettes" or "mini-lessons;" teachers referring to articles from scientific magazines; handouts from the teachers' reference materials; asking students to read ahead; teachers summarizing the main points; and encouraging one-on-one dialogues between the teacher and individual students, in and out of class, and class discussions among the students.

SUMMARY

The ZIMSTT A-Level Biology teachers initially conceived knowledge as a body of facts but when probed, they acknowledged that knowledge is tentative. Teaching and learning were conceived, on the one hand, as the giving of information to receptive students. On the other hand, teaching and learning were also conceived as guiding and facilitating students' active inquiry, discovery and sense-making.

The teachers conceived an ideal A-Level Biology teacher as one who is dedicated to his job with a high level of professionalism. The teachers conceived A-Level Biology in terms of its cognitive demands and career prospects. The teachers perceived their teaching styles in terms of facilitating their students to pass the final A-Level Biology examinations. They perceived as a knowledge base for teaching A-Level Biology knowledge of teaching, learning, students, subject matter and its practical work (the curriculum) and context.

The teachers' intentions for their students were focussed on getting students to use scientific knowledge and not on their constructing and reflecting on scientific knowledge. A variety of activities and approaches were used by the teachers in order for them to achieve their intentions for their students. This diversity of activities and approaches represents different ways and means which teachers use to facilitate active student involvement in interactive processes that yield meaningful learning. This was confirmed by their students during interviews.

In addition to this, a direct correspondence was noted between a majority of these teachers' responses to the questions about their intentions and what they do to achieve those intentions and increase their students' understanding and application of what is taught and their observed teaching styles, which were mapped along the various continua based on other data. Whereas, for a few of these teachers, a disjunction was noted between these aspects.

CHAPTER VII

THE A-LEVEL BIOLOGY STUDENTS OF THE ZIMSTT GRADUATES

During interviews with the researcher, the teachers were given opportunities to express their perceptions about their students' intellectual abilities, attitudes, and other inquiry skills.

GRADUATES' PERCEPTIONS OF THEIR STUDENTS' COGNITIVE SKILLS AND ATTITUDES

The 9 ZIMSTT A-Level Biology teachers were unanimous in acknowledging that the present cohort of A-level students are not like they used to be, before the O-Level Science syllabi were changed, in terms of the expected levels of performance. These changes involved the replacement of the O-Level General Science, the Combined Science, and the single Science subjects' syllabi with an integrated science syllabus, called "Science (Zimbabwe) (Nos. 5006/7) (1988)". This syllabus has been revised. But it still has a compulsory Core Science section for all the students and an Extended Science section for "those better able students" who intend to go further with Science. The teachers perceive these syllabi as "shallower" than previous O-Level Science syllabi. Hence, the point made by one of the teachers that, her students were

> . . . a mixed ability group and a mixed bag. . . . Some don't have even have a decent O-level English pass . . It becomes a problem because in Biology they have to read extensively and express themselves. From next year, a good English pass will be a requirement for selection into A-Level for us and we are re-introducing Biology as a subject at O- Level (MiFI, p. 4).

However, Mrs. Mi- described her students as not having an attitude problem to learning. She added that "Sometimes they lose heart because A-Level work is very demanding. Some even drop out" (MiFI, p. 11). Her reaction to these students is "to carry them along and push them to try harder" (Ibid.). When asked where the problem was, she explained.

> The preparation at O-Level, content-wise, is not adequate from the Core and the Extended Science syllabi. Students also get fooled by the A's they get at O-Level. That is, in terms of performance, they form a wrong impression of their abilities. The truth of the matter is that an "A" in 1991 is a different quality of an "A" in 1980 or 1976 (MiFI, p. 11).

What this teacher said, about the inadequacy of the Core and the Extended Science syllabi's preparation for A-Level work, was echoed by the one other teacher (GFI, p. 12) and one of the Science Education Officers, who monitor the teaching and learning of science throughout the country (C.EOI, p. 2).

The distribution of the final O-Level Science Grades of the A-Level students in these ZIMSTT graduates' A-Level Biology classes is presented in the Table 15, below.

Table 15

Final O-Level Science Grades of A-Level Students

O-LEVEL SCIENCE SYLLABUS/GRADES		A-LEVEL BIOLOGY TEACHERS B- N=22	C- N=22	D- N=11	G- N=18	Mi- N=31	N- N=9	P- N=22	TOTAL
CORE SCIENCE	A	15	11	7	15	29	9	19	95
	B	5	9	2	3	2	0	3	24
	C	2	1	2	0	0	0	0	5
EXTENDED SC.	A	4	5	2	4	14	3	2	34
	B	10	8	5	5	1	0	0	29
	C	0	3	2	0	1	0	0	6
BIOLOGY	A	0	0	n	8	3	3	2	16
	B	1	5	n	5	2	1	9	23
	C	5	0	n	0	0	0	0	5
PHYSICS/CHEM.	A	n	n	1	3	0	1	3	8
	B	n	n	5	7	3	1	8	24
	C	n	n	2	0	2	0	0	4
COMBINED SC.	A	n	1	n	n	1	n	n	2
	B	n	0	n	n	1	n	n	1
	C	n	0	n	n	0	n	n	0
BIOLOGY/CHEM.	A	5	5	n	n	n	n	n	10
	B	1	0	n	n	n	n	n	1
	C	1	0	n	n	n	n	n	1
PHYSICS	A	n	0	n	n	n	n	n	0
	B	n	2	n	n	n	n	n	2
	C	n	0	n	n	n	n	n	0
CHEMISTRY	A	n	0	n	n	n	n	n	0
	B	n	1	n	n	n	n	n	1
	C	n	1	n	n	n	n	n	1

KEY:
n = no one sat for that syllabus
0 = no one attained that grade
Sc. = science

Note that the Core Science syllabus is compulsory for all the O-Level candidates. The rest of the science subjects are optional, depending on the individual school's staffing situation. Sometimes a given class may be exposed to both the Core and the Extended Science syllabi and yet the students in the end may not sit for the Extended Science final examination. The grades for two classes (Mrs. M- & Mr. V-) were not collected.

An analysis of these grades shows that 50% of all students in the submitted lists had achieved an "A" in the Core Science subject, while about 20% of those that sat for the Extended Science subject got an "A" in it. Hence, one should not get the impression that all these students were selected into the Lower Sixth (L6) Biology with "A"s in O- Level Science subjects. Despite these seemingly good grades, some of the students are being perceived by their teachers as not performing to the expected standard of students with such in-coming grades. For example, one teacher described her Lower Sixth (L6) Biology students as being

> . . . not an exceptionally good lot. . . . They need motivation to learn and I motivate them by asking questions, putting in jokes, and getting them involved every time, by referring to diagrams of certain parts, or asking them to follow along on any particular thing that I want them to focus on in their textbooks or the handouts, which I give them, or by building shapes and models etc. (MFI, p. 4).

This same teacher added the following.

> We do a lot of counselling when they begin their year and when they relapse during the term. This was initiated by the Head of Department and the other subject teachers, who have generally observed this negative attitude to learning . . . we then push them to work harder psychologically by publicizing their test results on the notice board. . . . This practice

> is having both a positive effect, in terms of better performance, and a negative effective, which is reflected by the students becoming more demoralized and pulling down the results from the notice boards (MFI, pp. 4-5).

That is, the students are taken aside and talked to, both as a group, at the beginning of the year, and individually, throughout the term. Counselling seems to be practiced in other schools as well, as was reported by one headmistress (J.HI, p. 7).

Mrs. G- described her L6 students as being

> . . . very weak and not at all jerked up because their reasoning power is slow. . . . They lag behind and can only see the correct answer after giving you a wrong one. As far as their attitudes to learning goes, they find Biology difficult because they are not motivated from within. They are neither competing with self or with others (GFI, pp. 12-13).

At this point, the teacher retrieved her record book and showed me with a hint of exasperation, the range of marks of the class as a whole and of one particularly unmotivated and very weak student who was failing on all the tests. She indicated the following.

> During this second term he had 4/25, 7/20, 3/20 and 30% on the Mid-Term Examination . . . this one is generally a weak student, and I have no idea how he was selected. Others with "A"s in O-Level Biology and Physical Science are also not performing well. . . . The majority of students here have extra curricular activities they are involved in, which could be taking some of their study time (Ibid., p. 12).

By pointing out that even those students who came from O- Level with good grades are not performing well, this teacher is in a way underscoring what Mrs. Mi- said about the students' O-Level grades (above, MiFI, p. 11). When I asked how she tried to motivate such students, she informed me that she had asked them "to tell me whatever I do i.e., my mistakes which cause you not to do well on my tests, so that I can improve and you, in turn, can pass." Up until then, no students had come forward with any suggestions of what they felt she needed to do, in the way that she teaches, in order for them to enhance their learning. She added that she had reminded them that,

> . . . life is tough without at least an A-Level Certificate. The latter is now one of the main criteria of selection for almost everything from entry into the University, the Polytechnical Colleges, the Nursing Schools and the Teacher Training Colleges (GFI, p. 13).

She was being realistic and the students need not be reminded of this at all because, daily, they see the consequences and the futility of poor A-Level passes with their friends, who are unemployed, idle and feeling very frustrated about their still being taken care of by their parents. If they fail to make it then they will remain dependent on their parents for all their needs! She went on to tell me that she also tells the students,

> . . . to get the 'dependence syndrome' out of their heads, again, by reminding them of the social and economic status of the majority of their struggling parents, with the current retrenchment of workers because of the Economic Structural Adjustment Program (ESAP), and the devaluation of the Zimbabwe Dollar etc. Before, one educated member of the family could assist financially and materially other members of the extended family. Now, families are tending to become more and more nuclear in order for them to cope economically and not because **'anodada' meaning 'he is proud'** of his education and selfish about his possessions (GFI, p. 13).

That is, she uses the harsh reality of their predicament to try and drive the students to take their studies seriously and to work harder. Emphatically, she went on to tell me that she also pointed out to her students that ". . . gone are the days when one could live on thank you, thank you, all the time. As a matter of fact, one could raise a whole family that way!" (Ibid.).

With such a vivid reminder, the students should really start to put more effort into their learning. Another way she said she uses to motivate the students to revise their work was by, "Giving lots of tests and homework exercises, and when the students complain about the frequency of tests and exercises, I just tell them that the tests and the exercises are all a part of learning and it was one sure way of making them work harder" (Ibid).

Then she added with a smile that she always says, **"Hapana chinouya wakagara kunze kwetsvina"** (Ibid., p. 7). Literally translated, she said, **"Nothing comes to you while you are seated except dirt."** The point being made here is that to get anything, one needs to put forth some effort.

It must be pointed out that these students reported that they did not have textbooks and yet this is a former Group A school. These schools are known to have had enough resources before the massive secondary school enrollments, which took place after Zimbabwe attained its independence (see Tables 1 & 2, in Chapter I, p. 3).

In contrast to these students, another Lower Sixth Form (L6) class was described as having a positive attitude to learning Biology, by their Deputy Headmaster, who had taught them before he was promoted. He said, "They are generally good because their classes are very small, with 14-15 students only. Hence, the teachers get to know them and become family-knit. He can monitor what each is up to, at all the times" (Mu.HI, p. 18).

But the small size of the class did not seem to be sufficient because there was another Lower Sixth Biology class with only nine students also in a former Group A school, who were described by their teacher as "having an attitude problem to learning, which was not pleasing, because they are not really taking their learning as seriously as one desires" (DFI, p. 9). When asked why that was so in a school with such adequate teaching and learning resources, the teacher suggested the following.

> It may be due to the catchment area. The school is in "a Colored" neighborhood ("Colored" refers to progeny from inter-racial marriages and not the American connotation of any Black person), whose reputation is that they do not value education. Some of the African students come to school without a goal in education and have been made to attend school by their parents. Such students easily get derailed by their peers who don't care about learning. These students still have this negative attitude to learning despite the 'pep talk by the Headmistress' at the opening of school, which is echoed by the subject teachers, who also perpetually remind them and emphasize the importance of doing personal individual reading, during the lessons and during their free periods, and not expect to be pushed around and spoon-fed all the time (DFI, p. 9).

Thus, in this case, the attitudes being developed by the students seem to stem from the influences which are being exerted by both the students' peers and the school context.

On the other hand, another teacher indicated that his students had a positive attitude to learning. He explained this as having arisen from **the teacher's own projected positive attitude to Biology**. He said, "I consciously and deliberately tell them that

Biology is an achievable subject and you can do what you want with it" (PFI, p. 14).

So, students' attitudes may be influenced by their teacher's attitude. This was corroborated by some of the students and by another teacher (VFI, p. 10).

Mrs. B- explained the positive attitude to learning A- Level Biology of her students as being the consequence of her students having,

> . . . already developed confidence in themselves and knowing my limits i.e., my expectations of them with respect to what I can take and what I cannot tolerate from them, from our previous interactions and experiences at O-Level. This information gets passed on to the new Lower Sixth students, coming from other O-Level schools (BFI, p. 12).

So in this class, a positive motivation to learning was established as early as O-Level and it has been maintained by the teacher by insisting that the students should behave within her established limits.

Mr. C- had mixed feelings about his students and their attitude to learning A-Level Biology. He gave a response that made me curious about the unintended outcome of my presence, during the classroom observations. He had replied saying, "Before you came, I thought that the students were a good group but they seemed rather passive; their attitude toward learning seemed negative because they were not doing their work on time" (CFI, p. 11).

To which I responded and pointed out that to me, they had appeared to have been very attentive and that they had seemed to have been all well-motivated, during all the lessons which I had observed, during the whole intensive study period. Then, when I asked what my coming had to do with their attitude to learning, he replied with a broad smile and said, "Now they are positive and eager. That may be the effect of your video camera" (Ibid.).

The indications that "they are positive and eager" to learn were, according to this teacher, that "the students were asking more questions and were voluntarily responding to my questions ... These questions reflect on the students. That is, their responses give the indication that they are paying attention and also whether they have understood or not" (CFI, p. 11).

In a co-educational private (mission) boarding secondary school, the students' attitude to learning were described by their teacher as being

> . . . quite good for most of them, in terms of their response to instruction. For example, when given work, they all hand it in on time. After a test or an exercise, they will try and find out what they missed out or why they have failed. But the tendency of a few of the students when you are revising a test is for them to try and explain or defend their wrong responses. But most of these students do not do this (VFI, pp. 9-10).

When this teacher was asked what this showed, he suggested that it might be due to either a genuine lack of understanding or a negative attitude of trying to see how easily the teacher will give in to the wrong answer and give the student the marks. When asked how he will change his next Lower Sixth class' attitude to learning, the teacher replied, "It is difficult to change attitudes because it is more like an inborn thing. The students could have a positive or

negative attitude as a result of you yourself as a teacher (VFI, p. 10).

That is, the students' attitude may be a reflection of their teacher's attitude. This is echoing what was said by another teacher above (PFI, p. 14). When asked how this comes about, he explained.

> As a teacher you might be found wanting in terms of either **content** i.e., when the teacher is not giving **the amount of detail that students expect**, maybe because you yourself don't know or you decided students don't need this information. The result is that **the students will feel that the teacher is wasting their time**. Or, the teacher may have the appropriate content but may **not be preparing well for the lessons**, i.e., he just lectures with **the information not being given in a proper order** (VFI, p. 10).

He explained "a proper order" as the "sequencing of concepts, generally, from the known to the unknown; from the simple to the complex" (Ibid.). This teacher went on to explain that he knew what was "known" and "unknown" by his students through a question and answer session.

All the observed A-Level Biology teachers said that their A-Level students were "mature students." Some of whom were perceived as being capable of working independently" (for example, NFI, p. 5; VFI, p. 5).

SUMMARY

Hence, an assertion can be formulated **that the A-Level Biology students seem to be conceived by the majority of ZIMSTT graduates as not having been prepared adequately by the O-Level Core and Extended Science syllabi, for A-Level Biology study. Moreover, the students' incoming O-Level Science grades of "A"s and "B"s do not seem to** reflect their actual cognitive calibre. This is reflected, among other things, by how the students were perceived by their teachers to be, "not like they used to be ..." (MiFI, p. 4); "not an exceptionally good lot ..." (MFI, p. 4); and as being "very weak and not at all jerked up ... their reasoning power is slow ..." (GFI, p. 12- 13).

On closer analysis, it turned out that the five out of the nine observed A-Level classes which were perceived by their teachers as having a positive attitude to learning Biology were all the Upper Sixth (U6) Biology classes. The remaining four classes, with students whose attitudes were perceived by their teachers as negative, were Lower Sixth (L6) Biology classes. And yet, the majority of these students, both in the Upper Sixth (U6) and Lower Sixth (L6) classes, were perceiving themselves as having positive attitudes to learning A-Level Biology.

One possible explanation may be that the students, after their initial shock of the demands of A-Level work, in the L6 classes, adjust and soon get the hang of it and then start to work hard in ways which satisfy their teachers, by the time that they come to the U6 classes. Could it also be that the teachers were equating the students' not doing well with their negative attitudes? Or is it possible for one to have a positive attitude to a particular subject and yet be not performing up to the expected standard in that subject? If this is accepted in activities like sport and in learning to dance or in learning to play a musical instrument, then, why not in the learning of academic subjects like Biology?

Another surprising insight is how the same factor e.g. the detail of the subject matter content, had both a positive and a negative impact on the students' attitudes. The causes of these negative attitudes, from the teachers' perspectives, ranged from the students giving up because of the demanding A- level Biology syllabus detail, to the students' own lack of self-motivation, or as a reaction to the teachers' own attitude to the subject matter, his/her preparedness to teach, and his/her ways of presenting the content.

OTHER LEARNING SKILLS

In addition to describing their students' cognitive calibers, two of the A-Level Biology teachers also pointed out that their students were unable to carry out certain critical activities and processes. For example, making their own notes and the teacher then ends up dictating summaries to the students i.e., to the whole class [NFI, p. 3; GFI, p. 6; DFI, p. 10; & Tape D 2 (9/17/92)]. This was corroborated by their students (CSI, p. 3; GSI, p. 1; VSI, p. 2 & DSI, pp. 1-2). But some of the students justified this practice on the basis that they did not have textbooks (GSI, p. 1). The rest of the teachers reported that they never checked their students' note books because they felt that at this stage note-making was the responsibility of the individual students (e.g. PFI, p. 15).

Secondly, keeping up with their work was problematic too. Students in one class were observed obviously lagging far behind their teacher's lecturing, because they were failing to hand in their assigned homework on time. This was explained as stemming from the students' inability to budget their time for homework vis-a-vis extra-curricular activities and other competing subject demands (CSI, p. 3 & MFI, p. 11). The latter teacher was corroborated by her students [MSI, p. 5 and Tape M 19 (7/29/92)]. However, in one other class, the students, who felt the shortage of time, indicated that although they minded this practice of having notes dictated to them in class by their teacher, they did not complain because ". . . when the teacher dictates the notes to us, it saves us time and it gives us the guidelines for our reading of what's in the syllabus . . ." (DSI, p. 1). But, would not duplicated copies of the syllabus serve this latter function for the students even better?

The third observation was that the students seemed to have poor practical skills, as evidenced by their inability to carry out their practical work smoothly. For example, in one practical in which the students were studying prepared slides on "mitosis" and "meiosis," the students were having lots of problems in performing tasks, which should be routine by the time that they reach A-Level classes. Some of the students in this class were having problems of setting up the microscope and others of focussing and scanning for the specimen on the slide because they were doing so using the high power lens [Tape M 12 (7/17/92) and (GFI, p. 6)]. Students in the latter teacher's class felt that they needed more practice using the microscope and one of the interviewed students confessed that he had never handled a microscope before coming to A-Level (GSI, p. 4).

In a second observed practical, on the effect of heat on enzyme activity, there were **many breakages** due to rubber bungs beings forced into smaller test-tubes [Tape M 17 (7/28/92)]. **This particular practical session was not completed during the class time.** The students' pace was slowed down by the frequent teacher interruptions, during which she had to clarify one thing or another, depending on whatever she noticed the students doing wrong as she moved from group to group monitoring their progress. There were as many as four such interruptions, which the teacher justified during the post-observation conference.

> I am still trying to teach practical skills, and each time I see a mistake, I tell all of the students to avoid repetition and for them to learn as much as possible of the little things like keeping one syringe just one solution and keeping test tubes in order (Ibid., p. 2).

But these interruptions were wasting time for those groups of students who were doing the practical correctly! The interruptions reflected a **lack of understanding of the written laboratory instructions by the class**, despite the teacher and the class having gone over them before the practical was done in groups [Tape M 16 (7/27/92)]. In other classes, a student's problem of **drawing of diagrams directly from microscope slides** was reported (GSI, p. 4 and DFI, p. 4).

These A-Level Biology students were also reported by their teachers to be **unable to link or relate Theory with Practical Work**. An instance of this was observed in one practical session in which the students were doing a mock examination, based on Question #1 of a previous 1989 Biology Practical Final Examination.

> The objective of this item is to test the students' knowledge of how to test for a reducing sugar ... and also to test their ability to observe and deduce from their observations, in order for them to reach a conclusion (GFI, p. 8).

What the teacher had observed, as she moved from student to student, was that "the test tubes were still full of chemicals," that is, the students had not used the hydrochloric acid and sodium bicarbonate which had been supplied! When asked by the researcher what this meant to her, the teacher replied.

> It reflects that when this practical was done in class before, the students must not have understood what they were doing. They had gone through the motions of following the instructions without much thinking because the reasons why they had added those different chemicals had been explained to them. Hence, they had totally missed the principles of hydrolysis of the complex sugar and the neutralizing of the sodium bicarbonate solution. Students had not linked their theoretical knowledge with this particular practical (Ibid.).

This problem of failing to link theory to practical is not unique to this class. It was also reported in another school, "when the students were doing a practical on the effect of yeast on a disaccharide sugar" (VFI, p. 3).

One teacher, realizing that students do not forge these linkages on their own, was observed encouraging her students to do so. She did this by asking each student to find the connection between some aspect of the practical work and the theory by looking up the relevant theory sections (Appendix #10).

This problem of linkage is also related to the problem which was reported by one teacher, who said that students were **failing to integrate or to link content learned under different topic headings** of the syllabus e.g. the link between the Central Nervous System (CNS) and Respiration and between Genetics, Growth, and Reproduction. This teacher explained it as being possibly due to "students learning the Biology syllabus topics in isolation" (VFI, p. 4). These problems were echoed by the other observed ZIMSTT A-Level teachers (NFI, p. 3 & MiFI, p. 4).

Other characterizations of the A-Level students were given by one teacher, who perceived her students as having problems of **interpreting test questions**, and their inability **to distinguish between nuances of words in the instructions**, such as "describe," "discuss," "compare," "contrast" etc. That is, language seems to be a problem for the students. English is a second language for these students and it has been used as a medium of instruction for these students since as early as Grade three at the elementary level. This same teacher also complained about her students' reluctance **to give illustrations**.

> Seriously, they will give you a dry descriptive prose if you let them, and when they do, they give you a diagram which is either too sketchy or very artistic. . . . The other thing is their sketchy **content background** when they came into A-level. It is rather sketchy. . . . They also have problems of analyzing data, which I think may be linked with their language problems (MiFI, pp. 4-5).

What is being pointed out here are the students' poor drawing and analytic skills and their "sketchy content background". What is not clear here is whether the "sketchy content background" is because the student did not learn the science content well during his/her O-Level studies or whether the O-Level Science syllabus content is an insufficient preparatory basis for A-Level Biology studies. The latter was one Science Education Officer's perspective.

Punctuality seemed to be a problem in one observed A- Level Biology class. It was in the form of lateness by the students in getting to the Biology laboratory from other classes and the students not doing and handing in their homework on time [Tape #s M 3 (7/7/92); M 5 (7/9/92; M 9 (7/14/92)]. The teacher also informed her class just how far they already were lagging behind what she had planned for that School Term [Tape M 9 (7/14/92)]. On one extreme occasion, half of the class, who also take Mathematics, was delayed by half an hour from another class for some reason [Tape M 10 (7/15/92)]. This Biology teacher, after a very strong reprimand to the class had proceeded to teach. But then she did not stop teaching when the bell for the lunch break rang. She continued to teach, through that whole lunch period, after telling the class that, that was what she was going to have to do, in order for her to finish what she had planned to cover that day. This problem of the time constraint seemed to be exerting a marked influence on the pacing and the density of this teacher's subsequent lessons (see Chapter VIII, below).

A diversity of student cognitive abilities, skills and attitudes to learning is reflected in these teachers' descriptions of their students. Based on the data, the teachers' perceptions of students' cognitive ability can be placed on a continuum with low ability perceived at one end and highly capable perceived at the other end.

Teachers' perceptions
of students' cognitive
Low ability & <----- ability & motivation -----> High ability &
Not motivated Well motivated

(M-, D- & G-) <----- (C-, Mi-, P-, N-) -----> (B- & V-).

An interesting direct relationship was noted between the teachers' perceptions of their students and their observed teaching styles. For example, the three teachers with the lowest estimation of their students' abilities were found at the didactic end of the teaching style continuum. These three teachers are Mrs. M- whose students are "not an exceptionally good lot" and "who need motivation," Mr. D- whose students "still have a negative attitude to learning," and Mrs. G- whose students "are weak and not at all jerked up because their reasoning power is low." At the other heuristic end are Mr. V-, Mr. N- and Mrs. B- who saw their students as good and capable. But a contradiction is found with Mrs. Mi- because she perceived her students as "a mixed ability group and a mixed bag" and yet she had a heuristic teaching style. In spite of this single exception, an assertion was formulated **that for most of the teachers, their views of their students' ability and their observed teaching styles are correlated.**

THE A-LEVEL STUDENTS' PERCEPTIONS OF THEMSELVES

Self-images. During the interviews, the A-Level students were perceived unanimously by themselves as being different when compared with O-Level students in being more mature and the teachers were treating them as adults. They are capable of carrying on independent work. The latter was said to include "doing a lot of research, i.e., looking for more information and studying harder" (NSI, p. 1); "discussing among ourselves" (GSI, p. 1); and "spotting experimental errors and suggesting how to improve the results" (MSI, pp. 9-10).

Another lens for further insight into what students think about themselves was derived from asking the students themselves what image(s) they had of themselves as students [Appendix #3, Item #5 (b)]. Their images (Appendix #14.2) were fascinating because of their diversity within and between classes. Some of these images implied passive and receptive learners e.g., "a tape recorder because I just sit . . . and absorb . . ." (PSQ, #7;) and uncritical followers, e.g., "a vehicle because I need to be directed" (PSQ #12); and not the "independent workers" mentioned during the students' interviews. Other images reflected active sense-making and learning on the part of the student e.g., "a builder, because I study very hard" (BSQ, #17) and "a bee because I am always looking for information" (NSQ #7).

SUMMARY

It appears then that the observed A-Level Biology students perceive themselves more as passive and less as active participants. This distribution of students more at the passive end of the students' perceived involvement continuum correlates with the teachers' views of learning and teaching (see Chapter VI, above). The students' view of themselves as passive participants corresponds with the teachers' view and implementation of teaching as "giving information." On the other hand, the students who viewed themselves as active participants tended to belong to teachers who viewed "teaching as facilitating and . . . guiding" and as ". . . leading" their students to discover, relate and apply knowledge. But then there is also a contradiction that is reflected in the images some students had of themselves as active and as passive participants in the same class taught by the same teacher with either a predominantly didactic or heuristic teaching style.

THEIR ATTITUDES

A majority of the students reported themselves as having a positive attitude to learning Biology. The reasons they gave for this can be grouped into factors that are related to the following.

Their teacher's qualities. For example, the students wrote that they had developed a positive attitude to learning Biology because

> . . . I have a teacher who is qualified to do the job and she is friendly" (BSQ #12, p. 2).
>
> The teacher is brilliant and expresses himself well and clear (CSQ #16, p. 1).
>
> I understand the facts . . . the teacher has an influence on me. She helps me a lot when I am in darkness and she does not look bored if I say that I still do not understand what she would have explained for sometime (BSQ #20, p. 1).

This reflects the teacher's attitude to slow learners as being one of acceptance and tolerance. That is, she is patient with them and they feel free to indicate that they are "still . . . not understanding . . ." Another student in this class wrote the following.

> We got a good and cheerful teacher at A-Level, who boosted me to like Biology even more, such that I always got so motivated to work hard to avoid disappointment to the teacher and to myself as a consequences of my failure (BSQ #7, p. 2).

From the other classes the students wrote,

> We had an active, sociable and confident teacher (MiSQ #6, p. 1).

> The teacher was lively ... he has given me encouragement on the subject which I otherwise was becoming weary of (PSQ #7, p. 1).

Another student in this class corroborated this sentiment when he wrote the following.

> The teacher was really committed to make us learn and consequently he aroused all my interest in Biology. The teacher . . . is creative and motivating, making me like the subject even more. His attitude towards us the students creates a conducive atmosphere for one to pursue the subject. He, makes me appreciate the interdependence between living things. The teacher was lively and made the lesson joyful (PSQ #15, p. 1).

> We had a very interesting teacher . . . (GSQ #6, p. 1).

So the teacher's own qualifications, calibre, attitude to his work and to his students, his teaching style, demeanor, and the "conducive atmosphere" which he created in the classroom, all seem to be influential in making the students to develop a positive attitude to their learning Biology.

<u>The nature and the quality of the subject matter</u>. Students in eight out of the nine observed classes reported on their

questionnaire (Appendix #3, Item #1) that they had developed a positive attitude to learning Biology because of the subject matter being new, informative, and interesting (f=35); easy to understand (f=25); applicable to self and real-life situations (f=34); foundational for future career (f=4); detailed, demanding and needing a lot of research (f=25). Some of the interesting comments among these were the following.

> We scratched the surface at O-Level which only aroused my curiosity on the subject and I decided to pursue it at A- Level study and we are now doing an in depth analysis of the topics we had just grazed at O-Level (BSQ #18, p. 1).

The metaphor of "grazing" is not only interesting but also quite apt for describing the depth of treatment of the topics at O-Level.

> It (the study of Biology) develops skills on the field of how to better our social life (e.g. genetics in breeding better strains of cattle (MiSQ #19, p. 1).

> At A-Level it depends on how much you can apply what you have learned in solving problems. There is very little work based on recall. Passing A-level will then be determined mainly by our understanding of the concepts. A-Level Biology is very interesting but the problems come when you answer the questions (BSQ #9, p. 2).

These students are being influenced by the social applications of Biology and the need to understand rather than just memorize the concepts.

Inquiry skills which the students are developing. Two interesting comments, which were related to the nature of the subject matter, were made by the students, with regards to how the learning of Biology has encouraged and stimulated the students' sense and practice of inquiry.

> I was impatient to go to A-Level where we would go deeper into the subject. A-Level is a bit of a challenge and I enjoy it more. **It is satisfying my natural curiosity a whole lot more. It seems like the more I learn the more I want to find out.** I always find the biological explanation of simple everyday things . . . (DSQ #1, p. 1).

> **It (the study of Biology) is open, investigative and liberal**. Yet I enjoyed dealing with anything scientific, that is, **to ask the why? when? how things happen?** and sometimes, I would **wonder** what would have happened in another situation. I developed interest in science whilst still at primary school, with **encouragement from my teachers** and from the need to find out about why things are as they are (BSQ #14, p. 3).

The sense of inquiry motivates this student to delve deeper into the subject matter in order to try and come up with satisfactory explanations. This student went on to write the following.

> Science at O-Level was interesting and **challenging**. I am taking Biology and Chemistry, which provide me with opportunities to appreciate Biology as a subject. A-Level science is quite **advanced in analysis**. Some ideas are **abstract** and I have to visualize them in order to grasp them and to understand them. There is quite **a large gap between O-Level Science and A-Level Biology**. There is **a lot of new terminology** and a resultant increase in vocabulary which can be somewhat tiring and confusing. Initially, I was overwhelmed during the first days when we got our sets of textbooks - to imagine that they were all just for one subject! But now, **I have become an avid reader** (Ibid.).

Here is an example of a student who is undergoing some drastic metamorphosis on all the three levels i.e., in terms of thinking skills, attitudes, and inquiry skills (Refer to the Evaluation of the B.Ed. program below).

Career prospects. A few students were positively inclined to learning Biology because they perceived the subject as preparing them for medicine (f=4) (e.g. MiSQ #25, p. 1 and MSQ #15, p. 1).

The nature of the lessons. The students explained their positive attitudes as having been influenced by their Biology lessons, which they perceived to have been "... lively" (MiSQ #30, p. 1) with "lots of experiments and practicals which facilitated better understanding" (PSQ #s 8 & 19 and MiSQ #s 7, 10, 19 & 20).

Resources. One student gave the availability of teaching and learning resources as the reason for having developed a positive attitude to learning A-Level Biology. He wrote, "The school provides enough textbooks and we don't have to share and take turns taking the textbooks home to study" (MiSQ #8, p. 1).

However, there were a few students who reported themselves as having developed some **negative attitudes to learning A-level Biology** because:

> A-Level Biology is a bore with so many calculations (MSQ #5, p. 1).
>
> One thing that gets me unsettled about Biology is that **its syllabus seems to be longer**, for me, than the Chemistry syllabus (BSQ #2, p. 1).
>
> I am enjoying it at A-Level but I quite dislike the many long and complicated terms ... and I have **to work extra hard** than I did at O-Level (DSQ #2, p. 1).
>
> At O-Level it was ... very interesting .... But now at A- Level, Biology is a bit hard because it is now complicated having **to learn things in a complex manner** and there is also the Chemical Biology to be learned which is not easy for me with the limited Chemistry background that I have (DSQ #3, p. 1).

> There is too much to read (PSQ #13, p. 1).
>
> Evolution is a tangled mushroom of guessing games and figure juggling (PSQ #14, p. 1). [I did not get the meaning of these metaphors at all!)

It appears that what is causing the negative feelings is the hard work required to learn the A-Level subject matter. The students perceived it as more detailed, extensive, and complex than the O-Level content.

SUMMARY

Hence, this data supported the assertion **that the students' and their teachers' perceptions seemed not to be in agreement with regards to the students' cognitive abilities, attitudes to learning Biology and their manipulative skills.**

A great majority of the students perceived themselves as having positive cognitive and affective inclinations towards learning A-Level Biology. The factors which they reported as contributing to the development of these positive feelings included their making sense of what they were learning; the subject matter being easy, interesting, detailed, and demanding a lot of outside reading; the content being related to self and real-life situations; and the teachers portraying themselves knowledgeable and confident in teaching and managing their lessons. Apparently, the students came in with "A"s and "B"s from their O-Level Final Science Examination. But the majority of their teachers perceived these students' A-Level performance as mediocre; their attitude to learning as negative; and their manipulative skills as poor in some classes.

What is striking in this section is the apparent contradiction between the teachers and the students in how they perceive the students. This contradiction can be related directly to the contradictions and tensions in the continua of the teachers' views of knowledge (as a body of facts <---> as tentative) and their teaching styles (didactic <---> heuristic). These contradictions were discussed above.

THEIR LEARNING STYLES

It seems that the A-Level Biology students' perceptions of their own learning styles was such that they want to understand what they are learning more than learning it by rote. For some, ". . . learning involves listening to the teacher, jotting down main points during the lesson and compiling detailed notes using different reference books (CSI, p. 3) and practicing the diagrams" (PSI, p. 4).

One student said, "What I hear talking I don't forget ... but what I read I forget" (BSI, p. 18). A second student said,

> I think I am a slow learner because if I do something in class, I can't pass the test . . . so I have to go and read again. Then, maybe after that, I can try the test. So I have to do a lot of work, much more than what other students have to do (BSI, p. 18).

A third student reported that his learning style is like the second student's. He added,

> Mine is based on recall ... what I hear first, I put at the back of my mind and even though I compliment it with notes, I think what I heard first is what I really recall during exam time ... What I read on my own does not exist ... but when I share it, i.e., when I discuss about the reading with my friend it becomes easy to understand and remember (BSI, p. 19).

This student points out the importance of "discussion" among students and with the teacher. Although he thinks that his learning style "is based on recall" what he remembers will not be verbatim because of the mental processing that takes place during the discussions with other people.

These three students went on to describe how their teacher helps them to learn and understand better by encouraging student-to-student discussions. For example,

> . . . she divided us into six groups and gave us past exam papers, which we rotated for a whole term i.e., each person is given a day to work through the paper alone and then we usually met in our group on Thursday, the day before we returned the papers for rotation with other groups. Then each member in the group will be asked to read out the answer which he/she wrote and then we compare and discuss these responses (BSI, p. 20).

In these discussions differences are ironed out and then they come to a conclusion. But if a consensus cannot be reached,

> . . . then the group confers with the teacher. We all liked the learning in this manner because everybody made an effort and contributed and we reached a better understanding of the concepts, across the syllabus topics. Since this exchange of papers is an on-going exercise throughout the term, as we revise for our final examinations (Ibid.).

This practice of students discussing among themselves and thus learning and understanding better was reported in other classes (GSI, p. 1; MSI, p. 8; MiSI, p. 4 & PSI, p. 1). Hence, these teachers are encouraging cooperative learning. Ways of improving cooperative learning strategies have been described elsewhere (Slavin, 1983).

SUMMARY

What emerges from these data are two further contradictions. One is in how the teachers perceived the students' cognitive abilities, skills and attitudes to learning versus how the students perceived themselves. The other contradiction is between the students' images of themselves as passive participants and their perception of their learning styles as highly involved in making sense of what they are learning through having to "read again," "do a lot of work," "read on my own," "work through the paper alone," and "discuss about the reading with my friend" etc. In relation to the tensions and contradictions in the teachers' views of knowledge and teaching styles, it seems that for a majority of students their perception of being passive learners fits with their teachers' perception of knowledge "as a body of facts" to be memorized and of teaching as didactic "giving information." But a majority of the teachers described what they do to increase their students' intended learning and development in a way that reflected a heuristic teaching style and contradicted their view of teaching as "giving information." The few students who perceived themselves as active learners belonged to teachers with heuristic teaching styles and views of knowledge as tentative and changing.

TEACHER EDUCATION AND A-LEVEL BIOLOGY TEACHING:

A DESCRIPTION AND EVALUATION OF

THE ZIMBABWE SCIENCE TEACHER TRAINING

(ZIMSTT) PROGRAM.

VOLUME II

By

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CHAPTER VIII

TEACHING PRACTICES OF ZIMSTT A-LEVEL BIOLOGY TEACHERS

Participant classroom observations were made in order to get a deeper insight into the prevailing practices of the ZIMSTT Biology graduates, who were teaching A-Level Biology classes. This was done in two stages. Firstly, an extended intensive study was done of two teachers, who were teaching the same topic from its beginning to the end. Secondly, follow-up visits were done to the other seven ZIMSTT A-Level Biology teachers, in order to validate the assertions, which were formulated on the basis of the observations which were made during the intensive study.

AN INTENSIVE STUDY OF TWO TEACHERS

The sampling of the two teachers was done based on the geographic proximity of these teachers in the same city, within easy reach from one to the other. Both teachers agreed to be "shadowed" as they taught the same topic from the beginning to the end. Luckily their lessons dove-tailed into each other with a period in between, which left just enough time, for travelling between the two schools, before the next lesson. However, at times it meant not being able to

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hold our post-observation conference with the first observed teacher, while the lesson was still fresh in his/her mind.

The two teachers were Mr. C- and Mrs. M-. Both teachers had taken the one-year full-time B.Ed. program. Mrs. M- graduated in 1988 and Mr. C- graduated in 1987. They both took up A-Level Biology teaching immediately after graduation. Both were the Heads of their Science Departments. Their teaching loads were different. Although both had ten periods with O-Level classes, Mrs. M- had eleven periods with her L6 Biology class. While Mr C- had seven periods with L6 and 7 periods with U6 Biology classes. Mrs. M- had a total of 21 periods and Mr C- had 24. Hence, she was not as extended as Mr. C-.

The two schools were both former Group A schools, located in low-density communities. The community for Mr. C-'s school (#1) was predominantly white before independence and now had a large influx of black families. The community for Mrs. M-'s school (#2) was predominantly "colored" (i.e., inter-racial families). But the majority of the students in both schools were black. School #1 was a co-educational High School and school #2 was an all Boys' High School. Both schools did not have double sessions. Afternoons were devoted to extra-curricular activities, which included athletics, sports and clubs.

The two A-Level Biology laboratories differed to some extent. In school #1 the teaching and learning resources seemed to have been adequate when compared with school #2. All the students in the former school had the basic textbook which they were observed referring to in every lesson whereas, only a few of the students in school #2 had their own textbook. The rest borrowed from the few who had the textbooks. The teacher sometimes duplicated some chapters from her reference books for the students. But her school put limits on how much duplication each teacher can do [Tape MFI, p. 9 (9/11/92)].

In school #1 the science laboratories have separate areas and desks for lectures and for the students' practical work (Appendix #8, Figure 1). The students' desks during lectures (SDL) are arranged as a tier at one side of the room while the long fixed tables for practical work (SDP1) occupy the rest of the space in the room. Extra work places (SDP2) are along the walls of the room. There are storage cupboards underneath the tables. A similar arrangement of furniture was seen in the laboratories of Mr. D- and Mrs. Mi-. In school #2, there were no separate areas for lectures and practical work (Appendix #8, Figure 2). This arrangement of furniture was seen in the rest of the observed seven teachers' laboratories.

The first thing that was striking about school #1 and school #2 was the vast difference in the degree of general maintenance and cleanliness of the laboratories. Layers and piles of chalk dust were seen in school #2's laboratories and their microscopes were in a state of bad repair. In school #1 laboratories were swept and dusted daily. Despite the drought, the grounds in school #1 were kept immaculate, with a pond, whose plants were thriving well, in the middle of their court yard. The grounds of school #2 were not taken care of as well as in school #1.

The two teachers' students in both A-Level Biology classes had attained either A's or B's on their final O-Level Core and Extended Science examinations (Table 15). On the basis of those grades and the fact that they went through the competitive A-Level selection processes, these students were expected to be the cream of the crop and to do well. However, the two classes differed in a number of ways. Mr. C-'s students seemed to be a punctual, keen and lively group. They asked questions and participated actively during the lessons. Very few students in this class were not keeping up with their reading and note-making. On the contrary, in Mrs. M-'s class, a few of the boys seemed self-motivated. The majority seemed not to be.

Mrs. M- reminded her class of the importance of keeping up with their reading and note-making at the beginning of almost every lesson. Each time she asked for notebooks for checking, a majority of them would have neither made the notes nor even brought their note books with them. Even the announcement of a test would not move them much. They either persuaded the teacher to postpone the test, as was observed on two occasions, or they took the test and performed dismally on it. The ultimate evidence for me, that this class was not taking its studies seriously, was when they could not identify mitotic phases during the revision, first, with the "flash cards" which the teacher had made [Tape M 12 (7/17/92)]; and secondly, when making models of these phases, with chalk and strings which stood for the chromosomes [Video-tape MV (7/15/92)]. These students seemed to be rote-learners, because if it were meaningful learning that they were going through, then they should, by then, have been able to recognize these mitotic phases more accurately and without any hesitation, as was observed with Mr C-'s students.

An analysis of the images, which the students wrote about their teacher, themselves as students, their class, and their classroom (Appendix #14.2), indicated that Mrs. M-'s students tended to be competitive with little sharing. This confirmed the hunches which were developing from my participant observations. The opposite was observed with Mr C-'s students, who seemed to have developed into a cooperative community of learners. They seemed quite comfortable and at ease with each other, to be able to quiz one another; agreeing and disagreeing with each other's responses; and having to justify their arguments. In this class, lively class discussions were observed which the teacher had not planned for. That is, there seemed to be cooperative sense-making and significance attribution, among Mr. C-'s students. As a result, a lot of unintended meaningful knowledge construction took place which deepened the students' understanding. Mr. C- more than Mrs. M- provided his students with opportunities not only to acquire new knowledge but to integrate and apply it. For example, he was observed reinforcing his students' understanding, by giving them challenging tasks as a discussion (Appendix #11) and written exercises (Appendix #16). Whereas, Mrs. M- would just tell the students to go and make notes or study

(Appendix #17). She never gave her students any written exercises during the whole observation period, except as a test.

The teaching styles of these two teachers were also strikingly and consistently different. Most of the time, Mrs. M- tended to lecture referring to her notes frequently. Her students passively acquired the transmitted information, because even though she does ask questions, she answers them herself and thus end up having mostly a one-way communication. Few of her students jotted down notes as she taught (See all her lessons on the Video-tapes MV 1 and MV 2). Her image of scientific knowledge was "as a body of information in textbooks."

On the contrary, Mr. C- seemed to have had a better grasp of the content because he did not show that heavy dependence on his notes (See all his lessons on the Video-tapes CV 1 - CV 3). Classroom discourse was in the form of interactive dialogues with and among the students by using a question and answer format as opposed to the strict lecture mode of instruction. This was done at a pace which was comfortable for the students to acquire the information. He also explained the concepts in a variety of ways, as was seen during his lesson on the semi-conservative replication of DNA (Appendix #16).

Another difference which was noted was that Mr. C- was never in a hurry to leave the school grounds after teaching his classes. Hence, he was more available for and welcomed having the post-observation conferences at length. With Mrs. M- fewer and brief post-observation conferences were held because she had this and that thing to do in town. As a result, I had more informal post-observation discussions with Mr. C- about his lessons than I had with Mrs. M-.

Lastly, I was struck by the drive, energy and dedication with which Mr. C- exploited available science teaching and learning resources outside his own school. For example, he read many scientific magazines looking for relevant articles to reinforce concepts being taught (e.g. DNA: THE BLUEPRINT FOR LIFE [Tape C 17 (7/17/92)] and "Cheetah in Genetic Peril" [Tape C 14 (7/16/92)]. When I asked him how many of these articles he had collected, he showed me a whole thick file of them, which needed a systematic organization. This collection provided evidence of the teacher's extensive outside reading habits. Mr. C- had also organized a field trip to the Zambezi Valley for his U6 Biology class for ecological studies. Having a broken down film projector did not deter him from showing the films on DNA: THE MOLECULE OF HEREDITY; GENE ACTION; HUMAN HEREDITY; MITOSIS; MEIOSIS; MITOSIS AND MEIOSIS; AND SEX CELL FORMATION. [Tape C 23 (7/24/92)] The students appreciated the films greatly because the films clarified their thinking [Tape CSI, (7/21/92)]. He accomplished this by borrowing a film projector from another school across town. The films were borrowed from Audio-Visual Services (AVS) of the Ministry of Education. On the contrary, Mrs. M-, who was in the same predicament, did not show any films, even after her students had failed to identify her "flash cards" on mitosis. It also seems that the two teachers differ in the extent to which they assess and try to reinforce their students' understanding. These differences stand out vividly in the way these two teachers taught the observed topics on DNA, RNA, and PROTEIN SYNTHESIS (see below).

Classroom observations were started at the time when Mrs. M- was teaching the structure of DNA, while Mr C- had just completed that aspect of DNA. So the pre- and post-tests were based on protein synthesis (see Chapter IX below).

All the lessons were audio-taped and some were video-taped. What must be emphasized here is that the differences described above were quite vivid and yet the choice of these two particular teachers had been by chance (See Chapter III). Hence, the fact that these two teacher's teaching practices were so contrasting happened by chance and not by design. The contrasts between them seemed to represent opposite ends of the following.

Knowledge transmission mostly by lectures (Teacher talk & chalk)	<-------teaching------->	Knowledge construction through question & answer sessions.
Didactic	<-----teaching style------>	Heuristic
Rushed	<-----lesson pacing----->	Deliberate

Note that the above influence students' learning styles.

Knowledge reproduction	<--- assessment & learning--->	Knowledge production
Passive/Receptive	<------learning------>	Active
Factual acquisition	<----learning--->	Sense-making
Rote	<----learning------->	Meaningful significance attribution

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One-way communication	<-----classroom discourse----->	Two-way interactive dialogue
Competitive individuals	<-------learners----->	Cooperative groups
Dependent on text	<---teachers--->	Flexible (Refers to magazine articles)
Limited representations	<--explanations & illustrations-->	Multiple representations
Few, same type Need low-level thinking	<------questions------>	Many, varied, need high-level thinking
Teacher dominant directive	<----student----> involvement	Discussions among students
A body of facts	<---knowledge--->	Tentative facts
Dusty and needing repair	<---lab. maintenance--->	Polished and orderly & clean
Poorly stocked laboratory	equipment & <-----teaching-----> resources	Well stocked laboratory
Sketchy	<--------lesson plans-------->	Detailed

These continua were borne in mind as assertions, which were validated in the follow-up study of the remaining seven ZIMSTT graduates teaching A-Level Biology classes.

To illustrate and highlight a number of these differences, the two teachers' lessons on the theories of DNA replication (Appendices #s 16 & 17) are presented and analyzed below.

AN ANALYSIS OF TWO LESSONS ON DNA REPLICATION

An analysis of these two teachers' lessons on the theories of DNA replication reveals some interesting contrasts in the following aspects.

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The explanation of the semi-conservative process of DNA replication itself was analyzed with respect to:

1. the depth of treatment of the process, which differed between the two teachers. Greater detail was given by Mr. C- than by Mrs. M-. In his lesson, Mr. C- included the other two competing theories, that is, the conservative and the dispersive methods of DNA replication and the historical evidence for the semi-conservative replication method. On the contrary, Mrs. M- just glossed over the semi-conservative method. She omitted most of the comparative detail of the other competing theories of the mode of DNA replication.

2. The subject matter representation of the semi-conservative replication process was effected in multiple ways by Mr. C- compared with Mrs. M-'s presentation. Mr. C- used as many as four different kinds of subject matter representations, that is, by verbal exposition; diagrammatical illustrations; historical experimental evidence showing the relative sedimentation bands of the normal and heavy nitrogen incorporated daughter DNAs; and as graphic representations [See Video-Tape CV (7/2/92)]. On the other hand, Mrs. M- used the verbal exposition accompanied by some sketches on the board [See Video-Tape MV (7/8/92).

The lesson as a whole; both lessons were analyzed in terms of the following eight aspects:

1. elicitation of students' prior conceptions, was not done by Mrs. M- at the beginning of her teaching, with specific reference to how DNA replicates. In addition to this, while

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describing the Meselsohn and Stahl classical experiment, which facilitated the establishment of the semi-conservative mechanism, Mrs. M- did not elicit for her students' understandings of "heavy isotopes." By contrast, Mr.C- had asked a question, in an effort to elicit for his students' prior knowledge on the mechanism of DNA replication, before he proceeded to teach them about it. Realizing that his students did not know how a centrifuge works, from their previous science experiences, Mr. C- had diverted from proceeding with his lecturing, in order to demonstrate the centrifuging apparatus and how it works.

2. The density of concepts in the two lessons differed to great a extent. On the one hand, Mrs. M-'s lesson seemed to have included a lot of "noise" by going over concepts related to the structure of DNA; structure and types of RNA; and students building a string model of DNA to show "base pairing." These aspects were "noise," because they had been covered and revised amply in a previous lesson [Tape M 2 (7/7/92)]. Hence, not much time was given to explaining fully the new and somewhat difficult concept of the "semi-conservative theory of DNA replication." Time-wise, Mrs. M- spent ten minutes out of the total eighty minutes, which make up a double period, to discuss about the semi-conservative method of DNA replication. On the other hand, Mr. C- had devoted the whole double period to DNA replication alone. During this period, he discussed the three DNA replication theories and he had spent more time on explaining the semi-conservative theory.

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3. The students' activities in both classes differed also. In Mrs. M-'s lesson, the students had been engaged in answering revision questions, listening to the teacher explaining; and in making a string model, which she herself had referred to as "an illustration" (Appendix #17).

Surprisingly, it was observed that the models which most of the students had made were inaccurate because the teacher's instructions to the boys, who had helped her to distribute the pieces of string to the pairs of students, had not been explicit. The result was that some pairs of the students got a correct set of two longer equal-sized pieces of string, which represented the sugar-phosphate backbones of the DNA strands and pairs of unequal-sized shorter strings, which represented the purines and pyrimidines. But the other students had been given sets of equal-sized shorter strings. Hence, the latter students produced inaccurate models with the "base molecules" protruding beyond the DNA strand or with the hydrogen bonds, between the equal-sized purines and pyrimidines, running straight down the middle of the one helical turn of the sugar-phosphate strands, respectively, [Video-tape MV (7/8/92)]. It would appear that the students had used the pieces of string which they had been given, without thinking much about what the different lengths of the pieces of string were supposed to represent.

When this was brought to the attention of the teacher, she immediately stopped the class activity in order to rectify the situation. She then proceeded to show them how the model should be. While doing so, she revised the DNA structure and proceeded to teach about the

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about the replication of DNA molecule. The class never got another opportunity to re-build a correct model themselves during the rest of this class period.

4. **The nature of the homework assigned after these two lessons differed qualitatively.** For homework, Mrs. M- instructed her class to ". . . finish up. Read it again and you can make notes up to where we are. The day after tomorrow, obviously, you will have a test on nucleic acids (Appendix #17). The class had chuckled at hearing this. These students seemed not to take their assignments seriously. For example, they had not brought "the cut pieces" representing the three molecules of a nucleotide, which she had, apparently, asked them to prepare the previous evening, and they were observed chuckling at the assigned homework in this particular lesson. But when the teacher asked them, "Any problem with this?" No one responded.

On the other hand, Mr. C- gave an application exercise, from the results obtained by Meselsohn and Stahl (Appendix #16). During the post-observation conference on this lesson, Mr. C- explained that he had assigned the class this particular problem in order to check the extent to which the students had understood the semi-conservative mechanism of DNA replication and to reinforce that understanding. Thus, Mr. C- had used a concrete real life experiment as a way of assessing his students' levels of comprehension from their interpretations of the given graphs of the experimental results.

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Mrs. M- had not assessed for this. Instead, she had over-emphasized DNA, RNA and their structural differences. The homework for her class was for the students to read, catch up with their note-making, and to get ready for the test on nucleic acids.

Hence, it can be assumed that Mrs. M- uses tests to monitor her students' understanding. While Mr. C- said that he used homework to give his students an opportunity to show whether they have understood what he has taught, by applying that knowledge in solving a problem, which is based on that information. The test will then be used for re-enforcing that understanding.

5. **The levels of students' involvement** seemed to be almost the same, because both the teachers were basically using the lecture mode of teaching. The students in both classes sat passively and listened. The ratio of "teacher talk" to "student talk" was a little lower in Mrs. M-'s class than in Mr. C-'s class, because of the many questions that she asked (Flanders, 1976). That is, there was less verbal students' involvement in Mr. C-'s class. However, the quality of their mental involvement can be inferred to have been vice-versa, from the nature of the questions asked.

6. **The nature and frequency of questions** in both classes left much to be desired.

In Mrs. M-'s class, her lecturing was interjected with repetitious teacher-questions on the structure of a nucleotide; the specificity of purines and pyrimidine base pairings; and difference between the two nucleic acids. The nature of the questions were such that they required recall of one-word answers from the students, who tended to

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tended to chorus their responses as many as eight times (Appendix #17). The teacher seemed not to mind this practice, because she never reprimanded them to answer one at a time, during this lesson.

Only two students asked questions. There were many silences after most of Mrs. M-'s questions. This seems to indicate that her students had not got a clear grasp of the subject matter content, despite the repetitions.

Other observations were that Mrs. M- repeated each student's response. This encourages the rest of the class not to pay attention when another student is responding because they know that the student's response will be repeated again by the teacher. Mrs. M- nominated a specific student, six times, to respond to her question, immediately after she has posed the question (Appendix #17). This practice encourages the rest of the class not to put an effort at trying to come up with their own answers, because the possibility of being called upon to respond will have been eliminated, since the teacher will have already nominated the student to answer her question. Her "wait-time," being zero, does not encourage students' thinking much about whatever she will have asked. On a number of occasions, she was observed not waiting after she had posed a question. Instead she proceeded to answer her own questions. During one of the post-observation conferences with her, she had explained that she becomes impatient because there is so much to cover within the limited time that is available.

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Hence, the students in this particular lesson seemed not to have made much sense of what was being taught, in spite of more questions having been asked by the teacher.

In Mr. C-'s class, there were fewer questions which were asked by the teacher. The first question was a revision of what the students already had been taught, on the three parts of a polynucleotide chain. Two questions were to ask the students if they had understood a section that he had just finished lecturing on, before proceeding to the next section of the lesson. However, Mr. C- did invite his students four times to ask questions, if they had any. Only two students had asked a question. He did not answer all the students' questions himself. For example, he asked other students to try and explain to the student who had indicated that he did not know what "to centrifuge" meant. At that point, he realized that none of the students knew what centrifuging involved and how ineffective a verbal explanation would be. So he just stopped talking and retrieved an actual centrifuging apparatus from the adjacent storeroom and demonstrated how it works. A thousand words would not have been as effective as the demonstration.

In comparison with Mrs. M-, Mr. C-'s "wait time" was a little longer. He seemed not to be in a hurry at all. He paused after each question. He seemed to give students adequate "wait time," which facilitated the mental processing of the response, by each individual student. He did not answer his own questions. In addition to this, he gave additional clues to help the students' figuring out the correct responses. He demanded clarification of vague respo

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7. The nature of learning taking place during these two lessons seemed different.

In Mr. C-'s class, the nature of learning by his students was dominantly receptive because he had lectured extensively to them on the new material, during the greater part of the lesson. So the students in this class had sat and listened more than the students in Mrs. M-'s class. But before he started teaching the day's lesson, not only did he remind his students about the previous day's lesson, on the evidence of DNA as the genetic material, but he also showed his students how the day's lesson links back to what they had discussed before about the replication of chromosomes during the stages of mitosis and meiosis and their already acquired knowledge that the chromosomes are made up of DNA. In this way, Mr. C-achieved three things. That is, his lesson proceeded from the known to the unknown. His students were given an indication of how the new lesson fitted in the general scheme of what had gone on before. Hence, they were told the rationale of that new knowledge. Last but not least, the seemingly isolated concepts were tied together into a meaningful whole, during this lesson's introduction. He clearly stated the objective for this lesson, after the brief reminder of the previous lessons.

Despite the heavy lecturing dosage, which his students got, they seemed to have made sense of the semi-conservative method of

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DNA replication, from the four different ways the concept had been represented to them and by the way the teacher had clearly explained each stage with an illustration on the board, after asking the class what they expected to have happened at each stage. In this way, the students were not just absorbing it all like sponges. They were engaged in thinking as they tried to predict what would have happened at each stage of the replication process; as they would be comparing the actual observation with their expectations; and as they would be analyzing and interpreting the experimental result which were described by the teacher. In addition to this, Mr. C- gave a brief summary of each section of his lesson, before proceeding to the next session. All these strategies contributed to the apparent success of his total lesson presentation in achieving more "meaningful learning" (Ausubel, 1978) among his students.

In Mrs. M-'s class, the students were engaged in revision most of the time. When she was discussing the new material, the nature of the learning was receptive on the part of her students. During Mrs. M-'s lesson, only one of the students asked a question. Only one student had pointed out the confusion caused by the way that she was summing up the 3-5 direction of growth or addition of the nucleotides to synthesize a new poly-nucleotide strand of DNA. With the repetitious revision throughout her lesson, Mrs. M-'s approach seemed to encourage rote learning among her students.

8. The teachers' use of the blackboard was analyzed both quantitatively and qualitatively. The former was done by considering the frequency of each teacher's writing something, drawing an

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illustration, or pointing to a sketch, which was drawn earlier on during the lesson. Both teachers seemed comparable in their use of the board. As many as 28 times were counted for both teachers, when they either wrote the correct spellings of the new terms or illustrated each stage of the replication process under discussion. However, qualitatively, there seemed to be a difference in the significance of what was written on the board, in terms of student learning and understanding.

SUMMARY

The two teachers seemed to differ to some extent in the clarity of their foundational knowledge. This was reflected by their ability to make the distinction between those ideas that are big and ideas that are small and supportive pieces. This, in turn, had an impact on the clarity of their instruction, teaching styles, "wait-time," and also on the nature of questions asked and on the quality of their students' subsequent learning. In this particular lesson, the teaching style for Mrs. M- included her not giving the class a chance to think and attempt to give a response to her questions, i.e., her "wait time" is zero; dwelling on unnecessary repetitions and spending lots of precious time emphasizing trivia and yet she rushed over the difficult concept of "the semi-conservative method of DNA replication." On the other hand, in this particular lesson, the teaching style for Mr. C- entailed his deliberate pacing of his delivery of the lesson. Ultimately, all these varying teaching styles will

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styles will have an impact on their students' cognitive and affective achievements (See Chapter IX, below).

FOLLOW-UP STUDY OF REMAINING SEVEN TEACHERS

After the intensive study, the remaining 7 ZIMSTT A-Level Biology teachers, who were deployed in five different Regions of the Ministry of Education and Culture, were visited, in order to validate the assertions, which have were formulated from the intensive study and from interviews. At each school, a pre-observation conference was held with the teacher using an open-ended interview schedule (Appendix #5.1), in order to clarify his/her responses on the survey questionnaire (Appendix #1) concerning his/her thinking and beliefs about the various aspects of A-Level Biology teaching, which include the subject matter, teaching, learning, students and the milieu. Then the teacher was observed teaching his L6 and/or U6 Biology lesson(s). At least one lesson of each teacher was video-taped and used for the teacher's stimulated-recall during the post-observation conference (Appendix #5.2). The interviews and the observations were very enlightening, in terms of answering the research question of how these ZIMSTT graduates were coping with A-Level Biology teaching and the impact that they were having on their A-Level Biology students' learning.

INITIAL "TEETHING PROBLEMS"

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another. For example, when asked directly to describe what their first year of teaching A-Level Biology was like, one graduate reported that his initial difficulties and problems were:

1. **mainly in the practical** lessons, that is,

> . . . it was difficult to start teaching people **how to use the microscope**. This was a real hassle. For example, **how to estimate specimen sizes** was a real problem; **making accurate observations** and **recording them** and differences between a **drawing** and a **diagram** were not clear (VFI, p. 3) [9/30/92].

These microscopic skills were identified as being either lacking or weak in students on entry to A-Level by two other A-Level Biology teachers (PFI, p. 4 & MFI, p. 2 &3) and one student (GSI, p. 4).

When probed to distinguish between "a diagram" and "a drawing," the teacher explained that

> . . . a diagram is more of a record of what you see and a drawing is more interpretive. Also, students tend to draw all cells when in fact they should, instead, draw a representative section only. This stems from their being unable to identify the representative structures (VFI, p. 3).

This problem of students' drawing skills was mentioned by another teacher, who said that her students tend to be very artistic with their diagrams and drawings.

2. **The problems with the theory** lessons for this teacher were, firstly,

> . . . **the detail** required which was very demanding on the teacher to research. . . . There is **a big gap between O-Level and A-Level** in terms the depth of treatment of the content topics (e.g. the topic of photosynthesis (VFI, p. 5).

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The teachers were finding it difficult to make the students appreciate this detail and to link the different sections of the syllabus. When probed, as to what the effect of this "big gap" on the A-Level Biology students was, the teacher replied that "the students became so overwhelmed by this detail that some even gave up, like one girl in U6" (Ibid.). It seemed that teaching students to learn how to learn and how to integrate the different topics was being problematic for this teacher. When asked what teaching approach the teacher had decided to use in helping his students, he said that he was using the direct approach of breaking this mass of content into small sections and teach the sections individually. But the teacher did not explain what "teaching the sections individually" meant in terms of how he put it all across to the students.

A second teacher described her initial experiences of teaching A-Level Biology.

> At the beginning it was **difficult to interpret the syllabus,** even up to now. Secondly, I don't know my limits. Hence, **I tend to over teach** i.e. give detail over and above what the syllabus needs, because the examination questions ask for deeper knowledge than what the syllabus appears to demand. Now, I am better at it and I have gained some confidence teaching A-Levels. The other problems I experienced at the beginning was with **microscopic work**. . . . **I could not mark the students' diagrams**. I had faced the problem of deciding what marks to award and for what? (BFI, p. 2).

When asked how she had got over these problems, she quickly responded with a smile.

> I got the assistance of other experienced A-Level Biology teachers. What we did was that the other

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> teacher and I would mark the same diagrams independently and then we would compare and discuss how we had allocated out marks (Ibid).

That is, instead of trying to work it out alone, this teacher solicited the help from her more experienced colleague.

The first year was described by a third teacher as having been

> . . . tough because I had taken over the subject with the poorest results. So, I decided to concentrate on Paper I, which was compulsory, with essay questions. What I did was to give my students the previous examination question to write. Then I would go and read the Chief Examiner's Report on that specific Final Exam, and then I would use his comments to assess students' answers, i.e., to see if they are repeating the same mistakes, which were made by those students who sat for that Paper, which were described in the Chief Examiner's Report, and I bring those mistakes to the attention of the class and iron them out [GFI, p. 3 (9/24/92)].

This teacher was concerned about the poor results, which she assumed were due to the students' poor answering techniques on the final examinations. Her findings from the Chief Examiner's report were very interesting. She found out that "generally students are very vague about writing a biological essay." When asked if that was the case with her students and how that was played out, she explained that "they write five pages of good facts but not what was asked for". That is, they gave irrelevant facts, which were not answering the question. What she then did was to give her students copies of the expected answer and her detailed marking scheme, which she then used to train them how to interpret the demands of the question and how to give an concise answer.

The second problem which she faced, during her first year of teaching A-Levels, was in the setting of practical work using past practical ex

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practical examination items, because "the PTC paper had to be supplied by Cambridge and also because we did not have prepared slides in the school" (GFI, p. 4). This shortage of equipment was also felt during her ordinary class practical work. When asked how she overcame this latter problem, she indicated that she had relied on the experienced U6 Biology teacher in her Science Department, who suggested alternatives, after she had asked the U6 teacher, what sort of practical work he had done for this and that concept? She then reported that "This particular U6 Biology teacher was good at improvising. I then could gradually do it by myself . . ." (Ibid). So for Mrs. G-, the problems were centered on **the lack of equipment for practical work**. She had reported that she had no problems with the theoretical aspect of her teaching. That seemed to have been the case with all the other observed A-Level Biology teachers.

Hence, an assertion can be formulated **that ZIMSTT graduates teaching A-Level Biology** feel more confident **in handling theory lessons than practical lessons**.

Another set of teething problems were revealed by Mrs. G- when she was asked what she would change next time she teaches a topic like protein synthesis. She admitted that she had three other problems on this.

> At first, I was not confident. I tended to skip some information during the lesson. Later, I would realize what I would have done and then try to come back to it. Then the lessons were not flowing. . . . Now I am confident and my lessons flow (GFI, p. 16).

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That is, she had the problem of continuity, due to the omissions which she would try and rectify later, after becoming aware of the omission. The second problem was the following.

> The first time, you are concentrating more on what information to present; the impression the students will get; and what students are getting from what you are saying. So much so that thinking of questions in between was too heavy (GFI, p. 16).

That is, the teacher was too pre-occupied by getting the information across and not monitoring, by posing questions during the lesson, to see whether or not her students were understanding the concepts. Hence, she would ask questions to monitor her students' understanding only at the end of the lesson. As she said, next time she would change her presentation, i.e., "the arrangement of information such that, when explaining, I'd pose both my own questions and those from past exams, papers within the lesson" (Ibid). This was not done initially because, as the teacher explained.

> I didn't know how the questions were asked or the type of questions to ask . . . and there were too many things to concentrate on during the planning stage and during the lesson (Ibid.).

So, because of "too many things to concentrate on", before and during the lesson, the teacher did not think about the questions to ask.

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Mr. V- was asked some rather difficult questions during the lesson on the CNS. When he was asked how he felt about students' questions, i.e., if he had an understood policy about questions' :

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questions' from students during lessons, he said, "Usually, I allow questions but I don't invite the questions . . . because it leads to loss of progress and direction" (V. POC, p. 4) [Tape V2 (9/30/92)].

When he was asked why he felt that way, he responded saying, "people can ask anything when you ask for the questions." This was understood as asking questions for the sake of asking questions. He went on to add that ". . . there is a tendency to relate what is being learned in class to what goes on outside in their daily lives and this will "lead to loss of progress and direction." When probed with why he felt there was anything wrong with that, he replied, "We are teaching to cover a syllabus in order for pupils to pass. . . . There is a need to strike a balance between teaching for understanding and teaching for students to pass (Ibid. p. 5).

This prompted a curious question from the researcher on how the balance is tilting in this teacher's A-level Biology class? Without any hesitation, he acknowledged that his balance is tilting towards making students pass. He said that was important for him because "our education system is exam- centered, we are governed by that" (Ibid., p. 5).

SUMMARY

Hence, this data supports the assertion **that the ZIMSTT graduates seemed to have experienced a number of "teething problems" during their first year of teaching the A-Level Biology classes.** These problems included difficulties in their organization and the handling of practical and microscopy work; assessing students' responses, p

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responses, particularly in their practical work; interpreting the depth of treatment of the syllabus topics, in terms of deciding on the appropriate depth of coverage; how to improvise for the missing apparatus; subject matter representation; not having the subject matter knowledge on the Option Topics; not asking questions during the lessons, which were taught mostly by the lecture method, which focussed more on knowledge transmission than on assessing for their students' understanding.

The second assertion is that both the nature and the quantity of the teachers' and the students' questions seemed to be problematic. This assertion was based on meager evidence and thus needs to be studied further.

ADVICE TO NEW A-LEVEL BIOLOGY TEACHERS

Useful suggestions were given by the ZIMSTT graduates, based on their experiences teaching A-Level Biology, for any new B.Ed. graduate who gets deployed to teach A-Level Biology soon after graduation. Their suggestions included the following.

1. Study the syllabus before the school begins and identify areas where one needs assistance.

2. Group the topics in the way you think they link.

3. Talk to experienced teachers and find out what they do, i.e., how far they treat the topics; and how to teach a topic which you might understand but doubt how to best to pass it on to students (BFI, p. 13).

Notice "the knowledge transmission" paradigm that is implied by "how best to pass it on to students." This teacher reflects the need for a te

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need for a teacher to have "pedagogical content knowledge" in addition to the "subject matter knowledge."

> 4. Consider the Options early. Discuss with the students to come to a consensus of which Options they want to do with reasons. . . . This decision must be made by the end of their Lower Sixth Form year . . . (BFI, p. 13).

When asked why the students' input in the choice of which Options to be done was necessary, her reason was the following.

> It's important to involve students and come to an agreement, because if it is what they want they will work hard. . . . Because it is something that they have chosen, there will be more commitment on their part. . . . They'll have to live with it . . . and they'll work hard (BFI, p. 13).

The fourth piece of advice was given by a second teacher, who said that he would advise the new ZIMSTT graduate A-Level Biology teacher:

> 1. to know and understand (i) the depth of the A-Level Biology syllabus requirements; and (ii) the practical requirements of the A-Level Biology Examination by inquiring from other experienced A-Level Biology teachers;
>
> 2. to get past Practical Examination Papers and try them himself before giving them to his students, in order to expose and to give his students lots of practice in reading and following written instructions;
>
> 3. to read previous the Chief Biology Examiners' Reports from Cambridge (Appendix #25) on how students answered generally and on particular topics;
>
> 4. to use lots of resources other than the students' prescribed textbook in order for the teacher to be above the situation, all the time, so that he can give the students the depth that is required (DFI, pp. 11 & 12).

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All the teachers stressed the need for the prospective A-Level Biology teacher knowing the syllabus requirements and consulting with experienced colleagues and the Chief Examiners's Reports for indications of where students have difficulty and how to approach the work. It is interesting to note that one Science Education Officer used almost the same expression, when he stressed the need of the A-Level Biology teacher to read widely so that "he is always above his students' level of understanding" (A.EOI #1). Similarly, the value of referring to past A-Level Biology Examination Papers and the Chief Examiner's Reports on students' performance and the practice of consulting with more experienced teachers was also mentioned by all the other Science Education Officers and the teachers who were observed and interviewed. This way, the new teacher derives a lot of insight early, of what the syllabus is all about in terms of interpretation; depth of treatment; useful practical work; and general pedagogical approaches for the different topics; and what to expect from the students especially their weak points and how to rectify them vis-a-vis the examination requirements. In other words, seeking this assistance and undertaking all these initial explorations prevents one from floundering in the dark, with the possibility of not helping the students at all! Hence, this practice engenders "the norm of collegiality" as opposed to the "norm of isolation" (Bettencourt & Gallagher, 1990 & 1989). The teachers seem to be in agreement regarding the futility and fruitlessness of tackling the A-Level Biology syllabus topics piecemeal and at random.

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On the point about the choosing of the required three Options out of the given five, the practice varied. Some teachers consulted with their students (for example, BFI, p. 13) while other teachers chose unilaterally (for example, MFI, p. 13).

The advice suggested by a third teacher, who by the time the interview was held, had been teaching A-Level Biology in both L6 & U6 classes for three years, was the following.

> 1. The new A-Level teacher must have adequate reference books to supplement the main textbooks. With Options, it is difficult to get the references even though the titles are actually given in the syllabus document.
>
> 2. He must think of the practical work for the rest of the year and plan ahead. Without that, it is difficult to purchase what one needs on the spot. Therefore, assembling everything at the beginning of the year will avoid delays. As far as practical work is concerned, I was rushing around. At each topic, I'd check in the laboratory only to find there's nothing. Ordering the materials then would mean another month before you can do the practical work, and these will then be done at times when they are out of phase with the theory.
>
> 3. He must familiarize himself with whole syllabus, to know what he is expected to cover in the course of the two years. . . . If there is no school syllabus, then he must break down the prototype syllabus into Terms, which becomes the school syllabus. This enables him to check on his pacing in order for him to leave some weeks at the end for revisions (NFI, p. 20).

This teacher's advice was focussed on the new teacher having a thorough knowledge of the syllabus; planning and ordering of materials way ahead of time; and securing of reference materials to supplement the textbooks and for wider reading.

In addition to doing all this, a fourth teacher said, "the new A-Level Biology teacher must collect samples of past final examination

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examination papers, which he will use to get an idea of how much emphasis and detail the syllabus is asking for, after reading each topic (MFI, p. 13).

This raises the question of the extent to which the examinations are driving the instruction. That is, is all this reference to past examination papers an indication of teachers teaching their students for passing these examinations rather than for understanding?

A fifth teacher gave the following "cardinal points" that the new ZIMSTT A-Level Biology teacher must bear in mind and take note of the following.

> Firstly, **learn about the students' learning characteristics**. For example, A-Level students are generally well motivated and all that they need is for the teacher to be able to sustain that motivation. It might fade away if the teacher mishandles the subject (PFI, p. 18).

When asked how one "mishandles the subject", the teacher explained how this can be done by

> . . . disorderly presentation of data; being unsure of himself; being unprepared and allowing students to divert him from the course of his lesson. However, the teacher should not stifle the students' questions but should let students know the relevance and usefulness of their questions in relation to the lesson (Ibid.).

He went on to say that mishandling the subject also includes

> . . . the practice of avoiding certain topics and practical work just because they are difficult for the teacher and students will become quickly aware of that (PFI, p. 18- 19).

When probed for other student characteristics that the new A-Level Biology teacher must bear in mind, this teacher added one more.

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> The A-Level students are getting to be mature as young adults and that they can, therefore, be impressed upon if one puts the right values in them. Hence, the teacher must make sure that he contributes to their emotions and feelings, as far as citizenship and personal development is concerned. . . . The teacher must remember that he is not the only one responsible for this development. He needs to work towards the same values as the parents (PFI, p. 19).

That is, the teacher is to facilitate not only the cognitive but also the affective development of these easily "impressed" and "young adults," in agreement with their parents' values.

> **Secondly, the teacher must know his subject matter-knowledge** beyond the level that he himself acquired during the B.Ed. program. He must be someone who keeps abreast and keeps himself well-informed by very wide reading; watching T.V. educational programs and documentaries; and attending some of those seminars and workshops which are offered by the Museums and by the Zimbabwe Association for Science Education (ZIMASE) (PFI, p. 19).

When asked why this was so important, the teacher pointed out how knowledge was not like a coin, which does not change as it is exchanged. It is constantly being revised and changed. Hence, the need to keep abreast or else one imparts obsolete knowledge to his students.

> **Thirdly, the teacher himself must develop a positive attitude towards the subject** i.e. he must like the subject and treat it as part of himself (PFI, p. 20).

When asked how that plays out, he replied, "when you go home, practice some of the things you teach. Implement what you teach. Teach by example."

The point this teacher was making was that students will see through their teacher and his own attitude towards his subject will be unconsciously projected on to the students. This reminded me of what one of

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what one of the ZIMSTT graduates said about practical work which he had regarded as "time-fillers" during his B.Ed. studies and how "this negative attitude had rubbed off to my A-Level Biology students." (VFI, p. 18)

Mr. P- went on to add that the new A-Level Biology teacher must be confident as a teacher. He gave his own example to illustrate how the uncertainty, which had bugged him at the beginning, was due to his fear of not remembering the B.Ed. course contents. This fear arose from the teacher having taken up A-Level Biology teaching only after teaching O-Level Science for two years following his B.Ed. graduation. He said, "This confidence was boosted by a thorough revision and wide reading and also by asking for assistance and hints from other experienced A-Level Biology Teachers" (PFI, p. 20). Lastly, Mr. P- pointed out the following.

> The new A-Level Biology teacher needs to know the environment of the learner, of the subject, and of the school, from which to pick information and examples, for use as a Biology teacher. The tendency is to keep Biology in the classroom, resulting in the separation of school science and home science (PFI, p. 20).

This teacher was observed using the school orchard effectively to show the grafting that was done on lemons and oranges. He also illustrated how the knowledge of his milieu had contributed to his attempts to help his students to learn, understand, and apply what he was teaching them. For example, he had made use of the facilities in their local environment, like The Museum of Natural History and the center for The International Crop Research in the Semi-Arid Tropics (ICRISAT), as resources (see ChapterIV, above).

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SUMMARY

Hence, this data supports the assertion that based on their initial "teething problems," the ZIMSTT A-Level Biology teachers seem to have developed coping strategies, in order to facilitate smoother transitions for them, as they moved from teaching O-Level Science to teaching A-Level Biology classes. These coping strategies were offered as advice to the recent ZIMSTT graduates, who are going to teach A-Level Biology for the first time. They included: studying the syllabus requirements early; getting pedagogical assistance from experienced colleagues on areas reckoned to be problematic; studying past final examination papers and the Chief Examiner's Reports on them; planning for practical work ahead of time; knowing the subject matter knowledge, the milieu, the learner, the students' learning characteristics; being prepared and presenting materials in an orderly fashion; projecting a positive attitude towards the subject which one teaches; and referring to more resources than just the textbooks, so that their students may do likewise.

Having made the necessary adjustments, the ZIMSTT A-Level teachers seemed, on the whole, to be coping with their new responsibility of teaching A-Level Biology classes.

This study has also underscored what research has said about several aspects which are related to the practice of teaching. For example, with regards to the benefits of "breaking teacher isolation" leading to teachers talking and consulting with their colleagues about instruction (Bettencourt & Gallagher, 1990 & 1989); and about what knowledge base teachers need to teach (Ball &

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McDiarmid, 1990 & 1989); the fact that teacher development is an on-going process; and that the teachers must continue to be learners themselves (Ball & McDiarmid, 1988 and Feiman-Nemser, 1983). That is, if teachers are to increase in their effectiveness, it is not enough for them "to keep a chapter ahead of their students" (McDiarmid, et al., 1988). They also need to continue widening their knowledge of the subject matter, students, general pedagogy, learning, their specific subject matter pedagogy and milieu.

There is an apparent agreement among the ZIMSTT A-Level Biology teachers regarding their "advice" for new ZIMSTT graduates deployed to teach A-Level Biology classes. Implicit in this "advice" is the realization that knowledge is not static. Hence, the expressed need for teachers to continue reading widely in order to keep abreast and to be well- informed in their subject of specialization. This is contrary to the view expressed earlier of knowledge "as a body of unchanging facts." The teaching style that is implied in the teachers' "advice" is not one of "giving information" but of facilitating meaningful learning by "presenting material in an orderly fashion," "allowing students to ask questions," and by "referring students to more resources" other than just the text books. The learning that is implied is active sense-making rather than passive reception of information. As Mr. P- contended earlier knowledge or information was not exchanged unchanged among people like "coins with specific values" (PFI, p. 6).

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O-LEVEL AND A-LEVEL TEACHING COMPARED

All the A-Level Biology teachers acknowledged that teaching O-Level Science and A-Level Biology classes were two different ball games. They found O-Level science teaching to be relatively easier, in terms of the amount of detail of the content and demand of practical work required. Whereas, A-Level Biology teaching was described as

> . . . more difficult because its practical work demands a lot of skills. For example, in microscopy work, one has to record by drawing what was observed and in physiology there is more emphasis on setting up of experiments. Students should know what variables are and how to control them . . . and how to make valid comparisons between different experiments. In the theory part, there are too many fine details required and you cannot teach without having referred to a number of sources (VFI, p. 1).

In addition to the demands of more content and practical work, the need for thorough preparation for both the theory and the practical lessons was also emphasized by all the teachers who were interviewed (BFI, DFI, PFI, MFI, CFI, GFI, NFI, VFI and MiFI). One teacher mentioned that A-Level teaching is very demanding because

> . . . I have to be organized because A-Level students are adult students. The lesson should actually flow by having a thorough lesson plan of work and students can judge whether the lesson has proceeded well or not. A-Level requires a well-equipped laboratory because it has a lot of practical work to be done. The teacher must always be charged like an 'ever-ready battery' ready to answer their questions. But sometimes you can give a satisfactory answer there and then. At other times, since they are mature students, you can tell them to go and find out. But before you continue with your next lesson's teaching, you should discuss their findings and then give your own input (GFI, p. 5).

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> The A-Level teacher is a guide because the teacher cannot fill in all bits of information. As a guide, he needs direction because it involves interpreting the syllabus accurately. To do that I initiated **the Manicaland A-Level Biology Teachers' Association**. All schools are members except one. . . . There are altogether nine A-Level schools in Manicaland and two are private schools (MiFI, pp. 1-2).

This teacher felt that the role of the teacher is to be a "guide" because he cannot fill in all of the information. He perceives a guide as someone who has a sense of the direction to take. Having this sense involves "interpreting the syllabus accurately." To do this, the teachers assist one another in their Manicaland A-Level Biology Teachers' Association. When asked what sort of activities take place in this Association, the teacher explained.

> We use past exam papers to guide us on scope; seminars to help students to communicate their ideas and to diversify their experience; generally, to motivate them, because if you are going to stand in front of a large group, you can't go there blank. You have to look up information and do a good presentation. To make sure that we pay attention to detail during the course of the years we have seminars directed at certain topics on a given date. And in any one term we are talking of about 3 Students Seminars and 3-4 meetings for the teachers. The A-Level Students Seminars are an extension of the A-Level Teachers' Association (MiFI p. 2).

It sounds as if the varied activities that take place in the Students' Seminars do achieve a number of goals or objectives. These goals include teachers getting guidance in the scope of the syllabus topics and their students being motivated by the diversified experienced and the students developing their communication skills. When asked how these students seminars operate she explained that

> Each teacher brings his students to these seminars . .

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> each of the nine teachers has 20 students, we are talking of 180 students. These are divided into three groups and each group goes to one lab. The seminar chair people would have prepared a set of questions complete with answers. Then at times we have a quiz or a straight presentation by a student with questions from the audience for the students to respond to. We vary these activities really. Just before a final exam, we had a seminar on practical. The teachers had a meeting first to discuss what we feel are the short-comings of the students, as shown in the mid-year practical examination and in any other Chief Examiners' reports we have seen regardless of the subject as long as it has something to do with practical. We actually get information from there on where students go wrong. Recently, we had a seminar with Chikore High. They came here in the morning and did their practical. I don't know them. But I supervised them. But it's likely that I will pick up their mistakes more easily than their teachers (MiFi, pp. 1-2).

That is, Mrs. Mi- is being used like an External Examiner. Each student's experience is thus diversified by doing the practical work in unfamiliar laboratory surroundings and by having a different voice giving instructions. The different teacher's body language is also not familiar to these students. Hence, experience is diversified in terms of interaction, as well as in terms of

> . . . exposure to materials, which are not available in their own school, but are found at this other school, e.g., using bio-viewers and A-Level biostrips which are equivalent to the conventional or traditional slides required at A-Level (Ibid., p. 3).

When probed for other advantages of this practice of seminars and of mock examinations, she said,

> . . . students develop versatility in manipulating information given in a question. It should help them to adjust from one question to the other, i.e., . . . be able to switch on and off, as they change their frames of the mind. This, they have to do quickly, because they only have 2 1/2 hrs. in the examination. I always feel that at the end, practically, there is nothing to stop you from giving questions which require the

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> students to stretch himself a little further. This will give him the right impression that the A-Level syllabus is not an end in itself (Ibid., p. 3).

That is, the teachers are using these seminars and mock examinations for the purposes of giving students opportunities and practice of sharpening their thinking skills. When asked to give an example of this extension, Mrs. Mi- described how after the work on meiosis, genes etc. she had posed a question to the students that

> . . . with this in mind, and the present drought, how would you use this information to produce a drought resistant crop and when best can you manipulate this or that etc. Whatever it is that we are doing, we are putting whatever they learn in class in the context of society, and at the same time, making them understand that they are not getting all the knowledge about this lesson. We are simply getting the basics. We should stress that the syllabus is not an end in itself. It will prepare you to appreciate further knowledge which you will get from other sources (Ibid.).

This teacher seems to be stressing three points here. First, students are made to realize that what the teacher teaches them are just the basics. Second, what is being taught has wide social applications. Lastly, they should get more information from other sources. When asked what these "other sources" were, she indicated that, "I'd like to get such magazines as the American Scientist /or is it Scientific American, National Geographic etc." (Ibid.). She went on to explain how articles from such magazines might help.

> If you did a topic and then gave them a question to appreciate that there is more to this than what they have learned it in class. When you gave them an article, they will get satisfaction that we are not just looking at something that is abstract out there, or that Mrs. Mi- didn't have much to do with us and wanted to keep us busy. If they had an article, they will know there is something really applicable about it (the topic) (MiFI, p. 4).

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So, one "other source" from which further knowledge is derived are scientific articles from scientific journals and magazines. Such articles describe real-life applications. Hence, the students will not, hopefully, get the impression that they are getting knowledge per se or that they are just being kept busy. It is interesting to note that this teacher wanted more journal articles on research which is producing or constructing and using scientific knowledge rather than articles on research on science education. Teachers do not seem to be concerned about pedagogical aspects their teaching practices. Issues related to content seem to be foremost on their minds compared with issues of how best to teach this content to this particular group or class of students.

This practice of giving students handouts from magazine articles, or merely referring to them, was also observed on a number of occasions with another teacher. On one occasion, he was teaching about "Variation and Natural Selection." One student had asked something about extinction. The teacher quickly retrieved an article on "The Cheetah In Genetic Peril." The teacher read aloud this article to the students. A very lively and interesting discussion followed. A lot of unintentional teaching and learning took place during this lesson, as a result of the class trying to answer the arising questions raised by some of the students and from the teacher [Tape C 14 (7/16/92)]. In another lesson, the magazine article: "DNA: The Blueprint For Life" had been duplicated and distributed among the students. The teacher had effectively used this article during the lesson, by focussing the students' attention to its rel

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Hence, this data supports the assertion **that the ZIMSTT graduates seem to be in agreement with all their interviewed students in perceiving the A-Level Biology syllabus as being more demanding, than the O-Level Science Syllabus,** in terms of its conceptual depth, the practical work, and in terms of the amount of independent extra reading which the teachers and their students have to do.

JUDGEMENTS AND DECISIONS

Teaching by its very nature is an intentional activity. Therefore, teachers ought to be deliberate in every thing that they do in relation to the teaching and learning that they are responsible for. Initially, all the observed ZIMSTT A-Level Biology teachers admitted that they did not think about the judgements and the decisions that they make during their planning phase, and during and after their lessons. This does not mean that no decisions and judgements are made. It can be inferred that the decisions which are made were "immediate" and made "without the teacher's conscious awareness" (Eggleston, 1979). However, when the teachers were probed further, they could describe how they had made their various decisions and judgements during the different phases of their teaching practice.

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PLANNING DECISION

Analysis of the teachers' interview responses on what their planning decisions were and what they based them on, shows very close similarities among them. For example, when one teacher was asked what decisions he had made when he was planning for the lesson on the topic of "Protein Synthesis," he said the following.

> I looked through the syllabus for the concepts to be covered; decided on the order of dealing with the concepts, i.e., high concepts must be covered first and which to come later. To do this, I also considered the students' assumed knowledge, i.e., starting from the known to the unknown. In the case of Protein Synthesis, I had to go over what they knew of the DNA molecule from the O-Level Science Syllabus before teaching its replication (unknown to them), leading on to the process of protein synthesis [Tape C 21 (7/22/92)].

That is, this teacher makes judgements and decisions on the scope and sequence of the material. He starts off from where the students are, by taking into account their prior conceptions. He then maps this on to what is stipulated as the syllabus required level of knowledge and understanding.

He went on to describe how he divided the material into terms, weeks, and individual lessons. This process is done during the planning stage, at the beginning of the year. It is called "scheming" and is done in a "Scheme Book." The column headings across facing pages were "Week Ending; Topic; Teaching Units/Concepts; Aids/Sources; Apparatus; Class Activities/ Assignments; and Comments." This format of the Scheme Book was the same for all the observed teachers, in all the regions. The only difference that was noted was more specificity in terms of the content/concepts which were to be dealt with in a particular lesson, which w

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which was demanded by one Science Education Officer (P.EOI #5, p. 3). Other Education Officers seemed to have been satisfied with their teachers just stating the concepts/content which were indicated for each week and not specifically for each lesson.

Thus, this teacher's decisions were on the scope and sequence of the materials. These decisions were based on the syllabus content requirements and the students' background knowledge. In deciding on the sequence, the teacher ensured that at least "there is a flow to give a logical account or development of the process to avoid confusion" (CFI, p. 2).

The teachers also mentioned the judgements which they have to make in order to ensure that there is **continuity and linkages between their lessons**. For example, Mrs. B- mentioned how she makes judgements about the syllabus topics, in terms of which ones are linked to which, in order to sequence them accordingly. During an interview with four of her students, one of them commented, "Mrs. B- links the Biology topics. She is putting it as a single subject to show us that everything is linked" (BSI, p. 4).

Appreciating this practice, this student had added, "If you take Biology as one topic, and you do not divorce one topic from one another . . . it becomes easy, because some of the questions you get or problems you are dealing with, you have to know the information, which you learned when you first came here . . ." (Ibid.).

Using the example of topics on "enzymes" and "proteins," the students reported how Mrs. B- had made them recall their Term 1 work, that proteins were denatured by heat. Now that they were doing the n

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the nutrition topic and were learning that enzymes are protein in nature, the students were able to deduce that enzyme activity is affected by temperature. Later, the students did experiments to verify this.

While describing how their teacher helps the student to learn and understand what is being taught, one of Mrs. B-'s student indicated that "If there is a chapter we did long time before, which is linked to this chapter we are going to do, she asks us questions about that previous chapter, to see if we remember and to see if understood it" (BSI, pp. 3-4).

This way, this teacher, starts with what the students know and proceed to the unknown, and also to try and forge some continuity and linkages among the lessons.

The next decision was on how much time he allocated to each topic. The teacher responded with the following.

> I budget for the time to make sure that I don't spend unnecessarily too much time on each topic. Then I decided on which textbooks and magazine articles to refer my students to read more about the topic. Finally, I decided on the activities and these I distinguish between teacher activities and student activities. For this, I draw upon the textbook and my reflection of how I covered that topic with a previous group and make the necessary changes in my teaching approach techniques to try and be more effective with the present group. On this topic of protein synthesis, it was mostly teacher talk and asking questions because of the nature of the topic itself. Other choices are among various approaches, which include: teacher lecturing; students' written work; teacher-student question and answer; dictating notes versus students making their own notes; practical work to be done as either teacher demonstrations or individually or in small groups; students' reading assignments and giving lecturettes; having guest speakers; and field trip visits etc. (Ibid.).

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That is, the teacher decides on the nature of the activities and approaches to use for a given lesson. One teacher stressed "the need for balancing these activities for variety and for motivation" (PFI, p. 4). Variety is essential in order to accommodate the different students' learning styles, and also to avoid the monotony of hearing the teacher's voice all the time. All these approaches were observed being implemented, with varying frequencies, by the nine observed ZIMSTT A-Level Biology teachers. Each approach has its own pedagogic implications from the perspectives of the teachers, students, Headmaster's and Science Education Officers.

One teacher explained how the nature of the topic, and the availability of time and of audio-visual aids influenced the decisions which he made. For example, after one observed lesson, on "Tobacco Abuse," he pointed out that he had chosen between having the diagrams already drawn on the overhead transparencies and drawing the diagrams as the lesson progressed. When asked what difference this makes, he replied "drawing diagrams during the lesson takes time and the diagram may not be that accurate because you are rushing. Whereas, a pre-drawn diagram on an overhead transparency is accurate and they can still follow your teaching, stage by stage" (PFI, p. 4).

Another decision related to the treatment of the concept that this teacher considered was the depth of treatment. He indicated that "this is difficult to decide because the syllabus is not that specific. Recommended textbooks do not give an idea of how much one should cover. . . . Past exam papers help too" (PFI, p. 5).

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This use of past examination papers and other tests was reported by all the other observed teachers. These teachers explained why they used past final examination items for their tests after each topic, or for their mid-year mock examinations, instead of making up their own tests. They said that they did it

> . . . as a measure of the expected standard (VFI, p. 7).

> . . . because the final examination papers have a balance of the evaluation objectives of recall, comprehension, analysis etc. Students get to practice the final examination format (NFI, p. 5).

> . . . because the past papers guide us on scope (MiFI, p. 2).

Knowledge of students abilities was also an important basis for deciding on the time allocation and depth of treatment of topics by the teachers. One teacher said "if the concept is easy, we don't do too many activities centered around that concept" (MFI, p. 1). Moreover, knowledge of the students, in terms of who are fast and who are slow in comprehending, also influenced the teachers' decision of what content and scope was suitable for the various students. The slow students were given the bare minimum of the syllabus. The extra activities and exercises were planned for the better able students, in order to stretch their thinking capacities. Teachers made choices and decisions about the appropriateness of the assigned exercises for the different students in their classes.

Decisions on how the subject content will be represented were also made by the teachers, by choosing between the use of models, analogies, illustrations, charts, films, diagrammatic representations, and listing main points of the topic etc. depending on the

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on the difficulty of the topic and students' learning styles/modes. For example, one teacher said,

> . . . when deciding on the teaching method, strategies, and approaches for this lesson, I chose the teacher-talk broken up by the writing of the main points about the topic on board, which the students will use as a guide when they go and write their own notes later. They will be knowing what is important (Ibid., p. 6).

Surprisingly, a majority of the teachers did not seem to be giving much thought to the questions, which they were going to ask their students, during the following lesson. However, a few of the teachers mentioned thinking about the questions, during their planning stage. The role of these questions was perceived as "to enhance students' understanding" (VFI, p. 1) and "to stimulate student thinking" (GFI, p. 10). With regards to these questions, decisions were also made about not only their nature (objective multiple items, structured items and/or extended essay items), but also "about which will be tackled orally, in groups or in class sessions, and which will the students answer individually, as written exercises, in class or as homework" (PFI, p. 13). Judgements and decisions were made with regards "to the nature of the practical work and the materials needed to concretize the concepts" (DFI, p. 1).

All these planning decisions, judgements and choices were based on a variety of criteria. These criteria included considerations of the students' development stages, i.e., their levels of understanding; the substantive nature of the discipline; the stipulated syllabus requirements; the difficulty of the concepts;

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students' learning styles; the availability of time, equipment and other resources; the student' ability; the difficulty of the work; the nature of the topic; and the nature and amount of appropriate guidance required.

DECISIONS MADE DURING THE LESSON

During post-observation conferences, the teachers found it difficult to state what decisions, judgements and choices they had made during their lessons. But during the stimulated recall sessions, these teachers found it easier to recall, describe and explain the judgements and choices, which they had made, after the researcher had pointed out some specific instances during the lesson. One teacher pointed out that during the lesson, "One is constantly monitoring whether students are following or whether they are experiencing difficulty, based on their responses and body language, e.g., their facial expressions" (MFI, p. 1).

That is, a teacher is always making judgements about his students' levels of comprehension, as the lesson progresses. If they seem not to be following,

> . . . then one has to make the decision of whether to digress and dwell on this difficulty, that they are experiencing. If you do this, the planned lesson is not completed and it spills over into the next lesson. Hence, the teacher is faced with a subsequent decision of how to make up for the time (DFI, p. 2).

None of the interviewed teachers made any reference to making any judgements and decisions related to management issues. It seems that these teachers are not faced with discipline problems in their classrooms. This is consistent with the report that most teachers gave ab

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gave about their students being mature, disciplined and highly motivated.

DECISIONS AT THE LESSON'S END

All the teachers reported that they make decisions on how to assess their students' achievements. Depending on the nature of the topic and time available near the end of the lesson, the assessment was either through students giving a full verbal summary of the lesson, giving just the main points of the lesson, written homework, application exercises, or tests.

DECISIONS MADE AFTER THE LESSON

During the interviews, all the teachers said that they evaluated how well the lesson had progressed, i.e., how effective the approach which they had chosen to implement during the lesson had been, based on their students' reactions during the lesson, and the students' performances on the assigned homework exercises and on the tests, which are given at the end of each topic. These evaluations are recorded in the teachers' "SCHEME BOOK" under the "COMMENTS" column. On these comments, one Science Education Officer said the following.

> Generally, teachers do not think until a problem is exposed. Teachers don't think deeply about how a lesson has progressed . . . . This weakness is reflected in their evaluation comments of their lessons. They tend to give glorified comments like 'the lessons progressed well and the students/class understood except Jane or Bill. Teachers are not thinking about their shortcomings and how to correct them, which is a negative aspect towards teacher development (P.EOI #5, p. 5).

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That is, an analysis of these comments revealed global statements such as "Lesson progressed well;" and "The student/class understood except Jane or Bill." At this level of generality it is difficult to assess the reliability of these evaluations.

In those situations where a teacher identifies some problems of comprehension remedial action will be needed.
The nature and extent of the required remedial action needs to be decided upon in terms of its appropriateness. This also requires teachers to judge when to give these additional experiences to those students who may be at risk, or who may be slow in getting what is being taught.

SUMMARY

Hence, the judgements and decisions, which these teachers are making, during their planning and teaching sessions, are with regards to **(i) the students' backgrounds**, that is, in terms of their prior knowledge, ability, motivation and interest in the subject; **(ii) the content**, in terms of what specific topics to teach and the scope of these topics, that is, its depth and width; **(iii) the sequencing of topics**, which will include the rearrangement of the syllabus topics, in order to forge linkages between topics, and in order to ensure a logical conceptual development, by proceeding from the known to the unknown; from the simple to the complex; and from the concrete to the abstract etc. **(iv) the subject matter representation,** that is, what diagrams, models, illustrations, films, real-life specimens, exposition, analogies graphs, etc. to use.

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use, in order to cater for the different learning styles of the students; (v) the teaching approaches and techniques, that is, teacher-centered or student-centered; group or individual work; focussing on theory or practical; written or oral; demonstration or hands-on etc.; (vi) the time, that is, its allocation per topic, when the activity is to be done, and its pacing; (vii) the questions to be asked, that is, whether they are open or closed; (viii) the students' comprehension, that is, whether or not the students are following what is being taught; and (ix) activities to be done, that is, their nature, considering the time available, and the relative balance between the teacher's and the students' activities.

After the lessons, the teachers seemed not to be reflecting much on their practice and yet this is essential in their profession (Kennedy, 1987). The teachers were pre- occupied with planning for the next lesson. They admitted to not taking time to reflect on aspects of their practice, other than how well the class had understood. Their evaluating comments in their scheme books were not at all self-critical nor were the comments very illuminating on the extent of the their students' understanding. The latter observation was also made by the Science Education Officer (P.EOI #5, p. 6). That is, the teachers seem to be giving the impression that they do not reflect on their lessons critically. During a discussion of this observation, Douglas Campbell pointed out that one needs to distinguish between what the teachers can do from what they have too limited time to do. Hence, the general evaluative comments written in the Scheme Books by the teachers may be due to teachers feeling that th

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that they do not have time to spare for detailed critical assessments of their lessons, and not because they do not know how to evaluate their lessons.

SUPERVISORS' PERCEPTIONS OF TEACHING PRACTICES

Teachers in Zimbabwe are supervised internally by the Heads of each subject's Department and by the Headmaster and/or his Deputy. The title "Principal" is for the Head of a Teacher Training or Polytechnical Colleges. Externally, the monitoring is done by Regional Education Officers (E.O.s). Each E.O. monitors the teaching and learning of his/her respective subject, in all the schools, within his/her respective Region of the Ministry of Education and Culture. This supervision does not preclude the teachers having autonomy and latitude in how they teach the prescribed syllabus content.

During the study, an effort was made to interview all these supervisors. What was noted was that all the nine teachers being studied were also the Heads of their Science Departments. Hence, data on their teaching practices was derived from their self-reports on the survey questionnaire (Appendix #1, Item #15), and from their interviews and post-observation conferences (POC) with the researcher (Appendices #s 5.1 & 5.2).

Secondly, among the school Headmasters, only one Headmaster, one Headmistress and one Deputy/Headmaster were available during the school visits for interviews. The rest of the Headmasters were away for training to become the 1992 CENSUS Supervisors. The Deputy

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Headmasters, who were the Acting-Headmasters then, could only provide information about the school because they had never observed the ZIMSTT graduate in their schools teaching A-Level Biology classes.

Thirdly, only seven out of the eleven E.O.s were available for interviews. Among the four E.O.s who were not available, two were involved in the training of CENSUS Enumerators; one was at a National Science syllabus Panel Meeting, which was being held out of town, and the fourth E.O. had just gone on his annual leave of absence. Hence, the interviewed seven E.O.s and three Heads provided different perspectives of how the ZIMSTT graduates were coping teaching A-Level Biology classes.

THE SCHOOL HEADS' PERCEPTIONS

When the Heads of Schools, that is, the Headmasters and the Headmistresses were interviewed (Appendix #5.5), they were first asked what their perception of "an ideal A-Level teacher was", and then to describe, against this ideal, their perception of the ZIMSTT graduate who was teaching A-Level Biology in their school. Their responses were not only very enlightening, but also refreshing to hear. This was because they described a number of critically important aspects about teaching which practicing teachers, at any level of education, should develop and enhance in order to strive for greater effectiveness and excellence.

The first characterization was given by the Headmistress, who had many years experience of supervising teaching in her capacity as a Dep

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a Deputy Headmistress (six years) and as a Headmistress (ten years). Being an English major, she also had been the Head of the English Department, before getting promoted to become a Deputy Headmistress. When asked what the characteristics of an ideal A-Level Biology teacher were, this Headmistress said the following.

> I feel that they should show much more **scholarship, improvising and initiative**. They should always **do research** on some topic to produce a good lesson. I feel that their teaching practices should be **more practical-oriented**, with all the good facilities, we have in this school. Classroom discourse - the teacher must **express himself clearly** . . . and one must be able to follow the teacher's argument (J.HI, p. 3).

That is, she stressed scholarship, ability to improvise, having initiative, always researching, practical-oriented lessons and clarity of communication between the teacher and his students. The Headmistress went on to clarify what she expected of a good A-Level teacher by describing two types of teachers. She said the following.

> On the one hand, you have a teacher with not only the subject matter knowledge but **the drive and energy to stimulate the students' love of the subject**, because he **prepares to produce a lot of resource materials** for both the students and for the other staff in his Department. The teacher uses these materials regularly and positively (Ibid.).

Here, the Headmistress is stressing that a teacher needs subject matter knowledge, in addition, he must have a lot of "drive and energy to stimulate students' love of the subject." Jokingly, the Headmistress said that she personally subscribed to various journals which she brought to school to supplement the few that are brought by the teachers. She reported that she even brings some of them to school but her suspicion was that she was the only one who read them!

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The Headmistress went on to describe the second type of a good A-Level teacher, as one who does what has been described for the first teacher above, but in addition, "she loves her subject to the extent that at home she is planning, and on the way to school, she is on the look out for and notices relevant resources for teaching wherever she is" (J.HI, p. 4).

This characterization reminded me of Father Greg Croft, a former physics teacher at St. Ignatius College; and three former science education officers, i.e., Mr. Kabs Kabayadondo (Harare Region), Mr. Les Cross, and Mr. Rob Gordon (Matebeleland Region). While assisting all of them during the in-service workshops, which they had organized for the science teachers in their Regions (Harare and Matebeleland, respectively), I observed how each of them had the knack of improvising. They always collected and brought in "junk" which they imaginatively transformed, with ease, into usable apparatus with which they would demonstrate the teaching of some difficult scientific concepts most effectively. These three science educators symbolized my ideal science teachers.

The Headmistress then went on to point out that "in doing this, these teachers helped their students to apply the taught information by making it relevant to life" (Ibid.). Then, citing two examples of these two types of teachers, she indicated how:

> "one had started off with limited knowledge but prepared herself thoroughly, revised and used past examination papers to answer herself. Then, she had other experienced teachers mark her papers until she had reached the required standard" (Ibid.).

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The traits that this Headmistress was highlighting in this example were that a teacher needs to be aware of his/her limitations and work hard to overcome his/her lack of knowledge. An A-Level teacher needs to show conscientiousness and to make sure that one's students learn and get the relevant information. As she talked about the second example which she had cited, she felt that, "although he had overwhelmed the children with his **vitality and enthusiasm**, but it is that aspect of **energy and care** that mattered. He had the **wide vision** which stimulates and motivates" (Ibid.).

The description of these two types of A-Level teachers gives us a lot of food for thought when considering effective science teaching and learning, in terms of subject matter knowledge, attitudes toward the subject matter itself and towards the students, dedication to teaching, self-improvement and pedagogy etc. What I got from this is that an ideal A-Level teacher breathes, eats, thinks, and dreams his subject matter and its pedagogy always. Additional traits that are highlighted in the second example, as essential for a teacher to exhibit, are "vitality," "enthusiasm," "care," and "wide vision," which stimulates and motivates the students to learn.

However, this Headmistress expressed some concern about the ZIMSTT graduate teaching A-Level Biology in her school. She said the following.

> He is quiet and soft-spoken but keeps to himself. He covers his work if motivated. I must admit I keep pushing him . . . to make sure that he is keeping up with his work, because he has got himself involved with the Zimbabwe Association for Science Education (ZIMASE) activities, which I am pleased about. But he tends to

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> give it (ZIMASE) priority and not his classes. Last year, his results were very disappointing. All the students got O-Level passes. He depends too much on his B.Ed. notes and I have suggested that he lets students work by preparing 'lecturettes' now and then . . . (J.HI, p. 1).

This is the teacher who was observed dictating notes to his A-Level Biology class. When the Headmistress was asked how this practice, of dictating notes, was an indication of the adequacy of preparation by the B.Ed. Biology program for A-Level teaching, she had responded that "It depends on the individual student, in terms of how much they put into it and get out of it" (J.HI, p. 1). Since she had not seen the B.Ed. Biology courses' scope of the subject matter knowledge or content taught, she felt that she could not judge if any correlation existed or not.

Another contrasting picture of A-Level Biology teaching practice was described by a Headmaster, with more than 13 years experience as the Headmaster of an urban, government, and former Group B school, which is located in a high-density suburb. His major subjects, during his undergraduate studies, had been English, History and Zulu/Ndebele. He said that he had enjoyed Biology at school, because it was practical and was related to many sectors of life. He pointed out that he monitors closely the teaching and learning taking place in his school. When asked of his expectations of an A-Level teacher, he described them in terms of what influence he expected the B.Ed. experience to have had on its graduates' teaching practices. He said the following.

> I wish they could think better . . . as evidenced in discussions and when you observe teachers teach, you do see the differences between an enlightened teacher and

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> one without this enlightenment. What the B.Ed. does is open up the teachers' minds to wider horizons. At least they will be exposed to something better than their own 'cocoons' (S.HI, p. 8).

That is, the B.Ed. exposure was expected to have broadened the thinking horizons of the graduates beyond their "own cocoons" in which they had operated before their enrollment into the program. Such an exposure enlightens the person, who then reflects this enlightenment by thinking better. The Headmaster went on to say that

> . . . this thinking better should be accompanied by showing much more willingness to teach better . . . . The planning of their lessons must . . . reflect innovations in teaching . . . that come from inside them. Their teaching practice must be super. Teachers must be free to experiment, mix what they have collected with what they have read and picked from U.Z. and that which is naturally in them. Out of these pressures, they should come out with a modus operandi that brings about the success out of them, i.e., effectiveness (S.HI, p. 8).

What is stressed here is the feeling of the freedom to "experiment" with innovations of all sorts, in order "to teach better," driven by the goal of effecting "teaching practices, which must be super."

When asked what he meant by "teaching better", he cited his own experiences during the Post-Graduate Certificate in Education program which he went through. He recalled that his best lessons were the ones which he had taught after a lecturer's criticisms, after he had gone away, "when I was now trying my own thing, that is, a mixture of what the lecturer had suggested and what I thought was in my ability, to have an impact on whatever kids I was teaching" (Ibid.).

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In other words, for this Headmaster, the ideal teacher is the one who not only "thinks better" but also one who is "innovative," and "feels free to experiment," mixing that with what has been suggested by one's supervisors, in order to improve his lessons, and to "have an impact" on one's students.

The Headmaster then went on to say that he also expected the teacher "to teach deliberately." For him, this meant,

> . . . teaching without fear or pressure and teaching for the sake of getting to be understood. The kids are usually ready to respond in the same way, i.e., they are also deliberate in the way they receive the information from the teacher. The B.Ed. should, therefore, help improve the teacher to achieve that measure of deliberation (Ibid., p. 9).

That is, "teaching deliberately" can be interpreted as having reasons for whatever one does. The Headmaster proceeded to point out to the uselessness of the comments which teachers love to write on the students' reports, such as "could do better," "must put more effort" etc. He emphasized that "effort won't be forth coming until the targets of the teachers and of their students are the same . . . i.e., the where we are going to, and why are we going there . . . . Once this is achieved, the students won't need to be pushed to work, they become self-motivated" (Ibid.).

So for this Headmaster, an ideal A-Level Biology teacher is one whose thinking horizons are broad. He plans innovative lessons and teaches deliberately. He has self-motivated students who work together with the teacher towards the same goal of success.

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When the Headmaster was asked to characterize the teaching practices of the ZIMSTT graduate, who was teaching A-Level Biology in his school, he said the following.

> Mrs. B- is a very busy teacher in terms of her keenness to get kids to succeed. She has always impressed me as somebody who intended to do well. I have loathed to interfere with her, that is, in teaching, there's self-expansion of a teacher. And that a teacher should be allowed some latitude to discover what's in him or her. I have confidence that she knows her direction and never wants to let the school or her students down. She is one of the experienced teachers in this school that I entirely rely on, rightly or wrongly. Even before she acted as Head of Science Department, we precisely had asked her to become the second Head of Department, because of this impression of spontaneous development in her, that she seems to possess (Ibid.).

When I commented that the teacher sounded like she was a real asset to the school, the Headmaster told me of how, six to seven years ago, she had requested for a transfer many times to a school near her residence. He said that he had talked her out of it by making her see the reason why he had wanted her to remain there so that they develop the school together. She had agreed and had stayed on. With a tinge of remorse or sadness, he indicated to me that, "Of late, she has indicated that she still wants to transfer. We have worked together so much, so long, and so well that I feel she has left something to be emulated by other teachers. I have very reluctantly agreed because I know what I am going to miss in Mrs. B-" (Ibid., p. 2).

Here is a teacher with such a high level of performance that her Headmaster hopes that his other remaining teachers will "emulate" her ways, that is, her teaching practices, after she has transferred to this other school. When I quipped and said, "All

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Headmasters are the same. You all hate looking for replacements and so you tend to refuse transfer requests from your teachers," the Headmaster agreed that it may be so and added the following.

> In this case of Mrs. B-, it was also because she is good natured. She always discusses things with a smile. She gets you to arrive at sound conclusions by the way she thinks through a problem. She impresses me that much, I feel very strongly about it. We have been able to understand each other, in the sense that our target has been the same, i.e., we want to uplift the performance status of the school, despite of the heavy intake (Ibid., p. 3).

Wow! What a tribute to a teacher! There is a lot about this ZIMSTT graduate that has impressed her Headmaster. This includes her whole personality. She is a warm person, who is easy to get along with because not only is she understandable but also because her ultimate goal of "uplifting the performance status of the school, despite the heavy intake," is the same as her Headmaster's goal. The most commendable attribute that she was reported to possess is her ability to enable the Headmaster "to arrive at sound conclusions by the way she thinks through a problem." The making of sound judgements needs to be developed among our students too. I concluded, from all the Headmaster's portrayal of this particular ZIMSTT A-Level Biology teacher, that it sounded as if the Headmaster's impression of Mrs. B- was that she was a highly professional practitioner, who was being very effective in whatever she did in the school. Without any hesitation, the Headmaster had agreed saying the following.

> Definitely, I can tell you that she is one of the more successful teachers in this school. I don't know, perhaps when she is compared with teachers in other schools, because teachers do differ, but for sincerity of approach, for knowledgeability, spontaneity in

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> **teaching**, I can tell you, with no reservation, that anybody who is receiving her will see exactly what I have seen in her (Ibid., p. 3).

I could not help but agree with him about his portrayal of this teacher's teaching practices, attitude to work and general demeanor, from what I know of this teacher from my own previous interactions with her, as one of my B.Ed. Biology students and from my current research participant observations in her O-Level Science and A-Level Biology classes [Video-tapes BV 1 and BV 2 (9/15/92), respectively. When I reminded the Headmaster that Mrs. B- had been number one of her B.Ed. class, he said the following with a smile.

> I know and I was very happy to let her go and do the B.Ed. (Science) course, because I knew that when she came back, she could disseminate that **organizational power** among other teachers not just in the Science Department, but throughout the school (Ibid., p. 4).

When I asked what he meant by "organizational power" he referred me to have a look at the book in which she kept her Science Department's Minutes.

> **The minutes reflect continuity and a level of professionalism that is high. In attack to work, she is very mature** and she compares favorably with any other teacher, male or female. Students have never come to me to complain about her teaching as they have sometimes done with other weak teachers (Ibid., p. 4).

This Headmaster's portrayal of this B.Ed. graduate's teaching practices was not only very impressive, but also very pregnant with food for thought, in terms of what makes an effective science teacher. The pedagogic usefulness of these extensive quotes is that they provide some criteria (see all my emphases in the quotes above), on the basis of which, teachers can reflect and assess their own teaching practices. For the teacher educators, these extensive quote

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quotes can be deliberated upon, with their prospective student teachers, as ideal traits to aim for and develop in themselves.

Lastly, the third characterization of an ideal A-Level teacher was given by the Deputy-Headmaster, who had taught A-Level Biology after graduating from the B.Ed. Biology program. He stressed that his ideal A-Level teacher

> . . . is one who emphasizes student involvement . . . who is hard working . . . who has patience . . . who knows his subject matter; who has knowledge of his students to enable him to diagnose their weaknesses and follow-up on them and if he needs to go back to the beginning does. Such a teacher has schemes which give details indicating what he intends his students to be doing in each lesson, specifically and not globally for the week (Mu.HI, pp. 10-12).

This Deputy-Headmaster characterized his ideal A-Level teacher as having the habit of involving students, which is reflected in the teacher's scheme book by his thinking ahead about the activities which his students will be doing in each lesson. In addition to this, the ideal teacher in one who has knowledge of his students and the subject matter, which he makes use of in structuring his lessons. This includes having patience to go back, over the material, if he diagnoses students' weaknesses, which will be preventing them from understanding.

When asked to describe the teaching practices of the ZIMSTT A-Level teacher in his school, he reported that he had not yet had the opportunity of observing him teaching the A-Level Biology classes. The frequency and the intensity of the three Headmasters' supervision of the ZIMSTT graduates teaching A-Level Biology was not established during the interviews.

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Hence, an assertion was formulated that the school Heads' descriptions of these two ZIMSTT A-Level teachers represent extreme cases along a continuum of prevailing teaching practices which range from unsatisfactory to very satisfactory. The latter case was perceived as excellent and exemplary. These perceptions were based on their within-the-school classroom observation visits. Based on the ZIMSTT graduates' A-Level Biology students' 1992 A-Level Biology final examinations pass rates, the teachers can be placed on this teaching practice continuum thus:

Unsatisfactory <-- Teaching practices --> Very Satisfactory

(D- & M-) <----- (Mi- P- C-) -----> (B- & V-)

The results for G-, N- were not collected.

The various characteristics of a good A-Level Biology teacher, as perceived by these Heads of Schools, can be mapped on to the various continua of the teachers' views of knowledge, teaching style and learning, which were described earlier. Implicit in the characteristics of "being innovative," "teaching deliberately," "being practical- oriented," etc., is the view of knowledge as tentative and teaching as facilitating active meaningful learning by the students. Hence, these characterizations can be placed more towards the heuristic end of the teaching style continuum. A more didactic teacher with a view of knowledge as a static body of facts, teaching as giving information and learning as passive reception of

knowledge would not need all this "energy," "drive," and "high level of professionalism."

THE EDUCATION OFFICERS' PERCEPTIONS

The Education Officers (E.O.s) are professionals who got promoted to those posts of responsibility as a recognition of their having been effective teachers in their respective subjects. All the interviewed Science E.O.s had B.Sc. degrees in Biology (N=3) and Chemistry (N=4). On the average, they had taught O-Level Science classes for nine plus years and A-Level Science classes for five plus years. Before becoming an E.O., one of them had been a Deputy-Headmaster for two and half years and an Acting-Headmaster for a year. This same E.O. had also been a lecturer at a Primary Teacher Training College. A second E.O. had been a lecturer at a Secondary Teacher Training College. A third E.O. had been an E.O. in the Curriculum Development Unit (CDU), before transferring laterally to be an E.O. in the Schools Division, in the Head Office of the Ministry of Education. All the E.O.s are also Team Leaders of the final Science Examination Markers. Thus, the E.O.s are people with long and varied experiences in science education.

When the E.O.s were asked to describe their ideal A-Level Biology/Science teacher, and the prevailing A-Level Biology/Science teaching practices, one E.O. said the following.

> I would like to see a teacher who, in their lesson preparation, is keen not to spoon-feed students. But he is **keen to provide guidance, and situations, in which the students themselves get thoroughly involved in finding out**, from the textbooks or from the practical

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> point of view, and the teacher probes them to get on rather than someone who sits there and they get information from [Tape Bn.EOI #7, p. 4 (9/30/92)].

This E.O. was stressing teaching practices which make students independent and not "spoon-fed", that is, students who are active rather than passive learners, and the role of the teacher being to create situations and to urge the students to "get thoroughly involved." The E.O. proceeded to further explain.

> So I am looking at a situation where the teacher in most cases is presenting the problems and perhaps assisting in terms of the alternative methods for the students to consider, as solutions to the problems . . . and to increase the awareness of students in respect of their learning environment (Ibid.).

To clarify his point he cited the example of how.

> 'Education with Production' became a song . . . because school gardens were set up, which were never fenced. But they were protected by a number of trees, which had been cut in order to keep the goats away. The result was that we destroyed so much to get so little, in terms of outcomes (Ibid.).

What is implied by what this E.O. is pointing out is that teachers should also judge the reasonableness of the suggested solutions with their students. To do this, the students need criteria and values. To what extent this was being achieved was not ascertained. When asked what image of an ideal classroom the E.O. had, he replied.

> I would like to see the teacher in a classroom situation where he asks students to present discussion papers, on information which they would have dug up themselves, and the teacher's role is to correct and put right those aspects that might not have come out from the discussion, rather than the situations, where students think that it is the teacher who has all the information and is always right. They should have confidence in themselves to come up with something new which even the teacher is not aware of (Ibid.).

The metaphor/imagery of "information they will have dug up" is interesting. It highlights the active learning aspect of getting the information. Student put in energy and effort. The "dug up information" is then presented by students as "discussion papers." The roles of teacher and learner are blurred in such teaching practices. When asked whether he had seen this happening, the E.O. said that he had not seen this in the schools in which he had been observing.

Consistent with what he described above, this E.O. mentioned that he expected

> . . . lesson plans which are more concerned with students activities, i.e., which are explicit about the children experiences more than statements of what the teacher is going to do. This way, I will be sure that the teacher's focus will be on the children . . . doing and actually experiencing it themselves, and that it is not the teacher's experiences which are being filtered to the children while they (the students) are sitting (Ibid., p. 5).

The imagery of "experiences being filtered" suggests the teacher as the one who processes the information, which the students then just receive passively as it comes. As far as marking goes, he said, "I prefer lots of communicative comments rather than the tick and the cross and the total mark. The large tick is not the important issue but why they got the mark (3/10)" (Ibid.).

This E.O. would love to supervise the likes of Mrs. Mi- and Mr. N-, who were reported by their students to hold fruitful one-on-one dialogues with individual students over their written homework exercises and test performances.

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When asked what this E.O. thought or felt was the worst scenario which he had observed being practiced.

> I loathe teachers giving notes. I would rather prefer teachers to give questions or problems, which in being answered, will turn out to be the students' notes, which they are supposed to make on their own anyway. Teacher- made notes are not very useful to children. They don't seem to appreciate what it is they are trying to do (Ibid., p. 6).

Hence, this E.O.'s ideal teaching practices are those that engage students in active learning and sense-making and not those that encourage spoon-feeding by the teacher, or rote memorization by the students of the teacher-dictated notes.

When asked how the ZIMSTT graduates in his Region were teaching A-Level Biology, he indicated that he had not observed them. However, he had supervised one B.Ed. Chemistry graduate, who was teaching A-Level Chemistry. About this graduate he said the following. "When compared to B.Sc. graduates with or without the Post-Graduate Certificate in Education (Grad. C. E.), the B.Ed. Chemistry graduate compared favorably and was stronger in terms of teaching methodology than the B.Sc without Grad. C.E." (Ibid., p. 6).

The reason that this E.O. had not supervised any A-level Biology teaching was because he concentrates on A-Level Chemistry and Physics teaching. Biology is supervised by the other E.O. (Science) in that Region. The latter, (E.O. # 6) though being on sick leave, had graciously agreed for me to visit and interview him at his home. He indicated that he had observed the only two ZIMSTT graduates teaching A-Level Biology, in his Region. This E.O. felt tha

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that these two teachers were teaching well, as evidenced by their good A-Level results. The researcher had observed only one of these two teachers. The second teacher had been transferred, at the beginning of that particular term, from the address which the Ministry of Education had provided the researcher, to a school without A-Level classes. During the discussion, this E.O. pointed out, "The incentive for taking up A-Level teaching is not there. Hence, the B.Ed. graduates are applying to go to the Teacher Training Colleges and to become E.O.s" [Tape R.EOI #6, p. 1 (9/29/92)].

When asked how these graduates were coping in those respective posts? He said that "They do have problems as E.O.s. But they cope well at Teacher colleges because there they teach the subject as Curriculum Depth study and Science Methodology" (Ibid., p. 1).

His explanation of why B.Ed. graduates have problems as E.O.s was that "He gets to supervise in schools and he should do that for all teachers including regular graduates with B.Sc and Grad.C.E, who have more teaching experiences than him and then he gets problems on the academic side" (Ibid.).

This E.O. tried to explain the problem by suggesting that may be it is triggered by the B.Sc. graduates, who feel that they had more content during their period of studying the subject (3 years), compared with the B.Ed. intensive crush one-year or two-year program which the B.Ed. graduates had. On the other hand, the problem may be caused by the B.Sc. graduates having a negative and uncooperative attitude, stemming from being supervised by a B.Ed. graduate, whom he perc

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he perceives as having an inferior qualification. Nonetheless, the problem is real.

A third Education Officer, in a different Region, expected ". . . thorough preparation by the teachers, so that there is, basically, systematic learning going on . . . . The teacher must be switched on with the information at his finger tips . . . " Tape P.EOI #5, p. 4 (9/23/92)].

This E.O. is stressing the teacher knowing his subject matter content, so thoroughly that it is at his finger tips, and preparing thoroughly in order to engage his students in "systematic learning." What he meant by the latter was not probed for. However, this E.O. went on to describe further what his perception of an ideal teacher was. He said that he expected an A-Level teacher

> . . . to operate above the level of the students. An A-Level cannot teach an A-Level. I expects the teacher to know more than his students. In addition, I expect the teachers to write down his lesson plan with details of concepts and sub-concepts to be taught. I feel strongly that the teacher is accountable to his students and a lesson plan is an instrument of accountability of the teacher to his pupils, the Headmaster, and the E.O. Otherwise, how can I tell to what extent the teacher has given thought to what the lesson is intended to the achieve and how (Ibid., p. 3).

Although E.O. #1 differed from E.O. #5 on their relative fuss about written lesson plans, they do agree on the need for "a critical self-appraisal" after each lesson. E.O. #1 contended that "Every good teacher should identify where he was not effective, in one way or the other. . . . He should analyze the situation to identify the pitfalls and reflect on how to avoid them next time . . ." [Tape C.EOI #1, p. 4 (6/4/92)].

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This E.O. is stressing the need for the teachers to critically reflect on their practice, in order to "identify where he was not effective" and think of ways to avoid the identified "pitfall." When asked to describe the prevailing teaching practices, which he had observed in the classes, which are taught by ZIMSTT graduates, he said the following.

> The classroom discourse is satisfactory. The ZIMSTT teachers are confident in handling their lessons. They encourage their students to think, to participate intellectually in the lessons by posing questions, in order to make sure he gets everyone's viewpoint and to check that the students are following (Ibid., p. 4).

That is, the teaching practices are such that there is student involvement through verbal interactions, which are stimulated by their teacher's questioning, by means of which he monitors his students' thinking and their understanding. The E.O. went on indicate some negative aspects of prevailing practices. The first was that, "Teachers sometimes revert to 'chalk and talk' because of the type of topics and they overlook the use of practical work which would facilitate the assimilation of the material by the candidates more easily and much comfortably" (Ibid., p. 4).

This refers to the observed prevailing teaching practices classrooms in which the discourse is characterized by a one- way communication and with very little or no practical work, which the A-Level Biology syllabus stipulates. Secondly, the E.O. had noted that "Even at A-Level, few students are capable of real abstraction. A lot of them are still at the concrete level . . ." (Ibid., p. 5).

This comment reminded me of a lesson which I had observed before this particular visit, in another Region. The students in this c

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this class were using "paper cut-outs" (i.e., a circle was standing for a phosphate molecule; a pentagon for the deoxyribose sugar; and a rectangle for the base), to build a nucleotide and a polynucleotide, and then DNA molecule [Video-tapes MV (7/7/92 & 7/8/92)]. The teacher had justified this paper-model-building activity during a post-observation conference, saying that they had the potential of ". . . helping the students to visualize . . . and also to help their imagination . . ." [M.POC, p. 1 on Tape M 3 (7/7/92)].

The students in this class confirmed that particular model-building did help them to visualize the structures [Tape MSI, p. 6 (7/29/92)]. The last aspect which the E.O. had noted was the following.

> Generally, teachers do not think until a problem is exposed. Teachers don't think deeply about how a lesson has progressed . . . . This weakness is reflected in their evaluation comments of their lessons. They tend to give glorified comments like 'the lessons progressed well and the students/class understood except Jane or Bill. Teachers are not thinking about their shortcomings and how to correct them, which is a negative aspect towards teacher development (P.EOI #5, p. 5).

It seems that what is commonly prevailing is that the teachers forget about their lessons, as soon as the lesson is over, and then just embark on the planning of the next one. Professionally, the teachers may not be developing because they are not engaging in critical "reflection in and on their practice" (Schon, 1978 & 1983). The global "glorious comments" were also read in the other Regions by the researcher. When the E.O. was asked what he thought was making

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making the teachers not be reflective of their practices, he explained tentatively.

> Perhaps they are overburdened with work and with so many classes. It's more of 'Am I going to survive the day? Or, how can I improve the situation?' Our teachers have not mastered what effective teaching is all about, to be able to jump, i.e., to make a leap from their routines and say to themselves 'now I can think about it' (Ibid., pp. 5-6).

What this E.O. is inferring is that maybe the teachers were not engaging in self-critical reflection on their actions because of the limitations of time and due to large classes and heavy teaching loads (Appendix #7). This E.O.'s observation connects well with the point made earlier on about the teachers seeming not to be reflective about the decisions and judgements that they make. I then suggested that maybe what the teachers needed was to be provided with some officially scheduled "time out" to facilitate their "making their jump or leap from their routines" and reflect more about their teaching practices. The E.O. responded to this.

> Opportunities have been provided by the National Science Syllabus Panel (NSSP), which sent its syllabus drafts for the teachers to study, think about, and suggest improvements on. But the teachers had not responded. They were not vocal about the changes which they felt that they wanted to be made, even on issues which are glaring (Ibid., p. 6).

It could be that the teachers seem to think that what they think or feel does not count or matter and that what they feel like suggesting is not profound and professional enough to bother voicing it.

The E.O.s also highlighted the range of examples which the teachers used to illustrate a point. That is, there was a difference observ

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observed between the teaching practices of experienced and inexperienced teachers, in terms of multiple nature of the representations used to teach the science concepts.

This E.O. was also in agreement with the other E.O.s about prevailing teaching practices, which were reflecting a paucity of practical work by students. He also expected ". . . classroom discourse having more pupil-to-pupil interactions. . . . Teacher-telling must be reduced to a minimum. Student learning must be through finding out for themselves . . . . The teacher's role is to set the stage, to facilitate students' learning" (Ibid., p. 4). These expectations were also expressed in essence by another Education Officer [Tape E.EOI, #2, p. 3, (6/8/92)].

In addition to these aspects, E.O. #4 mentioned two other expectations. Firstly, he expected the teacher to "show interest in general . . . and, specifically, in reading scientific magazines. He must read widely and not stick to a basic textbook. He must be prepared to buy and rely on a stock of their own books" (Tape A.EOI, # 4, p. 6 (6/10/92)].

This E.O. was, in essence, echoing what was said by the Headmistress of one A-Level school (Tape J.HI (9/16/92].

With the exception of two teachers, Mrs. M- and Mr. D-, the rest of the ZIMSTT A-Level Biology teachers were observed having quite a varied collection of reference books in their preparation rooms cum "offices." Only two teachers, Mrs. Mi- and Mr. C-, were observed referring their students to scientific magazine articles which they had collected.

E.O. #4's second expectation was "the need for teachers to have continuous assessment of student learning" (Ibid., p. 7). The prevailing practice as far as this aspect is concerned was that "the teachers only think of assessment as being done at the end of each topic, during mock examinations, and mid-year examinations, i.e., though pencil and paper tests and homework written exercises now and then. Whereas, research says that there are alternative assessment approaches which have been shown to be effective (Kuhn & Malcolm, 1991).

Lastly, E.O. #3 mentioned how "teaching is situational and . . . we expect quick adaptability and coping as a measure of teacher thinking and that the teaching practice should be of high standard . . . . Sometimes, we meet mediocre cases, which are remedied by clinical supervision" (Tape J.EOI, #3, p. 3 (6/9/92)]. This E.O. had not supervised any ZIMSTT graduate teaching A-Level classes by the time this study was done. However, his perception of teaching as situational is intriguing. Hence, for him, possible measures of teacher thinking include the extent to which the teacher adapts and copes in these changing classroom situations.

There is a similarity between the E.O.s' and the Heads of Schools' views of an ideal A-Level teacher. Likewise, these E.O.s' views can be located on the various continua presented earlier concerning views of knowledge, teaching and learning. Their view of teaching as being "not keen to spoon-feed students" and "presenting problems and assisting . . ." negates the view of teaching as "giving information." The view of learning as passive reception and

knowledge as a static body of facts is also negated by the E.O.s' expectations that an ideal teacher suggest "alternative methods for students to consider . . ." ask students to "present . . . and discuss," and facilitate students' "experiencing it themselves" and not having the content "filtered to them."

PROFESSIONAL ASSISTANCE

Needless to say, it seems that the interviewed Heads of the A-Level schools and the Science E.O.s were all very concerned about raising the standards of science education going on in their schools. To try and achieve this, professional assistance of different sorts is provided in the following ways:

(a) Further study: For example, at one school the Headmistress said the following.

> I am always reminding my staff to realize that they are not stuck in the rut but that there was room to grow . . . . I encourage them **to study privately and upgrade their academic standing**. . . . Two teachers have, so far, responded to this plea. One has studied Shorthand and the other, a Home Economics teacher, did Cake Icing. This has led to the introduction of the "Cake Icing Club". Students have developed an interest in Home Economics and are going either to the University for Food Science studies or to the Polytechnical Colleges for Hotel Management [Tape J.HI, p. 8 (9/16/92)].

This push for teachers to improve their academic qualifications was also directed to the B.Sc. and the B.A. graduates, who do not have any professional training. The Headmistress said, "I insist on them (the graduates) getting their Post-Graduate Certificate in Education (Grad. C. E.)" (Ibid.).

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This practice of being supportive to the teachers who want to go on study leave, in order for them to up-grade themselves, was also reported by all the interviewed Headmasters and their Deputies. In addition to this sort of push, recommendations and suggestions for improvements are also given by the Headmistress and other Headmasters during their occasional classroom observations, depending on what would have been noted as amiss about the nature of teaching and learning, during the lesson.

(b) Departmental meetings, among the teachers themselves, was reported as providing a forum for the teachers to reflect on their practices, share ideas, and suggest ways of improving the teaching and the learning which is taking place in their classrooms.

(c) External professional assistance is also provided by the **Science Education Officers** (E.O.s). However, their supervision of the ZIMSTT graduates was reported to be minimal for a number of reasons which include, (i) the fact that the priority of school visits by E.O.s was being given to rural schools, whose teachers were in the majority untrained; and (ii) the escalating demand for the E.O.s, who are few in relation to the number of schools which need to be visited by these E.O.s.

(d) Workshops have been mounted by the E.O.s, for the professional development of the science teachers. These have not been focussed on ZIMSTT graduates' need per se. They have been mounted for all A-Level Biology teachers, like the one which I "gate-crashed" when I was in hot-pursuit to interview the science E.O. #4 for the Mashonaland East Region. This particular workshop

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(Appendix #18) focused on a number of crucial aspects: the A-Level Biology syllabus, planning and time allocation, criteria used for selection of syllabus Options, teaching approaches, comparative analysis of practical work programs and effectiveness of resource materials, preparation and administration of practical examinations, suitability and availability of textbooks, areas requiring improvisation, and a tour of exemplary laboratories, at Murehwa and Mutoko High Schools. The participants' responses, on their post-workshop evaluation, indicated that this workshop, as a whole, had been fruitful and that they felt "more confident about going back to my school to try and do the job better" [Tape A.EOI # 4, (6/10/92)]. Even though the topics were rushed over, the E.O. had met the teachers' needs to some extent. Hence, the workshop seemed to have been effective.

When one E.O. was asked what it was that he focussed on during his routine science lessons' observations, he said the following.

> I focus on methodology, i.e., to what extent the students are being involved. I am also very strict on the amount of written work. I can even issue an 'Inefficiency Form" because some teachers do not like to spend their time marking students' work, so they avoid giving written exercises, except for a test now and then. Their test items also leave much to be desired too. They (the teachers) avoid extended answer items. I have prescribed the minimum numbers of exercises and tests for the teachers in my Region [Tape P.EOI #5, p. 3 (9/23/92)].

What is stressed by this E.O. is the extent to which the students are involved during the lesson and the quality and quantity of the students' written assignments. When asked what sort of professional assistance he gives to his Science teachers in his

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Region, he reported that it was in the form of "recommendations for textbooks and resources for practical like the ABAAL series" (Ibid.). By the time that the interviews were held, This E.O. reported that his workshops had, to date, been targeted for O-Level Science teachers. He was planning future workshops to be targeted for the A-Level Science teachers.

Since the Science E.O.s are stretched thin they are concentrating on supervising the lower forms, which are being taught by untrained teachers. Hence, the ZIMSTT graduates who are teaching A-Level Biology are, virtually, on their own, with the occasional supervisory classroom visit from their own school's Headmaster or Headmistress.

SUMMARY

Hence, this data supports the assertion that **the ZIMSTT A-Level Biology teachers seemed to be getting minimal professional assistance internally from their Headmasters and externally from the Science E.O.s**. This assistance is given by the Headmasters during the post-observation conferences and by their colleagues during departmental meetings. External assistance is given during the E.O.'s school visits and during the science workshops, which they seem to organize on rare occasions. A point was made that the ratio of the numbers of the Science E.O.s to the numbers of science teachers is very low. Hence, the few E.O.s that are there are concentrating on supervising the lower Forms, which are being taught by untrained teachers. Thus the ZIMSTT graduates teaching A-Level

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Biology are working mostly on their own. They do not get the benefits of the E.O.'s expertise on a one-on-one basis.

CONCLUSION

Data presented in this chapter have provided evidence for diversity among the ZIMSTT graduates in their initial "teething" problems, coping strategies and subsequent teaching practices in A-Level Biology classes. These practices range from unsatisfactory to very satisfactory, and even excellent and exemplary in one case. The teaching practices can be mapped on to the various continua of views of knowledge, teaching, learning, and classroom discourse, which were discussed earlier. For example, the unsatisfactory teachers were the ones whose classroom discourse was mainly one-way. These teachers lectured and dictated the content as if it were "a body of facts." Their students listened and made notes. On the other hand, some of the teachers whose teaching practices were perceived to be satisfactory can be placed at the heuristic end of the teaching style continuum, although they also expressed views of knowledge as "a body of facts." Their view of teaching, however, corresponded better with their observed teaching practices of facilitating and guiding students to find information on their own and give "lecturettes" or "mini-lessons" and hold class discussions. These teachers engaged their students in interactive dialogues to make sense of what they were learning.

However, contradictions have appeared throughout this study. For two teachers who both lectured, the nature of learning that took

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place in their classes was different. Hence, it was not the lecturing per se that mattered but the content of the lecture itself. With one of the teachers, there was a lot of "noise" because too many other concepts were included and too little time was left for the new concept of DNA's semi-conservative mode of replication. The other teacher focussed on the latter concept for a whole class period. He used as many as four different representations to explain the semi-conservative process. In doing this he catered to students with different learning styles. Hence, the passive receptive learning was not the same in both cases. Students in the latter class made better sense of the semi-conservative process, as was revealed by their responses on the homework application problem assigned after that particular lesson (Appendix #16).

Similarly, the diverse characterizations by the Heads of Schools and the Science Education Officers of an ideal A-Level Biology teacher belong at only one end of the continua established earlier, with views of knowledge as tentative, teaching as facilitating knowledge construction, learning as actively making sense of natural phenomena, and a teaching style which is heuristic.

Unfortunately, none of the ZIMSTT A-Level Biology teachers is getting the benefit of these Science Education Officers' professional supervision. This is because the top priority of the Education Officers is to work with untrained teachers who are teaching lower level secondary school classes.

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CHAPTER IX

IMPACT OF THE ZIMSTT GRADUATES AND OF THE ZIMSTT PROGRAM

The ZIMSTT B.Ed. Biology program's impact within the Ministry of Education will be discussed both quantitatively and qualitatively, at different levels, from the perspectives of the various participants in the study. The impact of these 9 ZIMSTT Biology graduates on their A-Level Biology classes seems to have been perceived, on the whole, to be significant.

IMPACT ON STUDENTS' COGNITIVE DEVELOPMENT

Three measures were used to assess the impact of the ZIMSTT graduates on their students' learning and understanding of A-Level Biology. This was achieved by assessing the differences in their students' performances on measures obtained from **The Pre- and Post-Tests** (Appendix #19); from their responses on Item #7, on **The Students' Questionnaire** (Appendix #3, Item #7); and from the responses given by samples of students from each of the nine observed A-Level Biology classes during **The Student Interviews** (Appendix #5.3). The pre- and post-test measures were used with Mr. C-'s and Mrs. M-'s classes during the Intensive Study. But during the follow-up study of the remaining seven ZIMSTT graduates' cl

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classes, only the Students' Questionnaire and the Student Interviews were used to assess the conceptual development and cognitive achievement of their A-Level Biology students.

THE STUDENTS' INTERVIEWS

The students' interviews were held between the researcher and a sample of students in each of the observed classes (Appendix #6). During these interviews, the students' conceptual development was subjectively assessed by having the students compare their prior conceptions and their present understandings of the topic on DNA, RNA and Protein Synthesis. All the interviewees reported that they had no idea about how proteins were made. They had not even wondered about that! All that they knew about proteins was what they had learned at O-Level, from the Science (5006) and the Extended Science (5007) Syllabi Section 5: Science in the Community, p. 17). They all regurgitated almost verbatim that,

> . . . proteins are essential nutrients in our diet. . . The body uses proteins for building up tissues and enzymes and for repairing broken tissues. . . . Proteins are made up of chains of amino acids. . . . A protein deficiency leads to 'Kwashiorkor', the deficiency disease (CSI, BSI, DSI, GSI, MSI, MiSI, NSI, PSI & VSI).

But when the interviewed students were asked what they now understood about proteins and protein synthesis, they excitedly made an attempt at recalling the subject matter content, which they had been exposed to during their A-Level Biology lessons, the content of which is stipulated in the A- Level Biology syllabus [Cambridge Examination Board, 1992, p. 46, A (c) (iii)].

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During these interviews, the students were given as much time as they needed, to draw sketches to help them explain what they were describing (Appendices #12 and 13). These sketches helped the interviewees to focus, as they talked through the diagrams, in terms of sequencing the different stages of the protein synthesis process. **The detail and accuracy of the students' descriptions and explanations seemed to vary to a large extent, with a relatively large majority of the students giving rather incorrect and incomplete responses accompanied by inaccurate diagrams, at one end of the continuum, and very few students giving complete responses with accurate diagrams**, at the other extreme end of the continuum (Student Interview Tapes).

THE STUDENTS' QUESTIONNAIRE

The Students' Questionnaire was administered to all the students in the observed nine A-Level Biology classes. Through this instrument each class was given an opportunity to write all that they knew about protein synthesis (Appendix #3, Item #7). This questionnaire was administered by the researcher during her classroom visits, without having warned the students. So, what they wrote down was whatever the students could remember, without a deliberate revision, in order for the students to prepare for this exercise. It is important that one should note that, the time interval, from when the topic of protein synthesis was taught to when the students were asked to recall that information, varied from class to class. Only in two classes, that is, of Mr. C- and Mrs. M-, was th

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was the recall elicited soon after the topics were taught. For the rest of the observed classes, the students were asked to recall the subject matter some months after, that is, during the month of September, when their lessons on DNA, RNA and Protein Synthesis had taken place either during Term I (mid-March to April) or during Term II (mid-May to mid August).

AN ANALYSIS OF ITEM #7

After the students' questionnaire responses were collected, the pages with Item #7, on Protein Synthesis were photocopied, and the responses on Item #7 were then cut out and pasted onto clean pages for each class.

Then, these Item #7 responses were analyzed and categorized according to their degrees of clarity, accuracy, meaningfulness, and comprehensiveness of their content, diagrams, and explanations. This analysis revealed a wide diversity of responses, in terms of these qualitative criteria (Appendix #20: Table 16), which were both surprising and interesting, in terms of students' learning and the nature or levels of their understanding of this particular topic:

(a) In terms of accuracy of the content/facts, some of the students had their facts correct and others had the processes of transcription and translation confused, such as the following two examples.

(i) The first example had the following incompletely drawn and labelled "Diagram #1."

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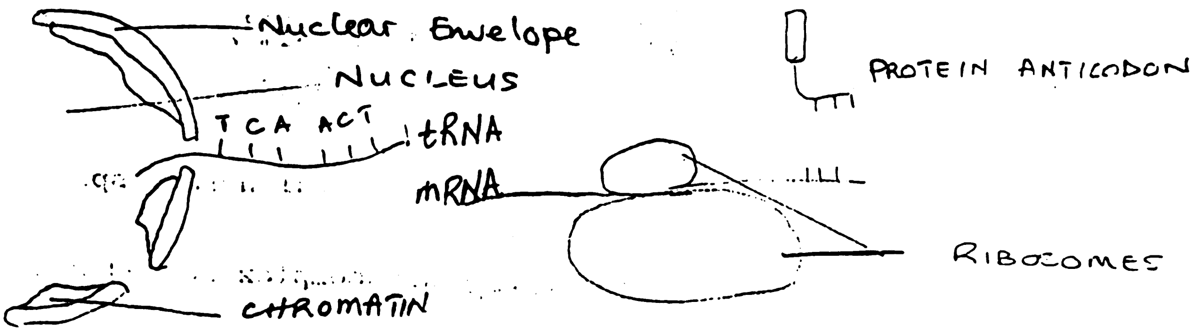
Diagram #1



This was accompanied with the following four statements, which reflect some degree of confusion:

- Coding of information from DNA to tRNA.
- The involvement of ribosomes in the assembly of a polypeptide (protein).
- The coding of the protein anticodon onto the code for the amino acid on mRNA.
- The conservative replication DNA (MiSQ #26).

(ii) The second example gave the following confused brief response with imprecise statements and wrong spellings (underlining mine) with no diagram.

(1) DNA unwinding and replication to RNA. (transcription)

(2) tRNA formation and transmission to cytoplasm.

(3) Ribosome attachment to mRNA triplets.

(4) Attachment of tRNA to ribosome.

(5) Triplet machings and protein formation (PSQ #6).

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(b) In terms of the amount of the subject matter content detail, a few students just listed terms, without explaining them.

(i) One example was:

Protein Synthesis

-DNA, RNA ---> mRNA, tRNA, rRNA.

-Amino acids - Polypeptides - replication - codon

-Translation & transcription - intreon

-Mutation (CSQ #4) (Underlining mine for the wrong spelling).

(ii) A second example was:

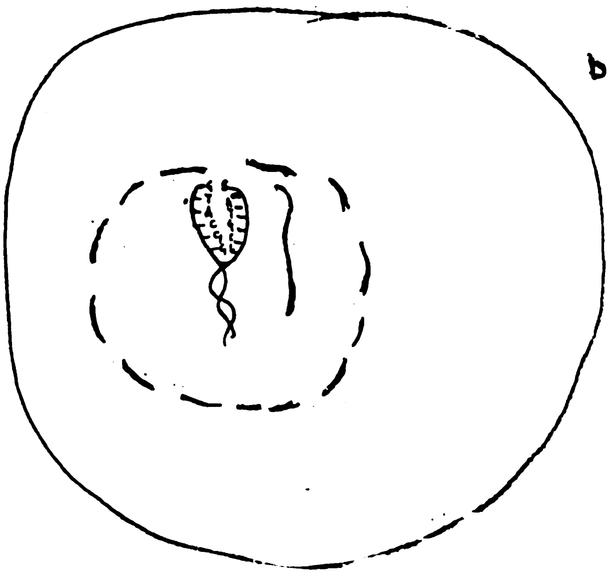
(a) Translation

(b) Transcription

(c) Nucleic acids (DNA & RNA) (CSQ #10).

(c) In terms of diagrams, a majority of the students (76.3%) who responded to this item explained without any diagrams and only as few as 35 out of the 171 observed A-Level Biology students, that is, 20.5% responded with a diagram of some sort. However, the quality of these diagrams varied with diagrams at one end that were outright meaningless, e.g. CSQ #15: Diagram #2.

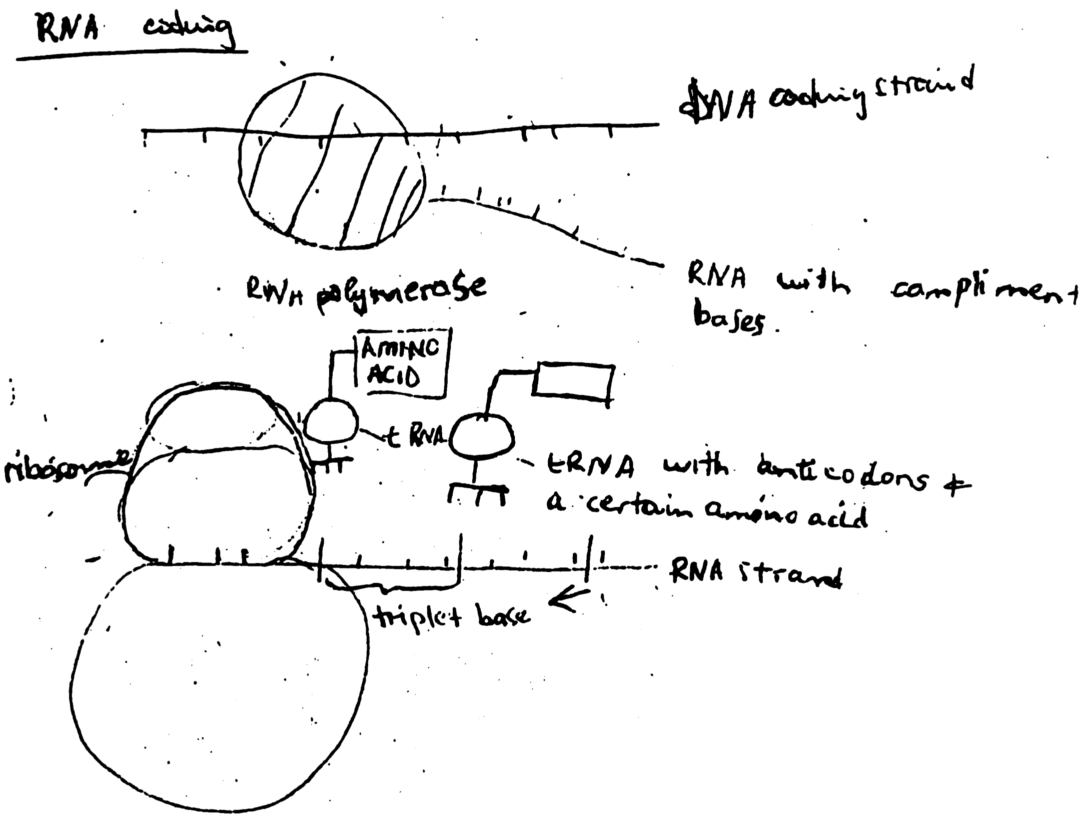
Diagram #2



DNA double helix unwinds

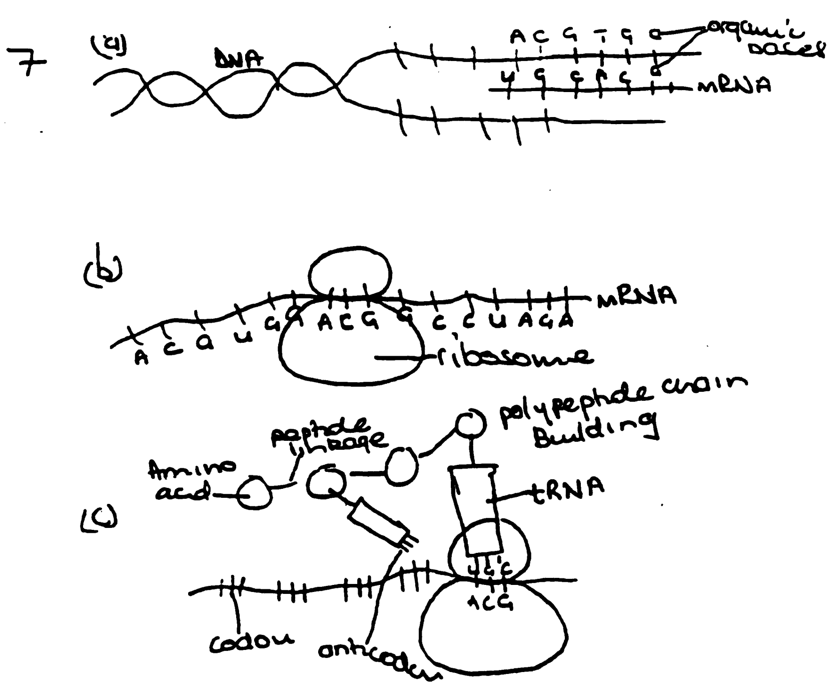
or rough and inaccurate, e.g. NSQ #8: Diagram #3.

Diagram #3



and diagrams, at the other end of the continuum, that **were clear, accurate and complete**, e.g. MiSQ #21): Diagram #4.

Diagram #4



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Similarly, the descriptions and the explanations also seemed to lie on a continuum. They ranged from explanations which were articulate, logically sequenced, clear and comprehensive (MiSQ #21), at one end of the continuum, to explanations which were either totally irrelevant, i.e., not answering the question at all (e.g. MSQ #12, who described accurately the condensation process during poly-peptide formation), or explanations which reflected unclear, confused and incomplete responses, at the other end of the continuum (e.g. MSQ #4).

There seemed to by a relationship between the differences in the quality of the students' responses with (i) their teacher's teaching styles; (ii) the time given for answering the questionnaire; and (iii) the length of the interval between the times when the topic was taught and when the questionnaire was administered. Examples of these possible explanations of the observed differences and relationships will be given below.

(i) EFFECTS OF THE TEACHING STYLES. Interesting differences were observed between the responses of the L6 students, who were taught by Mrs. M- and Mr. C-, whose teaching styles seemed to be at the different ends of the didactic-heuristic teaching style continuum, not only during their interview but also on their pre- and post- tests on protein synthesis, and between the responses of those students, who were studied a long time after the topic on protein synthesis had been completed. These post-instruction interviews were impromptu. Students were not told ahead of time. One

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of the items on the interview schedule asked students to say all that they knew before, from O-Level, and after being taught at A-Level, the topic of protein synthesis. What was interesting was that they all had the same prior ideas about proteins, that is, that they are made of amino acids; that the body needs them for building and repairing body tissues; and that the deficiency disease is "Kwashiorkor." But when it came to recalling what they had learned about protein synthesis from the A-Level content, it seems that students from teachers with a predominantly didactic style of teaching recalled far less than the students with teachers with a predominantly heuristic style of teaching.

During the interviews, the cassette tape recorder was switched off and the students were then given paper and pencil, in order for them to draw a diagram for the process, which they could then use to help themselves to describe the process of protein synthesis, by talking through their diagram. Not only were their diagrams sketchy and incomplete (for example, Appendix #12), but the interviewees from the didactic teacher also had problems expressing themselves [Tape M 18 (7/28/92)]. In contrast to this, the interviewees from the more heuristic teacher described the process more satisfactorily [Tape C 13 (7/15/92)] and their diagrams were more detailed and accurate (for example, Appendix #13).

Hence, an assertion was formulated **that a heuristic teaching style seemed to result in learning which is more meaningful and in long-term retention by the students than did a didactic teaching style.**

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An analysis of these students' responses to Item #7 of The Students' Questionnaire (Appendix #20) seemed to substantiate this assertion. It can also be asserted **that a student's learning style is influenced by the teacher's teaching style**. These teaching and learning styles represent extreme ends of two continua.

Knowledge transmission	<-- teaching -->	Knowledge construction
Knowledge acquisition	<---learning --->	Sense making or negotiating meanings

Ausubel (1963 & 1968) differentiated between rote verbatim learning, which leads to forgetting, and meaningful verbal learning, which leads to longer retention. It would seem that a didactic teaching style lends itself to students memorizing the knowledge, which is being taught by their teacher. Assessment by such teachers is by knowledge reproduction. For example, the structure of DNA was talked about, with very little variation in the teacher's expressions, in as many as four lessons [Tapes M 2 (7/7/92); M 4 (7/8/92); M 5 (7/9/92) & M 7 (7/10/92)]. Vivid evidence of poor retention on the part of this latter teacher's students, was their failure to identify "Phases of Mitosis" correctly, after it had been taught and gone over, as many as, three times. On this particular day, it was five days after its introduction [Tape M 5 (7/9/92)], and each phase had been drawn on a whole page. These pages had been presented as revision "flash cards" by the teacher. The students' responses to these "flash cards" revealed very little comprehension of the different mitotic phases [Tape M 12 (7/17/92)] compared with Mr. C-'s students [Tape C 12 (7/15/92)].

Hence, a heuristic style of teaching lends itself to meaningful learning, knowledge production, and sense-creation as students are engaged in sense-making and negotiation of meanings among themselves. Longer retention was evidenced by the ease with which Mr. C-'s students could (a) express in their own words the process of protein synthesis with a high degree of accuracy; (b) remember the mitotic phases and Mendel's First and Second Laws of Inheritance [CSI on Tape C 13 (7/15/92)]; and (c) the ease with which the groups of students had come up with the logical sequence of the events during protein synthesis [Tape C 6 (7/9/92)].

(ii) EFFECT OF THE TIME INTERVAL. Generally, relatively more extensive responses, describing the process of protein synthesis, seemed to be reflected more in the responses of those students who were visited and studied later in September (MiSQs; BSQs; PSQs; and NSQs), than in the responses of the students who were studied and interviewed in July (CSQs and MSQs), which was soon after they had been taught the process of Protein Synthesis. This observation seems to contradict what research says about short term and long term memory.

However, this seemingly better performance by the former groups of classes can be explained by the fact that the students in these classes had gone over that content material a number of times. First, they had studied the necessary content in preparation for

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their test, which they had written immediately after the topic was taught. Second, they had revised again, as the teacher went over their test responses, after he had marked the papers. Third, these students had also re-studied that content in preparation for their mid-year examination. Hence, their knowledge about protein synthesis had been reinforced at least three times. For those classes which had just completed learning the material on protein synthesis, their apparent poor performance might have been due to the possibility that the students had not yet had enough time to digest and process the information. That is, the material had not yet "gelled" or "crystallized" completely.

What is also interesting here is the coincidence that these four teachers who were visited much later were also observed to exhibit a more heuristic teaching style. Hence, what is influencing students' learning is an interaction of a multiplicity of factors.

(iii) EFFECT OF RESPONDING TIME. Another contributing factor which might have influenced the amount of detail written by the students was the time given for answering the questionnaire. This varied from class to class. That is, depending on whether or not the students had a class following the observed lesson, which the A-Level Biology teachers had made available for this exercise of responding to the questionnaire, some classes had at least forty minutes, while others had more time to respond to the questionnaire. Data indicating how long each class took to respond to the questionnaire was not collected.

However, regardless of this discrepancy of the time made available, a curious and interesting observation was made when comparing the quality of the students' responses in the same class. What was observed was that the same ranges of quality were reflected among students in the same class, who had the same amount of time. That is, in the same class some students gave relatively more comprehensive responses and others just gave a list of terms.

SUMMARY

Hence, an assertion was formulated **that the quality of the responses of the students, on protein synthesis, seemed to vary greatly within and across the nine observed classes.** The reluctance of the students to illustrate their responses which was mentioned by one teacher (MiFI, pp. 4-5), was confirmed during this study by the small number of responses, which were accompanied with a diagram. The majority of the students did not draw. **The quality of the diagrams seemed to range from clear and accurate illustrations to very inaccurate rough sketches. The quality of the explanations seemed to range from being clear and comprehensive to being short, shallow, and imprecise.** If these responses are indicative of the degree of conceptual understanding that had taken place among these groups of students, then it seems that only a few of the students had achieved complete understanding of the Protein Synthesis process. Hence, from these responses, besides being able to identify the levels of understanding of the individual students, one can also identify exact areas or aspects of Protein Synthesis which are still problematic for the students. For example, among these groups of students there is still some confusion between transcription and translation; codon and anti-codon; mRNA and tRNA etc.

THE STUDENTS' PRE-TEST AND POST-TESTS

Before The Intensive Study began, the students in the two Lower Sixth classes were pre-tested on their knowledge on DNA, RNA and Proteins Synthesis (Appendix #19). The post-test was the same test which was given as the pre-test. It was agreed, between the researcher and the two teachers, that one of us would have to mark both the pre- and post-tests responses of both classes. This was done in order to ensure marker reliability and consistency in the way in which the students' responses were interpreted, especially on the additional open-ended questions (Ibid., Items #22 & 23).

AN ANALYSIS OF THE RESPONSES

After the responses had been marked, each student's response sheet was numbered and an analysis was done of how they had scored on each item, whether correctly or incorrectly. This data was collated and tabulated (Appendix #21: Table 17.1).

An increase in the students' conceptual understanding can be inferred from the increase in the numbers of students who gave the correct responses on the post-test, after having got that particular item wrong on the pre-test. This is reflected in the responses on the rest of the test items.

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WHAT THE DATA TELL US

1. The items that were straight forward recall, for example, Item #s1-8, 11, 15-18 were responded to correctly by a great majority of the students in both classes.

2. There are at least five items on which more than half the total number of the students in both classes gave a wrong response on the post-test. This has implications for the extent to which conceptual understanding had developed among these students. These specific items were #s9, 10, 12, 13, 14, 19 and 21 in both classes and Item #20 in Mrs. M-'s class. These items required application of the concepts, principles, and analytic skills, in order to solve unfamiliar problems. These cognitive processes seemed to have been problematic for the majority of the students.

3. The data on Item #20 seemed to substantiate what has been inferred from the way the topic on the semi-conservative replication of DNA had been taught by the two teachers (see Chapter VIII above). That is, the presentation by Mr. C-, which utilized multiple representations, seemed to have engendered more meaningful learning when compared with the rushed treatment which the topic was given by Mrs. M-.

4. Lastly, none of the students in the two classes responded to the additional items on the post-test (#s 22 & 23). It may have been because of lack of time for some of the classes, which had only a single period to respond to the questionnaire; or it may have been because the students were not familiar with the term "polymer"; or they may not have understood clearly what the terms "replication",

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"transcription" and "translation" meant. The latter reason seems to have been the case, as this was reflected by the quality of the students' responses on Item #7 of the Students' Questionnaire (see above).

Hence, from the overall increases in the correct post- test responses, an assertion was formulated **that the students, in both classes, seemed to have acquired a vague knowledge about the protein synthesis process, to a some extent. But the levels of the students' understanding of the finer details of this process seemed to be still rather low, judging by their relatively poor quality of their diagrams and explanations (Item #7, above) and their inability to apply the ideas to solve unfamiliar problems, on the post-test.**

THE FINAL A-LEVEL BIOLOGY RESULTS

Both a quantitative and a qualitative assessment of the ZIMSTT graduates impact on their A-Level Biology students' learning and cognitive development was also based on their students' final A-Level Biology examination results (Table 18). These are presented below (Appendix #22.1).

The analysis indicates that the majority of the ZIMSTT graduates (5/7) had a pass rate of more than 50%, with three of them (i.e. Mrs. B-, Mr. C- & Mr.V-) getting higher than 80%, while 2/7 had a failure rate of more than 50%.

The two teachers (Mrs. G- & Mr. N-) from whom the grades for their classes were not collected had indicated on their questionnaire responses (Item #29) that they were having improved pass rates. Hence, the overall indication seems to be that the ZIMSTT graduates were having a positive impact on their students' cognitive achievements. One teacher rationalized this upward trend saying, "The trend is upwards because I'm more experienced and the syllabus changes are affecting the results for the better. Now there's less volume of the content" [Tape V2 (9/30/92)].

Here is an instance of where the maxim of "less is more" is proving to be true. That is, these teachers are now dealing with less content in the A-Level Biology syllabus with Option Topics and their students are learning and understanding the subject matter better. This was evidenced by the improved pass rates in 1992, for the majority of the schools, compared with preceding years. The results in 1992 were better than in 1991, whose results were, in turn, better than the results in 1990. This difference may be attributed to the differences in the calibre of the students, from year to year, which the teachers pointed out as they described their present students (see Chapter VII above).

What is interesting to note is that the school types of these teachers did not seem to be having an influence on these pass rates. For example, Mrs. B- is at a government former Group B day school, located in a high density suburb and has "hot-sitting." Mr. C-'s school is a government former Group A day school, located in a low density suburb and it does not have "hot-sitting" i.e., the school has two sets of students which are taught by the same teachers. One set has its classes in the morning, and the other set has its in the afternoon. The two sets overlap during the lunch break for the s

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school assembly. Lastly, Mr.V-'s school is a private Mission school which is located in the rural areas. It has no "hot-sitting" but classes continue in the afternoon. The students have supervised study periods in the evening. The only common thing among these three schools is the fact that they are all co-educational. It could be Mr. D- had a point when he mentioned that students in a single sex class are not as competitive as they are in a mixed class. The two classes with high failure rates are unisex classes, one is a girls' school and the other is a boys' school. These schools are both former Group A schools located in low-density urban areas in two different regions. The classes are taught by teacher of an opposite sex. The significance of this gender difference will be studied later.

Interestingly, among the teachers who had produced good results, some of them had not taken A-Level Biology themselves and the others had as little as two years experience of teaching A-Level Biology classes. That is, Mrs. B- and Mr. P- had only two years experience of teaching A-Level Biology classes. Mr. P- had taken A-Level Biology himself, but Mrs. B- had apparently not done so because she did not indicate it on her questionnaire. Mr. V- and Mrs. Mi- have both five years experience of teaching A-Level Biology. But Mrs. Mi- had taken A-Level Biology herself while Mr. V- had not. Moreover, these were the teachers with relatively more heuristic teaching styles and whose students were reported by these teachers to have had a positive attitude to learning (see Chapter VII above).

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On the other hand, Mr. D- and Mrs. M- both have two years experience teaching A-Level Biology classes. Mr. D- had not taken A-Level Biology himself and Mrs. M- did not return the questionnaire, which was given to all the observed teachers. She even refused to talk through it when I went back to collect it. Mrs. M-'s low pass rates are not really surprising, from what was observed during the intensive study, regarding her students' attitudes to learning; her low expectations of her students, with their seeming lack of motivation, as evidenced by their being always behind with their note-making homework, of which they were always being reminded by their teacher, both at the beginning and at the end of their lessons.

Similarly, Mr. D-'s very poor results can be understood considering his mode of teaching, which was predominantly reading and dictating from his own B.Ed. notes (see Chapter IV above). On the other hand,

> . . . the students' failure may be due to a lack of content knowledge, weak information-processing skills (as indicated by their dependence on teacher-made notes), some attitudinal and motivational factors, or a combination of these factors (Gallagher, personal communication).

This could not be ascertained from the data that was collected during the researcher's very brief visit to this particular school. Hence, this is one of the aspects that needs to be probed deeper in a future research study.

The availability of resources does not also seem to have an influence here because, in each of the above pairs of teachers with consistently good and bad results, one of them had adequate resources (e.g. Mrs. Mi- and Mr. D-) and the other teacher did not have much (e.g. Mrs. B- and Mrs. M-), respectively. What this implies is that it is the way the resources are used that makes the difference.

Hence, an assertion was formulated **that among these nine teachers, there seems to be no direct relationship between the teachers having taken or not taken A-Level Biology course themselves, the adequacy or inadequacy of the teaching and learning resources in the school, and the impact of the ZIMSTT graduates on their students' Final A-Level Biology Examination achievements.**

In some schools the results had been broken down by gender (Appendix #22.2: Table 19). Generally the boys seemed to be performing better than the few girls in all the classes whose results are presented here. None of the girls got an "A" or a "C". A majority of these 16 girls in the 3 classes with 28 boys scored "D.s" or lower. Only one girl, in Mrs. B's class, had scored as high as a "B".

Hence, an assertion was formulated **that the majority of these few girls seem to be under-achieving, when compared with their male counterparts**. In addition, the ratio of the numbers of boys to girls is high in favor of the boys. This gross gender imbalance in these three classes was representative of the rest of the observed classes (Appendix #6: Table 4). It appears that in the nine classes, the ratio of girls to boys is close to one girl to five boys. Thus, a study needs to be done, in order to dig deeper into the factors that are contributing both to the under-representation of the female students at these advanced levels of study and to their low achievements, when compared with their male counterparts.

The Final Examination Papers 1, 2, 3, and 6, on which these results reflecting the A-Level students' final performances were based, were set by the University of Cambridge Local Examinations Syndicate International Examinations, for the Advanced Level (Higher School Certificate). These papers were written in November 1991. These papers were analyzed, during this study, in order to isolate those items which were specifically focussed on the topics of DNA, RNA and Protein Synthesis which were observed being taught by the ZIMSTT Biology graduates.

The Examiner's comments on how the students had performed on each of the examination papers were also analyzed. The Examiner writes for each examination paper both general and particular comments on the individual items. Altogether there were four final examination papers:

1. Paper 9621/1 had 40 multiple choice items. It was an hour-long examination. On this paper, Items #9-13 were on the topics of DNA, RNA, and Protein Synthesis, and are copied below (Appendix #15.1). The Examiner's Comments on all the international A-Level Biology candidates' performance on these items are also given below (Appendix #15.1.2 & 15.1.2).

2. Paper 9621/2 consisted of structured questions. The instructions to the candidates state the expectations that ". . . answers should be illustrated by large, clearly labelled diagrams wherever suitable. . . . In addition, up to 2 marks in this question are awarded for quality of expression" (p. 1).

That is, students are urged to make their explanations clearer by voluntarily illustrating with "large, clearly labelled diagrams" and they are also motivated to do so, by being told that they will be awarded with 2 extra marks for expressing themselves clearly. These are some of the skills which the observed ZIMSTT A-Level Biology teachers indicated that their students have problems with (see Chapter VII above), and which they stress for their students to develop. In some of the Paper 2 items (e.g., #4 (a) on p. 8 and #4(b) on p. 9), diagrams are explicitly called for and are awarded as many as 10 marks! Hence, the students' development of this drawing skill should be taken seriously by the teachers and the students. Q.1 in Section A of this paper was compulsory for <u>all</u> students. It was on DNA, RNA and Protein Synthesis (Appendix #15.2.1). These comments are given below (Appendix #15.2.2).

What is interesting is that observations similar to mine were noted by Chief Examiner with regard to the incorrect spellings, confused statements, incomplete explanations, students' inability to remember basic facts, giving irrelevant responses and poor illustrations, as was noted by the researcher (Appendix #15.2.2).

These weaknesses also echo the points which were made by the ZIMSTT A-Level Biology teachers about their students' skills. For

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example, Mrs. Mi- mentioned how her students fail to distinguish the nuances of words like "state," "describe," "list," "explain," etc. and also fail to interpret the question and, hence, they just write all that they know, instead of what is specifically being asked for by the question. All the interviewed teachers complained about their students' drawing skills too.

All in all, it seems that the semi-conservative replication process of DNA was problematic for this group of candidates. I wonder how students in Mr. C-'s and Mrs. M-'s Lower Sixth Biology Classes would have fared on these items, considering their post-test low scores on this process (Appendix #21) and their responses on Item #7 on their questionnaire (Appendix #20).

3. **Paper 9261/3** was a 1 and a 1/2 hour examination on the **Option Topics of the Syllabus**. None of the set questions had to do with these topics on Protein Synthesis.

4. **Paper 9261/6** was a 2 and 1/2 hours practical test. Some of its items were on RNA, DNA, and Protein Synthesis. How the candidates performed on this paper was also commented upon (Appendix #15.3).

It seems, from the analysis of the comments, that the following practical skills were problematic for some students:

(a) drawing logical deductions from their observations; realizing the need for standardizing volumes of reactions etc.;

giving appropriate results and conclusions and tabulating the results (in Q.1);

(b) following detailed instructions; making accurate measurements and recording the results; identifying specimens; recording observations and interpreting them in the light of their biological knowledge (in Q.2); and

(c) using imprecise languages [e.g. gains food from the host instead of "statements to the effect that the connection is between the xylem/phloem of host and parasite and allows sucrose, amino acids, water, mineral salts . . ."] and drawing text book representations instead of what they are seeing on the microscope slide (in Q.3).

These are most of the practical skills, which the interviewed ZIMSTT graduates had indicated that their students were having problems with. It seems then that the difficulties are not unique to the observed A-Level Biology students.

Hence, an assertion was formulated **that the students seem to be experiencing some difficulties in understanding protein synthesis and in developing their practical skills**. This was not surprising because only two of the teachers reported that they elicited for their students' prior conceptions and tried to address these in their subsequent instruction.

SCIENCE EDUCATION OFFICERS' PERCEPTIONS

All the interviewed Science Education Officers, except one, could not comment on the differences in the impact which is being made by the ZIMSTT Biology graduates, in comparison with the impact which is being made by the B.Sc. graduates, with or without a Post-Graduate Certificate in Education (Grad. C.E), on the A-Level Biology pass rates. The Science E.O.s said that the final results are never analyzed by teacher qualifications on the national level. This level of analysis is done within each school (E.EOI #2, p. 1 & A.EOI #4, p. 2;). The former Education Officer expressed a subjective perception that "The impact of the ZIMSTT graduates on their students' final results was little. They have not been effective because they lack the subject matter knowledge demanded at A-Level" (E.EOI # 2, p. 1).

That is, this E.O. felt that the U.Z preparation, during the ZIMSTT program was insufficient. But then he qualified his response by pointing out that, "those who took the course over 2 years seem better equipped than the initial graduates of the one-year program" (Ibid.).

But he had not compared, statistically, the differences in the impact made by these different year ZIMSTT cohorts.

The Deputy-Chief Education Officer of the Examination Branch, in the Ministry of Education and Culture, pointed out another level of analysis, which is done and provided by the University of Cambridge Local Examination Syndicate for the International Examinations. This is the analysis of the performance of the total number of all the candidates, in all the international centers, who sat for each year's A-Level examination, in all the subjects. The totals for 1991 A-Level and O-Level are presented below (Tables 21.1

& 21.2, respectively). This set of data was provided by the Examination Branch of the Ministry of Education and Culture (Mark Sheet dated 02/06/92). This is very important data for this study because the present L6 students were part of the 1991 O-Level students. It appears that a majority of the A- Level candidates did poorly in the 1991 final examination, with only 24% of the candidates getting a Grade "C" or better.

Similarly, an analysis of O-Level candidates shows that only 15,8% of total number of the candidates who sat for the O-Level examination papers got a "B" or better, and 32.9% got a "C" or better, in the subjects taken. It must be noted that the present L6 students are the ones who produced these poor results. Hence, the low pass rates reflected here support the ZIMSTT A-Level Biology teachers' impressions and/or perceptions, concerning the calibre of their students' cognitive abilities (see Chapter VII above).

THE TEACHERS' PERCEPTIONS

Although the ZIMSTT Biology graduates' perceptions of their impact on their A-Level Biology students' learning was not elicited directly during the interviews, what they felt about their impact may be inferred from the way they described their A-Level Biology students' performances on the Survey Questionnaire (Item #29). On the whole, the teachers reported that their students' final A-Level Biology examination results were improving. This was supported by the analysis of the 1991 and 1992 final examination results (see above).

IMPACT ON STUDENTS' AFFECTIVE DEVELOPMENT

The ZIMSTT graduates' teaching practices' impact on their A-Level Biology students' affective development has been, on the whole, very significant, from the perspective of the students themselves (see Chapter VII above). A great majority of these students reported to be having very positive attitudes to their learning A-Level Biology because of a variety of factors, which included their teachers' personal and professional qualities and teaching styles; the nature of the subject matter; and career prospects, nature of the lessons etc.

IMPACT ON STUDENTS' INQUIRY SKILLS' DEVELOPMENT

A positive impact was also reported by the students, in terms of the inquiry skills, which the students were developing, as evidenced by some of the comments, which they made and which have been already cited (see Chapter VII above). If the ZIMSTT graduates' teaching practices are such that they stimulated the students' curiosity and a sense of "wondering," "asking questions," "become an avid reader," and "trying to find out more information," then they are having a positive impact on their students' inquiry skills, despite the teachers having noted problems with students weak practical skills, as they came from O-Level classes.

Unfortunately due to the nature of the topics being taught during the study period (i.e. DNA, RNA, Proteins and Protein Synthesis), there was very limited practical work to observe. In fact, only two classes (Mrs. M- & Mrs. G-) were observed doing practical work with enzymes, in two and one laboratory sessions, respectively. At the time the observations were made, the students' practical know-how appeared to have been quite limited. This was judged on the basis of these two observations, using the following criteria: (i) that their teacher still had to interpret the written instructions and procedures for the students before the practical work; (ii) that a number of avoidable breakages occurred, from delivery tubes being forced into rubber bungs and stoppers into test tubes, during the laboratory session. This reflected weak manipulative skills.

Unfortunately, the students' facility to design experiments was not observed during these three particular laboratory sessions. None of the remaining classes were observed having practical lessons. But, on the larger international scale, according to the Chief Examiner's Report (cited above), it appears that these difficulties, which were observed in the L6 students, persist up to the time that they do their final practical examination.

PROGRAM'S IMPACT ON THE MINISTRY OF EDUCATION

The last impact of the ZIMSTT Biology program is on the macro-level, that is, on the education system as a whole. The impact seems to be quantitatively slight, because very few of these ZIMSTT Biology graduates got promoted to become Headmasters, Deputy-Headmasters, Deputy-Headmistresses, Lecturers at the Teacher Training and Polytechnical Colleges, and Education Officers (see Chapter V above). But, qualitatively, these few graduates have filled some critical niches, in which they seem to be having a positive impact. This was reported by all their respective Principals, at the various Colleges, during the informal discussions, which I held with each of them, in order for us to share the outcomes from my visit with their ZIMSTT Graduate Lecturer(s) and any concerns, which the latter may have expressed.

IMPACT ON HEADS OF SCHOOLS

The ZIMSTT Biology graduates who had been promoted to become Deputy/Headmistresses and Deputy/Headmasters of secondary schools were commended very highly by their Headmasters for their hard work, good leadership and administrative styles. They were all reported to have been working well and in harmony with the rest of the teachers and staff within each school, and were exemplary teachers too. The criterion used in each case was, invariably, the final examination results of their students. Hence, they are also having a positive impact on their students, their schools and on the education system as a whole.

However, the nature of the positive impact of those ZIMSTT graduates that had become Headmasters could only be inferred from three sources:

(a) First of all, the fact that they had been promoted again from being a Deputy Headmaster, is indicative of their having been effective as a Deputy/Headmaster. It can thus be inferred because such promotions are done on merit based on the inspection reports and recommendations, which are given by the Education Officers and the Regional Directors.

(b) Secondly, the Headmasters seemed to have a pleasant working relationship with their staff members. This was inferred from the warm rapport and mutual respect among them which I observed as I was shown around the school and during tea and lunch breaks, which they all had in the staff room.

(c) Thirdly, the Headmasters reported to the researcher about the progress which these ZIMSTT graduates seemed to have made in working very closely, not only with their teaching staff, but also with the parents of the students and the grounds staff, in order to up-grade the overall quality of education offered by the school. These parents were perceived to be very supportive in terms of moral support, especially with disciplinary incidence and financial donations, and in terms of their sparing their time and energy to assist in various building projects and to come for PTA meetings and be involved in some of the decision-making processes that have a direct bearing on the quality of education of their children.

However, these ZIMSTT Biology graduates who had been promoted to become either Deputies or Headmasters of secondary schools wished that an element of Administration courses had been included during their B.Ed. program. At the time of the study, some of these graduates were contemplating going back to the University of Zimbabwe to enroll in the Educational Administration Master's program, in order to learn some principles of administration. This study did not elicit these ZIMSTT graduates' "administration teething problems" and the coping strategies that they adopted, as was done for the ZIMSTT graduates who took up A-Level Biology teaching. Regardless of this, and on the bases of the observations described above, it seems then that the ZIMSTT graduates who have been promoted to administrative posts are having a positive impact at that level.

IMPACT ON A-LEVEL BIOLOGY EDUCATION

In terms of being a stop-gap measure of meeting the need for A-Level Biology teachers, the quantitative impact of the ZIMSTT B.Ed. Biology program seems to be negligible, because only nine out of a total of eighty, that is, 11.25% of the B.Ed. Biology graduates had taken up A-Level Biology teaching, by the time this study was done. The qualitative impact of these ZIMSTT Biology graduates in their A-Level Biology classes has already been commented upon above.

Although these graduates seemed quite happy with their having been promoted to be A-Level Biology teachers, they each mentioned aspects of this job's responsibilities which they had not been happy about initially (see Chapter VIII above).

IMPACT ON TEACHER EDUCATORS

Those ZIMSTT graduates that took up Teacher Education, at the Teacher Training Colleges were coping and felt quite contented, as long as they were in the Science Department, teaching Biology as a Curriculum Depth Study. On the other hand, they were not particularly happy when they were moved to join the Theory of

Education Department, in order for them to teach the Education Foundation subjects such as Philosophy, Psychology, and Sociology of Education. This was done because the Theory of Education Department would be under-staffed in comparison with the Science Departments.

Hence, in all cases, despite the initial unhappiness which these graduates felt, they reported that they had done a lot of reading, and with the assistance of their more experienced colleagues, they had adjusted so much that, at the time the study was done, they felt that they were on top of the situation and they were then enjoying their new posts and were doing well in them.

The single ZIMSTT Biology graduate, according to the information that was made available to me, who had been promoted to become an Education Officer in the Statistics Unit of the Ministry of Education and Culture, was not applying much of what he had learned in the B.Ed. Biology program. He reported having made use of the little assessment content that was touched upon during the A-Level Methods Course. Hence, he had a lot to learn in this new post.

As far as I could make out, what seems to have contributed to the success of these graduates, in their new posts, has been a combination of factors which include their willingness to learn, their initiative, their flexibility in approaching their work, and their receptiveness to the suggestions being offered by their colleagues. Some of these qualities were recommended for an ideal teacher by the participants (see Chapter VI above).

CHAPTER X

DISCUSSION: THE GOOD THAT THEY ARE DOING

The diversity of teaching approaches which were observed being used included having lessons that were either theoretical or practical; didactic with knowledge transmission and reproduction or heuristic with knowledge construction and sense-making; classroom-based or field trips; and teacher-centered or student-centered.

These approaches were adopted in varying combinations, in order to achieve the teachers' objectives, which were centered around having their students develop an understanding, appreciation and application of scientific knowledge, processes and skills and a positive attitude to science.

While making judgements, decisions and choices among the different approaches, teachers reported facing dilemmas. For example, there were issues of teaching in order "to cover the syllabus" or "to uncover the concepts" in the syllabus; "teaching for understanding" or "teaching for passing the examination" (Mu.HI, p. 5). Other issues which presented dilemmas were about the scope and sequence of the content to be taught; the balance between teacher and student activities; and the pacing of these activities. Research has proved that teaching is an intentional activity, which is fraught with inherent dilemmas (Lampert, 1985; Jackson, 1986; Floden & Clark, 1987; and Cohen, 1988), because of the complexity of the classroom (Doyle, 1970). Teacher education programs ought to prepare teachers for such uncertainties and how to make reasoned judgements in those situations. The latter preparation was not done explicitly by the ZIMSTT program.

The teachers' teaching styles ranged from being didactic to being heuristic. The didactic teachers turned out to be those who had lower expectations of their students. These teachers were observed dictating notes, or holding question and answer sessions that were tantamount to drilling, and explaining laboratory written instructions to their students, while the heuristic teachers had higher expectations of their students. These teachers were observed providing their students with opportunities not only to acquire knowledge but also to integrate and apply it in unfamiliar situations. For example, opportunities to integrate the acquired knowledge were provided during field trips to research stations, during individual dialogues with their teachers in and out of class, and during class discussions, both in class and in the "Biological Society" and "Biological Seminars;" and during the preparation of "lecturettes" or "mini-lessons." Opportunities to apply their knowledge were provided during homework exercises, tests, discussions and during practical laboratory work. The active involvement of the students in such a variety of ways is an effective strategy in that it gets the students "more engaged in thinking about and reflecting on the subject matter of science, they learn more, understanding increases, and discipline problems in classes are greatly reduced" (Gallagher, et al., 1991, p. iii).

The relationship between a teacher's expectations, beliefs and thoughts, his/her teaching behavior, and his/her students' achievement has been indicated (Clark & Peterson, 1986 and Dusek, et al., 1985). What a teacher expects of his students often comes true. This is referred to as the "self-fulfilling prophecy" principle (Good & Brophy, 1987; Brophy, 1985; Brophy, 1983; & Brophy & Good, 1974). It prevailed in the observed classrooms. Hence teachers must have high expectations of all their students.

All the observed teachers had written schemes of work based on a uniform proforma plan provided by the Science Education Officers. But the detail of their lesson plans varied from teacher to teacher. Both "incremental" and "comprehensive" lesson plans (Clark, 1983 & Peterson, et al., 1978) were observed among the teachers. These lesson plans were not based on their students' prior conceptions. Hence, the conceptual change teaching strategies (Posner, et al., 1982; Hewson & Hewson, 1984) were not being implemented. A few of the teachers regularly checked their students' note books. Most of them did not do so. All the teachers were referring their students to more references than just the set text books. A variety of subject matter representations were being used in making the concepts clearer. These representations seemed to be accommodating the different students' preferred dominant learning styles, which they indicated as visual, auditory and kinesthetic. The deductive and the technical oriented laboratory approaches were implemented in the observed three practical lessons.

There was very close agreement among the observations of the Science Education Officers and those of the researcher of how the teachers helped their students to learn, understand and apply what they taught them and the students' perceptions of these practices and strategies, and their teachers' self-reports on them. These prevailing practices and strategies are discussed at length below.

(i) Charts, illustrations and pictures were used by the teachers. Their students reported that these pictures and diagrams facilitated their learning and understanding of what was being taught. This is in agreement with what has been reported in research (Waddill and McDaniel, 1988; Larkin & Simon, 1987; Mayer, 1989; Gentner & Gentner, 1983; Mayer, 1989 & Mayer & Gallini, 1990).

(ii) Models and modeling were also used by the teacher. Models have been reported to enhance students' learning and understanding (Hesse, 1963). Among the four basic kinds of models that were described (that is, the representative model, the theoretical model, the logical model and the analogue model) (Ost, 1987. pp. 363-366), only the representative and the analogue were observed and reported to have been used by the ZIMSTT graduates. These three dimensional models helped the students "to visualize the parts" and processes, for example the process of mitosis, which would have been, otherwise, inaccessible to them.

A word of caution is in order now about the use of models in science teaching, that is, with regards to the quality of the model and arising misconceptions and the possibility of the students not synthesizing the information represented by the model and instead learning the model. The issue then is the extent to which these teachers work out the limitations and pitfalls of each model with their students.

Modeling, that is, the process of making a model, was observed in only one class, using pieces of string and cut outs to represent the structure of the DNA molecule (Appendix #17). But in this particular lesson, "the pedagogical power of models and modeling" as described by Ost (1987, pp. 367-369) seemed not to have been realized.

(iii) Analogies were reported to have been given by the teachers in order for them to explain the scientific concepts better. Students reported that these analogies helped them to understand better the scientific concepts and processes which were being taught, than when their teachers merely talked about these difficult or abstract concepts. Research has reported similar effects (Glynn, 1991; Halpern, 1990; Gick and Holyoak, 1980; Novick & Holyoak, 1991 & Gilbert, 1989) and the effect of overcoming students' misconceptions (Stavy, 1991). But in order for the analogy to be effective, the students have to know the analog in order for them to make sense of the target (Petrie, 1979). For example, the lock and key analogy would be meaningless to students who had not had any prior experiences with and knowledge of locks and keys and how they work.

As with models, students have to recognize how the analog has attributes which are not shared and hence, not explanatory of the target. These dissimilar attributes have the potential of making students wrongly infer qualities about the target. That is, analogies also have the potential of students developing misconceptions (Donnelly & McDaniel, 1993 and Spiro, et al., 1989).

The ZIMSTT teachers need to be aware of the full potential of analogies, which, as Treagust (1993) pointed out the following.

> From a teaching perspective, the use of analogies can enhance students' understanding since they open new perspectives. In addition, when teachers use analogies, this creates an increased awareness on the part of the teacher to take students' prior conceptions into consideration in teaching. By becoming more aware of students' conceptions, differences between students' ideas and those of the teachers become more evident (p. 4).

But it was apparent, during the study, that the elicitation of students' prior conceptions by the observed teachers was rarely done. And yet, identifying and confronting these prior conceptions is an essential step in teaching for conceptual change, according to a "constructivist" perspective of learning (Anderson & Smith, 1987; Berkheimer & Cheney, 1989; Driver, et al., 1985; Driver, 1981; Hewson & Hewson, 1984; Hewson, 1981; Liem, 1987; Nussbaum & Novick, 1982; Pines & West, 1986; Posner, et al., 1982 and Roth, et al., 1983).

There is need for the teachers to use not just one but multiple analogies (Duit, 1991; Spiro, et al., 1989 & Treagust, 1993), considering the limitations and the constraints of analogies. This strategy will also enable the teacher to cater to and accommodate his students' differential prior experiential knowledge and learning styles.

As with self-generated analogies (Wong, 1993 a & b), it is possible that the students can be made to reflect on their knowledge, during modeling activities. This can be achieved by leaving the decision to the students of what model to build, in order to represent and explain whatever concept/process they have learned. This is in contrast to the approach of the teacher pre-emptying the model, by providing the necessary materials for the model, which the teacher has in mind.

All this literature points to the need for not taking the offered analogies, whether generated by the teacher or by the students, without critically analyzing them together with the students. This will enable both the teacher and the students to determine the degree of accuracy of representation of the analogies and their potential misrepresentation, and to assess, there and then, what sense each student will have made of the analogy - preferably in writing.

(iv) Questions asked at the beginning of the lesson by the teacher, were reported by the students to have helped them to understand better. This enabled the students to relate and use what they already knew to understand the new information better than when the information was just given "out of the blue." On this Dewey (1956) wrote the following.

> As a teacher, he is not concerned with adding new factors to the science he teaches; in propounding hypothesis or in verifying them. He is concerned with the subject matter of the science as representing a given stage and phase of the development of experience. His problem is that of inducing a vital and personal experiencing. Hence, what concerns him as teacher is the ways in which that subject may become a part of experience; what there is in the child's present that is usable with reference to it; how such elements are to be used; how his own knowledge of the subject matter may assist in interpreting the child's needs and doings, and determine the medium in which the child should be placed in order that his growth may be properly directed. He is concerned, not with subject-matter as such, but with subject-matter as a related factor in a total and growing experience. Thus to see it is to psychologize it (p. 23).

What is being stressed here is the importance of the students experiencing instead of being told about the subject matter by the teacher. Students tend to ask more questions when they are interacting first hand with some phenomenon. Hence, this principle of learning by doing has relevance for science education. The nature of the questions asked will depend to some extent on the students' background knowledge.

Research has shown how students' prior conceptions may impinge on present learning and hence the need for teachers to understand their importance and to challenge any existing misconceptions (Osborne & Gilbert, 1980; Posner, et al., 1982) in order for the students to achieve meaningful learning (Ausubel, 1968 & 1963). Learning best proceeds from the familiar (experienced) to the unfamiliar. Hence, fruitful lesson plans are those that are focussed on addressing students' incorrect and incomplete prior conceptions

[Anderson & Smith, 1987; Anderson & Berkheimer, (no date); and Berkheimer et al., 1988]. This is related to the need for continuous assessment. That is, assessment should be used to inform and help teachers to modify their instruction, so that their instruction becomes more effective (Gallagher, verbal communication, during the Assessment in Aid of Science Instruction (AISI) Project Seminar, held at Michigan State University, February 4, 1994).

(v) Question and answer sessions were reported to have aided students' understanding of taught concepts. The relationship between the type of questions asked (open/divergent and closed/convergent) and the thinking skills encouraged (productive and reproductive, respectively) has been established by research. The observed prevailing practices reflected a paucity of questions. Moreover, those questions which were asked were predominantly examples of closed questions. The teachers, for the most part, were observed asking convergent questions.

Wong (1993 a) added two other groups for categorizing questions, i.e., questions "clarifying existing problems" (p. 376) and questions which lead to "discovering new problems" (p. 377). Wong also pointed out that "merely being able to grasp and articulate the question represents an important growth in understanding" (p. 377). He also cited Miyake and Norman (1979) as having argued that "asking a question is more than a request for knowledge; it also indicates an understanding of what is not known"

[Wong, 1993 (b), p. 1265]. Hence, asking of questions must be encouraged in the teaching and learning situations.

One kind of question was asked for the purpose of breaking an otherwise long monologue by one of the teachers. This was "What do you think happened?" This encouraged the students to make conjectures and guesses. These conjectures were tested immediately against what the students heard from the teacher during the rest of the lesson. The students were actively involved. Popper (1965) stressed the role played by conjectures in the development of science. Hence, questions are needed to elicit more information, criteria, evidence, and clarifications. Questions are essential for moving the dialogue or discussion on. As Lipman (1991) pointed out, "To ask the question is to compel people to think differently about the world" (p. 231).

Hence, the paucity of questions observed would suggest the habit of uncritical, receptive learning on the part of the students. There is need for the teachers to model the asking of critical questions and open questions which require higher order cognitive processes of analysis, synthesis and evaluation (Bloom, 1956) on the part of the students, who will then be expected to give extended responses. Strategies for inculcating higher-order (critical and creative) thinking among the students have been developed and proved effective (Fisher, 1990 & Litowitz, 1993).

Differences in the cultural backgrounds of the participants has been shown to influence students' classroom behavior and teacher expectations. For example, an African child is not expected to challenge the elders, whereas, an American child of the same age will exhibit a more open questioning attitude towards what the adult tells him/her. Hence, if teaching and learning is taken as a game with its own rules, to succeed the players have to know the rules and how to play by these rules. If one of these rules is the asking of questions, then students must know how to ask questions appropriately and how to ask the right questions (Sharp & Reed, 1992). Interesting studies have been done in relation to the effect of social and cultural factors on the achievement of minority children who are attending schools which are governed by the mainstream cultural values and genres of language use (Heath, 1986, and Ogbu & Matute-Bianchi, 1986). To succeed, these minority children have to learn and be proficient in using these mainstream genres of language. Question-asking is one of the genres of language.

Lastly, the potential of question asking is realized in the discoveries that are made as the answers are worked out. Bruner (1960) observed.

> It would seem that an important ingredient is a sense of excitement about discovery; . . . discovery of regularities of previously unrecognized relations and similarities between ideas, with a resulting sense of self-confidence in one's abilities . . . (p. 20).

The purpose of teaching, in the final analysis, is to have the students make better sense of what they are being taught. Question-asking is one of the effective tools for realizing this goal. These questions must focus on both the substantive and the syntactic nature of the discipline (Schwab, 1978 & 1966 and Gazzard, 1993).

Apparently, question-asking is not always easy (see Chapter VIII above). One of the teachers indicated that question-asking, in the midst of her teaching, was one of her "teething problems" during her first year of teaching A-Level biology classes. Her focus had been on the content that she was teaching. Other teachers' "teething problems" included getting tough questions from their students, which resulted in either the teachers experiencing "revelations at the chalkboard" (Schulke, et al., 1991), or experiencing "uncomfortable moments." The former resulted in enhanced clarity of understanding by the teacher. The latter was the result of the teacher realizing that he himself had not clearly understood the concept/process, that was being asked about.

(vi) Practical work, which included the study of specimens (living and preserved), slides, or carrying out of experiments, was reported by the students to have helped them to understand better. Many students learn best when they generate their own questions from hands-on engagement with a genuine case or phenomenon. The value of laboratory work has been pointed out (Tamir, 1989; George & Lawrence, 1982).

During this study, only one revision laboratory class on slides and two practical lessons on enzymes were observed. These laboratory sessions portrayed the deductive (verificative) and technical skills-oriented approaches. The question that arises has to do with the extent to which the other approaches (inductive, exploratory and science process- oriented) were being used by these teachers. These different approaches serve different purposes which include the development of concepts, cognitive abilities, attitudes, manipulative skills and understanding the nature of science. As far as the latter is concerned, Schwab (1966) pointed out that the laboratory is intended to display the phenomenon, which gives rise to the problems; the circumstances surrounding the acquisition of data for solving these problems and difficulties of working with and among these circumstances. In this way, students will experience doing science like scientists do.

Teachers need to train their students in following laboratory manual instructions and also in designing their own experiments and to have a balance of these two types of laboratory work. Laboratory work should not be done out of its theoretical context or skipped and/ or regarded as "time-fillers" (VFI, p. 12). Laboratory sessions need to be organized in such a manner that students are encouraged to ask questions which lead to further inquiries (Zesaguli, 1992 a & b). Hence, taken seriously, the laboratory activities have the potential of developing the students' cognitive, affective and manipulative skills. Unfortunately, the discussion on the nature of the laboratory work in this section is limited because only three A-Level Biology practical lessons were observed during this study.

(vii) Explanations by the teachers were reported to aid student learning and understanding. One teacher pointed out how she ensures that her explanations are understood by "making sure that the sequence, language and vocabulary are well understood".

While the teachers' explanations were clear in the majority of cases, students were given few opportunities to generate full explanations and the nature of the explanations which were given by the students left much to be desired. One-word answers for recall-questions which the teachers posed during the class sessions comprised the vast majority of oral replies from students. This poor quality of explanations could also have stemmed from the paucity of those teachers' explanation-seeking "why?" questions. These would require students to give extended responses as they attempted to give their explanations.

Teachers have to remember that being able to explain is one of the objectives of science teaching. That is, explaining is one of the skills required of a scientist, in addition to being able to describe, predict, and control (Anderson & Smith, 1987).

One of the simplest and most effective approaches to encourage good explanations of a scientific phenomenon is asking students to create, apply and evaluate their own analogies, as a heuristic for constructing, evaluating and modifying their own evolving explanations (Wong, 1993 a & b).

(viii) Discussions are related to the above sections. Students reported how discussions in and out of class, with the teachers and among the students alone, helped them to develop better understanding of the scientific concepts. This was achieved in a number of fora. In class, students were asked to read ahead, hold class discussions (as was done on Option Topics) or give "mini-lessons" or "lecturettes" to the rest of the class and then answer questions from the rest of the students.

Out of class, individual presentations were given as one of the students' club activities in the "Biological Society" and "Biology Seminars." These presentations required individual prior reading on the part of the students as they prepared for these talks. In so doing, they provided opportunities for students to acquire and integrate knowledge into some meaningful whole, on their own, before they could present it coherently. Then the question and answer sessions, during the general discussion, provided opportunities for students to frame questions which require further clarifications or which identify problematic issues, and for the presenting student to respond to these questions as satisfactorily as he can.

These verbal interactions are essential for the development of higher-order thinking skills. In these discussions, the students seem to have been sensitized to problematic issues, particularly, with respect to drug addiction and drug dependence. This was observed when the discussions were based on the Option Topics of the syllabus in three classes. The students reported that they had been exposed to different ways of thinking and points of view. The students had listened to one another and engaged in critical argumentation which led, at times, to conflict as they came to the realization that any given life-style can be perceived from multiple perspectives and that any given problem can be solved in more than one way.

These discussion lessons were exemplary of the potential of the "community of inquiry" (Sharp, 1993), as an alternative pedagogy in science education, which was characterized by Gazzard (1993) as being capable of integrating and incorporating ethical, epistemological, and metaphysical inquiry into children's classrooms in ways that are meaningful to them. This will happen when all the students participate in the discussions (Reed, 1992).

As students discussed in class about the Option Topics e.g. "Drug and Alcohol Abuse," "Genetic Engineering," and "Applied Genetics," or in their "Biological Society" and "Biological Seminars," the students were not enacting the role of knowledge consumers. Instead they were provided with an opportunity in which they made use of the knowledge that they had learned and also to reflect critically on their espoused views, values, beliefs and knowledge. Hence, they were developing in all the dimensions that constitute scientific literacy (Michigan Board of Education, 1991, p. 9, Fig. 1) and they were also sharpening their skills of judgement (Lipman, 1991). In addition to group discussions, dialogues held between the teacher and individual students were also reported to have helped students achieve a better understanding of the content taught.

Lipman (1991) described a continuum in which lie different kinds of talk. At one extreme he placed talk which is non-manipulative and which is also non-purposive. At the other end is talk which is manipulative and purposive. Dialogue lies between the ends of this continuum. Lipman used the analogy of walking to highlight the features of a dialogue. That is, "dialogue is not aimless talk; in a dialogue . . . disequilibrium is enforced in order to move forward. . . . A dialogue is an exploration, an investigation, an inquiry by participants engaging in it collaboratively . . . cooperatively . . . (p. 232).

These latter two terms are often used synonymously meaning to act or work together with another or others for a common purpose. A model for developing cooperative learning strategies has been proposed (Johnson, et al., 1990; Slavin, 1983). Research has also shown how uncooperative students end up not learning as they resist their teachers' efforts to facilitate their learning (Willis, 1977). Fortunately, most of the students in this study sought and entered into the described dialogues and interactions with their teachers voluntarily, to discuss both academic and personal matters.

Lastly, during these teacher-student dialogues and class discussions, the students' intellectual growth is achieved by the students internalizing their dialogue with their teacher in their thoughts (Vygotsky, 1962 & 1978 Wertsch, 1985). Hence, more of these discussions should be carried out in the Biology lessons.

(ix) The deliberate pacing of the lessons was appreciated by the students in seven of the classes. Whereas, in the other two, the students wanted their teachers to go faster. An example of a teacher making sure that students understood before going on was in Mrs.

Mi-'s practical lesson (Appendix #10). As a result of the deliberate pacing of this practical lesson, none of the students had gone over all the intended slides because of the time which the students had taken to look up the pre-requisite information, which they needed to make sense of the slides. Hence, less material was covered but it was well understood. Dewey (1916/1944) argued the following.

> The apparent loss of time involved is more than made up for by the superior understanding and vital interest secured. What the pupil learns, he at least understands . . . students will not go so far, perhaps, in the 'ground covered', but they will be sure and intelligent as far as they go . . . (pp. 220-221).

This underscores the belief that it is educationally better when less content is taught and if it is understood thoroughly than when more detailed content is taught and not understood well.

(x) Differences of the teachers' "wait-time," after posing questions, are related to the differences in the pacing of lessons. Prevailing practices reflected situations in which there was zero "wait-time" (Appendix #17) and situations in which the teachers paused after posing a question (Appendices #10 & 16). The latter even rephrased their questions, if the students' response was less than desired. Research has demonstrated differential mental engagements among the students in these two kinds of situations (Brophy & Good, 1974). During the ZIMSTT Methods courses, the candidates need to be made aware of the established fact that longer pauses, coupled with the uncertainty of whom the teacher may call on, and the practice of picking those students who are not raising their hands, forces all the students to attempt to think and synthesize some sort of response.

(xi) The other ways in which the students reported that they understood better was when their teachers made use of audio-visual aids such as films and overhead projectors; role-playing; reference materials from which to extract scientific articles and other relevant handouts; field trips to research stations; and inviting outside speakers to talk on topics of their expertise. All of these helped them to get a better understanding of the content. The teacher rationalized these strategies and approaches as means "to broaden their (the students') biological horizons" and to facilitate their understanding to a greater extent. The teachers were familiar with these because their teacher education program had stressed their importance.

Thus, teachers used a variety of means and ways to help their students learn and understand. The effectiveness of these strategies has been documented by research. But the extent to which the full potential of each of the strategies was realized by the teachers was not examined in this study. That will be the focus of a subsequent research study.

(xii) Assessment, which the teachers in this study reported, was limited to homework exercises, tests at the end of the topics, and mid-year and end-of-year examinations. That is, the nature of their assessment was limited to pen and pencil tests of student learning. It would also appear that the teachers are not using alternative forms of assessment (Kuhn & Malcolm, 1991 & Pines, et al., 1978).

(xiii) The impact made by the ZIMSTT graduates in their posts, i.e., whether as Deputy Headmasters, Deputy Headmistresses, Headmasters, Teacher Training College Lecturers, or as A-Level Biology teachers, were perceived by their supervisors as positive, on the whole. The effectiveness of the ZIMSTT graduates' teaching practices with their students was also established using four measures (See Chapter IX). The results indicated that the students had undergone some conceptual development in their understanding of the topic (DNA, RNA, and Protein Synthesis). Items on these measures required students to describe, explain, predict and control variables. The results indicated that these students performed relatively better on recall items than on items which required them to apply their knowledge. Lastly, the students indicated that they had, in the majority of cases, developed positive attitudes towards their learning Biology. This gives further evidence of the ZIMSTT graduates' positive affective impact.

Overall, the observed patterns of what teachers are thinking and doing either maps on or shows discontinuity with some of the theories and taxonomies that were part of the conceptual framework that guided this study. For example,

1. A majority of the observed lesson plans corresponded directly with the proposed taxonomy in that some of them could be categorized as "incremental" and others were "comprehensive" (Clark, 1983). The former concentrated on objectives (Tyler, 1950) and content (Peterson, et al., 1978). The latter focussed more on the learner and the instructional process (Mrs. B- & Mrs. Mi-). However, none of the lesson plans were based on Yinger's (1977) three-stage planning model of "problem-finding, problem formulation and solution, and planning the implementation stage." This can be linked with the lack of self-critical reflection and a questioning habit of mind on the part of the teachers.

2. A discontinuity was observed between, on the one hand, the teachers' views of knowledge as a body of information, teaching as giving information, and learning as passive reception of knowledge, and, on the other hand, the teachers' actual teaching approaches and strategies which tended to be heuristic in most cases.

3. The diverse strategies e.g. models, modeling, analogies, practical work, discussions etc. which the teachers were implementing were reported by their students to have facilitated their understanding. Similar positive effects have been reported in the reviewed literature (see above and Chapter II).

4. Without realizing it, the teachers in most cases were implementing the "constructivist theory of learning" (Driver, 1981 &

Driver, et al., 1985) in that they were facilitating the construction of meanings and knowledge with their students by the way that they guided their students to interact with ideas and things.

5. However, there was a disjunction between the conceptual change teaching and learning model (Anderson & Smith, 1987; Driver, 1981; Posner, et al., 1982; Driver, et al., 1985 and Hewson & Hewson, 1984) and these teachers' prevailing teaching practices. In the majority of cases, the teachers did not elicit their students' prior knowledge on the topic to be taught. The few that did, did not help the students to realize the inadequacy or incompleteness of their prior conceptions. The teachers did not confront their students' prior conceptions. Hence, the students never became dissatisfied with their prior conceptions. Moreover, the fruitfulness of the new concepts was never explicitly indicated. Hence, it can be inferred that the conceptual change teaching model was not being implemented. The consequence of these otherwise effective teaching practices was that the students failed to achieve "deep understanding" (Gardner, 1991, p. 118). Evidence for this was their inability to describe, explain, predict and apply satisfactorily the information taught on Protein Synthesis in unfamiliar problems (see Chapter IX above and Appendices 20 and 21).

CHAPTER XI

THE SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

In Chapters I - III, the nature and the evolution of the Zimbabwe Science Teacher Training (ZIMSTT) Program was described. It was implemented as a stop-gap measure for alleviating the dire shortage of A-Level Science teachers, which resulted from the increases in students enrollments, due to the social and political changes that took place after the country achieved its independence in 1980. The one-year Phase I and the two-year Phase II ZIMSTT in-service programs up-graded certified and experienced O-Level Science teachers, by giving them more subject matter content knowledge, so that they can teach up to A-Level, in one of the Science subjects.

In Chapter V, a description of the ZIMSTT graduates experiential backgrounds was given. These were qualified O-Level science teachers, a majority of whom had at least two years of teaching experience. These participants in the ZIMSTT program enrolled into the B.Ed. program for academic, professional and personal advancement. They perceived the program to have placed high levels of cognitive demand on them. They reported working under pressure throughout because of time constraints and the shortage of books in the library at the University of Zimbabwe.

This research was a follow-up study of the ZIMSTT Biology graduates. It was done using both qualitative and quantitative methods in order to find out (i) how these graduates were coping with teaching A-Level Biology classes; (ii) the nature of their teaching practices; and (iii) the impact that they were having on their students. Data were collected and triangulated from a variety of sources. The summaries of the findings will be presented by answering three basic questions.

WHAT HAPPENED TO THE ZIMSTT BIOLOGY GRADUATES?

After graduation, only a few of those who graduated from the ZIMSTT Biology program (N=80) were promoted to become Teacher Educators (N=8), Headmasters (N=4), Education Officer (N=1), A-Level Biology teachers (N=9); the rest (58/80) went back to teach O-Level Science classes or left teaching for other pursuits. The reasons given on the survey questionnaire for not taking up A-Level Biology teaching included the graduates not wanting to move their families; not being attracted by the small supplementary allowance given to A-Level Science and Mathematics teachers in relation to the high demands of A-Level teaching; not wanting to live in the rural areas with poor living conditions, etc. Hence, it can be concluded that only nine out of the eighty ZIMSTT Biology (1986-1990) graduates (11.25%) had taken up A-Level Biology teaching. This low percentage underscores two previous tracer study findings. The first study concluded the following.

> With regards to achieving its long term, i.e., to increase the numbers and to improve the quality of the teachers of science and mathematics at high school level (especially at 'A' Level) the ZIMSTT project has been partially successful. . . . A tracer study of former 49 students (i.e., ZIMSTT graduates) reveals that, although all remained in teaching, only 31% of the respondents are now actually teaching 'A' Levels . . . (Boeren & Kuchocha, 1990, p. 3, Conclusion #2).

The second study concluded the following.

> Very few of the respondents were teaching A-Level. More former Chemistry students were teaching A-Level than any other group while fewer former Biology students were teaching A-Level than any of the other groups (Jaji & Hodzi, 1992, p. 51, Section 4.2.3).

Hence, this issue of the ZIMSTT graduates not taking up A- Level Science classes needs to be looked into.

However, in these various promotion posts of responsibility, the B.Ed. program was perceived by the ZIMSTT graduates as having a positive influence on their work. However, the A-Level Biology teachers did not perceive the program as having prepared them adequately for the new A-Level Biology (No. 9261) Syllabus since they all reported to have initially experienced similar "teething problems" (see summary of these below). It seems that experience teaching at one level and the one-time in-service program, which imparted additional subject matter knowledge, have been shown to be necessary but not sufficient to prepare the teachers adequately for teaching at a higher level. Hence, an inference was made about the teachers having learned Biology, at the University of Zimbabwe, as an academic discipline, without adequate reference or emphasis having been put on "how to effectively transform their academic knowledge into instructional activities in the classroom" [Sanford (1988) quoted in Skulk, et al., 1991]. In this case, it needed to be for the sake of their A-Level Biology classes. That is, each time a topic was dealt with during the ZIMSTT program, discussions about how that subject matter content can be taught to and represented for the A- Level Biology students should be included. The most difficulty was experienced by these A-Level Biology teachers when it came to teaching the Option Topics of the syllabus. An issue was raised with regards to the availability of the appropriate reference materials for these Option Topics. This issue needs to be addressed by the Ministry of Education and Culture.

The ZIMSTT graduates that became Teacher Educators felt that the program had not prepared them for lecturing in Education Theory courses. Similarly, those that became Headmasters felt inadequately prepared by the program for their administrative responsibilities. These issues need to be addressed by the ZIMSTT program lecturers at the University of Zimbabwe.

The ZIMSTT A-Level Biology teachers are teaching at both government and private, rural and urban secondary schools whose contextual factors are impinging on their teaching. These contextual factors are described in Chapter IV. They include the shortage of time for all the teachers and the shortage of teaching and learning resources, that is, laboratory equipment, chemicals and textbooks for students in most cases. Headmasters were perceived to be always saying, "We are in the red. There is no money." Hence, it appears that the teachers were operating under very difficult situations. This state of affairs was exerting pressure on the teachers which, in turn, was having a negative effect on their teaching practices to a great extent (see Chapter VIII).

The most negative repercussions of some of these pressures included the practices of teachers dictating notes; students not doing much outside reading; practical work either being postponed and, hence, being done out of context and/or being "talked about," i.e., not being done at all; and teachers rushing "to cover the syllabus topics" without adequately "uncovering the concepts."

Contradictions were noted in the way these various pressures played out in the different classrooms and what teachers did in their reactions to this. Some of the teachers became victims of their situations and succumbed to doing nothing about it, as evidenced by their skipping the practical work whenever they did not have the equipment for it their school. Other teachers in worse situations, as far as resource availability was concerned, found ways and means of circumventing the problem. These means included borrowing from other schools and seeking materials from marketing houses. In this way they rose above their otherwise grim situations and managed to teach effectively. This leads to the next question.

WHAT ARE THE ZIMSTT BIOLOGY GRADUATES DOING IN THEIR A-LEVEL BIOLOGY CLASSES?

To get a full appreciation of their present teaching practices, it was necessary to find out the teachers' perceptions of their A-Level Biology students and their conceptions and beliefs about knowledge, teaching, learning, subject matter, their milieu, and how their teaching A-Level practice had evolved from the time that they had graduated from the B.Ed. program. These findings are described in Chapter VI.

In most cases, knowledge was conceived as a body of information, in its final form, ready to be transmitted from the textbooks via the teacher to the students and in terms of the processes of its construction and validation. Some of the teachers holding this view described teaching as "giving information." Other teachers holding this view of knowledge perceived teaching as guiding students to find out more information; developing a positive attitude towards the subject; facilitating and guiding students to develop inquiry skills; making students apply their knowledge through role-playing and by guiding them to discover; leading students to think; developing a questioning attitude; developing higher-order thinking skills, e.g., analysis and making inferences, etc. No one mentioned teaching as helping students form communities where cooperative inquiry and learning takes place. But some of them were observed organizing the teaching and learning activities in their classes in such a manner that their students were actively involved in learning cooperatively.

Similarly, a contradiction was also noted with a majority of teachers who held the view of knowledge as a body of unchanging information but conceived learning not as passive reception of information. Instead these teachers conceived learning either in terms of students sharing and acquiring knowledge; or in terms of students finding out information; and/or in terms of students changing their behaviors, attitudes, and existing knowledge. And yet the teachers hardly elicited their students' prior knowledge.

An ideal A-Level Biology teacher was characterized by the teachers as showing a high level of professionalism, which included interacting professionally with their colleagues; being dedicated to the job; putting in a lot of time, energy and drive; reading widely; collecting materials for teaching; and preparing thoroughly for the lessons. Other personal ideal traits included creativity, initiative, independence, dedication to the job, self-confidence, and a willingness to teach better etc.

If these traits are used as assessment criteria, then the evidence from the data indicates that a majority of these ZIMSTT A-Level Biology teachers were meeting these criteria to a large extent. In other words, a majority of the ZIMSTT A-Level Biology teachers are showing the "extended level of professionalism" as opposed to the "restricted level of professionalism" (Norman Atkinson, personal communication). "Energy," "drive," "initiative," "willingness to teach better," and "dedication to the job" were all evident in the way the majority (7/9) of the teachers approached their work and sought outside resources for teaching and learning. "Sincerity of approach," "thorough lesson preparation," and "teaching deliberately" were reflected by the way the teachers felt accountable for their students' passing. "Knowledgeability" was being intensified by the wide reading which all the teachers reported to be doing in order to meet the challenge of teaching the

A-Level students who were perceived as being "more mature." "Spontaneity" was reflected in the manner in which the teachers tackled students' questions during the lessons (Mr. C- was the best example of this trait). Lastly, "organizational power" was reflected in the way all these teachers related as Heads of their Science Departments with the other science teachers (Mrs. Mi- was the best example of this trait, not only as the Head of the Science Department but also as an Acting-Deputy Headmistress and the Organizer of the Manicaland A-Level Biology Teachers' Association and as the Convener of the A-Level Biology Students' Biological Seminar meetings).

Most of these teachers' lessons were presented with "vitality and enthusiasm" which was rubbing off from the teachers to their students. This positive effect was observed during their lessons and it was reported by the students during interviews. To witness this was the most exciting and inspiring aspect of the study. This was also reflected in how the students were all very keen to do well and were hoping to proceed to the University of Zimbabwe for further studies in medicine, engineering and pharmacy etc. [for example, See Video-tape C 2 (9/7/92)]. Lastly, all the teachers were active members of both their Regional Science Syllabus Cluster Panels and their Regional Zimbabwe Association for Science Education (ZIMASE) Branches. Despite some of their identified weaknesses, these teachers are exhibiting an "extended level of professionalism." They all expressed a burning wish for opportunities for further studies but they all need financial assistance to make this possible.

A-Level Biology was conceived, by both the teachers and their students, as being not only preparatory for further studies at the University but also as being cognitively very demanding in terms of its conceptual depth, the practical work, and the amount of independent extra reading which the teachers and their students have to do. This is related to the issue of the adequacy of the preparation by the ZIMSTT program and the O-Level Science syllabus, respectively.

The teachers and their Headmasters and Education Officers were in agreement that the knowledge base that an A-Level teacher needs, in order to teach effectively, is more than just subject matter knowledge. It was pointed out that a teacher needs knowledge of the individual students (i.e., their interests, abilities and levels of motivation, etc.), pedagogy, the environment, the curriculum, the specific subject matter content and its specific methodology, and the previous level's science syllabus which the students have just passed.

These beliefs and conceptions influence the teachers' teaching practices which were described in Chapter VIII. At first these prevailing practices were observed being implemented in the A-Level Biology classes taught by two ZIMSTT graduates, who were "shadowed" for about four weeks, and in the classes of the other seven graduates during the subsequent follow-up classroom visits. All the teachers reported that they had experienced some conceptual, practical and pedagogical problems during their first year of teaching A-Level Biology classes. These "teething problems" included difficulties in their organization and the handling of practical and microscopy work; assessing students' responses, particularly in their practical work; interpreting the depth of treatment of the syllabus topics, in terms of deciding on the appropriate depth of coverage; how to improvise for the missing apparatus; subject matter representation; not having the subject matter knowledge on the Option Topics; not asking questions during the lessons, which were taught mostly by the lecture method, which focussed more on knowledge transmission than on assessing for their students' understanding.

Despite these problems the teachers developed some **coping strategies**, which they offered as advice to newly deployed ZIMSTT graduates who are to teach A-Level Biology. These coping strategies included studying the syllabus requirements early; getting pedagogical assistance from experienced colleagues on areas reckoned to be problematic; studying past final examination papers and the Chief Examiner's Reports on them; planning for practical work ahead of time; knowing the subject matter knowledge, the milieu, the learner, the students' learning characteristics; being prepared and presenting materials in an orderly fashion; projecting a positive attitude towards the subject which one teaches; and referring to more resources than just the textbooks to encourage their students to do likewise.

By the time this study was carried out, which was four to six years after completing the program, all of the observed ZIMSTT graduates who were teaching A-Level Biology felt that they were now "on top of the situation." That is, they were now coping very well teaching the A-Level students. However, the teachers felt that these students did not seem to be adequately prepared for A-Level studies, despite the fact that they had been selected for A-Level Biology classes because of their good grades of "As and "Bs on the O-Level Science Core and Extended syllabus. The research data indicated that the students reflected a diversity in terms of their understanding of scientific background knowledge, manipulative skills, attitudes to learning A-Level Biology and learning styles (see Chapter VII) and in terms of their cognitive achievement (see Chapter IX).

The classroom discourse which was observed by the researcher and reported by the students was either a one-way communication or interactive dialogues or a combination of both.

A variety of strategies and approaches were implemented by the teachers to varying extents in order to achieve their intentions for their students' learning and development (see Chapter X). These means included the use of diagrams; models and modeling; analogies; audio-visual aids; appropriate pacing of lessons; practical work; showing real- life specimens; giving real-life problems; students presenting "lecturettes" or "mini-lessons;" teachers referring to articles from scientific magazines; handouts from the teachers' reference materials; asking students to read ahead; teachers summarizing the main points; and encouraging one-on-one dialogues between the teacher and individual students, in and out of class, and class discussions among the students. This diversity in teaching approaches contradicted the views of teaching as "giving information" and learning as passive reception of knowledge which is viewed "as a body of information."

The images which were given by the students and by the teachers provided another lens through which prevailing A-Level teaching practices of the ZIMSTT graduates were studied. The diversity of images which had been formed by the teachers and their students corroborated the diversity that was observed in their classrooms.

The judgements and decisions which these teachers were making during their planning and teaching sessions are also described in Chapter VIII. Initially the teachers had problems stating them. After some probing they did give examples of these decisions and judgements. These decisions and judgements can be categorized as "immediate" rather than the "reflective" types (Eggleston, 1979). These were with regards to the students' backgrounds, the scope and sequence of the content, the subject matter representation, teaching approaches and techniques, the activities to be done, the time to be spent on a topic, the questions to be asked, and the assessment of the students' comprehension. These decisions are made in response to the nature of the demands which are placed on the teachers. These demands include the conceptual difficulty of the A-Level Biology content, time limitations, low motivation of their students, and shortage of teaching and learning resources.

It was also apparent, from the global evaluative statements and the absence of self-critical comments in the teachers' scheme books, that the teachers seemed not to be self-critical about their practices, nor did they develop the habit of questioning among their students. Their theories or philosophies about various aspects of their practice are tacit. They are not accustomed to holding conversations about these aspects. Their ideas about them had to be dragged out of them. But once they started, there was no stopping them. Moreover, they had very sound and interesting ideas (see Chapter VI and also Chapter VIII). For example, the ideal teacher attributes are appropriate to develop as part of a teacher's repertoire of personal resources because those that have them seemed to be more effective than teachers that do not have them, as shown by their students' pass rates on their final examinations. Interactions with their E.O.s and other teachers would provide opportunities for critical reflection for the teachers.

Lastly, an issue surfaced with regards to the minimal internal and external **professional assistance** which was being given to these ZIMSTT up-graded teachers, by their Headmasters and their regional E.O.s, respectively. The factors that were contributing to this state of affairs included the facts that the up-graded teachers were themselves the Heads of their Science Departments; the classroom observation visits by their Headmasters were infrequent; and the ratio of the numbers of the Science E.O.s to the numbers of science teachers was very low. That is, the E.O.s were "spread thin on the ground." Moreover, the few E.O.s that were there were concentrating on supervising the lower Forms, which were being taught by untrained teachers. Thus, the ZIMSTT graduates teaching A- Level Biology are working mostly on their own. They do not get the benefits of their

E.O.'s and Heads of Schools' expertise on a one-on-one basis. The organized workshops and seminars seemed to be too few and far between, and when they did take place, they tried to focus on too many aspects of teaching and learning at each meeting (Appendix #18). This state of affairs is serious in light of the teachers' initial "teething problems" and their occasional experiences of "uncomfortable moments" as they teach the A-Level Biology syllabus. Hence, there is the issue of time which is related both to the issue of the relative numbers of E.O.s to teachers and to the issues of the frequency and the nature of the professional assistance, i.e., the quantity and quality of the classroom supervision visits and the workshops which the E.O.s can implement effectively. This leads to the third question on impact.

WHAT IS THE IMPACT OF THE ZIMSTT BIOLOGY PROGRAM ON THE EDUCATION SYSTEM, AS A WHOLE, AND IN PARTICULAR, OF ITS BIOLOGY GRADUATES ON THEIR A-LEVEL BIOLOGY STUDENTS?

The evaluation of the impact which the ZIMSTT program has had on the Ministry of Education and Culture and on the A-Level Biology students was described in Chapter IX.

The impact which the ZIMSTT Biology program has had on the Ministry of Education and Culture has been indicated by the data to be quantitatively minimal in terms of its aims of ". . . producing manpower for Curriculum Development, to teach at Teacher Training Colleges, and to service other division of the Ministry of Education (ZIMSTT, 1988, p. 1). This conclusion was based on the numbers of the ZIMSTT Biology graduates who were servicing the different divisions of the Ministry of Education and Culture. Altogether the ZIMSTT program has produced eighty Biology graduates, that is, twenty per cohort (1986, 1987, 1988, 1989-90). The 1991-92 cohort was still in session when this study was done. Out of these eighty graduates, nine became A-Level Biology teachers; four became Heads of Schools; eight became Teacher Educators (some of which were in the Science Departments and others were in the Educational Foundations Departments); and one became an Education Officer (Statistics) at the Head Office of the Ministry of Education. That is, 22/80 (27.5%) of the ZIMSTT graduates were promoted "to service other divisions of the Ministry of Education." The majority of the ZIMSTT Biology graduates 58/80 (72.5%) either went back to teaching O-Level Science or took up other jobs outside the Ministry of Education and Culture. None of them joined the Science Team in the Curriculum Development Unit (CDU) of the Ministry of Education and Culture.

On the other hand, the ZIMSTT program has had a qualitatively positive impact on the work of its graduates in their various posts of responsibilities.

The impact which the ZIMSTT Biology graduates have had on their A-Level Biology students' cognitive, affective and manipulative skills development is also described in Chapter IX. The nature of these students is described in Chapter VII. There was a contradiction between what the students reported about their own cognitive abilities, attitudes to learning A-Level Biology, and manipulative skills which they had developed and what their teachers perceived. According to the teachers, the fact that the students came in with "As and "Bs from their O-Level Final Science Examination was not commensurate with their A-Level Biology performances. The majority of their teachers perceived these students' A-Level Biology performances as mediocre, their attitude to learning as negative, and their manipulative skills as poor. Whereas, the students perceived themselves as having positive cognitive and affective inclinations towards learning A-Level Biology. The students' positive inclinations were based on their ease of making sense of what they were learning; their perceptions of the nature of the subject matter as being easy, interesting, detailed, and demanding a lot of outside reading; and its being related to self and real-life situations.

The students reported that the manner in which the teachers portrayed themselves, taught, and managed their lessons was also having a positive affective impact on them.

The impact which the ZIMSTT graduates were having on the students' conceptual understanding and manipulative and cognitive skills development was assessed on the basis of their students' responses on the Students' Questionnaire, Item #7 (Appendix #20) and on their Pre- and Post-test scores (Appendix #21). The 1991 and 1992 A-Level Biology Final Examinations results of these graduates' U6 classes (Appendix #22.1) were also used as an indicator of the teachers' impact on their students' cognitive and manipulative skills development. The majority of the A-Level Biology teachers (5/7) had better than 50% pass rates, and only 2/7 were still having more than 50% failure rates (Appendix #22.1).

These various measures revealed that the students do well on recall items but not on items which required them to apply their knowledge to unfamiliar problem situations. In addition to this, the problems which the students displayed during the few observed practical lessons seem to persist up to the time that the students write their A-Level Final Examinations. This was reflected in the Cambridge A-Level Biology Examiner's Report (Appendix #15.3). For example, the Chief Examiner reported that many candidates spelled the four DNA bases incorrectly confused concepts, e.g., **transcription** with **translation**; failed to devise a single table to accommodate results and conclusions; failed to show their ability to record observations and interpret them in the light of their biological knowledge; used imprecise language; and lost marks in the drawing because a text book representation was given etc.

The impact which the ZIMSTT graduates have had on their A-Level Biology students' affective development was more positive than on their cognitive and conceptual development and their manipulative and inquiry skills development.

CONCLUSIONS

What emerges from the data is that there is more diversity or heterogeneity and less homogeneity among the ZIMSTT graduates who were teaching A-Level Biology classes, with respect to their thinking and their prevailing teaching practices. Several continua were posited with respect to the diversity in the teachers' views about knowledge, teaching, and learning; their perceptions of themselves, their school context, their students, of an ideal A-Level Biology teacher and of their teaching styles etc.; and their observed teaching practices. These continua are listed below with the relative and approximate placements of the teachers (see page xvi).

1.1	Knowledge transmission mostly by lectures (giving information)	<-------teaching------->	Knowledge construction through question & answer sessions (facilitating & guiding students to discover knowledge)
1.2	Didactic	<-----teaching style------>	Heuristic
1.3	Limited representations	<-------explanations & illustrations ------>	Multiple representations
1.4	Few, same type Need low-level thinking	<---questions--->	Many, varied, Need high-level thinking
1.5	One-way communication	<---classroom discourse--->	Two-way interactive dialogue

(D- & M-) <-- (G-, V- & P-) --> (N-, C-, Mi- & B-)

2.1	Knowledge reproduction	<--- assessment & learning--->	Knowledge production
2.2	Passive/Receptive	<------learning------>	Active
2.3	Factual acquisition	<----learning--->	Sense-making
2.4	Rote	<------learning------->	Meaningful significance attribution

(D- & M-) <-- (G-, V- & P-) --> (N-, C-, B- & Mi-)

3.1 Competitive individuals <-------students-----> Cooperative groups

(D- & M-) <-- (G-, V- & P-) --> (N-, C-, B- & Mi-)

3.2 Not motivated with a negative attitude to learning <---students---> Motivated with a positive attitude to learning

(M-, G-, D- & C-) <------> (P- & B-, N-, V- & Mi-)

4.1 Dependent on text <---teacher----> Flexible (Refers to journal articles & many reference books)

(D- & M-) <-- (G-, V-, P-, N- & B-) ---> (Mi- & C-)

4.2 Dominant & directive <----teacher-----> Open & Interactive

(D-, M- & V-) <-- (G- & P-) --> (C-, N-, B- & Mi-)

5.0 Sketchy <--------lesson plans--------> Detailed

(D- M- & G-) <-- (V-, P- & N-) --> (C-, B- & Mi-)

6.0 A body of facts <---knowledge---> Tentative facts

(D- M- & G-) <-- (V-, P- & N-) --> (C-, B- & Mi-)

7.1 Dusty and needing repair <---lab. maintenance & equipment---> Polished and orderly & clean

7.2 Inadequately equipped laboratory <------resources ------> Adequately equipped laboratory

(M- & G-) <-- (P-, B- & C-) --> (N-, V-, D- & Mi-)

8.0 Passive <-- parental & school --> Active
administrative support
& enthusiasm

(M- & G-) <-- (P- & C-) --> (N-, V-, Mi- B- & D-)

Sometimes the relative placement or mapping of these teachers along these continua has a direct correspondence (e.g. the teaching and learning continua). But at other times contradictions were noted between the teachers' views and perceptions and what they were observed practicing in their A-Level Biology classes. For example, in terms of the adequacy of the teaching and learning resources, the schools' science laboratories were placed along the following continuum.

Inadequately <--------- resources ---------> Adequately
equipped equipped

(M- & G-) <------ (P-, B- & C-) ----> (N-, V-, D- & Mi-)

The following discussion will make reference to these continua and their relative teacher placements. For four of the teachers at the extreme right of the resources continuum, there was a direct relationship between their placement on this continuum and their relative mapping on the continuum of the range of support and enthusiasm which these teachers were given by their school administration and by the Parents and Teachers Management Board (PTA). At one end of the continuum there is "active support" that the school administration and the parents take to facilitate the timely and adequate provision of teaching and learning resources. At the other end of the continuum the support is "passive", that is, it is mostly verbal in that minimal action is taken to try and meet the needs of the teachers.

However, a contradiction is noted with Mrs. B-, whose school enjoyed great support and enthusiasm from the parents. Unfortunately, these parents could only do so much on their below average incomes. Hence, her laboratory was not that well equipped and yet Mrs. B- was placed at the extreme right of the teaching style continuum indicating a heuristic teaching style.

However, there is a one-on-one correspondence between the placement of the teachers at the extreme left of the resources continuum with their relative placement at the extreme left of the observed teaching style continuum, except for Mr. D- and Mrs. B-, in particular. Mr. D- was placed at the extreme right side of the resources continuum, indicating very adequate resources, and yet he was placed at the extreme left of the teaching style continuum, as having a traditional didactic teaching style. Similarly, Mrs. B-'s resources are not at all comparable with those in Mr.D-'s laboratory. She was placed somewhere in the middle of the resources continuum, and yet she was also placed at the extreme right of the teaching style continuum, as having a heuristic interactive teaching style.

But Mrs. M- and Mrs. G- present a rather different situation. They both had limited resources and a very didactic teaching style. That is, their placements on the resources and the teaching style continua correspond. It is difficult to infer accurately to what extent they were the victims of their school contextual factors or to what extent their teaching styles reflected their deliberate influencing of their situation. Their students were sharing text books and had low motivation to learning. They did not do their homework readings and note making on time. They came to subsequent lessons not adequately prepared to actively participate and contribute in class. Hence, Mrs. M- and Mrs. G- may be deliberately resorting to spoon-feeding, that is, to a didactic teaching style and avoiding an interactive style of teaching. In the former case, their teaching style would be reactive and, in the latter case, it would be proactive to the situation. The question emerges of whether what is observed prevailing is a reflection of acquiescence on the part of these two teachers or whether what is observed is a product of their deliberate determination.

Other varying patterns and degrees of correspondence and contradictions were also noted when the placements of the teachers on the rest of the established various continua were compared or were mapped onto one another (see above). Hence, one cannot use a particular teacher's relative placement on any one of these established continua to make inferences about the nature of the rest of that teacher's views and other aspects of his/her teaching practices.

Therefore, caution is needed not to try and generalize about the ZIMSTT graduates' relative placements on these various continua because of the limited classroom observations which were made of these teachers. A totally different picture of these teachers' prevailing teaching styles might emerge if these teachers were to be observed teaching different students or for a longer period of time or in dealing with a variety of the syllabus topics.

RECOMMENDATIONS

On the basis of the issues raised and the conclusions reached, the following recommendations are suggested as feedback to the various levels of participants who are associated with Science Education in the country.

1. For the ZIMSTT Biology program implementers, there are two aspects that need to be addressed. The first has to do with the manner in which the ZIMSTT candidates were taught during the program. Research has demonstrated how teachers tend to teach as they were taught. Hence, the shift in pedagogical strategies from a didactic to a heuristic paradigm needs to be modeled by the ZIMSTT staff for their ZIMSTT candidates during the program. In addition to this, the ZIMSTT staff needs to go further than just teach the subject matter content. They also need to hold discussions with the ZIMSTT candidates focussed on how to transform that particular content for classroom instruction in a manner that does not mirror the traditional didactic cultural over-ay of content per se.

The second aspect to be attended to by the ZIMSTT staff is the need for them to revise the program content, in order for it (a) to include aspects of "Administration," as indicated by those graduates that became Headmasters; (b) to treat Education Theory Foundations in greater depth, as indicated by those graduates that became Teacher Educators; and (c) to put more emphasis on A-Level practical work, with particular emphasis on microscopy work, marking of the students' diagrams, interpreting the A-Level syllabus, questioning techniques, and improvising apparatus, as indicated by those graduates who became A-Level Biology teachers.

2. **For the Science Education Officers**, there is a need for professional assistance even for the trained and experienced teachers and particularly for the newly up-graded teachers who have moved into a new level of teaching. There is also a need for organizing still more seminars and workshops which focus on a few aspects of teaching and learning at each meeting. These meetings should be regular and more often, with greater emphasis on heuristic teaching approaches and strategies. Pre-requisite to this change in practice is the change in vision by the teachers. As was exemplified by the Toledo Mathematics and Science Support Teacher Project (Gallagher & Lanier, 1988), such innovative changes in practice tend to lag behind the changes in vision of the implementers and will require commitment and persistence, because such changes were reported to take place at a slow pace and in spurts (Zesaguli, 1991).

3. **For the Ministry of Education and Culture**, there is a need for it to maximize the returns from its large financial investment which was incurred by releasing the teachers on study leave, with full pay, in order for them to participate in the ZIMSTT (Science) program. These returns should include an increased number of the ZIMSTT (Science) graduates who take up A-Level teaching. This may be achieved by not only improving the incentives for A-Level teaching

but also by assisting the rural secondary schools to improve their teachers' living conditions and by providing on-going teacher support services by Education Officers. Hence, there is need for the Ministry of Education and Culture to appoint more Science Education Officers (E.O.s) per region to reduce the current high ratio of science teachers to E.O.s, so that supervision visits by the E.O.s will not only be focussed on the untrained teachers and those that have reached their salary scale barriers, but also on the trained teachers.

In addition to the above recommendation, there is need for the Ministry of Education and Culture to (a) provide further opportunities for the ZIMSTT graduates, who became Teacher Educators and Headmasters and A-Level Biology teachers, to undertake further studies, for example, the Dip. Ed., M.Ed. in Curriculum Studies or Educational Administration, and M.Ed. (Science) respectively; (b) to secure more foreign exchange to facilitate not only the timely repair of equipment at the Audio-Visual Services but also the importing of both the reference materials on the Option Topics of the A-Level Biology syllabus and books for the University of Zimbabwe's library; and (c) to increase the amount of money which is made available within the school for the Science Head of Department's use as petty cash, in order to reduce the borrowing that is currently going on between schools. Resources for the teaching and learning of science in all the schools need to be expanded in order for cater for the learning needs of the increased student enrollment.

4. For the National Science Syllabus Panel, which includes the Science Team at the Curriculum Development Unit and the Science E.O.s, there is a need to up-grade the content of the O-Level Science Core and Extended Syllabi, so that it provides a more adequate conceptual and practical preparatory base for A-Level Biology studies.

5. For the Science teachers, there is a need for them to address three issues. The first issue is centered around focusing less on "covering the syllabus" and more on "uncovering the content" in a way that their students understand. This state will be indicated by more accurate, clear and complete explanations and illustrations. The second issue is centered around the need for the teachers to enhance their questioning habit of mind, which is a pre-requisite of scientific inquiry (Litowitz, 1993). The Zanzibar Fifth Science Camp can serve as a model of how to effectively accomplish this (Zesaguli, 1992a, 1992b). The third issue is centered around the need for teachers to reflect more on their teaching practices and to be more self-critical as they evaluate how their lessons have gone, as was indicated by the E.O.s. Hence, the teachers need to be given opportunities to enhance their higher-order thinking skills which are required to accomplish all these things.

6. Lastly, the Education Theory Course, which was perceived by the ZIMSTT graduates as repetitious of the work that was covered at their Teacher Training Colleges, needs to be revamped extensively in order to facilitate the development of philosophical habits of mind which are needed for self-critical reflection. This can be

achieved by introducing a "hands-on" philosophizing course which has proved effective at developing critical and creative higher- order thinking skills in quite young children (Santi, 1993; Gazzard, 1993; Fisher, 1990; Lipman, 1993; Lipman & Gazzard, 1993; Lipman, 1991; Lipman 1988; Lipman, 1984; Lipman, et al., 1980; Sharp & Reed, 1992; & Zesaguli, 1993a, 1993b).

In closing, I must own, as does Clandinin (1985), that

> As researcher, I cannot enter into a teacher's classroom as a neutral observer and try to give an account of her reality. Instead, I enter into the research process as a person with my own personal practical knowledge. My knowledge of teaching interacts with that of my participants. . . . The research process is, accordingly, an interactive, dialectical one characterized by Dwyer (1979) as 'a particular form of social action that creates dialectical confrontations and produces inter-subjective meaning' (p. 211). The meaning created in the process of working together, is a shared one. Neither teacher nor researcher emerges unchanged. In terms of narrative it is appropriate to view this process as the negotiation of two people's narrative unities (p. 365).

That is, the interactions which I had with all the participants during this research study made a big impact on me. I derived much insight, joy and pleasure in working with them all. I hope that the benefit was mutual, despite the brevity of some of these shared moments. I sincerely hope that the recommendations suggested here will make a difference in the quality of Science Education in Zimbabwe.

APPENDICES

APPENDIX #1

THE ZIMSTT BIOLOGY GRADUATES' QUESTIONNAIRE

Dear ZIMSTT GRADUATES,

I am carrying out a follow-up study of all the B. Ed (Science) Graduates, who took the Biology option only because of time constraints. This study is part of my doctoral dissertation research requirements with the College of Education, Michigan State University. I am studying the nature of the knowledge base needed for teachers to teach at A-Level and also the teachers' thinking and decision making processes and how they impact on their A-Level teaching and their students' learning Biology. Hopefully the results from the study will provide essential information and guidelines for the improvement of the Zimbabwe Science Teacher Training (ZIMSTT) Program offered in the Department of Science and Mathematics Education, at the University of Zimbabwe, so that it can better meet the needs of the future ZIMSTT B.Ed. (Science) Biology Candidates, who intend to teach A-Level Biology.

The questionnaire which you are kindly being asked to fill in is admittedly long. The reason is that I cannot come and hold interviews with each of you nor can I observe everyone's A- Level Biology classes. Hence I have to rely on your self- reports about your thinking and your A-Level teaching practice experiences. To avoid fatigue, you may respond to each part of the questionnaire at different sittings. But bear in mind that I am also under pressure to compile all your responses within a very limited time frame. Hence, I will appreciate your filling in the responses within one week after you receive the questionnaire.

The questionnaire has four parts to it. Part I is about your school context and your personal experiential background. Part II elicits your beliefs opinions about science teaching in general and about Biology teaching in particular. Part III elicits your feelings about the experiences which you have had as a student in the B.Ed. Biology Option Program. You will also describe and evaluate your subsequent educational experiences after getting the B. Ed. (Science) degree, in light of what you went through during the B.Ed. Program. You will be asked to suggest recommendations for improving the B.Ed. (Biology) Program so that the future graduates are better prepared to cope with A-Level Biology teaching. Part IV is about some aspects of your past and present A-Level students.

Pseudo-names will be used in the final report in order to ensure for your anonymity. You will have open access to the final report from the Dept. of Science and Mathematics Education, University of Zimbabwe, Harare, Zimbabwe, and from the College of Education, M.S.U., E. Lansing, MI 48823, U.S.A.

Please return the completed questionnaire to me, as soon as possible, using the enclosed self-addressed stamped enveloped, i.e. mail it to:-

JOSIE ZESAGULI
Faculty of Education,
University of Zimbabwe
Box MP 167, Mt. Pleasant,
Harare, Zimbabwe.

Thanking you in advance for your cooperation, contribution and assistance in this study.

Your sincerely,

Josephine K. P. Zesaguli.

ZIMSTT BIOLOGY GRADUATES' QUESTIONNAIRE

For some of the items below, please fill in the blank spaces provided. Use extra paper if you need to write more. For the rest of the items, tick in the space next to your choice of option.

PART I: CONTEXTUAL AND PERSONAL BACKGROUND

A: CONTEXTUAL BACKGROUND

1. School Name: ____
2. School Location: Rural ____ Urban ____
3. School Responsible Authority :
   Government ____ Private (Church) ____
   Private (Parents or District Councils) ____
4. A Level Biology Classes consists of :
   Boys only ____ Girls only ____
   Both boys and girls ____

5. Region of the school:

Harare ____ Mashonaland East ____
Masvingo ____ Mashonaland Central ____
Midlands ____ Mashonaland West ____
Manicaland ___ Matabeleland North ____
Matabelenad South ____.

B. PERSONAL BACKGROUND

6. Your Sex: Male ____ Female ____

7. Your Age :

20-25 years ___ 26-30 years ____
31-35 years ___ 36-40 years ____
41-45 years ___ 46-50 years ____
Above 51 years ____.

8. Your previous science teaching experience by the time you enrolled into the B. Ed (Biology) program, in terms of the class (or Form), the Science subject taught to that class, and the number of years that subject was taught to that class.

Science Subject(s) Taught	To which Form/Class?	For how long?

9. The year you enrolled into the ZIMSTT (B.Ed.) Biology Program was in 19_____ with an O-Level / A-Level School Certificate, and which teacher training certificate i.e. Certificate in Education (C.E.) / Standard Teacher Certificate (STC) / T1 / T2 / T3 / T4.

10. Before enrolling into the B.Ed. Program you were:

A Primary School Teacher ____
A Secondary School Science Teacher ____
A Primary Headmaster ____
A Secondary School Headmaster ____
A Head of Science Department ____
Other (Specify)

____
____
____

11. The B.Ed. Program you took was:

One year full-time ____ Two years full-time _____
Two-years part-time ____

12. You graduated i.e., received your B. Ed (Science) degree in 19___.

13. After graduating from the University of Zimbabwe as a ZIMSTT Graduate, you worked int he following position(s) during the indicated period(s):

Position held	From -- to ---
O-Level Science Teacher	____________
A-Level Biology Teacher	____________
A Headmaster	____________
A Science Lecturer at a Teacher Training College	____________
An Education Officer	____________
Other (Specify)________________________	

14(a) After getting the B. Ed. (Science) degree, when did you begin teaching A-Level Biology?

Immediately ____ 1 term ____ 2 terms ____
3 terms ____ 2 years ____ 3 years ____
4 years ____ 5 years after graduating ___
Or you have not yet taught A-Level Biology classes ____.

14(b) If you have not taught A-Level Biology classes, please give the reasons, in the space below, for your resuming teaching O-Level science classes only.

C: BELIEFS AND OPINIONS ABOUT SCIENCE TEACHING

PART II: BELIEFS AND OPINIONS ABOUT BIOLOGY TEACHING AND LEARNING

Please answer the following questions as fully as you can on the back of these pages. Be sure to number your responses correctly.

15(a) From your viewpoint as a teacher what do you intend your students will understand when they complete your Science/ A-Level Biology course? (In answering this, be sure to include subject matter goals and student development).

15(b) Given your intentions described above, how do your students learn the subject matter and achieve the development you intend?

15(c) Given your intentions and the students actions described in part (a) and (b) above, what actions do you (the teacher) take to increase students' learning and development? Be sure to include both your teaching and assessment that is part of your teaching.

16. What "metaphor" or "image" or "simile" best describes you as a teacher? [Explain. That is, as a teacher, I am like a------------------ because I ------------------------ --

PART III: B. Ed. (Biology) PROGRAM EXPERIENCES

Please answer the following questions with detailed lists on blank papers, using the underlined expressions as your sub- headings. Feel free to use any extra papers if you need to.

17. What factors influenced you to apply for enrollment into the B.Ed. Biology program ?

18. How would you describe/characterize your experiences during the B.Ed. (Biology) program? What did you get out of the program?

19. Which of your expectations (hopes) when you enrolled in the B.Ed. program?

20. Which of these expectations were met? How?

21. Which of these expectations were not met? Explain.

22. Explain how the ZIMSTT B.Ed. Biology program experiences influences your work as a teacher.

23. How well do you feel that the B.Ed. (Science/Biology) program prepared you for A-Level Biology teaching or for your work as a Deputy Headmaster / Headmaster/ Education Officer/ Lecturer at a Teacher Training or Poly-Technical College?

24. What were the major strengths of the program?

25. What were the major weaknesses of the program?

26. What recommendation would you suggest for improving the B. Ed. (Biology) program so that it prepares the ZIMSTT Graduates to cope better with the demands of A-Level Biology teaching?

PART IV : YOUR A-LEVEL STUDENTS

27. How would you describe your A-Level Biology students?

28. Describe and explain aspects of their A-Level Biology classes that these students:
    - 28.1 find easiest to learn?
    - 28.2 find most difficult?
    - 28.3 most enjoy?
    - 28.4 most dislike

29. For each year that your students wrote the A-Level Biology examination, describe how they performed in the table below:

Year	Performance	Explanation of these results

APPENDIX #2

NETWORKING TRACER LETTERS

APPENDIX #2.1: NETWORKING LETTER TO HEADMASTER

Dept of Science and Math. Education
University of Zimbabwe
Box MP 167, Mt Pleasant,
Harare, Zimbabwe.

5 September 1992

The Headmaster/Deputy Head

I am carrying out a follow-up study of all the B.Ed. (Science) graduates, who took the Biology option only.

Last term, I sent a questionnaire to all these graduates. Some of them did return it and others did not. This left me with an uncertainty of whether the latter was due to the fact that the teachers were no longer at the addresses which had been given or whether the questionnaires had been set aside and forgotten because of something else.

Hence, I am asking for your assistance in

(i) passing on this second copy of the questionnaire to the teacher, if he is still there; (ii) clarifying this for me, by filling in this attached reply slip and mail the slip and the questionnaire back to me using the enclosed self-addressed stamped envelop; and (iii) indicating the teacher's new address if he/she was transferred to another school, Teacher Training or Polytechnical College.

This assistance will be greatly appreciated.

Yours faithfully,

JOSEPHINE ZESAGULI
(Lecturer: Department of Science and Math. Education)

HEADMASTER'S REPLY SLIP

Please indicate the status of the B.Ed. (Science) graduate teachers in your school by ticking against whichever statement applies.

1. The teacher is still teaching in this school and I have passed on the questionnaire to him/her. ____________

2. The teacher is no longer at this school. __________
His/Her new postal address is

____

____

____

____

3. New postal address is not known.____

Thanking you in advance.

Yours sincerely,

Josephine K.Zesaguli.

APPENDIX #2.2: NETWORKING LETTER TO TEACHER

Dept of Science and Math. Education
University of Zimbabwe
Box MP 167, Mt Pleasant,
Harare, Zimbabwe.

7 September 1992

Dear ZIMSTT Graduates,

As you know from my previous communication to you, I am carrying out a follow-up study of the B.Ed. (Science) graduates, who took the Biology option only.

I am mailing this second questionnaire copy even to those of you who did return the first one to me. If you are one of these please, just respond again to :-

Part IA	Numbers 1-5
Part IB	Numbers 14a and b
Part II	Numbers 15-16
Part III	Number 23

These items have been modified to make them clearer. If you had not sent in the first copy, please fill this second copy completely and ignore the first one.

Secondly, I need your assistance in locating the following B.Ed. Science Biology Graduates, whose names are on the attached list. Please put their current or last known school, Teacher Training and Polytechnical College addresses against the names of those your are aware of their whereabouts.

Please mail both the questionnaire and the list back to me using the enclosed stamped self-addressed envelop.

Thanking you for your assistance.

Yours sincerely

JOSEPHINE ZESAGULI

APPENDIX #3

A-LEVEL BIOLOGY STUDENTS' QUESTIONNAIRE

1. Describe hour attitude to Biology/Science and how much you enjoyed/liked/hated/disliked it at O-Level and at A- Level. Explain what caused you to feel that way.

2. What is it that your teacher does when he/she teaches to make you (a) learn and understand and (b) use/apply what you have learned.

3. What practical skills are you competent and confident to carry out in Biology/Science.

4. What rules operate in this class? That is, what are the do's and the don't's?

5. What <u>image</u> do you have of (a) your teacher; (b) yourself as a student; (c) your A-Level Biology class; (d) your classroom; and (e) your school? [Probe with the following sentences:

   (i) My teacher Mr/Mrs. -- is like a -- because he/she --. (ii) As a student I am like a -- because I ---.
   (ii) Our A-Level Biology class is like -- because we --.
   (iv) Our classroom is like --- because it ---.
   (v) Our school is like --- because it ---.

6. What do you see as the goals of A-Level studies?

7. What were the major ideas about protein synthesis?

8. What was the effect of the researcher's presence in your classroom and her interactions with your class?

APPENDIX #4

A-LEVEL BIOLOGY TEACHERS' QUESTIONNAIRE

1. The following are the rules of practice i.e the do's and the don'ts that operate in my A-Level Biology class

2 (i) As a teacher I see myself as a ___________ because I ____

(ii) The learning environment in my A-Level class is like a __________________ because they _________________________ ____

(iii) I see/regard my a-Level students as _________________ because they ____

(iv) Teaching A-Level is like _________ because __________ ____

(v) This school is like ____________ because it expects the teachers to ______ and the students to ________________ ____

(vi) The school community (PTA) is like __________ because it____

3. My A-Level teaching is guided by the following practical principles ____ ____

4. What is helping me to cope in teaching A-Level Biology are the following ____ ____ ________ and the problems I face are due to ____

5. When I plan for and actually teach A-Level Biology lessons, I make the following judgments and decisions regarding ____ ____

6. After years O-Level teaching and now teaching A-level, my teaching style has been transformed/changed/modified in the following ways ____ ____

7. Your recommendations for improving the ZIMSTT (B.Ed.) as preparation for A-Level Biology teaching are __________

APPENDIX #5

INTERVIEW SCHEDULES

APPENDIX #5.1: ZIMSTT TEACHERS' PRE-OBSERVATION INTERVIEW

The researcher held informal open-ended pre-observation conference with the teachers who were to be observed teaching in order to clarify their responses which were elicited on the Survey Questionnaire concerning what their thinking and understanding is about the following areas:

- the nature of the subject matter of A-Level Biology;
- A-Level Biology goals;
- lesson planning;
- A-Level Biology instruction;
- A-Level students and how they learn;
- A-Level Biology assessment ; and
- the respective roles of the teacher and the students during the A-Level Biology lessons.

During this pre-observation conference, the observer will ask the teacher:

(a) What aspects of the ZIMSTT Biology program do you feel prepared you for teaching A-Level Biology. That is, what was over- and under-emphasized in relation to the teaching of A-Level during the program?

(b) What is the nature of the lesson to be observed. That is, what do you intend the students to achieve? Why? How? Using what materials? Any anticipated problems? Lastly,

(c) What would you like me to focus on as I observe your lessons?

APPENDIX #5.2: ZIMSTT TEACHERS' POST-OBSERVATION INTERVIEW

1. How do you feel the lesson progressed?

2. To what extent were your objectives achieved? Explain.

3. Did the lesson proceed as planned?

4. What judgements, choices and decisions did you make during the lesson?

5. Did you get any "sudden revelations at the chalkboard"? What about "uncomfortable moments"?

6. Where to next?

APPENDIX #5.3: A-LEVEL BIOLOGY STUDENTS' INTERVIEW

1. Before I came to sit in your L6 Biology lessons,
   - 1.1 What subject matter did you study?
   - 1.2 How did the teacher help you learn and understand/use the content of the text?
   - 1.3 What was the nature of practical work?
   - 1.4 Did the teacher refer you to other sources? Which ones? How do you feel about this?
   - 1.5 How did the teacher explain the concepts? [This will lead to some ideas about their teacher's view of the scientific knowledge and about learning.]
   - 1.6 How does the teacher use examples to help you understand? [Real-life or text book examples]

2. When I sat in your class the teacher revised/mentioned the concept/topic X as having been taught already,
   - 2.1 What did you understand about X before you studied it in your A-Level class?
   - 2.2 How did A-Level classes/lessons change your thinking about this concept/topic X?

3. How would you characterize your teacher's teaching style?

4. How would you characterize your learning style?

5. What are the differences between O-Level and A-Level teaching and learning?

6. What were your ideas about proteins and protein synthesis,before the A-Level teacher taught you about it? What are your ideas about these now? What were the major ideas about "protein synthesis"?

APPENDIX #5.4: ZIMSTT STAFF'S INTERVIEW

1. When and how did you get involved in the ZIMSTT Project?

2. What are your perceptions about how the ZIMSTT Program was conceived, developed and implemented? [i.e., its (i) aims and objectives; (ii) candidates (thinking learning styles and lab skills); (iii) program offerings (staffing courses, materials and equipment, time allocation); facilities; (iv) assessment and evaluation of students; and (v) preparation for A-Level teaching for Biology/Chemistry/Physics/Mathematics?]

3. To the best of your knowledge, how many of the ZIMSTT graduates are teaching A-Level (Biology/ Chemistry/ Physics/ Mathematics)? Have you had any feedback on how are they coping? If yes, what was the nature of the feedback? From whom? In what form?

4. How is the B.Ed. (Science) perceived by the ZIMSTT candidates? By the public at large?

5. What is your opinion/ attitude/ feelings about the ZIMSTT program? Explain.

6. What aspects of the ZIMSTT program are over-emphasized or under-emphasized given the ZIMSTT candidates' O-Level teaching experiences, levels of expertise, and your perceived needs for A-Level Biology teaching?

7. What changes would you like to see implemented in the ZIMSTT Biology program? Why?

APPENDIX #5.5: SCIENCE SUPERVISORS' (H/M & E.O.s) INTERVIEW

At the beginning of the interview, I will first of all introduce myself and explain the nature of my study. I will point out how the interviewee's input will provide another viewpoint or lens for looking into the ZIMSTT A-Level Biology teachers' teaching practices.

1. How long did you teach O-Level Science? A-Level Biology/Chemistry/Physics?

2. How long have you been a Science Supervisor? (i.e. either as a Head of Science Department / a Headmaster / or as a Science Education Officer either in the Region, in the Standards Control Unit, or in the Examination Branch of the Ministry of Education)?

3. How long have you observed A-Level Biology lessons taught by the ZIMSTT Graduates? How would you describe or characterize these lessons?

4. What has been the outcome/impact of these ZIMSTT Graduate teachers' A-level teaching practices in terms of what the students carry away from the instruction, i.e., along three dimensions of:
    (a) cognitive achievements;
    (b) affective changes; and
    (c) the quality of their inquiry skills.

5. How have the previous A-Level Biology students taught by the ZIMSTT Graduates fared nationally on the Cambridge A-Level final Biology Examination?

6. What is your assessment of the adequacy of preparation for A-Level Biology teaching, which the ZIMSTT Graduates get from the ZIMSTT (B.Ed.) (Science) program at U.Z.?

7. What kind of professional assistance do these ZIMSTT A-Level Teachers get? From whom? When? How often?

8. What recommendations would you suggest for the ZIMSTT program implementation in order to improve its preparation of the ZIMSTT Candidates for A-Level Biology teaching?

9. What are your expectations with regards to the A-Level Biology teachers' (a) thinking; (b) lesson plans; (c) teaching practices; (d) classroom discourse; and (e) students' learning?

10. What similarities and differences have you observed with regards to these aspects [4(a) - 4(e)] above, between A-Level Biology teachers with and without the ZIMSTT B.Ed. (Science) degree? Explain.

11. What knowledge base does an A-Level Biology teacher need to have in order to teach A-Level Biology classes?

APPENDIX #6

TABLE 4: STUDENTS OBSERVED AND INTERVIEWED DURING THE STUDY

		TOTAL STUDENTS		INTERVIEWED	
CLASS	**/TEACHER**	**BOYS**	**GIRLS**	**BOYS**	**GIRLS**
U6	B- (N=25)	20	5	2	1
L6	C- (N-20)	18	2	5	2
L6	D- (N=9)	1	8	0	2
L6	G- (N=20)	15	5	2	2
L6	M- (N=18)	18	0	2	0
U6	Mi-(N=31)	31	0	4	0
U6	N- (N=9)	5	4	3	2
U6	P- (N=21)	20	1	4	0
L6	V- (N=23)	18	5	2	3
TOTAL	**9 Trs.(N=176)**	**146**	**30**	**24**	**12**

Girls : Boys = 30 : 146 = 1 : 4.8
To the nearest unit = 1 : 5.

APPENDIX #7

TABLE 5: A-LEVEL BIOLOOGY TEACHERS' TEACHING LOADS

	O-LEVEL				A-LEVEL		TOTAL
TEACHER	1	2	3	4	5	6	
Mrs. B-	0	0	0	24*	0	10	34
Mr. C-	<------10* ----->				7	7	24
Mr. D-	0	7	5	10*	8	0	30
Mrs. G-	7	0	12*	0	10	0	29
Mrs. M-	<------10* ----->				11	0	21
Mrs. Mi-	6	6	6	0	0	12	30
Mr. N-	0	0	0	0	11	11	22

Mr. P-'s and Mr. V-'s TIME TABLES WERE NOT COLLECTED.
* = Not specified for which four O-Level Science classes.

APPENDIX #8

SCIENCE LABORATORY FURNITURE ARRANGEMENTS

KEY: B = Blackboard

TD = Teacher's demonstration Table
SDL = Students' desks during lectures/discussions
SDP1 = Students' desks during practical work;
SDP2 = Extra work surfaces
ST = Store room
PR = Preparation room;
D = Door
SPD = Side perimeter work places.
F = Fume Cupboard

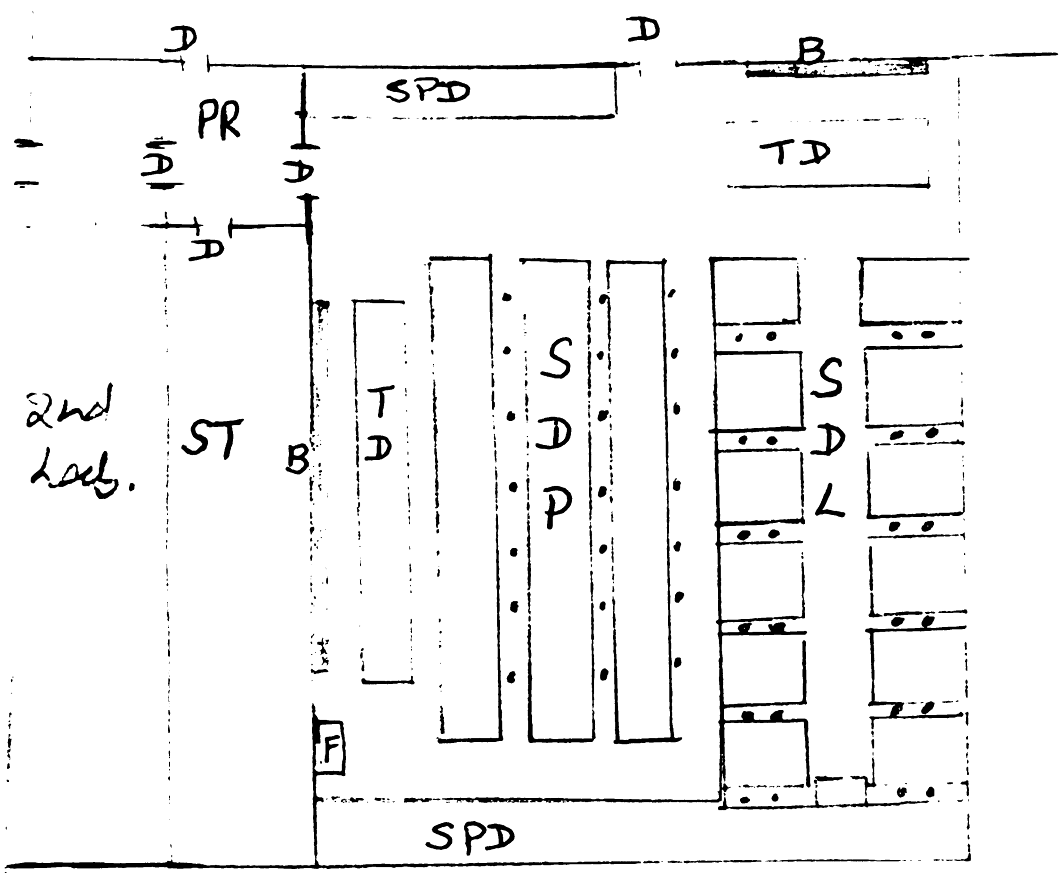


FIGURE 1: Science Laboratory Furniture Arrangement #1 [e.g. in the labs. of C-, D- & Mi-]

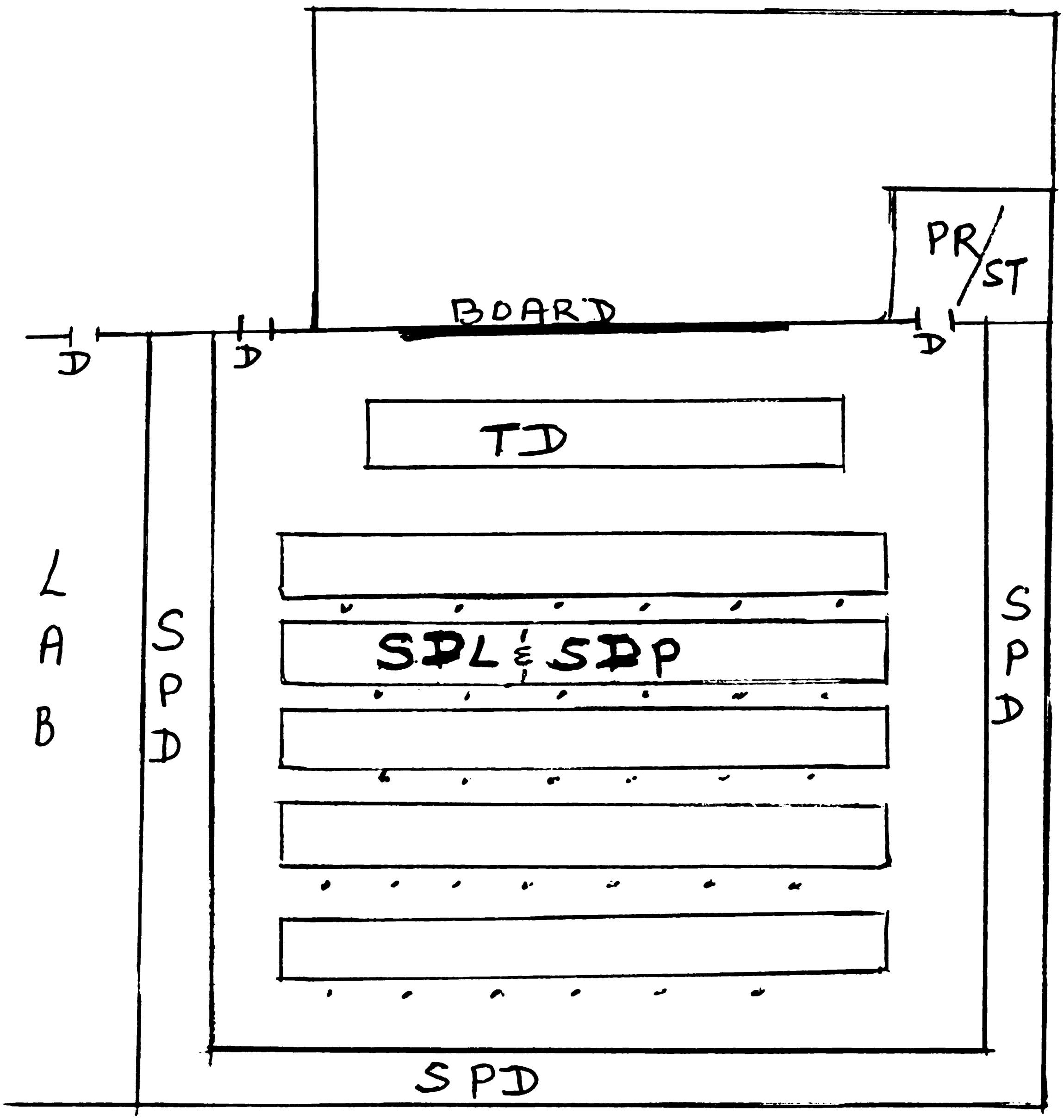


FIGURE 2: Science Laboratory Furniture Arrangement #2
[e.g. in the labs. of B-, G-, M-, N-, P- & V-].

APPENDIX #9

A POEM:

CHILDREN LEARN WHAT THEY LIVE

If a child lives with criticism, he learns to condemn.

If a child lives with hostility, he learns to fight.

If a child lives with ridicule, he learns to be shy.

If a child lives with shame, he learns to feel guilty.

If a child lives with tolerance, he learns to be patient.

If a child lives with encouragement, he learns confidence.

If a child lives with praise, he learns to appreciate.

If a child lives with fairness, he learns justice.

If a child lives with security, he learns to have faith.

If a child lives with approval, he learns to like himself.

If a child lives with acceptance and friendship, he learns to find love in the world.

(Anon.)

APPENDIX #10

LESSON TRANSCRIPT OF MRS. Mi-

Teacher: Mrs. Mi-
School: X Boys High
Class: Upper Sixth (U6) Biology
Subject: Biology
Date: 10/02/92.

During the pre-observation conference, before this lesson, the teacher had informed me that she was through with teaching. They were now just in the process of revising. Hence this particular practical lesson was going to be a revision exercise, with the students practicing looking at microscopic slides (biostrips) using the bioviewer. When the students were settled down, the teacher introduced me, because these were a different set of students from those I had observed during one of her theory lessons the previous day. Then the lesson began:

[**KEY**: Tr. = Teacher; St. = Student.

Tr.: The objective to-day is to revise slides seen before. Today we are going to do a practical, as revision in preparation for the examination. In today's practical we will be using mainly biostrips. There are 3 different kinds to be done. During the first third of the class, take the plant, into consideration ... second third of the class take Life Cycle of a Mould ... and last third of class take meiosis in humans. You should be using diagrams on unlined paper, because you don't want to be guided by the lines. You should be able to work out the proportion for each of the diagrams that you do, and we will come round and watch you as you work. Are there any questions which you want to ask? [No response] So please collect your biostrips and bioviewers. Choose the one that you want to start with. At the end of it all you should have done all three. So one period for each biostrip. [This was plenty of time allocated to each biostrip.]

[Students purposefully go about collecting their bioviewers and strips from the cupboards and select the biostrips, which were in the boxes, which the teacher had set on the side table, near the tables at which the seven students had settled. Only seven students were present, because the total U6 Biology students (N=31) are too many to do practical work together. So they have been divided into such smaller groups. The teachers preferred having to repeat the practical work, as much as four times, with each of the groups, in order to give individual students adequate attention. This reflected "drive", "energy" and "dedication" on the part of the teachers.]

Tr.: Make sure that you have ample light. I shall come and discuss with you individually.

[Students quickly settle down and begin to study their selected slides.]

[I then move the tape recorder as she moves from student to student, in an effort to capture the dialogue between the teacher and individual students.]

Dialogue with Student #1

[I missed the questions at the start, as I moved the tape recorder nearer to her and student #1]

Tr.: What are the homologous chromosomes?
St: Yes?
Tr What is labelled CH there?
St: Chiasmata
Tr: What is the function of those?
St: Chiasmata?
Tr: Mmmh (Yes).
St: For crossing-over.
Tr: Why do you want crossing-over to take place?
St: For variation.
Tr: To produce variation. OK. And what sort of division are you looking at?
St: [Some pause] Sexual?
Tr: Generally what sort of division is occurring in the different frames you are looking at?
St: Prophase.
Tr: Division? Is it mitosis or is it meiosis?
St: Meiosis.
Tr: It is meiosis and what do you get out of that division?
St: (Inaudible) Stage 5?
Tr: Out of meiosis, what do you end up with? What are the products?
St: Haploid cells.
Tr: You end up with haploid cells. What is the importance of meiosis, in your opinion?
St: To produce variation.
Tr: Right, you want to produce variation and that happens as a result of the exchange of material at the chiasma. Anything else?
[Silence]
Tr: How else would you produce variation, other than by simple crossing-over?
St: At anaphase, when homologous chromosomes are separating.
Tr: Right, there is independent Assortment and also at fertilization where you increase the amount of variation that you get. Why is meiosis necessary in sexual reproduction?

St: For fertilization.
Tr: For fertilization? Why do we want fertilization to take place?
St: To produce a zygote.
Tr: What sort of zygote?
St: Zygote with ... er ... haploid ...
Tr: Is the zygote haploid?
St: Having genetic material from both parents.
Tr: So you are talking about the re-establishment of the diploid condition. OK. Go ahead and do diagram of bivalents, chiasma formation and then indicate how you could use an understanding of this to solve the problem on er ... producing rust-resistant potato....
St: Am I to draw all this?
Tr: I said a few of the stages which I mentioned.

[Teacher moves to the next student #2

<u>Dialogue with Student #2</u>

Tr: What's your strip on?
St: Mosquito stomach.
Tr: What's in that mosquito stomach?
St: Some pimples.
Tr: What pimples?
St: Cysts.
Tr: What's in those cysts?
St: Sporozoites
Tr: What stage of the life cycle of the malarial parasite are we looking at?
St: It is the sexual stage.
Tr: It is the sexual and we said the pimples are lying in the walls of the stomach of the organism. How then do they get into the host like man?
St: They are taken through the saliva.
Tr. ... That thing is in the stomach and the salivary glands are right in the head of your mosquito. How do you get the two together?
St. What?
Tr. [Repeats and continues] How do we get the sporozoites together with the salivary glands?
St. The cysts burst in the saliva.
Tr. They will burst into the saliva?
St. They burst in the saliva.
Tr. They burst in the saliva?
St. They burst in the saliva and produce the sporozoites.
Tr. I want you to find out exactly how the sporozoite will get into the salivary glands. Right. That will be after sexual reproduction. Why is it so important for the malarial parasite to have 2 hosts during its life cycle? Take that question down, i.e., why is it necessary for the maralial parasite to have 2 hosts in its life cycle? And secondly I want you to find out

why ... Put it down as number two ... What characteristics make parasites successful? This is a general question, you can make use of your knowledge of other parasites also.
[Tr. moves on to Noah]

Dialogue with student #3

Tr. Noah, what are we looking at?
St. I am looking at human meiosis.
Tr. Where is it taking place?
St. In our ovaries and testes
Tr. OK. i.e., the ovaries and testes. What do we start off with?
St. There are the germ cells.
Tr. Right. We start off with germ cells and what is happening in those germ cells?
St. They first divide by mitosis into 4. Then they divide meiotically to form the ...
Tr. They divide meiotically to form the ... er ...
St. I am forgetting the proper term. But there are the cells which you ...
Tr. [Directs the question to the student sitting next to Noah to help him out]
Tr. After meiosis, what do you end up with?
St#4 After meiosis?
Tr. Mmmh (Yes).
St#4: You end up with haploid cells.
Tr. You end up with haploid cells. Haploid cells that we call?
St.#4 Spermatogonia.
Tr. Is that what you end up with? Spermatogonia?
St. The haploid cells are actually the sperms.
Tr. OK. Let's put it this way. Take down the following forms and find out their difference.
[Student looks for paper]
Tr. You can write them on the lined paper 1. spermatogonia and spermatozoa. You want to make sure you understand when to use which term. You end up producing haploid cells. This could happen in either the ovary or the testes and what you end up with are the gametes and the gametes are haploid. What is the importance of meiosis?
St. OK. Meiosis will produce haploid cells which will ... er ... recombine to form a zygote and the meiosis will also produce the um ... er ... the chiasma ...
Tr. [Cuts in] What process produces the zygote?
St. The zygote?
Tr. Mmmh (Yes).
St. It is fertilization.
Tr. It is fertilization. Why do you want fertilization to take place before you can make that zygote?
St. Generally, the haploid cells do not develop further.
Tr. Mmmh (Yes). Why not?

St. [Pause] They seem to lack some of the information which will enable it to develop. So by recombining ... I mean ... the information from the er ... in the form of DNA from the two cells enables.
Tr. [Cuts in] So you are saying you want the full set of growing instructions.
St. [Cuts in] Yes.
Tr. You are re-establishing the diploid condition. OK? And why?
St. [Cuts in] Another importance is that meiosis enables variation to take place since there is ... er ... this formation of chiasmata ...
Tr. Right. Chiasma formation producing variation. How does it do it?
St. The [Pause] There is [Pause] I mean er ... I beg your pardon?
Tr. How does... er ... chiasma formation produce variation? Mmmh?
St. There is an exchange of genetic information between haploid, I mean between homologous chromosomes.
Tr. Right. And then? After that exchange there [pause] should be independent assortment.
St. [Cuts in] That's right.
Tr. (Continuing) which will then produce variation (with emphasis she continued) New linkage groups will be established that way. I want you to think about this question that is related to meiosis. Take down your questions. Number one, sorry [There was a knock at the door - Tape was put on pause while the teacher attended to the student outside]
Tr. Noah, I want you to er ... You said you want to re- establish the diploid condition and you said that if we have got half the set of growing instruction as is the case in the haploid cell, there is failure to develop normally. Once the diploid number has been re- established, normal development will take place. But what of situations in which you have got more than the full set of growing instructions? And I am giving you a question that I want you to look at. [Pause and she dictated] Under what conditions would the following be observed: Turner's syndrome [Bell goes] Klinefelter's syndrome [Teacher spells the term for the student] Down syndrome and (b) what would happen in the case of polyploid in plants? I want you to cite specific examples ... check in <u>Farmers' magazines</u> you may find something on plants. [Pause] And after looking at these questions, review again the significance of meiosis.
St. Yes. Thank you.
Tr. [Leaves Noah and moves towards John, and jokingly asked] John, are you having a cold?
John: [With a big smile] Yah (yes).

[The rest of the students subdue their itch to laugh]

Tr. Then I'll keep away from you.
John [Laughs] Why?
Tr. I'll tell the Head I'm lactating and I don't want to spread the cold I get from you to the baby.

[The whole class bursts out laughing]

Josie: Please Noah move the tape recorder to John's place
Noah: Am I drawing everything?
Tr. You can do just frames 1, 3 & 5. Or you can do just as well 1, 4 and 5.
[Teacher turns her attention to Edwin, sitting next to John]

Dialogue with student# 4

Tr. What have you got here?
St. I'm looking at the life cycle of a mould
Tr. To which division of organism does your mould belong? [Pause]
St. I beg you pardon?
Tr. To which Division [emphasized does the mould belong?
St. [Pause] I have forgotten.
Tr. Do you want me to call it a Phylum? To which phylum?
St. Protista?
Tr. protista? OK. I want you before we continue to use your textbook and find out where exactly this organism belongs. When you have that sorted out, I'll came back and go over it with you.
[Tr. moves to the next student]

Dialogue with student #5

Tr. What have we got here?
St. Er.. a saprophyte.
Tr. It is a saprophyte. Is that a Division
St. [inaudible]
Tr. OK. What sort of nutrition are you observing in this one?
St. It's a
[Josie interrupts to ask both the Tr. and student to speak louder to each other because it was break time and there was louder noise than this dialogue,from outside.
St. [Continues] It's heterotrophic nutrition.
Tr. It's heterotopic nutrition. But we have got different types of heterotrophic nutrition. Which type is this one? Is it a parasite or saprophyte?
St. It is a saprophyte.
Tr. What do you mean by that?
St. What this pin mould does is that the whole mass of the mould grows into the food which in may case is a tomato. Now the whole mass of the mould grows inside the tomato and then we have got hairs outside. Now it forms um a complex network of hyphae which are fine hairs. These secrete enzymes which breakdown the food so that it can be absorbed.
Tr. So that, you are talking about absorptive nutrition?
St. Yes!
Tr. Does the tomato have to be alive or does it have to be dead, in order for this organism to thrive?
St. Er... it can be alive?

Tr. Alright. I want you to take down these two terms: saprophyte and parasite ... What are the differences between those two?
St. I'll start off with parasite?
Tr. Mmmh (Yes).
St. A parasite is an organism, which thrives at the expense of another organism. It gets already digested material from another organism. For a saprophyte ... um ...
Tr. What about a saprophyte?
St. I cannot recall that one.
Tr. You cannot recall that one? Look it up!! Then I'll come and discuss this with you.
St. OK.

[Teacher moves on to student #6]

<u>Dialogue with student #6</u>

Tr. What's a saprophyte? Edwin?
Edwin: A saprophyte is an organism which feeds on dead organic matter.
Tr. Right! It feeds on dead organic matter. In the case of a parasite, the organism has to be alive so that it actually registers a loss. OK. And on its life cycle look at frame number four. What can you see in number four? [Student peers through the bioviewer]
St. (Pause) Now... er...
Tr. [Impatiently] What is labelled 'S'
St. As 'S'?
Tr. Yes.
St. Those I think are spores.
Tr. Spores, would those be haploid or diploid?
St. They are haploid.
Tr. Spores are haploid and what happens to them?
St. [clears his throat] When the spores are dispersed, like that they wait for er...
[A voice form outside shouting "well, well, well ..." comes through]
Tr. [Jokes about it] And to think their voices are breaking as well and you'll pick that!
Tr. [Turns her attention back to the student] Yes?
St. [Continues] What happens is that here we have got a food which is the tomato, and when these spores are dispersed, they fall on another food and then they develop er new hyphae.
Tr. Yes they develop into new hyphae. What is the function of hyphae?
St. Hyphae?
Tr. Mmmh (Yes).
St. Er... like I said it forms a complex network inside the whole food matter. It secretes enzymes which liquifies the tomato so that it can be absorbed.
Tr. So it is mainly used for ... um ... for absorptive nutrition?
St. Yes.

Tr. And from those hyphae, I also take it that you develop aerial er sporangiophore and sporangia so that you can use them for vegetative reproduction as well. Each one of these hyphae, that you are looking at here could at any of these points, actually give rise to a different organism. There is reproduction for you. But at the same time the numbers are increasing through asexual reproduction. But if you look at frame number 6, you'll find that in that particular frame, you have a zygospore. Would that be haploid or diploid?
St. This one is diploid.
Tr. It is diploid. How then do we get haploid spores from that diploid zygospores?
St. [Clears his throat] When the two swollen heads of the hyphae touch, then the gametes form and, you know, the two contents fuse and by this fusion ...
Tr. [Cuts in] We now make our zygospore and we want these (emphasizes) haploid spores from that zygospore. [Pause]
St. We want what?
Tr. We want haploid spores from that diploid zygospore. How do we get that?
St. Er.. It grows into another sporangium.
Tr. How do we get these haploid spores from the diploid zygospore?
St. Um (pause) we have meiosis.
Tr. We have meiosis taking place and from that we can produce spores. What sort of um components, what sort of hyphae would actually form or produce gametes? We have identical or different hyphae? If they are different in what way will they be different?
St. They have got to be different and [pause]
Tr. They have got to be different in what way? Think of what we said about spirogyra? You don't have one spirogyra deciding that it is going to fuse er ... to conjugate with another. There must be some form of attraction [Pause] Check again in your textbook, I'll come back.
St. Thank you.
[Student quickly opens his textbook and starts to read]

[Student #4 raises his hand, which the teacher notices, as she moves away from student #6]

<u>Second interaction with student #4</u>

Tr. Yes?
St. I have found it.
Tr. Right. What have you got now? Which Division?
St. It is fungi.
Tr. The Division is Fungi and what sort of fungi are you looking at here?
St. [Pause] I have not checked on that one.
Tr. You haven't checked on that one? It is a zygomycetes that we are look at.
St. [Puzzled] Zygomycetes?

Tr. Zygomycetes or zy... (inaudible)? Why do we call it a zygomycetes?
St. It is because of the er the spore that is formed.
Tr. What do we call that spore that is formed?
St. Zygomycilia.
Tr. We call that a spore or a mycelia?
St. We call it a zygospore.
Tr. We call that a zygospore. Right! Is that zygospore haploid or diploid?
St. It is diploid.
Tr. What about these spores which are being dispersed here at that point? Would those be haploid or diploid?
St. These ones are haploid.
Tr. How then do we get haploid spore from a diploid zygospore?
St. I think that as they are exposed to the wind, they are then blown out, I think they will combine as opposite er They will be opposite sex such that ... er ...
Tr. [Interrupts and corrects] It is not opposite sex. We have plus(+) and minus (-) strains ... But lets talk about you and then come back to our question. Are you diploid or haploid?
St. Myself?
Tr. Yah! (Yes!)
St. I'm haploid.
[The whole class laughs]
St. [Shouts above that laughter] I am diploid!
Tr. If we want haploid cells from you, what then happens to you? Aren't you lucky? Yes?
St. Meiosis will take place.
Tr. OK meiosis will take place and then we will form?
Student and teacher [chorus] : Haploid cells...
Tr. OK. Our zygospore is diploid and we want haploid spores out of that diploid condition, what should take place?
St. Meiosis.
Tr. Right you have meiosis taking place and that meiosis will produce two types of spores because you had two types of hyphae initially forming the gametes. What two types of spores will then be formed?
St. The positive and negative spores.
Tr. Ok. plus (+) and minus (-) spores. I want you to do a diagram showing the life cycle of this organism in your exercise book OK?
St. Right now?
Tr. Yes. Now. And then you can do your diagrams on Frames 1, 3 and 5.

[Tr moves on to student #6 whom she had talked with before and stops to attend to him]

Second interaction with student #6

Tr. Are we sorted out now?
St. No.
Tr. Still looking it up?
St. Yes.
Tr. OK.

[Tr. moves on to student #7 who has raised his hand]

Dialogue with student #7

Tr. Magaya, what is the problem?
Magaya: I have got a question
Tr. Yes? Speak louder.
Magaya: Why are sickle cells not affected by malaria?
Tr. Are you talking about hemophiliacs or sickle-cell anaemia?
Magaya: Sickle-cell anaemia.
Tr. Does someone want to answer that question? (Pause) Why are sickle-celled individuals not affected by malaria? They are actually selected for in areas like the Mediterranean region, where malaria is a major killer. Its part of the selection pressure in that environment. But these individuals are not affected. Hence, their incidence is actually, that is, the incidence of sickle- celled individuals is eventually higher in areas where that is exerting selection pressure. What is the reason? Mr Gonzo?
St. The plasmodium cannot live in sickle-celled blood.
Tr. Yes... whether it be P. falciparum or ... it cannot live in sickle-celled red blood cells and for that reason, such individuals can be beaten by mosquitoes and would not suffer from malaria.
[Teacher moves back to student number #6]

Second interaction with student #6

Tr. What are we looking at here?
Josie: Please move the tape recorder?
Tr. [Laughingly objects] I am not here to move this thing. It's possible this thing was off all along.
Josie: You must be joking!!
Tr. It's your fault.
[Teacher talks with the student #6]
Tr. Which one are you looking at?
St. The life cycle of a mould.
Tr. Which Division do you find the mould in?
St. Fungi.
Tr. What are the characteristics of fungi?
St. They are saprophytic.
Tr. Saprophytic. Is that the general characteristic?
St. It's one of them.

Tr. It's one of them. OK. Think about the potato blight, Phytophora infestans, is that a parasite or a saprophyte?
St. It is a parasite.
Tr. So, what are you going to say about the mode of nutrition of these organisms?
St. They are heterotrophic.
Tr. OK. they are heterotrophic and they can either be parasitic or saprophytic. How do they get their food if they are parasitic?
St. If they are parasitic?
Tr. Mmmh (Yes).
St. We have the hyphae penetrating the outer membrane of the ... say of the plant.
Tr. [Impatient] Which membrane of the plant? [Jokingly added] You make it sound as though the plant is in a veil and then these things go through the veil and presto the food in there!
St. The epidermis layer.
Tr. Uh (Yes) Right. The epidermis and it can actually go through the cuticle layer or the guard cells to reach the photosynthesizing cells. What term do we give to the component or part of the hyphae that is responsible for absorbing nutrition, directly form either the host or the dead tissue? [Pause] [No response]
Tr, Look it up and [Jokingly] If you do not get the answer, there won't be any salvation for you!
[Teacher continues]
Right, think about what we said about the pollen tube. What are the two functions of the pollen tubule?
St. Pollen tube?
Tr. Mmmh (Yes).
St. Pollen tube, well, it directs the pollen grain to where the ovule is.
Tr. Well done and what else?
St. And also, its formation er stimulates .... er ... [Pause]
Tr. Stimulates what?
St. The production of ... er ... I mean the formation of the pericarp.
Tr. [Addressing the whole class] Right, What is the function of the pollen tube other than the delivery of the gametes, the male gametes to the embryo sac. What else does it do? [Pause] Magaya?
Magaya: To give protection to the pollen grain.
Tr. To the pollen grain? It's protecting the nucleus. But there is something more important and pertinent than just protection. Shoniwa?
Shoniwa: It acts as a haustoria.
Tr. It acts as a haustoria area. What do we mean by that? [Pause] [Interrupted by the tape to be moved]
Tr. What would you call that? You have already got the answer
St. I didn't get it.
Tr. Magaya come again. Mr Edwin here did not get you.
Magaya: It's (haustoria) an organ which absorbs nutrients for the embryo.

Tr. Is it just for the embryo?
Magaya: For the whole organism ... [Inaudible]
Tr. Ok. Now what do you think? After hearing his answer, what should you call that component which is involved in direct absorptive nutrition of this particular organism like your Phytophora infestans.
St. I have forgotten.
Tr. [Impatient, surprised, and slightly irritated] you have forgotten what he has just given to you? Think about it and I will come and discuss it with you.
[Teacher moves on]
Tr. Have I seen this one?
St. Yes.
Tr. Ok. and I don't want to see malaria again [Tr moves on and offers to keep moving the tape]

Dialogue with Student #7 (Magaya)

Tr. What have we here?
St. The leaf.
Tr. That's the leaf. Ok. What frame number is that?
St. Number 6.
Tr. Number 6 [Teacher peers through the bioviewer to see this frame] Which part of that leaf is most prominent in that slide?
St. The vascular bundles.
Tr. You have got your vascular bundle and it is in the midrib of that particular leaf. What tells you that you are looking at a vascular bundle?
St. There are some ... we have a division between the xylem vessels and the phloem vessels and we have got er...
Tr. [Cuts in] How do you know that this is xylem?
St. Xylem vessels are actually er ... They have got a big vacuole.
Tr. Is it a vacuole? What's the correct term to use there? Or would you like to call it a lumen?
St. Yah, we can call it a lumen.
Tr. OK. You say you have got your xylem tissue showing large lumen? Anything else?
St. There is cambium which ...
Tr. [Interrupts] What about the walls? Lets look at the walls of the xylem vessels first.
St. The walls are thick.
Tr. The walls are thick looking at the presence of the wide lumen as well as the thickened walls. What do you think is the importance of this to the function of xylem?
St. The wide lumen actually increases the surface areas? Vol? for the movement of the water molecules up into the plant [up the plant] and the thick walls are there to ensure that there is strength, so that the calls won't burst, when we have got water moving.
Tr. When you have water moving you don't want the cells to burst?
St. Yes, so they ensure maximum strength from the pressure.

Tr. Suppose really that you haven't got enough water in the xylem vessels why would you need those thick walls?
St. They also provide mechanical support for the er the plant stem.
Tr. Suppose you don't have enough water in the lumen, why would the strengthened wall be significant then? [Pause] Have you tried putting water in plastic?
St. Yes.
Tr. Right. You empty the plastic, what happens to the walls?
St. The plastic crumbles and just like they become flaccid.
Tr. It collapses. The plastic will collapse. Now you empty your xylem, you try to put water into your plastic again, do you find the job easy or not?
St. It's not very easy.
Tr. Now think of xylem, and think of a xerophyte, like a plant in this drought, suppose the walls of the xylem were like the walls of a plastic that we have been talking about ...

End of Tape Side A

TAPE SIDE B

Tr. Repeats the question "Now think of this Xerophyte plant - in this environment and we are short of water and the walls of the xylem are just like plastic, what would happen to the walls of the xylem now that there is not any water.
St. If they were like a plastic and we have shortage of water, (Tr: mm uh) it means the walls would collapse.
Tr. The walls would collapse so the fact that the walls are lignified is necessary, is important really to keep the pipes open, the xylem vessel open so that water can pass through very readily, even though when water is absent, the pipes will remain open and the second thing is that the lignified thing will give mechanical support. The fact that you have wide lumens simply increases the capacity of the xylem vessels so that a lot of water can be transported to the leaves. What are the uses of the water? You said there is er ... let us look at your slide [Teacher peers through the bioviewer].
Tr. Right, you said there is palisade tissue. What is the function of that palisade tissue?
St. It contains chloroplasts which are involved in photosynthesis.
Tr. Chloroplasts that can be used for photosynthesis. Look at the palisade layer and compare it to the spongy mesophyll [Student peers through the bioviewer]
St. The palisade layer (cells) are close together and elongated whilst the spongy mesophyll (cells) are circular in shape and they have got airspace between them.
Tr. What do you think is the significance of that difference?
St. Air space in the spongy mesophyll allows the free movement of carbon dioxide into the leaf and then the elongated palisade cells make sure that there is increased surface area for the absorption of light.

Tr. Right, you have lots and lots of chloroplasts there and compare the epidermal surface on the upper surface of the leaf and that on the lower surface. Check on the epidermis again [Pause while student peers into the bioviewer] What is the significance of that? That is, the presence of the epidermis and cuticle?
St. The cuticle reduces evaporation of water from the leaf.
Tr. And, the presence of epidermis?
St. The lower epidermis? [Student peers through the bioviewer] The lower epidermis contains some stomata which ...
Tr. [Cuts in] On the lower epidermis you have some stomata and why are those important?
St. They allow the movement of the carbon dioxide (air) into the leaf and then the release of oxygen and water out of the leaf.
Tr. So we are talking about gaseous exchange aren't we?
St. Yes.
Tr. And you mentioned loss of water through the stomata, why is this important?
St. The loss of water is also from er for it is a by-product of photosynthesis.

Tr. You want to get rid of a by-product of photosynthesis. Fine.
St. And also, when the water evaporate from the leaf it cools the leaf, so that the cells of the leaf won't collapse.
Tr. Yes it cools the cells of the leaf. Anything else that you catch in the transpiration stream?
St. The evaporation of the water helps also, when the water evaporates, it actually creates a concentration gradient from the leaves up to the roots of the plant so that water can be absorbed up into the plant.
Tr. What, other than water is brought into the transpiration stream?
St. Mineral salts.
Tr. It could also bring numeral salts. I want you to take down the following questions and think about it.

Q1. Water is lost during transpiration [Bell goes]. Describe the uses of the left-over water in plant.
Q2. Identify the different cell types in Frame 6 and note the obvious structural characteristics that enable you to identify them.

[Tr. moves to another student who cannot identify something in his bio-strip]

St. What are bivalents? ...
Tr. Look them up. Once you have done that you can look at the slide bivalent again.

[For some reason the voice in the tape becomes higher and speed is faster]

Tr. [Summarizes the lesson] After looking at all the practical that you have done I have noticed a few things that you must bear in mind. May be you want to take down these points and think through the points, while you are studying for your practical, as well as when you are doing revision for you Theory Papers. The first thing is:

1. Identify the key features of each of the specimens that you are given, taking into consideration the questions that are asked in relation to that particular specimen.

2. Secondly, when you are looking at these specimens and slides and the like, think of the relevant Biological principles applicable in that particular situation e.g. You are given a leaf - you want to think about photosynthesis. What about photosynthesis? Maybe it is the concentration of chlorophyll. Maybe it is the exchange of gases that are used in the process. Maybe in that same breath, you want to look for exchange areas like the stomata and the like. Where do the principles that you have learnt fit in? And that should help you pick out the key features and the like.

3. And thirdly, as Homework, I want you to go over the questions that I have given out. Remember I have looked at different slides with different people. Swop that material and look through it. Come in the lab anytime and do some more work, on the particular slide which you think you still have problems with. [Pauses and scans the class. She points out,

(a) Mandi, you may want to look at classification again.
(b) Masunga, I didn't see your work on meiosis so you want it before you do your exams.

4. While you are looking at the meiosis slide, think of a possible models to help yourself appreciate what happens to the chromosomes, the chromatid, the bivalents during the process. [Pause] Come to the laboratory, during their next free time, to finish the rest of the assigned biostrips.

5. Before the bell goes, I'll give you an opportunity to ask Mrs. Zesaguli questions on anything. Remember she knows a lot. She was my teacher at U.Z.

[Students stare at me with utter disbelief written all over their faces. Then some of the students asked me questions, which were focussed on genetics, embryology and evolution. Others asked about the circulation system: (1) Why is the foramen ovale in the fetus? (2) What are the consequences of the foramen ovale not closing in the adult? (3) When does the foramen ovale close? (4) Why do birds and mammals have their double circulation? It was fun revising with these students, who seemed so highly motivated to learn.]

Tr. So, I'll see you tomorrow. Good afternoon. [The boys file out quietly].

COMMENT:

Throughout this lesson, Mrs. Mi- went from student to student and spent a lot of time with each asking questions. I was really struck by the fact that these one-on-one interactions were deliberate and never rushed. If, during the discussion, the student was stuck, i.e., could not answer or explain what the teacher will have asked, the student was stopped from proceeding and given an opportunity to look it up in his textbook. While the student was doing this, she moved on to the next student, and later came back, when she saw that the former student was back on his bioviewer. This happened throughout the lesson. Students were actively making sense of the material, being made to link it with their theory, and also being called upon to help each other. All in all, I thoroughly enjoyed this revision lesson.

End of Lesson

APPENDIX #11

DISCUSSION QUESTION

"4. Rearrange the following sentences in the correct order to form a logical account of translation in procaryotes

A The tRNA with the anticodon to AUG forms hydrogen bonds with the complementary codon on mRNA and brings the amino acid methionine into position on the ribosome.

B The ribosome moves along the mRNA until the codon AUG is aligned in the appropriate position on the ribosome.

C The signal to start translation is the codon AUG.

D The ribosome moves along to the next codon and the first tRNA is released.

E On one loop of the molecule is a group of three unpaired bases called an anti-codon.

F Near the 5′ end of the mRNA is a sequence of bases called the **ribosome binding site** which enables it to attach to a ribosome.

G There are at least twenty different kinds, each one chemically linked to a particular amino acid.

H The polypeptide is released from the ribosome.

I Amino acids are added one by one to the growing chain until the ribosome reaches one of the termination codons UAA, UGA or UAG.

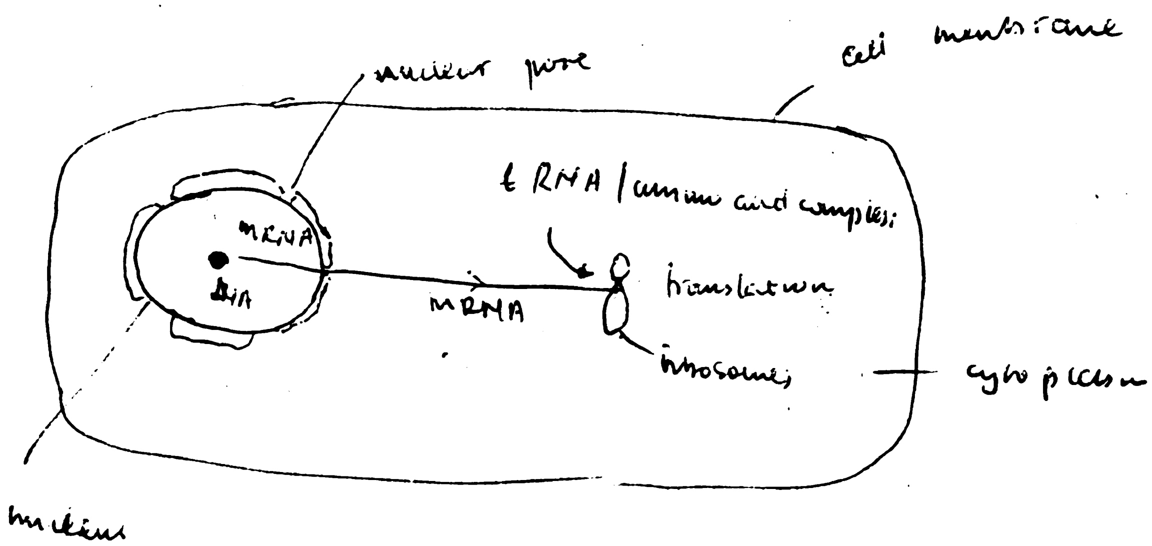
J The next codon binds with the appropriate tRNA and a peptide bond is formed between the amino acids brought adjacent to each other on the ribosome.

K In the cytoplasm are molecules of tRNA, short single strands which are folded and held in shape by hydrogen bonds between complementary bases."

(Burnett, L. 1988, pp. 69-70, #s 4-9)

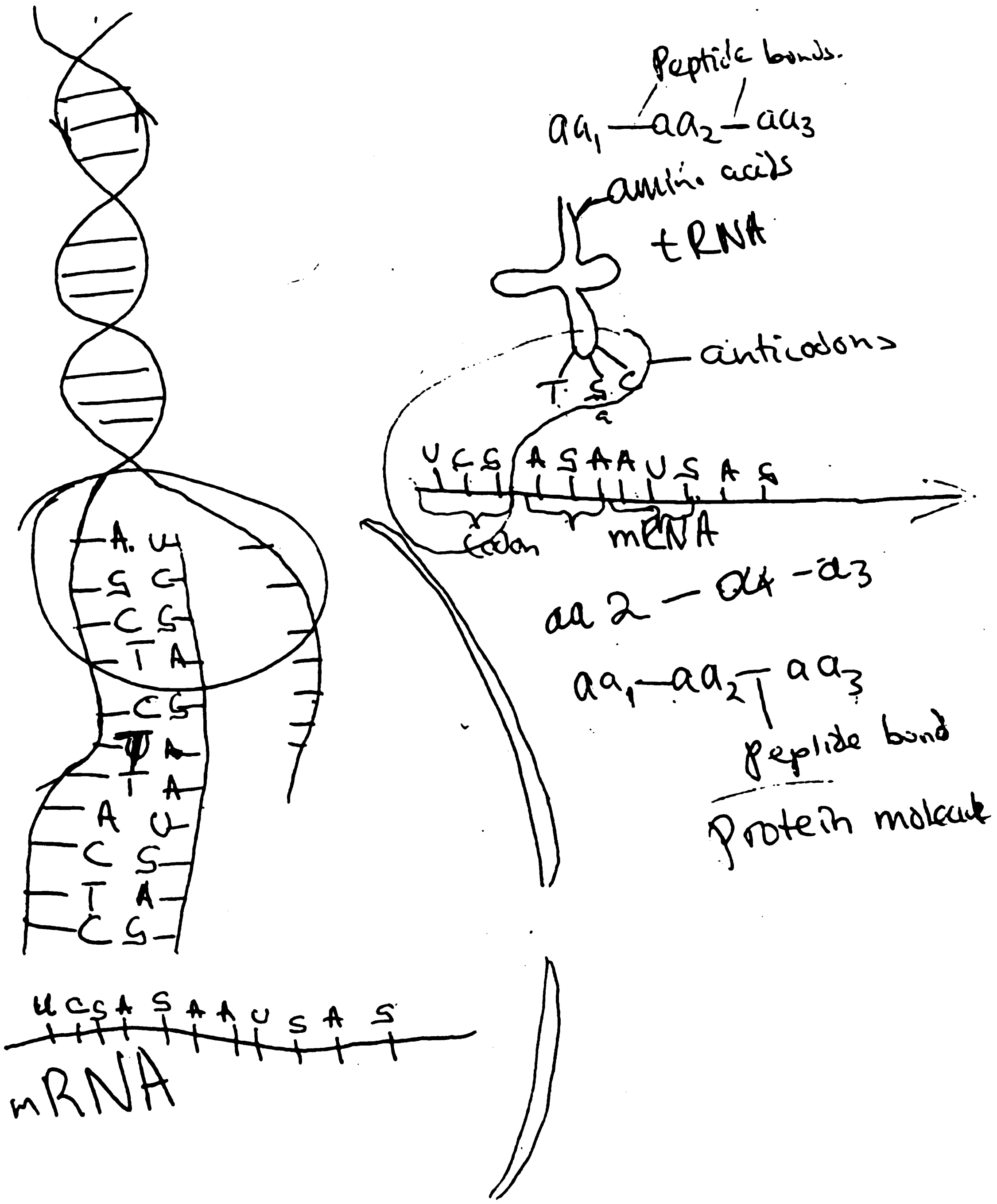
APPENDIX #12

STUDENT #1'S INTERVIEW SKETCH OF PROTEIN SYNTHESIS (BSI)



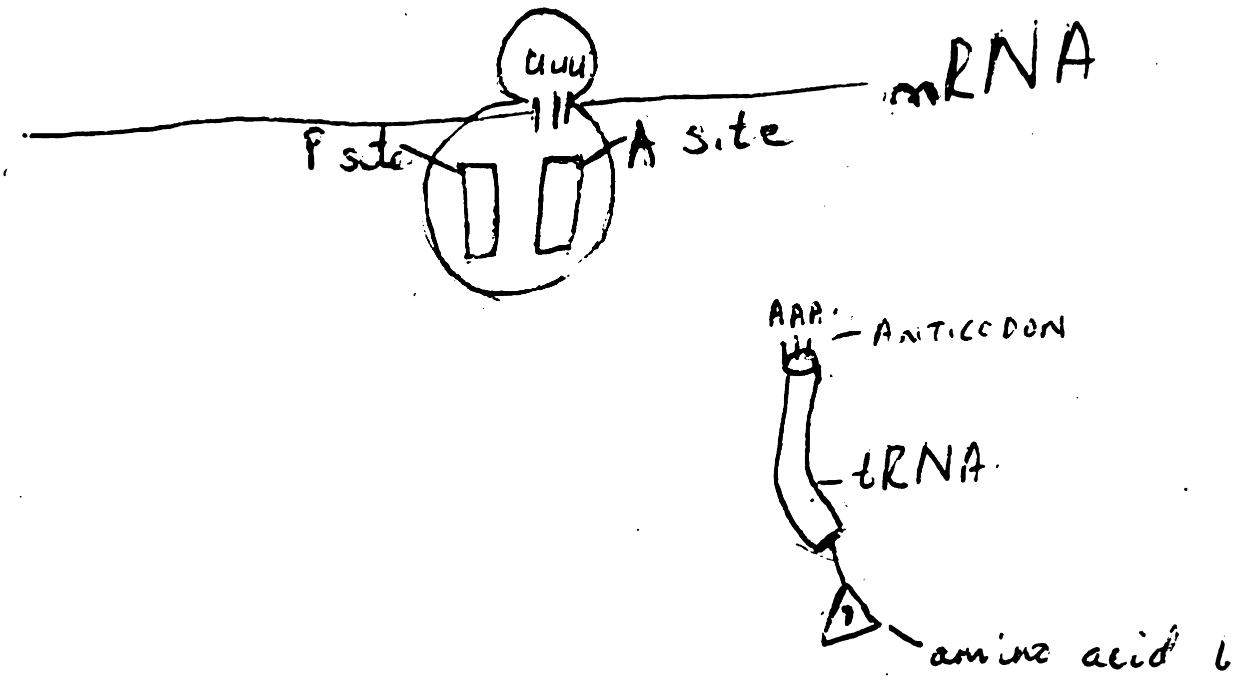
APPENDIX #13

STUDENT #2'S INTERVIEW SKETCH OF PROTEIN SYNTHESIS (CSI)



APPENDIX 13.2

STUDENT #3'S INTERVIEW SKETCH OF PROTEIN SYNTHESIS (MSI)



APPENDIX #14

IMAGES A-LEVEL BIOLOGY TEACHERS AND STUDENTS LIVE BY

APPENDIX #14.1: IMAGES BY ZIMSTT GRADUATES

	TEACHER	STUDENTS
1.	driver of a ship	ship at sea
2.	assistant	workers
3.	tour guide	tourists
6.	facilitator	clients
8.	vehicle	passengers
10.	shepherd	sheep
13.	conscientiser	participants
14.	safari guide	discoverers
16.	shepherd and counsellor	sheep
17.	driver and guide	active passengers
18.	compass needle	crew in the ship
19.	sower/farmer	seeds
20	elder sibling	younger siblings

APPENDIX #14.2: IMAGES BY A-LEVEL BIOLOGY STUDENTS

1. Mr. C-'S CLASS:

QRE#	TEACHER	STUDENT	CLASS	CLASSROOM	SCHOOL
1.	-	a follower	-	-	-
2.	a good person	a good student	-	-	-
3.*	an enzyme (reactant)	a victim	-	-	-
6.*	a leader /backbone	a follower	-	well-equipped	-
7.*	a parent	a son	-	-	-
8.*	a bus driver/pilot	-	-	-	-
9.*	professor	a slave*	-	-	-
10.*	a Messiah	a sheep	-	not well ventillated	-
11.	-	-	disciplined	conducive to learning	-
12.	a driver	-	-	-	-
13.	the best of my Trs./ an enzyme	acceptor	-	-	-
14.*	parent	serious student	-	-	-
15.*	flexible helpful/ a Highway code	-	co-operative	-	-
16.*	President	acceptor of information	-	-	-
17.	Hard-working	-	-	well-maintained	-
18.*	memory bank of a computer	a baby	atm. of mutual support	-	-
19*	a good shepherd	a captain of the ship	-	-	-
20.	a strong willed Tr./Hardworking	-	educational- w/ pictuers & specimens		- -
21.*	activation energy	a reactant	interactive		-
22.*	an angel from God	a donkey	interact w/ each other		-

2. MRS. B-'S CLASS.

1.	[parent]	a child	a family	an over-crowded bus	-
2.	a mother	a reciever	a mass of well coordinted parts of a mechanical engine	-	-
3.	parent	child	home	a lab.	-
4.	a mother	* builder	a team	simple & comfortable	-
5.*	a friend	a small child	discussion group	reading room	-
6.*	Christian	student	lab.	a library	-
7.	parent	child	tutorial	a library	-
8.*	Guardian	-	-	-	-
10.	parent	*an ox	a community	-	-
14.	competent	-	-	life itself	-
17.	parent	a slave	family	hospital laboratory	-
18.	Hard	dedicated & commited	-	-	-
21.	a mother	a great person	a community	home	research center

3. MR.D-'S CLASS.

1.*	lionness	*a cat	a symbiotic group	-	-
2.*	orchestra conductor	a young baby	*an army	-	a convent
3.*	a clown	spectator	*a bunch of nerds	chemical	-
4.	-	puppy	a family	museum	small city
5.	parent	a little Grade 1 pupil	a committee	-	-
6.*	Koala bear	puppy	a group of hungry children	*a church	-
7.*	Preacher	a trained animal	the wind	space w/ interesting things to look at	-
8.	-	-		*a jail	-
9.	catalyst	person	a helper	*a jail	-

4. MRS. G-'S CLASS.

1.	mother	child	a family	lab. nice w/ hardworkimg people	
5.	mother/	a son	a big family	one of our room at home	-
6.	mother	-	-	-	-
7.*	a working bee	children	a family	-	-
8.	-	an angel	* "a askorokoro"	-	-
9.	biologist	-	a family	-	-
10.	the best Bio.Tr.	*a roller coaster	a family	a general Sc. lab.	-
11.	mother	a kid	children from one family	-	-
12.	student	scientist	-	a theater	-
13.*	a saint	a child	*a broken down lorry	orderless place & dirty	-
14.	a good Tr. makes me understand	not serious	slow needs pushimg	equipped	
15.	shepherd	sheep	a team	Biology	-
16.	shepherd	a non-concerned person	has to work harder - not doing well	deteriorating Needs repairs	standards going down

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5. MR.N-'S CLASS.

1.	a father	a puppy	-	a hall	-
2.*	a lion	a chick	*stars	a lab.	college
3.	instructor	parasite	family	our own	united
4.	*a cook	a master	*armed soldiers	a dining hall	-
5.*	a tap of water	*a fighter	a group of bees	colored flower	- -
6.*	a hare	*an ant	a society	* an industry	-
7.	shepherd	*a bee	a family	*seacoast	-
8.	a soldier	Jesus' disciple	*a group warriors	-	-

6. MRS. M-'S CLASS.

2.	-	*a raven	"self-sufficient" (not sharing)	well-lit	-
3.*	an eagle	*a slave	*ants (coop)	-	-
4,6	mother	a son	a family	-	-
7,10& 5.	mother/ sister	-	a football team	-	-
8.	mother	needy person	family	*a church	-
9.	caring	a driver	-	a lab.	-
10.	mother	son	a society	-	-
11.	-	-	not cooperative	a good atmosphere	-
12.	friend	Olympic	-	-	-
14.	parent	-	*a battlefield w/ no sharing & competitive	-	-
15.	an eagle	-	-	-	-
16.	a mother	a puppy	*brothers in arms in a jungle & "the fittest survive"	*torch chamber	-

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7. MR. V-'s CLASS

1.	active	athletic participant	heading for light	nicely constructed	a good school
2.	soldier	a child	family	house	helping
3.	coach	player	team	training ground	
4.	captain	footballer	cooperative	palace	-
5.	priest	daughter	family	zoo	-
6.	joker cheers us up	child to learn	pond full of happiness	court of juries eager to know	-
7.	a good Tr.	competitive student	patriotic sharing	well provided & ventilated	
8.	parent	child	family	museum	
9.	a bee	sociable	family	blast furnace	

8. MRS. Mi-'S CLASS.

1.	sherpherd	a man	-	museum	conducive to learning
2.	parent	a child	*an arena	*workshop	home
3.	sherpherd	-	*a swam of bees	-	clean
4.	parent	*a slave	family	theater	-
5.*	a	*a tail	*an education furnace	museum	-
6.	a driver	*a cooker	museum	-	-
7.*	a walking stick/ sherperd	hungry lion	a flock sheep	-	-
8.*	a good commander	a young curious	an army of poor & good soldiers	-	-
9.	a mother	*a gudget	-	*graveyard	-
10.	*a Jesus	*a parasite	*Legion of Doom	*academic Power House	-
11.	a mother	a beggar	-	conducive to learning	-
12.*	a dove	a warrior	-	well equipped	-
13.	a good leader	Mendel?	-	museum	-
14.	resource-ful	a hard worker	a divided camp	well maintained	-
15.*	Samaritan	a sheep	a herd sheep	nature	-
16.	a leader	*a soldier	a kraal of bulls	research team	-
17.	parent	-	-	home	-
18.	messenger	recipient	people in a race	-	-
19.	mother/ friend/ guardian	a symbiont	a group of conspirators	-	-
20.*	a sieve	a book bug	a battallion of soldiers	*home	-
21.	*an angel	a disciple	a family	*a heaven	-
22.	mother	an orphan	a crowd at stadium	a Varsity Bio. lab.	-
23.	parent	a follower	-	*courtroom	-
24.	a nice Tr.	-	-	palace	clean
25.	*servant	*salt	a swarm of bees sharing	-	
27.	*prophet	*a gomand- -iser	*a cooperative	*heat -ing house	-a cell
28.	a bus driver	a follower	*congregation	-	-
29.	a model Tr.	-	-	-	-
30.	*a savior	*a parasite	-	a library	-
31.	mother	*lion	crop field	incubator	

9. MR. P-'S CLASS.

1.*	catalyst	*beggar	a group of uneducated people	a lab.	-
2.	parent	a child	a family w/ few radicals	uncood- -inated house. inadequate & broken down.	gateway to ed.
3.	lecturer	a college student	a small small	-	-
4.	*initiator /catalyst	*a reactant	inquisitive	a lab.	-
5.	helper	*a plant	family	operating theater	society
6.	helper	a worthy person	a Boys' High School	woodwork shop	a good school
7.	father w/ pvt. talks	a tape recorder	one big family	lecture theater	an inde- pendent State
8.	* a doctor	-	a colony ants	-	-
9.	a genuine person	*a slave	a small community	workshop	a small community
10.	lecturer	a young boy	hard working	unfinshed classroom	-
11.	a good	-	cooperative	-	-
12.	lecturer	*vehicle	research team	lecture room	-
13.	friend	computer	one big family	lecture room	*church
14.	is good	not working "a foreigner"	competing team	inadeq- uate equip- ment	deterio- -rating Needs repairs
15.	brother	a sheep	*paradise	*a pub	college
16.	parent/	a child	a family	a home	-
17.	lecturer advisor	a child	a family	a home	-
18.	a helper	a sufferer	a mixture of good & bad guys	-	needs repair
19.	dedicated man	a young scientist	cooperative/ a society	always *clean	- -
20.	-	forgetful	a society	*kitchen	-
21.	respect -ful	data hungry	-	lecture room	-
22.	Good in practical	enjoy practicals	enjoy Biology	- -	- -

APPENDIX #15

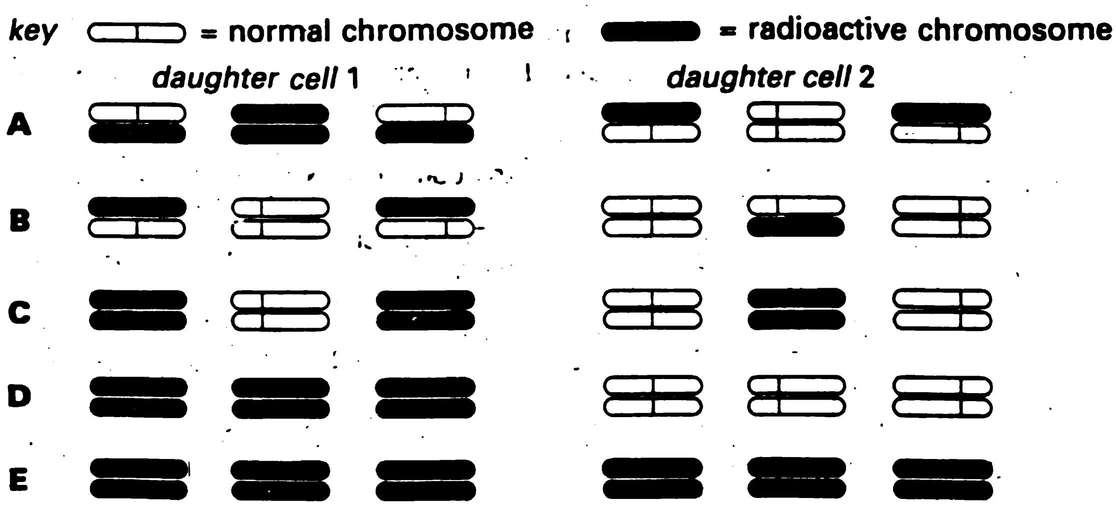
1991 A-LEVEL BIOLOGY FINAL EXAMINATION PAPERS

APPENDIX #15.1 : Paper 9261/1

"9. The following experiment was carried out.

1. Haploid cells containing 3 chromosomes each, were grown in a medium containing radioactive thymine so that all the DNA was labelled.
2. Cells in early interphase were then transferred to a medium where the available thymine was not radioactive.
3. A single cell was immediately isolated and allowed to divide once. When the two daughter cells reached the next metaphase, they were fixed and their 3 chromosomes were inspected for radioactivity. Which diagram represents the distribution of radioactivity at metaphase in the two daughter cells?

[Diagram]

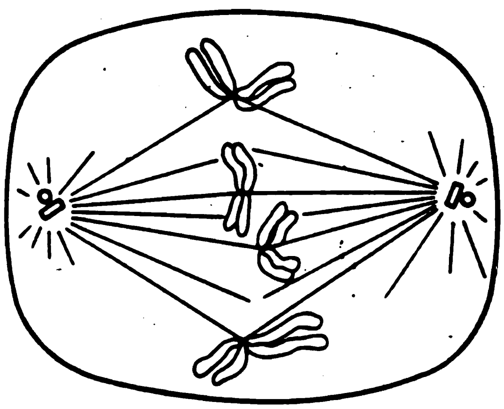


10. Which of the following is involved in the inter-chain linkage between complementary strands of DNA?

A covalent bonding between the sugar and nitrogenous based
B covalent bonding between the sugar and the phosphate
C covalent bonding between adjacent sugar groups
D hydrogen bonding between the nitrogenous bases
E hydrogen bonding between adjacent sugar groups

11. The diagram shows one stage of mitotic cell division.

[Diagram]



From the position of the cell organelles and the chromosomes, what stage of mitosis has been reached?

A early anaphase
B early telophase
C mid metaphase
D late prophase
E late anaphase

12. If **x** units of DNA are present in the nucleus of a cell which has just divided, what is the relative amount present in this cell during prophase of the next mitosis?

A **x**/4 B **x**/2 C **x** D 2**x** E 4**x**

13. Below is a part of DNA genetic code for six amino aids.

CGG	codes for alanine	TTT	codes for lysine
GCG	codes for arginine	AAA	codes for phenylalanine
CCA	codes for glycine	CAA	codes for valine

The diagram shows part of a mRNA molecule, but the corresponding part of the protein formed was found to be arginine - glycine - lysine - valine - alanine

C G C G U U A A A G U U G C C

Which triplet contains a single transcription error?

A the first
B the second
C the third
D the fourth
E the fifth" (Ibid., pp.3-5).

The following are extracts from the Chief Examiner's comments on the 1991 A-Level Biology students' performances on all the papers.

APPENDIX #15.1.2

EXAMINER'S COMMENTS ON PAPER (9261/1)

General Comments

There were 3226 candidates for this paper. The marks achieved ranged from 2/40 to 40/40 with a mean of 25.5 and a stand deviation of 7.08. Straightforward questions which most candidates answered with little difficulty were Q.1, 6, 7, 8, 10, 13, 14, 15, 18, 19, 22, 23, 25, 26, 27, 31, 32, 36, 37,and 39. No question on the paper was unduly difficult. The Examiners were pleased with the candidates' generally high level of preparation.

Comments on Individual Questions

Q.9 This was a difficult question with much guesswork in evidence. The easiest route to the answer was by elimination of the distractors. The DNA has replicated twice in an unlabelled thymine medium. Therefore,according to the semi-conservative hypothesis, only one of a pair of chromatids could be labelled, On replication in the "normal" medium, one only of each chromatid pair would be labelled. On the second replication before metaphase in the daughter cells only one out of the four chromatids would be labelled and these would be distributed randomly between the two cells.

Q.11 Although this question was fairly easy, it did not discriminate very well, meaning that too many of the more able candidates were choosing another option, probably late prophase (D) or early anaphase (A), both relatively popular. The diagram of metaphase is similar to those found in standard textbooks and clearly shows undivided centromeres and no trace of a nuclear envelope.

Q.12 It was pleasing to note that the majority of candidates know when DNA replication occurs in the cell cycle. However, there are still too many who think that DNA replication occurs during mitosis." (p.29)

For Q.10 and Q.13 (See General Comments, above).

APPENDIX #15.1.3

TABLE # 20: PROPORTION CHOOSING EACH OPTION

(Correct answers are asterisked) (Extracted from p.31 of the Report)

Question Number	A	B	C	D	E	Discrimination (point biserial)
9	0.17	0.34*	0.14	0.18	0.16	0.38
10	0.02	0.06	0.01	0.87*	0.05	0.38
11	0.14	0.01	0.67*	0.15	0.02	0.23
12	0.01	0.06	0.25	0.66*	0.02	0.47
13	0.05	0.83*	0.06	0.03	0.03	0.38

APPENDIX #15.2.1
Paper 9261/2

"Q.1 (a) State three differences between RNA and DNA.

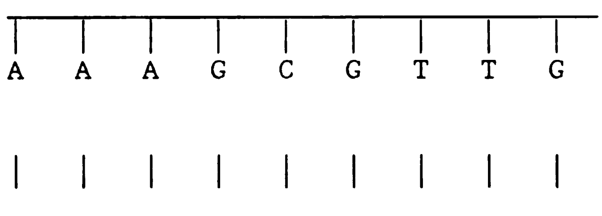
Difference	**RNA**	**DNA**
1	....	....
2	....	....
3	....	....

[3]

(b) The diagram below shows the sequence of nitrogenous based on part ofa strand of DNA and the corresponding region of a strand of messenger RNA. Using the letters provided in the key, indicate on the diagram the complementary bases which would be found on the strand of messenger RNA.

KEY
A = Adenine G = Guanine
T = Thymine U = Uracil
C = Cytosine

Strand of DNA



Strand of messenger RNA

(c) State briefly why it is thought that the arrangement of the bases in the nucleic acids in the form of a 'triplet code'

....

....

....

....

....[3]

(d) Distinguish between **transcription** and **translation**.

....

....

....

....

....

....[5]

(e) (i) Define a gene mutation.

....

....

.... [2]

(ii) Name one chemical factor and two other environmentalfactors that can cause a gene mutation.
Chemical factor

....

Other factors
....[3]

(f) Name two organelles, besides the nucleus, which contain DNA.

1 ....
2 ....[2]

(g) Name two compounds containing adenine, (i) one of which is an energy source in the cell, and (ii) another which is a hydrogen acceptor.

(i) Energy source in the cell...........................
(ii) Hydrogen acceptor ....[2]"

(Ibid., pp.2-3)

APPENDIX #15.2.2

COMMENTS ON PAPPER (9261/2)

General Comments

"Only a very few candidates appeared to have had to rush to complete the paper. Most of those who did appear so spent too much time and wrote far too much on parts of some of the structured questions. For example, in Q.1 (e) (i), they wrote mini-essays, defining a gene mutation, crammed into the three line space provided. Many candidates still do not appreciate that the space provided for the answer is a guide to what is expected from them.

In answer to the free-response questions, too many candidates just write down all they could think of which might be relevant to the topic, presumably believing the more they wrote the better their answer. They must learn to plan and structure their answers."

"Comments on Individual Questions

Q.1 This proved to be a good reassuring first question for the majority of candidates and there were many excellent answers.

(a) Most candidates gave the three expected differences (RNA single, DNA double-stranded, RNA ribose, DNA deoxyribose and RNA with uracil in place of thymine). A number of weaker candidates found it hard to find a third difference. They either indicated that there were several sorts of RNA but only one sort of DNA occurred only in the nucleus whereas RNA could be found in the cytoplasm as well as the nucleus or referred to the presence or absence of oxygen in the sugars. In spite of the fact that the key gave the correct spellings for the four bases, many candidates spelt them incorrectly. Thymine was often spelt thiamine for example.

(c) Some candidates had difficulty in stating why it is thought that the arrangement of bases in the nucleic acids in the form of a "triplet code". Statement such as 'one would code for one amino acid and two for sixteen ', without further elaboration, were common. Others explained the code, mentioning codon, anticodon and amino acid sequence rather than the reasoning behind it . Still others defined a triplet code but failed to mention why the code in the form of a triplet of bases.

(d) Some candidates confused **transcription** with **translation** and vice versa. A surprising number thought that the complementary base sequence of DNA was transcribed on to a strand of already-formed mRNA.

(e) (ii) There was some confusion over what was a chemical factor and what was not. X-rays were often named as chemical factors." (Ibid., p.35)

APPENDIX #15.3

COMMENTS ON PAPER (9261/6)

"General Comments"

There was a considerable variation in performance between the best and the weakest candidates but it was clear that more candidates overall were getting to grips with the demands of the papers this year. At the top end of the range there were excellent, high-scoring responses indicative of mastery of the practical skills tested."

COMMENTS ON INDIVIDUAL QUESTIONS

"Q.1 Since the candidates were asked to record the color of the contents of the tubes after mixing, it was possible to mark correct trends in the results. This overcame some variability in the results of the procedure which Centers undoubtedly experienced. Throughout the question, deductions which were drawn by candidates were credited by the Examiners, when they were made logically from their observations, even though these may have been different form the ideal ones. The weakest aspect of most responses in (a) was in (iii). Usually, some correct statement about urea concentrations was made but few explanations related this to different rates of reaction which were due to differences in substrate concentration. That an enzyme was employed, was overlooked.

Most candidates scored well in (b) (i), but in (b) (ii) only a small minority gained credit by pointing out that the volumes of reactants should be standardized or, in the Benedict's test, tubes should b e heated for the same length of time.

Results and conclusions given in (b) (iii) were appropriate, but more difficulty was experienced in devising a single table to accommodate them. A significant number of candidates lost marks by reference to 'protein/glucose occurring in low concentrations' rather than stating that they were absent (where appropriate).

Q.2 It was considered not unlikely that candidates would have previous experience of the material supplied and it was pleasing, therefore, to find that all but a small minority followed the detailed instruction carefully and obtained reasonable chromatograms. Credit was given for making accurate measurements and recording the results. The weakest aspect of the work of candidates was in identifying the pigments, particularly the two chlorophylls. That the resulting chromatogram was different from those given in many standard A-Level texts was regarded as being an opportunity for candidates to show their ability to record observations and interpret them in the light of their biological knowledge. Many rose to this challenge.

Q.3 In (a) (i) most candidates identified the parasite without difficulty. Observations given were accurate and appropriate. (a) (ii) was answered less well: Examiners gave credit for statements to the effect that the parasite must be the smaller of the two and that one plant, because of its flexible, weak stem, was unlikely to be able to support itself independently of the other plant. The most frequently overlooked features in (a)(iii) were the presence of some tissue differentiation in the 'process' connecting parasite to host. The term 'haustorium' was not expected and any appropriate annotation was credited if it indicated the extent of penetration of the structure to the vascular tissue of the host. Many candidates lost credit in (a) (iv) by their use of imprecise language e.g. 'gains food from the host'. This kind of response also omitted reference to the visible features present. Statements to the effect that 'the connection is between the xylem/phloem of host and parasite and allows sucrose, amino acids, water, mineral salts ...' were required.

Most candidates recognized K6 as a blood vessel, fewer recognized it an artery, but many lost marks in the drawing because a text book three-layered representation was given, whereas the specimen showed two layers. Relative thickness of the layers was not accurately shown and the wall: lumen dimension were usually misrepresented. The structural features of the walls were known. Most candidates now know how to calculate the magnification of a drawing.

The features expected in (b)(iii) were: thick walls to withstand blood at high pressure; presence of elastic tissue to produce the recoil needed to maintain flow during diastole and appropriate reference to the smooth muscle e.g. arteriostriction was allowed although, strictly speaking, it does not occur in an elastic artery." (Ibid., pp.45-46)

APPENDIX #15.4.1

**TABLE 21.1: TOTAL SUBJECTS TAKEN ANALYSIS
NOVEMBER 1991, ADVANCED LEVEL**
(Excluding General Paper)

TOTAL SUBJECT ENTRY:	GRADE A	B	C	D	E	O	F	X
38 752	1248	3 203	5078	6042	6288	8924	4931	3038
	3.2%	8.2%	13.1%	15.6%	16.2%	23.0%	12.7%	7.8%

TOTAL NUMBER OF CANDIDATES 17,777

APPENDIX #15.4.2

**TABLE 21.2: TOTAL SUBJECTS TAKEN ANALYSIS
NOVEMBER 1991, O-LEVEL**

TOTAL SUBJECT ENTRY:	GRADE A	B	C	D	E	U	X
1010533	36150	123105	174963	152223	156453	336227	31412
	3.6%	12.2%	17.1%	15.1%	15.5%	33.3%	3.1%

TOTAL NUMBER OF CANDIDATES 209887

APPENDIX #16

LESSON TRANSCRIPT OF MR. C-

Teacher: Mr. C-
Class: Lower Sixth
Subject: Biology
Topic: DNA Replication
Date: 7-2-92
Time: 12:00 Noon

1. Students greet me politely as they come into the laboratory.

2. Teacher introduces me, and explains my presence.

3. Teacher continues from yesterday's lesson, which I did not attend.

Teacher: Remember yesterday we were looking at the nature of the genetic material, and we were looking at the evidence to show that DNA is the genetic material and we looked at three pieces of evidence ... (inaudible) So from those experiments, you can conclude that the DNA is genetic material. In fact, the next thing we want to look at today is the replication of that genetic material. [Teacher writes "THE REPLICATION OF DNA" on the board]

Teacher (continues): Right, from what we have discussed together, we can tell the structure of the DNA molecule. We know that it is a double-stranded molecule consisting of two polynucleotide chains and each polynucleotide chain has three parts to it. **Which are these three parts?**

Student #1: Sugar.

Teacher: Yes?.

Student #2: A base.

Teacher: Yes?

Student #3: A phosphate group.

Teacher: Then when those nucleotides are joined together they form a chain. So, in the case of a DNA molecule, we said it is a double-stranded molecule. What it means is that it has got two chains. They are anti-parallel to each other. In fact, what we have is a sugar-phosphate backbone with the bases at right angles to this sugar-phosphate backbone. **The question is, what holds these base pairs to have your DNA molecule?**

Student: Hydrogen.

Teacher: Yes, so we have these hydrogen bonds, which help to hold these base pairs. [Teacher indicates the H-H bonds on his sketch of the DNA molecule]

Teacher: In fact the one thing we said about our base pairs is that they are complimentary to each other. We have our two kinds of bases. We have pyrimidine bases and purine bases. One of the pyrimidine bases usually pairs with a purine base. So in the case of a DNA molecule, there are four types of bases: Cytosine, Guanine, Adenine and Thymine. We said Adenine will always pair Thymine and Cytosine will always pair with Guanine. So we have got these base pairs. So, that part we have discussed is that we now know that they, the genetic material, will control all the activities inside the cell. The other thing we know is that it consists of, in fact, it is the element which makes up the chromosomes, and we have looked at chromosomes, when we discussed at the processes by which new cells arise from the existing cells (i.e., mitosis and meiosis). So your DNA molecules makes up your chromosome. Then we also said that chromosomes, in addition to may be made up of DNA molecule, there are some proteins which coat that DNA molecule. So that's what is meant by chromosome. And we looked at mitosis, i.e., the behavior of chromosomes during mitosis and the behavior of chromosomes during meiosis. So when we were discussing those two processes of mitosis and meiosis, we said maybe in one of the phases of those two processes, the interphase, there is replication of DNA. So, from what we said, replication of DNA, it means a new molecule of DNA being synthesized before the cell can undergo your cell divisions, i.e., mitosis or meiosis. So this is the thing which we want to discuss, because your chromosome is made of DNA molecules. So, if the chromosomes, during interphase replicate, it means it is the DNA molecule which is replicating. A new DNA molecule is being synthesized, during interphase, before mitosis or meiosis can occur. Right? So, that is, what we now want to look at is er... Right, a number of kinds [Pause] or what can I say?, pieces or types er your (Pause). In fact, the...er...point here is that a number of kinds of DNA replication have been proposed. There are three kinds of DNA replication which have been proposed. The first kind of DNA replication which has been proposed is what they call <u>the conservative kind of DNA replication</u>. [Teacher writes "<u>the conservative kind of DNA replication"</u> on the board].

Teacher [continues]: Then the other kind of DNA replication which has been proposed is what they call <u>the semi- conservative DNA replication</u>. [Teacher writes "<u>the semi- conservative DNA replication</u>" on board]. Then the last kind of replication which has been proposed is what they call <u>the dispersive replication</u>. [Teacher writes "<u>the dispersive replication</u>" on the board].

Teacher [continues]. So these are the 3 types of theories which have been put forward as to how the DNA replicates. There is the conservative form of the replication. There's the semi-conservative, and there's the dispersive replications. So, what we want to, maybe is try to look at this one. [Teacher points to the first theory on the board]. Then the conservative and we look at the semi- conservative and after that we go to ... because at this stage, and the biologist or geneticists believe that your DNA molecule, when it replicates, it replicates by this [teacher pointing to "semi-conservative" on the board] the semi-conservative kind. So, we are going to look at the evidence to show that DNA replicates by this kind i.e., the semi-conservative. But before we go into the evidence, I first want to discuss with you, what they mean when they say that DNA replicates by the semi- conservative method or by the conservative method. Right. I'll start with the conservative method.

Teacher [proceeds to explain] From what we have discussed, we have said that DNA molecule has two strands, and these two strands we said are anti-parallel to each other. So with this ... er ... hypothesis, they say instead of unzipping with this other theory [Teacher points to "semi-conservative"], they say these two strands of DNA molecule unzip i.e., they separate. Then after separation, you have a new poly-nucleotide being formed. So with the conservative maybe hypothesis, it hypothesizes that this double-stranded molecule does not unzip. What happens is that an entirely new double- stranded DNA molecule is formed at the side or along side the original. So, [Teacher illustrates on the board] if here you have the original DNA molecule, with the semi- conservative ..er.. sorry, the conservative hypotheses, they say, alongside this original DNA molecule, you will have a new DNA molecule being synthesized. So, that is basically what this semi-conservative [conservative?] theory proposes.

Teacher [summarizes the main points and continues]: So you'll be starting with the assigned DNA molecule being synthesized, with the result that the first generation offspring [Teacher points to the parental and the daughter molecules on the board's illustration] because they will be your progeny of this one. Your first generation offspring will be exactly like the original DNA molecule. So, it's just a question of a new molecule being synthesized along the parental DNA molecule. That,is what is basically said about the conservative method of replication. So, instead of unzipping, an entirely new DNA is formed alongside the parent one. So, the result is that in each maybe generation, this [Teacher indicates on board], would be the first generation progeny you'll be having the same genetic, maybe, material as what we have in the parental DNA molecule. So, that is basically the semi..er.. sorry, the conservative mode of replication. [Pause]

Teacher [proceeds]: Then with the semi-conservative mode of replication, what it proposes is that the parental DNA molecule, first of all, unzips i.e., the hydrogen bonds which hold the bases together break. So, you'll tend to have, maybe, a situation of something like this. [Teacher illustrates the unzipping on the board]. That is, as this strand separates from the other strand, that is the first thing which happens; i.e., the unwinding of the complimentary strands, and these, they separate due to the breaking of the hydrogen bonds between the complimentary bases. Then, each of these separated strands, maybe, will now act as what is called a template [Teacher writes "template"on the board] and basically, when they are going to be synthesized, in each one of these complimentary base pairs. Then the complimentary base pairs, if you take this one on the left [Teacher pointing to the strand on the board] it will act as a template, and you'll have another new polynucleotide chain being formed alongside it.

Then on the other one, which is on the right, [Teacher points on the board], you will also have another new polynucleotide chain being formed, along side that one and the base sequence on the new polynucleotide chain which are formed, is going to be determined by the base pair sequence on the original parental DNA molecule.

Teacher [summarizes]: So, the main point is that the original DNA molecule unzips and why it unzips is the result of the breaking of the weak hydrogen bonds between the polynucleotide chains. Then after the breaking of those strands, each of those strands is going to act as a template or what is called a molecular mould, on which a polynucleotide chain is going to be formed. Then the base sequence, that is going to be formed on the new polynucleotide chains, which are going to be synthesized, is usually determined by the base sequence on the original parental chains. So, if, suppose you take this parental chain on the left, the base sequence may be a TAG and so on. The base sequence on the new one, the one which is going to be synthesized, is going to be determined by the base sequence of the original. So the base sequence which is going to be formed in that position [Teacher pointing to the TTAG part of the diagram molecule], will be the complimentary base of the Thiamine, which is going to be Adenine, and the same sequence on this position [pointing to the next base], will be complimentary to that Thiamine, and it is Adenine and that process is repeated along the chain. And the same happens with the other chain. So in the end, you are going, you're having two identical DNA molecules, which are going to be produced and these molecules are identical to the parental DNA molecule, because what is really happening is that the new molecules which are formed are going to carry the same base pairs as the original DNA. So, the daughter molecules which are going to be identical in their ... maybe ... base sequence. The other, maybe, things I need to say is that this breaking and synthesis of this new molecule, it involves the use of enzymes [Teacher writes "enzyme" on the board]. So we are having, maybe, an enzymes, sorry, enzyme, which helps to break and separate polynucleotide chains. And we are also having an enzyme, which helps to synthesize the new molecules. So, the enzymes which are involved, the first one which helps to separate parental polynucleotide chains is called DNA polymerase. [Teacher writes "DNA polymerase" on board and continues] Then we have another enzyme which is involved in the synthesis of new nucleotide chains, and this one, they call DNA nuclease. [Tr writes it on board], because it is going to help to paste up the various nucleotides, which are found in the cell's nucleus. So, there are enzymes which are involved in the breakage and formation of new nucleotide chains. So your polymerase is involved in the separation of parental strands. Then you have the DNA nuclease which is involved in the joining together of newly formed and synthesized polynucleotide chain. So, that is, maybe, the theories that have been proposed as to how the DNA molecule replicates. The point is, since we have looked at the chromosomes replication, when we were discussing mitosis and we have also said that the chromosomes is replicating, so **how it is going to replicate?** There are three (3) ways of DNA replication proposed, i.e., the conservative, the semi-conservative, and the dispersive methods. But the most important, accepted, is the semi- conservative method. There's evidence for it. The others you need to know too but the most important is the semi- conservative replication. **Any questions?**

Students: Are there any specific conditions that necessitate that this replication occurs in [Very difficult to hear]?

Teacher: What do you mean by "conditions?"

Student: Like you apply something and then replication occurs.

Teacher: If you apply something like what?

Student: I don't know, anything.

Teacher: In fact let me try to answer you. Here's what they say, that the DNA molecule itself has got its own recognition sequence and maybe some pairs of DNA, that which are going to make it recognize that aspect of DNA replication, so that, maybe, your replication...er...in fact, there are enzymes involved which recognize this maybe replication because your replication can [inaudible] recognize ... DNA molecule in the form like this. [Tr points to board illustration] So usually, you can have the replication starting on that portion, and one reason why that can happen is that there are these enzymes which will help it to recognize where the replication should start and there is also a coding sequence which starts the whole process. **I am not very sure what you meant by "conditions."**

Student: I suppose the answer is the coding sequence.

Teacher: Yes, there is a coding sequence in the DNA which starts the replication. **Any other questions?** [Silence.] So the main point is as what I said. What is the most important for an is the semi-conservative mode of replication and the main point is that the parental DNA molecule unwinding and each of the parental strands acts as a template on which the new molecule is synthesized. Then the daughter molecules which are going to be formed are going to be exactly alike since you are having parental DNA molecules acting as templates. So the molecules which are going to be produced will be exactly alike. Then the other thing is that we have enzymes which are involved in that process that is the breaking up and the synthesis of new polynucleotide chains.
Then, with the conservative as I said, instead of unzipping, we have an entirely new double helix being formed alongside the parental one. So, that is really the main difference. With the semi-conservative, there's that unzipping. So, those are the two kinds of replication that, maybe, you need to know about. Right? So, the next thing that is important, as I said, is to discuss <u>the evidence that DNA replicates by the semi-conservative one</u>. [Teacher writes this on board.]

Teacher [continues]. Alright, the experiments which have been done to show that the semi-conservative mechanisms is the mode of DNA replication were done in 1958, by some two (2) biologists: <u>Meselsohn & Stahl</u> (Tr writes names on Board) and what they used was bacterium, <u>E. coli</u>. Remember yesterday we looked at <u>E. coli</u> when we discussed how <u>E. coli</u> was used to show that DNA was the genetic material .. (Inaudible) One thing about <u>E. coli</u> is that it is having a singular DNA molecule. So it is a prokaryote. So it has a singular chromosome that's a good thing about <u>E. coli</u>. Unlike human beings that have double sets of chromosomes. So, what they did was to take cultures of <u>E. coli</u> and they grew these cultures for many generations in a medium containing heavy isotopes of nitrogen. Cultures of these bacteria were grown in heavy isotopes of nitrogen fifteen for many generations. **And what do you think happened after growing this bacteria for many generations in a medium of heavy nitrogen?** In fact, the generation time is around 50 minutes. So if you start with an adult <u>E. coli</u>, if the conditions are suitable, it can be use to produce new offspring in 50 minutes. That' the generation time. So they grew the <u>E. coli</u> in heavy nitrogen for many generations. **So the question is what do you think happened?**

Student: The bacteria became labelled.

Teacher: What do you mean "bacteria?"

Student: The bacteria's DNA molecule.

Teacher: Why the DNA molecule"

Student: Because it has nitrogenous bases.

Teacher: In fact, what happened was that all the DNA i.e., the chromosome of _E. coli_, became labelled with nitrogen fifteen and what we are saying is that it is the DNA molecule, and not the protein coats, or the poly- sacharides, which surround the bacteria. It is because your Nitrogen is mainly an element in the bases, in the nitrogen bases, which are parts of your DNA molecule. So, that is the first thing they did growing the _E. coli_ in a medium containing heavy nitrogen. The result was that the DNA became labelled with nitrogen fifteen. That was the result. [Teacher writes on board.]

Teacher [continues]: Then the next thing they did maybe, was to grow these bacteria, which had been growing in a culture of nitrogen fifteen, they were now allowed to grow in a medium containing the normal nitrogen. That was the second thing that they did. So, those cells which contained nitrogen fifteen were transferred to a culture which contained normal isotope i.e., nitrogen fourteen, and so, that was their second stage.

[Bell ringing]

Teacher [continues]:Then after introducing the bacteria in a medium with nitrogen fourteen they waited and what they did then was maybe to wait until after the first generation period, after they have reproduced. So at intervals i.e, at times corresponding to the generation time of _E. coli_, they then removed samples of _E. coli_ from the culture medium and extracted the DNA of _E. coli_, analyzed the DNA in terms of nitrogen fourteen and nitrogen fifteen.

Teacher [summarizes]: From the first generation parents it takes 50 minutes to the first sample generation. Then another 50 min. to the 2nd generation sample. 50 min. to the 3rd generation sample etc.

Teacher [continues]: The assumption was that after waiting for these minutes, some new progeny would have been produced in this culture. What they did to the removed samples was to extract the DNA from the bacteria. That was the other thing that they did. Then they centrifuged that DNA at 40,000 g, i.e., 40 x gravity as the speed of the centrifugation. The idea is that they centrifuged the extract for 20 hrs...and this centrifugation, it took place in a solution containing what they call your caesium chloride. What happened is that, during centrifugation, the heavy caesium chloride solution, began to sediment at the bottom of the centrifuge tube like this [Teacher illustrates the different layers on board and continued] And they went on to examine this under the ultraviolet light and the DNA appeared in the centrifuge tube as a narrow band [Teacher points at band in the diagram]. That is how they carried out the experiment. As for the results, I'll discuss them with you, what they obtained.

Teacher [recapitulates]: So in terms of the methods they carried out. Firstly, they grew the E. coli in a medium with heavy isotope of nitrogen. The result was that all the E. coli had their DNA labelled with nitrogen fifteen. Secondly, they took that culture medium with labelled DNA molecules and introduce to a medium with nitrogen fourteen and allow those bacteria to grow in that medium. Then after periods corresponding to the generation time, they removed samples. Suppose they started at time zero, after 50 minutes they removed samples and put in a tube containing caesium chloride and centrifuge. Then they had to wait for another 50 to 100 minutes from start to extract a second sample and a third sample; and so on. What happened was that the DNA settled may be at a point where its density was equal to that of caesium chloride. That was the method. Then with the results, maybe we are going to discuss results. But as for the method, I don't know if you have any questions?

Student: What sample is equal to caesium chloride? It is the first sample or the second sample?

Teacher: It is in both. In fact, it is in all of the generations they studied. But the point is that each time they centrifuged the extra in caesium chloride, the DNA molecule settled at a point where its density was equal to that of caesium chloride, regardless of which sample. Any other question on the method before we have to go into the results? [Silence]

Teacher [Proceeds]: Right. As for the results, if there are no questions. [Teacher(rubs the board].

Student: What is the meaning of "centrifuge?"

Teacher: Who can answer that?.

Another student [explains (inaudible)]

Teacher: In fact it's a physical technique of separating substances by spinning at high speed. [Teacher leaves the room and brings a centrifuge from the prep/store room and demonstrates how it works.] Here are the devices ... centrifuge tubes in which you separate ... spinning at very high speed ... the things you are separating according to their different densities ...

Teacher [continues]: Alright. So now as for the results, we have said we are to extract and place the caesium chloride solution in the tubes. After centrifuging, the DNA appeared as a band [Teacher points to diagram on board] I'll first give you their cells. [Teacher writing on board.]

1. For first cells growing, there is just one band. Maybe there was just one DNA. [Silence. Teacher shades the DNA band in the tube on the board]. Right, those diagrams will help us now. Anyway, they grew the E. coli in nitrogen fifteen. What they did also was to extract the DNA and put in the centrifuge tube.

Side B

Teacher [continues]: Look at this one. What they did was to explain their experiment, and we should also try and follow their argument from what we have discussed about the semi-conservative replication. We have said with the semi-conservative, we are starting with the original, I am going to use dotted line, and show all the E. Coli being grown in nitrogen fifteen had their DNA like this. [Teacher sketches on the board] So it was extracted, put in a centrifuge and the DNA came to settle at a point where its density way maybe equal, about this point. [Teacher points on board illustration]. This is what we are talking about nitrogen fifteen. How can we explain this? It is because from what we have said, these two strands separate and we have this one departing from this and it acts as a template and this new one forms and that new one forms. But this one has nitrogen fifteen and this one has nitrogen fourteen. This one nitrogen fourteen and this nitrogen fifteen, since it is the original. These new ones which are being synthesized are using nitrogen which is not labelled. It is normal Nitrogen. So, it is no longer heavy like this in terms of density. So, if this one's density was at this position, then this one is lighter and so the density of this molecule should not be the same density as that molecule. Hence, that difference. So its band is found at a point slightly above. Do you follow?

Class [choruses]: Yes.

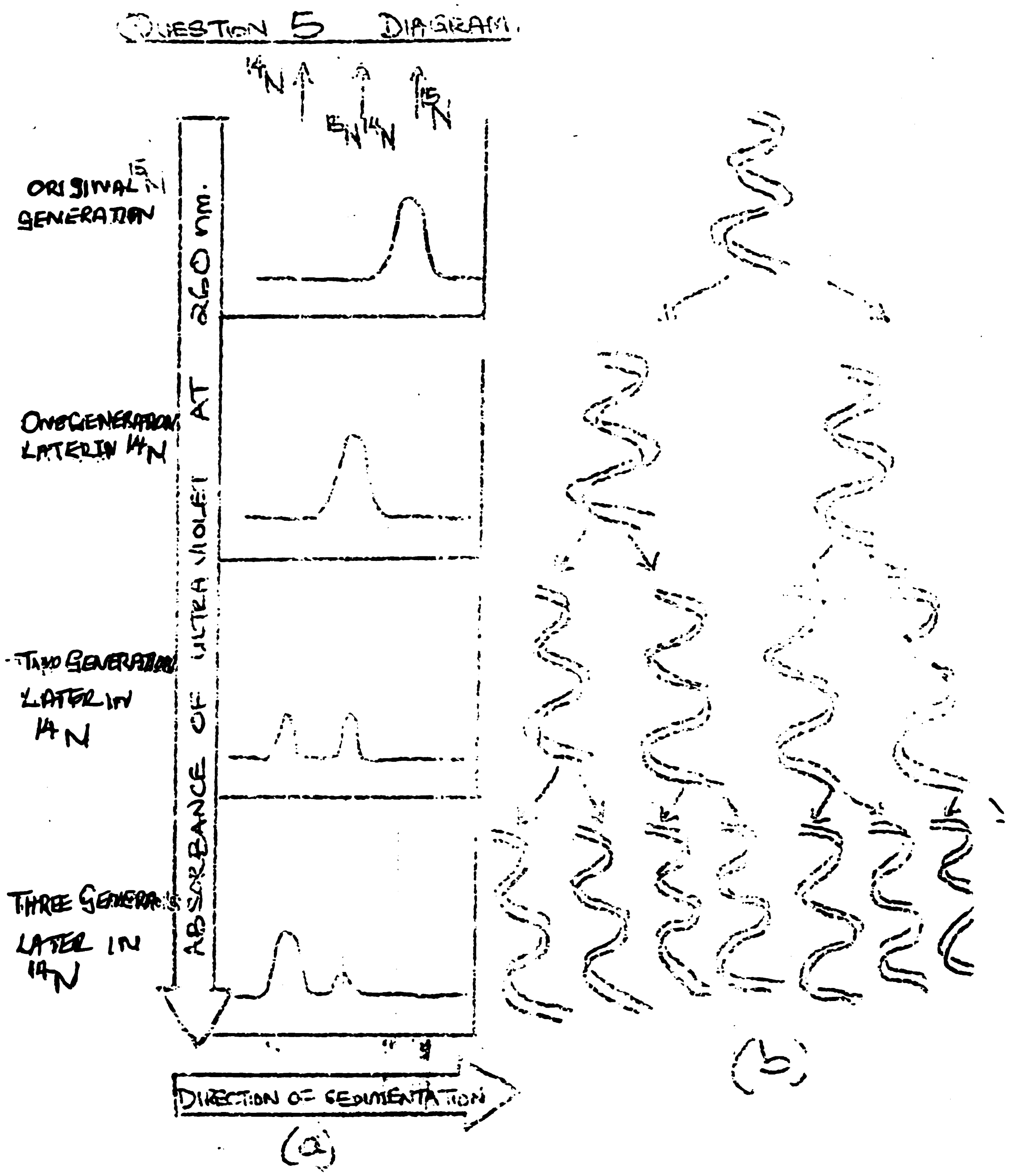
Teacher [continues]: Then, if this went on to replicate, then you have this one replicating and you have that original and then you have this one acting as another parent. And so you have a new one synthesized here and there, but with nitrogen fourteen. So, one replication will have a new one synthesized here and there. So all in all, there are two of the same kind as those. The first generation with parental strand with nitrogen fifteen and you have a completely new kind which does not contain the original parental strand, but have nitrogen fourteen and so their density is different from the nitrogen fifteen, and so you have another band, the same size, but slightly higher band. And the same could be said here [Teacher pointing to board diagram]. So, you have one and two giving this band like the original, i.e., the thickness does not change. But the new ones one to six, the density is the same since they are at the same position, but the size of the band is different; they are decreasing. And so, they used those results to explain this idea.

Teacher [using a different representation continues]: So, if you represent the nature of the DNA molecule with this bold line to represent nitrogen fifteen [Teacher draws two solid lines for DNA strands.] So, all will carry nitrogen fifteen. And if this [Teacher draws a dotted line] represents nitrogen fourteen, then all the DNA molecules will have half nitrogen fifteen. and half with nitrogen fourteen. Then with this one, you have some that are dotted like this [Teacher illustrates] and the other one should be bold. The new one will have nitrogen fifteen. Some will be the new species with nitrogen fourteen and some with half nitrogen fourteen and half nitrogen fifteen. So, that was the explanation. So, they used these results to explain the semi-conservative mechanism. That it! Any questions? [silence.]

Lastly, I have a question for you on this for homework. Take this information down. [Teacher dictates the homework]

HOMEWORK EXERCISE

Meselsohn and Stahl performed an experiment with the bacterium of E. coli. They grew the cells for several generations in the presence of heavy isotope of nitrogen. This labelled with nitrogen fifteen all the DNA of the progeny that were produced from the initial inoculum. The nitrogen fifteen-labelled cells were then placed in nitrogen fourteen containing medium. The DNA reproduced in subsequent generations was extracted. The DNA from the different generations was compared using the technique of differential centrifugation using a caesium chloride density gradient to separate the DNA containing nitrogen fifteen from DNA containing nitrogen fourteen, as the nitrogen fifteen-labelled DNA is heavier and more dense that ordinary nitrogen fourteen- containing DNA. The position of nitrogen fifteen and nitrogen fourteen DNA absorbance was measured in ultraviolet light at 260 nm (nanometers). The results, I am putting on the board.


QUESTION 5 DIAGRAM.
14N
15N14N
15N
ORIGINAL 15N GENERATION
ONE GENERATION LATER IN 14N
TWO GENERATIONS LATER IN 14N
THREE GENERATIONS LATER IN 14N
ABSORBANCE OF ULTRA VIOLET AT 260 nm.
DIRECTION OF SEDIMENTATION
(a)
(b)

THE QUESTION:

Do you consider that the data presented suggests that replication of DNA in E. coli is conservative or semi- conservative? And what are your reasons.[The bell rings] The books I have, come and get them. [Teacher dismisses the class.] [Students get their books on their way out.]

APPENDIX #17

LESSON TRANSCRIPT OF MRS. M-

Teacher: Mrs. M-_
Class: Lower 6
Subject: Biology
Topic : DNA/RNA/SEMI-CONSERVATIVE REPLICATION
Date: 7/8/92
Time: 10:00

KEY: Tr. - Teacher and St. - Student. The underlined is mine.

[Lesson begins with Teacher giving correct one word answers to the last test]

Tr.: For every graph you must use 3/4 of the page. Now, boys, I think here you ought to take graphs seriously. Graphs are very important biological tools. They summarize the information. They tell us a lot about things just by glancing at them. You must know how to construct and use graphs in Biology. Every graph you write must have a heading. Some people wrote graphs without headings. They are very meaningless. Graphs must have a heading. If you didn't give it a heading that's how you lost points. For every graph you must make sure that you use about 3/4 of the page you are given. So, if it is a page like that [Tr. draws on board]. I don't want to see a graph that occupies this side of the page [Tr. indicates a small area in one corner] What are you going to do with the rest? Are yom going to give your brother ... I don't like that. So use at least 3/4 of the whole page. So use a scale that will make you use the whole paper. Is that clear? And also I gave you a point for correct shape of the graph and also for which parameter goes to the X axis and which will goes to the Y axis. Anyway I realize that there's a lot to say about graphs. [Tr. is pacing among the students] I owe you a whole lesson on graphs, how to plot graphs, how to interpret them and so on. But I was so pleased about the number that passed. So that was it. Remember roughly we are still short on time and after all you come so late for lessons. Today you brought some shapes. I asked you to make some shapes yesterday. Can I see the shapes on the table? Put them on the table I am just coming to view the shapes.

St.: Excuse me, I have not brought mine ... [Tr. interrupts]

Tr.: There's no time to talk about excuses, when you knew what I asked. Who has brought the shapes i.e., if you have cut the shapes and are on top of your table? [Tr. walks back to the board and rubs the board]

10:05 A.M.

Tr.: Today we are looking at the DNA, so far we have been looking at the building blocks. We looked at the phosphate group, the purines, and then we saw these coming together with the sugar to make the nucleoside and nucleotide. And so today we want now to look at how then a nucleic acid can be formed? [Tr. writes "nucleic acid" on the board] Now if we can have perhaps some shapes just representing a nucleotide. **We said a nucleotide is made up of what? What are the components of the nucleotide? Kevin?**

Kevin: Phosphoric acid, a hydroxyl and a base. [Tr. writes "base - sugar - phosphate"]

Tr.: These two (base and sugar) make what?

Class [choruses]: Nucleotide.

Tr. We also talked about the bonds. **We said the bond here we call it what?**

Class [choruses]: Phosphor-ester bond.

Tr.: How is it made? What is the reaction there?

Class: [Choruses inaudibly]

Tr: Yes. And then this reaction, the reaction that makes up this bond is as well a sharing reaction. **Now this nucleotide, we can actually have two of these together to make what? With two nucleotides like this, what do we make?**

Sts. [Chorus]: Dinucleotide.

Tr.: Yes. Dinucleotide. If **we have many of these, what do we make?**

Sts. [Chorus]: A poly-nucleotide.

Tr.: Now a polynucleotide can be regarded to be a strand. Now if we look at DNA, it is made up of 2 poly- nucleotides, two strands. But lets see how these strands come together i.e., how they are going to make the DNA. First of all, we also need to understand DNA in terms of its structure. Like proteins, it has what we call the primary structure. Now do you remember the primary structure of protein? [teacher writes on board]. **What did** we say about the primary structure of the protein?

St.: The number and sequence of amino acids.

Tr.: Yes. The number and sequence, in this case, if it is the protein then it is the number and sequence of amino acids. Now if we are talking about a poly-nucleotide and then we are talking about the primary structure, what did you think to be the primary structure of the DNA? Sergeant?

10:10 A.M

Sergeant: The number and sequence of the nucleotides.

Tr.: Yes. You are correct. The number and sequence of the nucleotides gives us, therefore, what we call the primary structure of the DNA. Now let's refer to diagrams, which you have in your handout, so that you can see the primary structure of a DNA. You'll see that on page 413, page 413. How many nucleotides are making that strand or that poly-nucleotide on page 413?

St.: Four.

Tr.: Is that correct? Kevin?

Kevin: Yes.

Tr.: Yes. They are four nucleotides so you can see a strand has already been formed. Now what kind of sugar is used here in all the nucleotides? What type of sugar? Yes?

St.: Deoxyribose sugar.

Tr.: Yes. Deoxyribose and then of course notice that all the bases are going to be on one side. So if you were going to make another er nucleotide here, you'll find that you will also have the bases on this side. If you had brought your shapes you were going to build them up so that you'll have one nucleotide here and one nucleotide there. And in each case, you can see that this, we are going to have make all our bases on one side and here we will have all the phosphate groups on one side and that will build up a strand, a DNA strand like that [Tr. demonstrating with her cut pieces on the board] Now when we look at the secondary structure, the secondary structure, is now how these two strands will come together. Now, how then, if we look at this nucleotide, where are we going to fit another strand? How do the strands come together and bond each other? If we have another strand this side so that here we will also have the bases and here we have phosphate groups and somewhere here we'll have our sugar. Like that [Tr. draws on board] Now here we see that we always have specific base pairing. In other words, we have seen that purine bases will always pair with pyrimidines. So if we have Adenine what is it going to pair with? Adenine? Come on, at the back? Walter?

Walter: Thiamine.

Tr.: Yes. It will pair with Thiamine. If we had Guanine? Guanine? It will pair with what? Yes?

St.: Cytosine.

Tr.: Yes. How this pairing er we said there is what type of bonding is going to be involved?

Sts [Chorus] Hydrogen bonds.

Tr.: In your handouts again you have the hydrogen bonding there, well illustrated. I also want you to see how it happens on page 414. Here we see Thiamine and Adenine. Notice the hydrogen bonding there. Now the more bonds I mean the more pairs we have the more bonds we will have and so this will stabilize the two chains. This kind of bonding will keep the two chains together and they are going to be stable like that. So now if we end up with two chain like that [Tr. indicates on board] Therefore we have already looked at the secondary structure of the DNA. You find that DNA has also its tertiary structure which is more complicated. In other words, after the coming together of the strands like that [Tr. indicates on the board] The DNA has its helix form. Or rather it is helical, isn't it? What do we mean when we say helical? [Silence] What do you understand by the term helical? Yes?

St.: It is spiral.

Tr.: Yes, it is spiral. That means it actually er moves, it's like er ... it's winding on an imaginary? What?

St.: Cylinder.

Tr: Yes. Which other thing did we study about which has this structure, which is spiral? Do you remember?

St: Protein.

Tr: Protein, isn't it? Yes, so the type of helix in this case is actually the alpha helix [Tr. writes "alpha helix" on the board] So realize that when these two strands come together, the bases are inside, isn't it? And then the phosphate groups are outside and finally we are going to have a spiral form, isn't it? A spiral shape so that this kind of winding which takes place is sometimes referred to as a double helix. The kind of helix because of the spiral nature and winding is double helix. **Why double? Can you suggest why we say double helix? Yes?**

St.: Because we have two strands.

Tr.: Yes. We have two strands and these two strands are sort of winding together. They are forming the spirals together. And the two strands, remember they are parallel. Now the two strands are parallel but sometimes we regard them as being anti-parallel, because, as these two sort of two strands join, you find that the way they join is such that, if we draw again [Tr. draws the sugar molecule C1, C2, C3, C4, C5 and we said this phosphate group is going to be joined at the carbon five, isn't it? [Tr. puts phosphate at carbon 5] and **then if we have another nucleotide there we will have what?** The phosphate group there isn't and the phosphate group will also be joined to carbon 5 of this sugar there. And then of course the base is going to be at carbon one of that so that these are two nucleotides. This is a dinucleotide. Now if you look at that [Tr indicates on the board] This is moving in a 3 - 5 direction, isn't it? In other words, we are building it in that way. It is going to be formed. We can put more and more and more in that direction. So when we talk of the direction we can say that it is 3-5 direction. We are talking about the carbons here and the way the nucleotides are going to build on each other. Now when we put our nucleotide on this side, of another strand here, we have said these bases here are going to be ...er... sort of inward and so there, we are also going to get this base you said to carbon what to carbon one, isn't it? And so, that will be carbon one. Then of course you going to have the phosphate group at carbon five like that at carbon five [Tr. writes on the board] So that as we look at this strand here [Tr. points on diagram] we are also going to have five and er then we will have the three, **which is the three now this side, now and then we will have another what?**

Class: [mumbles inaudibly].

Tr.: Huh?

St.: Phosphate group on three [meaning on carbon 3]

Tr.: Yes. That's when we are going to have another phosphate group at three. So that at least the nucleotide is going to be built like that. Now, what I want you to focus on, in this coming together of this nucleotide and that nucleotide, [Tr. points on board] is that they are sort of anti-parallel, because this one is going in the 3-5 direction and this one is going into the 3-5 direction [Student raises his hand]

Tr.: Yes?

St.: This is confusing. You said both of them are 3-5, but one is 3-5 and that other one is 5-3?

Tr.: Which one is 5-3? This one is 3-5 and you want to say that one is 5-3? You want it vice versa so that this one is er 3-5? **Mmm, can you say that again?**

St.: This one is 3-5 and the other one 5-3.

Tr.: That's what I'm saying, isn't it?

Class [disagrees and choruses]: No!

Tr.: [emphatically indicating on the board diagram] **This one is 3-5 in that direction. OK? And this is er 5-3. OK, if you want, except in this case, I had shown different directions, isn't it? You say the same numbers and point at different directions or you can say the same numbers I mean different numbers. [Not at all clear to me]. So it can be 3-5 in that direction or it can be 5-3 and so it could be in that direction. OK? Yes. Now when we have such joining we say that these two poly-nucleotides are anti-parallel. Yes. I want you to have a look at two anti-parallel nucleotides. On what page is that? Yes?**

Sts. [chorus]: Page 414.

Tr.: In this, can you see how the three-five and the five-three direction going down on that one? Notice that we were saying the first strand and I mean the second strand and then also notice the base pairing there, Thiamine and adenine, adenine-thiamine, guanine and cytosine and so on. Now, you see that we have built up the er the DNA. We have got the DNA built up. The other important feature perhaps we need to emphasize is the fact that these two poly-nucleotides are complimentary. **Can we say they are identical?**

Class [choruses]: No!

Tr.: Why are they not identical?

St.: When two things are complimentary they are not identical.

Tr.: OK.

[Class laughs]

Tr.: Can we stop talking about complimentary, I have said that they are complimentary, then I said, are they identical? Then you said, " no". I wanted a reason, why they are not identical. I know I've told you they are complimentary, they are not identical. **But why do we say they are not identical, and they are complimentary? Huh?** [Silence]

Tr.: Why? [Silence] Come on! The answer is there! You are looking at them. **Ok, if they were identical what were they supposed to look like?** They were supposed to have the same bases, the same sugar, the same what? (No pause) Phosphate groups. Then the two strands would be identical. If we had [Tr. indicates on board] Thiamine and Thiamine then Adenine and Adenine, so that at least whatever we have on this side is similar or identical to that side, then we would say the two strands are identical. But in this case they are complimentary. That means, at least if we look at this strand here [Tr. points to one strand] it sort of compliments, especially because of the base pairs there. **We have seen that at one time we have what?** Purine and in the other case we have Adenine. So we can't say this one has adenine and er I mean this one has got pyrimidine. This now has got purine and then we say they are identical. In that case, they are complimentary so that's the DNA.

10:25 A.M.

Tr.: Now I want us to put down all the features that we have talked about. In other words, if you were to look at all the characteristics of DNA, how does it look like? Rather not the structure of the DNA, if you can summarize what you have been looking at, what would we say? Lloyd?

Lloyd: The secondary structure of the DNA molecules.

TR.: What?

Lloyd: The secondary structure?

Tr.: Can you say something straight forward on the secondary structure?

[No response]

Tr.: We are talking about the structure. Suppose the DNA is in front of you like that and you want to describe the DNA, what would you say about it, so far? Huh? Yes?

St.: It has double-strands [Tr. writes "double strands" on the board]

Tr.: What else about the DNA? Yes?

St.: Helical structure.

Tr.: Yes. It is a helix [Tr. writes "helix" on the board] Yes? What else can you say about it?

St.: The strands are anti-parallel.

Tr.: Yes. The two strands here are anti-parallel, isn't it? [Tr. writes "anti-parallel" on the board] What else can we say? Anything else to add on this? Yes?

St.: The amount of Adenine is equal to the amount of Thymine.

Tr.: Yes. As we build, because always you'll see adenine is always pairing with thymine isn't it? So the amount of adenine is going to be the same as the amount of thymine, isn't it? [Tr. writes "the amount of Adenine is going to be the same as the amount of Thymine on the board] Yes?

Tr.: What else? So the same applies to Guanine and Cytosine, isn't it? Yes? Any other? We are still on the structure of the DNA?

St.: The thing that holds the strands together are hydrogen bonds.

Tr.: Yes. In other words, the two strands, double stranded, these are held by er ... hydrogen bonding. Yes, you are right. [Tr. writes "hydrogen bonding" on board]

Tr.: Now, so far, I have given you some strings er phosphates backbone and the smaller ones are going to be the bases. I want you to make an illustration [Tr. meaning 'model'] of the DNA. I am going to give you <u>two minutes</u> to do that. Do that in front of you

[Siren rings]

10:30 A.M.

[Class works with the strings and a little confusion is apparent]

> Tr. [interrupts]: Come on, I want you to devise a better way of illustrating the DNA with what I have given you.

[Class continues with the task in pairs. Teacher and researcher continue to move from pair to pair. Researcher brings to the attention of the teacher the mistake in the way the models were coming out. Tr. stops the class].

10:35 A.M.

Tr.: Okay,I can see a few mistakes in some of your models. Now lets reason out and I want you to look at your model and improve it. [Tr. picks the two longer strings] Obviously, these are two long strands, isn't it? Now when we say one complete turn, we are looking at, perhaps, as your strands will wind or coil from here and back again. That's one complete turn, isn't it? Now when we put our base pairs we have said the bases are going to be inward and the phosphate groups which we have said are the backbones here are sort of outward. Then I have given you the short strands. The shorter er those are the bases. So you should actually put one like that and another like that, isn't it? [Tr. demonstrates with 1 shorter and 1 longer strand] To show that here we must have two bases that are projecting from the outside strand like that. Now, if the information is that 10 nucleotides are going to er are found in one complete turn, is that possible with your strand and your smaller strands to put at least 10? So we have said this is one complete turn. Now if we also look at the measurement here, remember when we are talking about DNA, we are talking about a very minute thing (inaudible) We can't even see it clearly with our light microscope. Someone said that if you were to er open a cell, look at the nucleus, take out all the DNA, stretch them one after the other, you would have something that is at least two meters long. So, all the DNA that are in the nucleus of a human cell, if they were stretched, one after the other would gives us a total length of two meters. Remember that these are very small. So one complete turn will at least, will give us, is about er 34 er Angstroms. I think when you came first week, we were talking about measurements for very small objects, and we discussed these Angstroms. [Tr. writes "34 Angstroms" on the board] And if we look at the width of this er ... lets use that diagram on page 417 showing the measurements to appreciate how big or how small what we are trying to build up is like. That one, the width is about 20 Angstroms, isn't it? Yes, and 34, I mean if 10 nucleotides give us 34 Angstroms, that means **one nucleotide is about what? 3.4 Angstroms. I want you to count and make sure there, that, if you've have got 10 nucleotides, is that true? According to this er diagram there? For a complete turn, do you have 10? 10 of them?**

Sts. [Chorus]: Yes.

Tr.: So let's go back again here to this one here, er to the structure of DNA,to what we have said. We have said the DNA is double stranded [Tr. writes "double-stranded" on board] and the bases of the strands are going to be held by hydrogen bonding. Now here I think we must also further explain how these strands are going to be situated. We must explain that the phosphate groups are to be outward, to project outward, isn't it? And then the bases project inward and hence bonding with other bases from another string. [Tr. writes "bases project inward" on the board] and as they project outward realize that they form the backbone. That's why I gave you two strands, two long strands. Those were actually standing for the backbone. It is interesting to find that the phosphate groups last time, we said these are ionized, isn't it? If they are ionized, and then they are projecting outward, that means er they are likely also to combine and also to make other bonds, isn't it? With other materials. **When we looked at the nucleus, I think we mentioned these. Did we say about any er particular kind of protein, that are going to sort of er cover or combine with these bonds or protect them or whatever? Yes? Do you remember what the proteins are?**

St.: The histones.

Tr.: Yes. Histones, isn't it? Histones, so they are able to do that especially because the phosphate groups are going to project outward and they are ready because they have got er they are ionic. They are ionized and hence they are able to also form some bonds with the histones and histones are proteins so we know that proteins can also have other ionized groups like that. Actually all what we are discussing er are the result of work, by two gentlemen, who have given us most of this information. The two gentlemen I am sure now at A-Level you have heard about them isn't it? **What are the names of these two men, who did a lot of work on the DNA and RNA?** [Silence]

Tr.: Yes?

St.: Watson and Crick.

Tr.: Yes, Watson and Crick.

10:40 A.M.

Tr.: Now if we can summarize their work. Therefore, their work on the DNA. They [Tr. writes "Watson and Crick's work" on the board] Actually, they established the base pairing. They found out that it was true that it was actually true. Actually, these men, after hydrolyzing or say breaking down these nucleotides and then building them up, they came up with a model of DNA and in that model we have all that information. For instance, that the base pairing of A-T, G-C was correct and also demonstrated it on their DNA. They also found that DNA is a right-handed double helix, like we have discussed. So, in their model, they actually demonstrated or showed that it is helical i.e., winding the spiral shape and we say double that is the two strands are going to wind together like that [Tr. points to diagram of the helix on the board] and then they also demonstrated that the base pairs we also bonding because of the hydrogen bonds. We discussed the hydrogen bonding when we were looking at protein. They also showed the anti-parallel nature of the two strands which we have already shown there [Tr. indicates on board]. So, you can see that they supplied the information and then put all the information to work i.e., they demonstrated it on the DNA model. Well, I will give you an assignment to go and find a bit about their lives. They are very important. As you see they did great work. You need to know about them and how they worked and so on. But anyway we would also like to look at how the DNA is going to replicate. **How do we have more DNA from one DNA?** [Pause] [No response] Remember we said that DNA is important because it carries hereditary information isn't it? If it carries hereditary information, this information must be preserved. It must not at least be changed. Otherwise, like we saw in Acetabularia, isn't it? It must have that information so that future generations of the Acetabularia mediterranean will always have this information. So this must be handed from one DNA to the other, without changes. Changes would also perhaps er drastic changes would also perhaps alter the genetic material and hence the next generations would not also look exactly like the previous ones. So we would like to see how the DNA, therefore, would end up with other DNA of its type, of its primary and secondary structure. Well what happens is:

10:45 A.M.

DNA REPLICATION

Tr.: What happens is er if we look at one DNA as double stranded as it is [Tr. illustrates on the board] the DNA is going to unwind or it is going to uncoil. So, if it uncoils, in this case, we'll show just a part which will uncoil. So it will be like that, isn't it? It has uncoiled. This part has uncoiled. Now, when it uncoils like that, then we are also going to have here certain nucleotides, first nucleosides, perhaps, which are around in the nucleus. Remember in the nucleus, we'll have lots of this materials, lots of deoxyribose sugars, and lots of bases. They are just scattered as units, not coming together as such. So these are going to join and form nucleosides and nucleotides. So after, then, we can start seeing them joining together forming nucleoside. The way they form nucleoside is by sort of copying this information [Tr. points on DNA diagram on the board] But remember, as they copy, they are not going to have identical, they are not going to build identical strands. But they are going to build complementary strands as well. So you actually see the nucleosides then the nucleotides coming together then forming di-nucleotides and then poly-nucleotides and these are copying this one which has unwound. And so after a time, you can actually see a strand forming like and later a helix form, will also take place like that. The same is also taking place, here and there. The same is taking place and so as it continues unwinding. **What do we have now?** [No pause] You'll have obviously four strands. [Tr. indicates the four strands on the board] But of the four strands, let's notice an important thing, we will have two old strands and two new strands. We will call them daughter strands and the old strands we will call them parent strands. You have got these diagrams in your books on page er ...

St.: Page 419.

Tr.: I want you to look carefully at a DNA, at two DNA strands, which have unwound, on which some nucleotides are going to form. [Class studies the diagram] and then, on the next diagram, you can see fully what is going to take place. Now this method of forming of other new strands, we call it the semi-conservative method [Tr. writes term "semi-conservative method" on the board] Where the old strand will give rise to two daughter strands like that, and in the end, we are going to have two new DNAs, as you can see, and each is going to have a parent strand and a daughter strand. So you can see from ... er ... DNA ...

10:48 A.M.

SIDE B

Tr.: ... So now, if you look at the molecular mass of the first generation, you find that it is sort of er average, isn't it? And then if you look at the second generation and the third, it is clear now what is happening. In other words, the semi-conservative method is actually well illustrated in that experiment, and through those diagrams, which have been illustrated there.

Class [studies the diagrams as teacher moves about] Do you see that? [Silence] So, that's how the DNA actually is going to replicate. There are of course other er methods. But anyway we are not going into their detail. We will study this one, the semi-conservative method. After that, we are only left with only a few items for today. We want to roughly go through the RNA.

10:50 A.M.

RNA

Tr.: RNA is quite simpler that DNA. [Student interrupts]

Tr.: Yes?

St.: Why is it that on the new DNA there in no Cytosine and Guanine?

Tr.: Can you tell us the page and the diagram you are looking at?

St.: Page 419 [Researcher asks the student to repeat his question]

St.: Why is it that on the new DNA there isn't Cytosine and Guanine. There's only adenine and thymine?

Tr.: He is looking at page 419 and he is saying on the new one we do not have what?

St.: Cytosine.

Tr.: Cytosine and what?

St.: Guanine.

Tr.: Yes. Perhaps we have to look at this. [Tr. goes to the board] Suppose you are looking at a nucleotide in the old DNA like this. After unwinding, it will look like this isn't it? We said as the new nucleotide is going to be er as new nucleotides are formed, they are going to form complementary nucleotides. So these nucleotides will be complementary to this one [Tr. indicates them on the board] So that, if this one, for instance, if this base was Adenine what shall be this one?

Sts. [Chorus]: Thiamine.

Tr.: Thiamine, isn't it? So the nucleotide we are going to form here should have Thiamine there. [Tr. indicates on the board] So, the nucleotides are actually coming together and building up. But there are copying their bases [Tr. points on the board diagram] But they are not going to make them identical. In they are copying, this one is going to be complementary to that one. Is that so? [No pause] So, in other words, the sequence. If we can look at the sequence which we had on page 419, can you look at the old one below, the old one was below. It was TTAG, from the end, **are we together? Are we following?**

Class [Chorus]: Yes.

Tr.: TTAG. So the new one, what is it going to be? AAT and so on.

Class [Chorus]: C [TR. interrupts]

Tr.: So, in other words, in each time, the bases here are going to be complementary to the next ones, which are going to be built. That's why we say now that the nucleotide so formed is going to be complementary to this one, because if we had purine then pyrimidine bases are going to be built up and the bonding and so on. Thank you for the question. Any other question? [No pause] I didn't say we are going away from the DNA at all. We just want to look at the RNA and then we come to compare the two. Yes. **Any other questions so far?** RNA is so simple and straight forward isn't it? DNA is a bit more complex. RNA is single stranded [Tr. writes "single-stranded" on board] So, here we are looking at a single strand, at a poly-nucleotide, isn't it? We are not looking at two strands as such. RNA, already I'm sure, **when we were studying nucleotides, we mentioned 2-3 things about RNA, do you remember? Themba? Do you recall what we said in the making up of nucleotides?**

Themba: We said the Cytosine is replaced by Uracil.

Tr.: Is it cytosine really?

St.: Thiamine.

Tr.: Yes. Instead of Thiamine the RNA is going to have all its bases as Uracil whenever we have T in DNA, in RNA we will have U. So its base is Uracil instead of Thiamine [Tr. writes "Uracil" on the board]

10:55 A.M.

Tr.: And still there's something else which we said concerning the sugar, do you remember? Yes?

St.: DNA contains deoxyribose and RNA contains ribose sugar.

Tr.: Perhaps you should have also mentioned it here, [Tr. goes back to the board] that all the sugars for this one are deoxyribose [Tr. writes "deoxyribose" on the board] and for this we have got what? Ribose Sugar. So the sugar which is going to be used here is a ribose sugar. So RNA has got a ribose sugar. That's why we say that it is a ribonucleic acid and that's why there we say deoxyribonucleic acid, isn't it? Yes. So, basically, those are the three important aspects of the RNA. But, anyway, now let's have a comprehensive perhaps [Tr. goes back to the board] Perhaps I left two more. We have single- stranded, Uracil, Ribose, we also noticed that here we have got 3 main types of RNA. **We have what we call tRNA and have the mRNA and, finally, we have what?**

Class [Chorus]: Ribosomal RNA.

Tr.: The ribosomal RNA. Yes. So we have 3 types there. Whereas, in the DNA we don't have these. Now names like er if you also notice the RNA is actually transcribed from the DNA. **The DNA is actually going to have what? [Silence] How is it going to form some more? By? [Silence] Huh? How do we get more DNA from the original? By?**

Class [Chorus]: Replication.

Tr.: Yes, by replication. So these DNA are formed here by replication, but RNA here are formed by transcription. But anyway in your exercise book, if you can have a page, and lets compare the RNA and the DNA. **If you can compare at this stage, the RNA and the DNA? Yes?** [Tr. erases the board] **Who can give us the first comparison? Walter?**

Walter: DNA has deoxyribose and RNA has ribose sugar.

Tr.; Yes. The pentose sugar in DNA is deoxyribose and the pentose sugar in RNA is ribose. Yes? Anyone the second point? Another comparison? Yes?

St.: The ratio in bases of RNA is not 1:1 as for DNA.

Tr.: Yes. Now perhaps that is a more complex comparison. Can we come to the easier ones and then when we have built them up because we can't talk of the ratio before even talking about a more complex one. **We'll come to it but lets start with simpler things, on which we are going to build that one. Yes?**

St.: RNA is single-stranded and DNA is double-stranded.

Tr.: Yes, RNA is single-stranded and DNA is double-stranded. Now, if RNA is single-stranded, therefore it means it has its primary structure isn't it? That sequence and the number of nucleotides. **Does it have its secondary, tertiary and so on?** [Silence] Anyway to be precise, it must have, because you'll find that single strand, if it is tRNA, it will actually make a certain shape so as to carry out its function. I think in your books you can look just quickly, I want you to appreciate what I'm saying, on page 426, quickly.

[Class opens the page and study the diagram]

Tr.: That's tRNA. It has that shape, can you see the shape? It has its primary structure and the secondary structure will, therefore, be the way this is going to fold forming loops, codons, and anti-codons and so on. So you see, but basically, as we are saying, the RNA here has its primary structure and especially the secondary structure does not have much to do with the helix, double strands and so on. Their primary structures are, therefore, different. Isn't it? Yes. So, the emphasis is [Tr. writes "RNA is single- stranded" on the board] Yes? Any other important points? [Silence]

Tr.: There is much to compare.

St.: DNA has Thiamine and RNA has Uracil.

Tr.: Yes. What is Thiamine and Uracil? They are..?

St.: Bases.

Tr.: **What kind of bases?**

St.: Pyrimidines.

Tr.: Yes. They are pyrimidines. So you start all by saying: **for pyrimidine bases in DNA it is Thiamine and the pyrimidine base in RNA is Uracil.** That's right. **Any other comparison?** [Silence] One day I know, I'll give you this question, the problem is, usually, there will be, say 6 points, and if you are supposed to write an essay, on the differences between DNA and RNA, some people have the tendency to list down the skeletal matter without going into detail. That's why you see I'm emphasizing. You find that one point can be discussed isn't it? On Uracil and Thiamine, instead of just mentioning, you actually said these pyrimidine bases and so in these pyrimidine bases in RNA you have got uracil in DNA you have got what Thiamine. **Yes? Another point? If we can make progress, how many points have we written down so far?**

Class [Chorus]: Three.

Tr.: Three? Then we can also talk of how they are going to be formed or to multiply. DNA? **What is the process called?**

Sts. [Chorus]: Replication.

Tr.: Replication, isn't it? **More DNA can be formed from 1 DNA by replication and yet from RNA, what can you say about RNA? Sam? [Silence] Huh? Max?**

Max: Transcription.

Tr.: Yes, transcription. **How is this transcribed?** These will be the next item [Tr. writes "transcription of RNA" on the board] When RNA is transcribed, it is actually copied from the DNA. In other words, the DNA serves as a template just like here. We said that the old, the parent, this old DNA, were templates for the daughter DNA. So in the making up of the RNA, [Siren goes] we are also going to see that RNA actually can only be formed by copying a certain part of the RNA.So that particular part that has information on a particular RNA [Meaning DNA] will unwind or uncoil and then nucleosides, nucleotides will also start building and that is transcription, because, in this case, we are only copying a certain part to make RNA [meaning DNA]. So, basically, those are the differences between RNA [and DNA] But you have got the handouts to read more and find out er <u>for your homework, finish up. Read it again and you can make notes up to where we are</u>. The day after tomorrow, obviously, you will have a test on nucleic acids.

Class [chuckles]

Tr.: **Any problem with that?** Today we are supposed to have er that practical on enzymes? But the enzymes which you are supposed to use are not available. We are looking for them. They are likely to arrive tomorrow morning. So, **can we have a practical, the practical tomorrow afternoon? Yes?** [Silence] So, tomorrow afternoon we will have our practical. Anyone who needs a handout? [No response and the students are leaving the room. She did not really dismiss them]

11:08 A.M END LESSON.

APPENDIX #18

AN A-LEVEL BIOLOGY WORKSHOP PROGRAM

MINISTRY OF EDUCATION AND CULTURE
MASHONALAND EAST REGION PROGRAMME FOR A-LEVEL SCIENCE WORKSHOP
9 - 10 JUNE, 1992.

Day & Time	Topic/Activity	**Chairperson**
Day 1		
0745	Welcome, Programme's review and Announcement.	
0800	Syllabus interpretation School syllabus (subject officer).	A. Chivere
0845	OFFICIAL OPENING	A. Chivere
0900	Selection and teaching options (subject teachers)	Teacher
1030	TEA	
1100	Teaching strategies - Theory work, Practical work, Assignments and Group	Subject Officer
1200	Comparative analysis and effectiveness of Resource materials (Display of textbooks. Comments user schools)	A. Chivere
1300	LUNCH	
1400	Tour of school laboratories. Discussion of observations. (Teacher in charge of the lab). [We went to Murehwa High School]	

DAY 2 0745	Announcements and review of programme.	
0800	Administration of Practical examinations (advance instructions, ordering of materials, preparation and setting up of practical, test run, supervision and invigilation). (Exam. Branch & Subject Officer)	M. Ndowora
00930	Areas requiring improvisation. (Teacher and demonstrations)	Teacher
1030	TEA	
1100	Teaching approaches to selected difficult topics (Teachers) Officer	Subject
1230	Evaluation and payment of travel costs	
1300	Lunch and Departure	

APPENDIX #19

PRE- AND POST- TEST ON DNA, RNA AND PROTEIN SYNTHESIS

1. Which of the following is correct

	Present in DNA	Present in RNA
A.	uracil	thymine
B.	deoxyribose	ribose
C.	single strand	double strand
D.	4 different nucleotides	5 different nucleotides

2. One of the nucleotides present in mRNA has the composition
   - A. adenine - ribose - phosphate
   - B. uracil - deoxyribose - phosphate
   - C. thymine - ribose - phosphate
   - D. guanine - deoxyribose - phosphate

3. In which of the following pairs, are BOTH strands of nucleic acid complementary to strand **X**
   - A. 1 and 3
   - B. 2 and 4
   - C. 1 and 2
   - D. 3 and 4

Strand **X**	1	2	3	4
A	A	T	A	U
C	C	G	C	G
A	A	T	A	U
G	C	C	G	C
T	T	A	U	A

4. A mRNA is
   - A. translated from protein
   - B. transcribed into protein
   - C. translated into DNA
   - D. transcribed from DNA

5. The approximate number of different amino acids that have been found in proteins is:
   A. 3 B. 4 C. 20 D. 64

6. A free transfer RNA molecule can combine with
   - A. one specific amino acid only
   - B. any available amino acid
   - C. three different amino acids
   - D. a chain of amino acids

7. The number of bases present in one codon is:
   A. 1   B. 2   C. 3   D. 4

8. Protein synthesis occurs in ribosomes attached to the
   A. cell membrane
   B. Golgi body
   C. nucleolus
   D. endoplasmic reticulum

Items 9, 10 and 11 refer to the same answers numbered in the list
   1. DNA molecule   2. tRNA molecule   3. mRNA molecule
   4. amino acids   5. ribosome

9. Which of these must be present in the largest number for the successful synthesis of a single protein molecule to occur
   A. 1   B. 3   C. 4   D. 5

10. Which of these controls the order in which amino acids are added to a growing protein molecule?
   A. 2   B. 3   C. 4   D. 5

11. On which of these are anticodons present?
   A. 2   B. 3   C. 4   D. 5

12. If each amino acid weighs 100 mass units, what is the weight in mass units of the protein molecule synthesized from a mRNA molecule which is 600 bases long?
   A. 2000   B. 6000   C. 20,000   D. 60,000

13. The accompanying table shows three different mRNa molecules (each containing a base sequence) and the three different protein molecules synthesized from them.

mRNA	Repeating sequence	Protein
A G A G A G A G	A G A G	**X**
C A U C A U C A U	C A U	**Y**
A A U G A A U G A A U G	A A U G	**Z**

Which of the following shows the correct number of different types of amino acid in each protein molecule?

	X	Y	Z
A.	2	1	4
B.	1	3	4
C.	2	1	3
D.	3	1	4

14. The accompanying sets of results shows an analysis of the DNA bases contained in the cells of a cow's thymus.

Which of the following is a possible correct identification of the bases?

Base composition

	X	Y	Z
A.	cytosine	adenine	thymine
B.	thymine	adenine	cytosine
C.	adenine	cytosine	thymine
D.	cytosine	thymine	adenine

15. DNA molecules isolated from a rat cell and a human cell are found to differ in order of their

A. bases only B. sugars only C. phosphates only
D. bases, sugars and phosphates

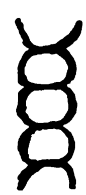
16. Successful replication of chromosomes does <u>NOT</u> require the presence of

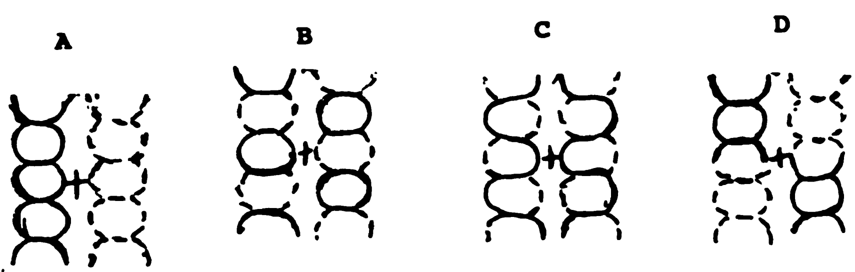
A. ribosomes B. a DNA template C. nuclear enzymes
D. adenosine triphosphate

17. During DNA replication the following events occur
1. winding brings about the formation of two double helices
2. bases of free nucleotides bond with bases on the DNA strand
3. hydrogen bonds bread allowing DNA strands to unzip
4. bonds between adjacent nucleotide molecules form

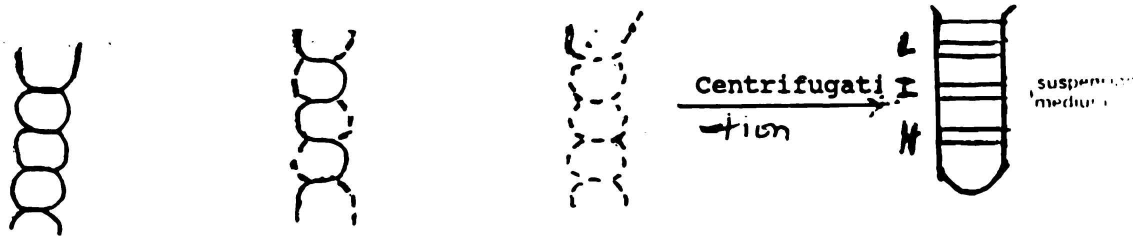
The correct order in which these occur is:
A. 1,3,2,4
B. 3,2,4,1
C. 1,2,3,4
D. 3,4,2,1

18. If ____________ = an original DNA strand and ----------- = a new DNA strand, which of the following daughter DNA molecules will result from replication of DNA molecule **X** shown opposite



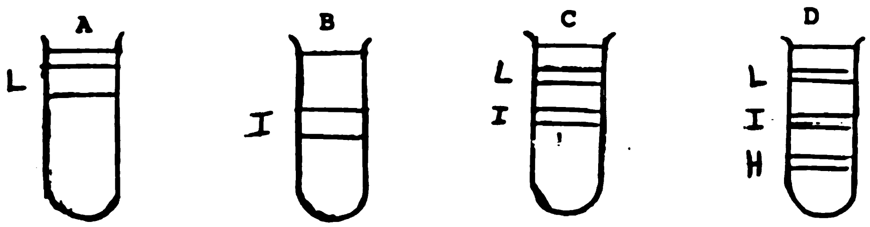


Items 19 and 20 refer to the following information: The diagram below shows three types of DNA molecule ________ represents a single DNA strand labelled with 15N (a heavy isotope of nitrogen) and -------- represents a dingle DNA strand labelled with 14N (normal nitrogen). A mixture of these can be separated as follows:



Heavy DNA (H) | Intermediate DNA (I) | Light DNA (L)

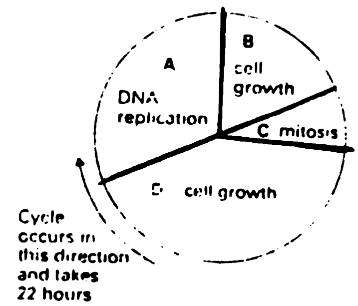
19. If bacteria grown for many generations in 15N are transferred to 14N medium for one generation which of the following will result an extracting and centrifuging their DNA?



20. When a molecule of heavy DNA is replicated for two successive generations in (14)N medium, the DNA molecule formed will be

	heavy DNA	intermediate DNA	light DNA
A.	0	100%	0
B.	50%	0	50%
C.	0	50%	50%
D.	50%	50%	0

21. The diagram below shows the stages that occur in an actively dividing mammalian cell. If the drug aminopterin (which inhibits thymine formation) is added to a culture of actively dividing cells, at which stage in the cell cycle will most cells be present 16 hours after addition of the drug?



ITEMS ADDED ON THE POST-TEST

22. What is a protein a polymer of?

23. What do these processes mean to you?
    a. replication b. transcription c. translation

APPENDIX #20

TABLE 16: AN ANALYSIS OF STUDENTS' ITEM #7 RESPONSES

CONTENT		DIAGRAMS			EXPLANATIONS		
Confuse	**List terms**	**Meani-ngless**	**Rough Sketch**	**Clear**	**Short & not full**	**Full**	**Total Respon-ses**
CSQ #s 8	4*, 8*, 9,10 & 16	1, 6, & 7*.	15, 20 & 22	0	5,9*,11, 17,18,13, 14.	0	17 L6
BSQ #s 4, 14	11 & 18	0	0	0	1,2*,3,10 ,12,17,19 20,6 & 7*	0	14 U6
GSQ #s 0	8 & 15	15	0	0	1,6,7,13 15* & 16	0	9 L6
DSQ #s0	5	0	0	0	1,2*,4, & 7	0	5 L6
MSQ #s	10	3,4,5, 12*, & 17	6,8,9, 11 & 16	0	3*,4,7,8, 11,12*,13 & 17	0	13 L6
MiSQ #s 26, 28 & 31	0	1,3,4, 7,8,10, 24,26, & 28*	16, 23 & 25	21*	2*,3,4,5, 6,7,8,10, 14*,13* 15,11,22, 23,24,25, 27*,28 & 29	21* & 30*	26 U6
NSQ #s 0	0	1 & 4	8*	0	1,2,4 & 8	0	4 U6
PSQ # 0	0	1,4 & 7	0	0	1,2,3,7 9,4,5 6 & 10	0	9 U6

VSQ # 1,2,3,6,7 8 & 9	0	0	0	0	VSQ # 5,10 & 12	0	10 U6

APPENDIX #21

ANALYSIS OF PRE-AND POST-TEST SCORES OF TWO CLASSES

TABLE 17.1: PRE-AND POST-TEST SCORES.
KEY: K = correct, R = wrong, & N = left blank.

Item #	Tr.	PRE-TEST			POST-TEST		
		K	R	N	K	R	N
1	C1	19	1	0	20	0	0
	M1	15	2	0	18	0	0
2	C2	15	5	0	17	3	0
	M2	13	4	1	15	3	0
3	C3	13	7	0	15	5	0
	M3	17	1	0	17	1	0
4	C4	14	6	0	19	1	0
	M4	16	2	0	14	4	0
5	C5	16	4	0	17	3	0
	M5	17	0	1	17	1	0
6	C6	4	16	0	16	4	0
	M6	14	4	0	15	3	0
7	C7	4	16	0	16	4	0
	M7	4	14	0	16	2	0
8	C8	14	6	0	14	6	0
	M8	17	0	1	16	2	0
9	C9	4	16	0	7	13	0
	M9	4	14	0	9	9	0
10	C10	13	7	0	7	13	0
	M10	3	15	0	5	13	0
11	C11	6	14	0	15	5	0
	M11	8	10	0	13	5	0
12	C12	2	18	0	9	11	0
	M12	0	18	0	3	15	0
13	C13	5	15	0	7	13	0
	M13	2	16	0	3	15	0
14	C14	0	0	20	8	12	0
	M14	0	0	18	8	10	0
15	C15	0	0	20	15	5	0
	M15	0	0	18	11	7	0
16	C16	0	0	20	13	7	0
	M16	0	0	18	16	2	0
17	C17	0	0	20	13	7	0
	M17	0	0	18	11	7	0
18	C18	0	0	20	12	8	0
	M18	0	0	18	14	4	0
19	C19	0	0	20	6	14	0
	M19	0	0	18	5	13	0
20	C20	0	0	20	12	8	0
	M20	0	0	18	6	12	0
21	C21	0	0	20	4	16	0
	M21	0	0	18	4	14	0

1. **PRE-TEST SCORES:**

(a) For Mr. C-'s class N=18 (two absent),
Total = 129, Average = 129/18 6.45

(b) For Mrs. M-'s class N=18,
Total = 128, Average = 128/18 = 7.11

2. POST-TEST SCORES:

(c) For Mr. C-'S Class N=20,
Total = 262, Average = 262/20 = 13.1

(d) For Mrs. M-'s Class N=18,
Total = 234, Average = 234/18 = 13.

DISCUSSION: ANALYSIS OF STUDENTS' PERFORMANCES ON THE TEST ITEMS

1. On both the pre-test and the post-tests, a majority of the students in both the classes knew about the structures and the differences between DNA and RNA and the synthesis of mRNA by transcription, since they all got Items #s1-5, and that proteins are synthesized in the ribosomes (Item #8).

2. A majority of Mrs,M-'s students got Item #6 on both the pre- and post-test. Whereas more than half of Mr. C-'s students did not know the specificity of tRNA for a particular amino acid, on the pre-test but they got it on the post-test.

3. On Item #s7 and 11, on the pre-test, more than half of the students in each class did not know about the "codon" and "anticodon" in relation to the bases ,mRNA and tRNA. But on the post-test, the responses indicated a better conceptual grasp of these concepts.

4. On Item #9, a majority of the students failed, on both the pre- and the post-tests, to indicate that amino acids occur in the largest numbers for successful synthesis of a single protein molecule to occur, compared with DNA, tRNA, mRNA, or ribosomes. This may not have been necessarily because the students did not know the relative roles of these molecules, but that an analytic skill more than a recall or a knowledge reproduction skill was being tested for here, which the students may have failed to demonstrate.

5. The responses on Item #10, about mRNA determining the order in which amino acids are added to a growing protein molecule, got reversed with a majority of the students getting it correctly on the pre-test and a majority getting it wrong on the post-test. This may be due to the students having guessed on the pre-test and definitely not knowing on the post -test. This phenomenon of guessing correctly and then getting it wrong the second time around was also observed on other items in both classes (See Table 16.2):

TABLE 17.2: GUESSED ITEMS' FREQUENCIES.

IN MR. C-'S CLASS:

Item #	2	3	5	8	9	10	11	12	13
Frequency	2	3	1	1	3	9	3	2	1

IN MRS. M-'S CLASS:

Item #	2	4	5	6	8	9	19	11
Frequency	2	3	1	1	1	4	3	1

There were more incidences of students guessing with Mr.C-'s students (Total frequency = 25), compared with Mrs. M-'s students (Total frequency = 16). May be this is related to the manner in which she had revised over and over, with her class, the structures of DNA and RNA molecules.

That the students had not understood a specific concept or principle or process was indicated by the students getting the same item incorrectly on both the pre- and post- tests (See Table 16.3).

TABLE 17.3: ITEMS MISSED ON BOTH PRE- AND POST-TESTS

IN MR. C-'S CLASS:

Item	3	4	5	6	7	8	9	10	11	12
Frequency	2	1	2	4	4	4	10	3	1	9

Item	13	14	15	16	17	18	19	20	21
Frequency	12	12	5	7	7	8	14	8	16

IN MRS. M-'S CLASS:

Item	3	6	7	9	10	11	12	13
Frequency	1	1	2	5	10	4	15	15

Item	14	15	16	17	18	19	20	21
Frequency	10	7	2	7	4	13	12	14

6. There was an increase from less to more than half of the students, who gave the correct responses in both the classes on the pre- and post-test, on Item #9, concerning the presence of anticodons on tRNA.

7. Item #12 required application of the students' understanding of a codon, specifying for any particular amino acid, being a triplet of bases, in order for them to calculate the weight of a protein molecule, which is 600 bases long, having been given the weight of each amino acid. This item was missed by a majority of the students in both of the classes, on both the pre- and the post-test. However, on the post-test, more of Mr. C-'s students (45%) could solve the problem than of Mrs. M- (33.3%).

8. A majority of the students in both classes failed to figure out the different types of amino acids in each protein molecule, given the repeating sequence of bases in the mRNA. This item required the students to apply their knowledge of a codon being a triplet of bases in the mRNA for a specific amino acid.

9. Item #s 14-21 were left blank on the pre-test by all the students in both the classes, that is,

(a) On Item #14, the students did not know that there are equal amounts of the complementary bases in DNA.

(b) On Item #15, the students failed to use the fact that rat and human cells are different proteins with different amino acid sequences, which were synthesized from a different sequence of codons on their DNA.

(c) On Item #16, the students failed to eliminate what was <u>not</u> required for the successful replication of chromosomes among the structures and chemical given.

(d) On Item #17, the students did not know the proper sequence of events that take place during DNA replication.

(e) On Item #18, the students did not know how the parent strands of DNA serve as templates, which determine the formation of the daughter strands.

(f) On Item #s19 and 20, the students did not know the semi-conservative method of DNA replication, as proved by the cultures grown in heavy and normal nitrogen medium, to enable them to figure out the relative ratios of the heavy, intermediate, and the light DNA molecule in these cultures after progressive generations in the light medium of nitrogen fourteen,

10. On Item #21, the students failed to determine, at which stage of the cell cycle, will most cells be present, when aminopterin, which inhibits the synthesis of thymine, has been added to a medium in which there are actively dividing cells.

11. However, on the post-test, after both classes had been instructed on the content, which was assessed on the pre-test, it appears that there was an increase in the number of students, in both classes, who had understood the concepts, particularly, in the Item #s 1-8, 11, 15-18, and for students in Mr.C-'s class, Item #s 12 and 20.

12. But there were also indications of some students who still had not understood thoroughly the finer details of these processes nor could they apply the concepts, the principles, and the analytic skills, in order to solve the unfamiliar problems. Such students represented more than half of the students in each class. They missed on Item #s 9, 10, 12, 13, 14, 19 and 21, on both the pre- and the post- test. These questions focussed on aspects of protein synthesis and the application of its concepts and principles. These include, the triplet bases making up a colon; the specificity of colons for particular amino acids; complimentarily of the bases and therefore are in equal amounts; and the semi-conservative replication process as illustrated by culturing of DNA in heavy and normal nitrogen containing media.

13. None of the students tackled the additional Item #s 22 and 23, which were included in the post-test.

14. The one-sided t-tests for both classes showed a significant difference between their pre- and the post-test scores. That is, instruction made a difference in both classes. However, a two-sided t-test of comparing between the two classes' pre-tests and their post-tests indicated that one cannot say that the two sets of means were significantly different. A larger variability and a larger difference between its pre- and post-test was seen in Mr. C-'s class than in Mrs. M-'s class which had a smaller variability and smaller mean differences. It appears as if Mr. C- has effected a larger change in his students than did Mrs. M-.

APPENDIX #22.1

TABLE 18: 1991 & 1992 BIOLOGY FINAL EXAM. RESULTS

TR/YR	A	B	C	D	E	O	F	TOTAL	%PASS	%FAIL
B/91	0	1	4	2	2	8	3	20	45.0	55.0
B/92	2	5	7	5	2	2	2	23	91.4	8.60
C/91	0	0	0	1	6	17	5	29	24.1	22.0
C/92	0	1	1	5	6	9	5	27	81.4	18.6
D/91	0	0	0	1	2	8	0	11	27.3	72.7
D/92	0	0	0	2	2	5	0	9	44.4	55.6
Mi/91	0	1	1	6	13	10	1	32	65.6	34.4
Mi/92	0	2	4	6	11	12	2	37	62.2	37.8
P/91	1	1	4	4	6	2	1	19	84.0	16.0
P/92	0	0	4	4	7	7	1	23	65.0	35.0
V/91	0	2	3	5	1	2	0	13	84.0	16.0
V/92	1	1	2	5	2	1	0	12	91.7	8.8
M/91		NOT SUBMITTED*							34.4	65.6
M/92	0	0	2	0	5	16	4	27	25.9	74.1
NATIONAL SCORES:										
	29	**104**	**218**	**298**	**380**	**589**	**180**	**2827**	**72.8**	**27.2**

The Grade X column at the far right was left out.

APPENDIX #22.2

TABLE 19: ANALYSIS OF A-LEVEL FINAL RESULTS BY GENDER

TR/YR/SEX	A	B	C	D	E	O	F	TOTAL	%PASS	%FAIL
B/92	B	2	4	7	3	2	1	0	19	94.7 5.3
	G	0	1	0	2	0	1	0	4	75.0 25.0
TOTAL		2	5	7	5	2	2	0	23	91.3 8.7
V/92	B	1	1	2	3	2	0	0	9	100 0.0
	G	0	0	0	2	0	1	0	3	66.7 33.3
TOTAL		1	1	2	5	2	1	0	12	91.7 8.3
D/92	B	0	0	0	0	0	0	0	0	0.0 0.0
	G	0	0	0	2	2	5	0	9	44.4 55.6
TOTAL		0	0	0	2	2	5	0	9	44.4 55.6

TOTAL Bs (Boys) = 28 and Total Gs (Girls) = 16

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