THE POTENTIAL OF A PROFESSIONAL DEVELOPMENT SCENARIO FOR SUPPORTING BIOLOGY TEACHERS IN ERITREA

Andemariam Teclai Tecle

DOCTORAL COMMITTEE

Chairman:	Prof. dr. H.W.A.M. Coonen ▪ University of Twente
Promotor:	Prof. dr. J.J.H. van den Akker ▪ University of Twente
Assistant promotor:	Dr. W.J.W. Ottevanger ▪ Free University of Amsterdam
	Dr. J.M. Voogt ▪ University of Twente
Members:	Prof. dr. K.T. Boersma ▪ University of Utrecht
	Prof. dr. Tj. Plomp ▪ University of Twente
	Prof. dr. J.F.M. Letschert ▪ University of Twente
	Prof. dr. F. Osaki ▪ University of Dar es Salaam, Tanzania

CIP-GEGEVENS KONINKLIJKE BIBLIOTHEEK, DEN HAAG

Teclai Tecle, Andemariam.

The potential of a professional development scenario for supporting biology teachers in Eritrea.
Thesis University of Twente, Enschede – With refs.
ISBN 90-365-2293-5.

Layout: Sandra Schele
Printer: PrintPartners Ipskamp - Enschede

THE POTENTIAL OF A PROFESSIONAL DEVELOPMENT SCENARIO FOR SUPPORTING BIOLOGY TEACHERS IN ERITREA

PROEFSCHRIFT

ter verkrijging van
de graad van doctor aan de Universiteit Twente,
op gezag van de rector magnificus,
prof. dr. W.H.M. Zijm,
volgens besluit van het College voor Promoties
in het openbaar te verdedigen
op woensdag 22 februari 2006 om 13.15 uur

door

Andemariam Teclai Tecle

geboren op 20 november 1973

te Asmara, Eritrea

Promotor:	Prof. dr. J.J.H. van den Akker
Assistent promotor:	Dr. W.J.W. Ottevanger Dr. J.M. Voogt

Preface

The study would not have been possible with out the assistance, support and encouragement I received from many individuals and organizations in the course of the study. First I would really like to acknowledge the Faculty of Educational Science and Technology (now Behavioural sciences) for awarding me the TO fellowship to work on the PhD research at the department of curriculum (CRC), University of Twente (UT). Special thank goes to Jules Pieters, who was the Dean at the time and members of the TO fellowship selection committee that awarded me the opportunity to purse an ambitious research proposal.

Throughout the four years of the study many individuals from Eritrea and The Netherlands have provided me the assistance for getting through the different milestones of this PhD work. I would like to thank Petros Hailemariam, Abraham Tecle, Asmeret Habtemicael and Tedros Sium at the Ministry of Education of Eritrea for their contributions in the front-end analysis and a logistical assistance despite our complicated system of ''exit visa'.
My sincere gratitude goes to a number of teachers, students and schools that allowed me to conduct the research activities inside their classrooms. You gave me the alias 'the doctor' even before the UT 'rector magnificus' while shuttling between classrooms in your respective schools. Space would not allow me to acknowledge all of you, but a few I should mention by names for your contribution during the formative evaluations of exemplary materials and video-lessons: Samsom Asmelash, Kalib Abdenur, Nugusse Maakel, Yemane Habte, Biniam Tekie, Feven Afwerkie, and Simon Tsegai.

I am also thankful to my former colleagues at Asmara Teacher Training College. You made it productive and comfortable for me working there during my research activities in Eritrea. I always cherish your 'jokes' on my PhD research and about 'Holland' during the tea-time! Particularly I am indebted to the director, Mebrahtu Gilagaber for his humble and unwavering moral and logistical support during my stays. Mebrahtu, I am inspired with your recurring note on relevance of our educational research to Eritrean context; hopefully I did not fail you on that respect!

In the Netherlands many people need acknowledgement for their part on this PhD work. Kevin Mckenney for proof reading and editing the final draft of the book. My expert appraisal scientists: Mieke Kapteyn, René Almekinders, Nico Peek, Annette Thijs, and Joke Voogt. I am grateful to your feedback and insights for improving the curriculum materials and overall design of the professional development scenario. I consider myself privileged to have been supervised by Jan van den Akker, Wout Ottevanger, and Joke Voogt. I am graceful for your coaching and steering me throughout the research pitfalls as well as bringing out the good ideas out of me during my PhD trajectory. Beside, I would like to extend my gratitude to all the CRC members, especially Minke van der Put and Sandra Schele for the lay-out and logistical arrangements.

I am also greatly indebted to the International Office of the faculty of Behavioural sciences, Dionysia Loman, Frances Leusink and Jan Nelissen. Here, it's appropriate to mention the magnificent social and professional skills of Dionysia for dealing with visa, accommodations and other problems throughout my stays. Particularly, for the many letters that thickened my file and solving the complicated visa arrangements with IND. May I say to all of you a huge '*Dank u heel veel*'!
Thanks a lot to my PhD colleagues Ken Chavunduka, Frank Tilya and Fidelis Mafumiko. The academic and social discussions we had, have been so constructive and at times eye opening experiences. You have been supportive during the writing of the book and Mom's hospitalization. I would like also to thank my Eritrean friends: Tedros, Fetwi Yosief, and Henok your encouragements and support in one or another, while I am in the country and abroad. Moreover, my extended relative in The Netherlands and Germany thank you for your encouragement, and above all for making me concentrate on writing the book when Mom was in the hospital.

Last but not least, my heartfelt thanks go to my core and extended family. My mother, brothers and sister, thank you for taking care of the household in my absence and of curse pushing me to finish earlier, though that was not possible. My wife, Selamawit, who has been supportive throughout and made me concentrate on the study. Thank you very much for assuming the responsibility and taking care of our daughters when you all needed me most. To my lovely and gorgeous daughters, Saron and Elisabeth, it is your love that made me keep on the course against all the odds. I owe so much to you and it is you that I dedicate this book.
Finally I would take this opportunity to thank God for everything He did to me. To Him be all the glory and praise!

God bless you all,

Andemariam T. Tecle
Enschede, Winter 2005

Dedicated to my gorgeous daughters Saron & Elisabeth

Table of contents

LIST OF TABLES

LIST OF FIGURES

LIST OF BOXES

CHAPTER 1
Introducing the study

This chapter presents background information on the study "The potential of a professional development scenario for supporting biology teachers in Eritrea". Section 1.1 explains the origin of the study, while Section 1.2 describes the context of the study. It describes the history, geography, and population of Eritrea, and also presents a historical overview of Eritrean education. Section 1.3 includes the aim and research questions that steered the overall course of the study. Section 1.4 outlines the research approach adopted in the study, and the final section 1.5 provides an overview of the chapters in the dissertation.

1.1 ORIGIN OF THE STUDY

There is a general consensus that educational change is a difficult and complex process. More often than not, this difficulty comes from the number and dynamics of factors that could potentially affect the process of implementation (Fullan, 2001; Hargreaves, 2002). Literature on educational change clearly reports the lack of sustained impact on teaching practice at the classroom level and the pervasive challenges in keeping educational change going (van den Akker & Plomp, 1994; Datnow, 2002; Fullan, 2000; Hargreaves, 2002; Huberman & Miles, 1984; London, 1993; Verspoor, 1989). According to Fullan (2001), implementing educational change involves changing practices at all levels: the teacher, the school, the district, and the national level. Changes at the classroom level can entail teachers using new materials and new teaching approaches, and requires a shift in their beliefs in line with a proposed change. These aspects of potential change are considered necessary to achieve the ends and are indeed demanding since teachers have to work on so many fronts at once (Fullan 2001; Hargreaves, 2002). Within the complex context of educational change, curriculum materials together with other strategies can play important roles for supporting teachers at the initial stages of the implementation (van den Akker, 1988b, 1994; Ball & Cohen, 1996; Ottevanger, 2001). Curriculum materials that are tuned to educational change can communicate the reason for the intended change; they can convey the practical meaning of the

change through a few exemplary lessons on selected topics, as well as offer teachers the opportunity to experiment with the lessons and gain insight into what the change entails for their classroom practice and students.

In lieu of implementing educational change, the Department of Curriculum at the University of Twente's Faculty of Behavioural Sciences has been investigating the *design methodology and characteristics* of curriculum materials in a variety of domains. This line of research has been explored in a Dutch context by a number of people: van den Akker (1988a) in design and implementation of primary science education; Voogt (1993) and Keursten (1994) in the implementation of courseware in secondary science and social science respectively; and van den Berg (1996) and Roes (1997) in the integration of exemplary curriculum materials in in-service education. This line of investigation captured my interest doing my master's research project. I considered the development of quality curriculum materials as a point of intervention for improving the teaching practice of biology teachers in Eritrea where curriculum materials were often the only resources at their disposal. Given such a problem, I embarked on a master's research project to investigate the potential of exemplary curriculum materials with procedural specifications for supporting biology teachers (Tecle, 1999). One of the concluding recommendations of the master's study has been to conduct further research on the potential of embedding exemplary curriculum materials in an in-service scenario. At that time in Eritrea the preparatory phase of a new curriculum (i.e. Curriculum-2003) was underway (MOE, 1999), and it appeared plausible to use this innovation context for studying the potential of a professional development scenario for supporting biology teachers while implementing the change. In 2000, a proposal was made to the Department of Curriculum to pursue this line of investigation. The faculty of Behavioural Sciences funded the study through a fellowship.

1.2. CONTEXT OF THE STUDY

1.2.1 Eritrea: history, geography and population

After 30 years of war, the state of Eritrea obtained its *de facto* independence in 1991 and its official independence in May 1993. This occurred following a UN supervised referendum in which over 99% of the people voted in favor of independence. Eritrea had been an Italian colony between 1889 and 1941, a British Protectorate from 1941 to 1952, a federated state (with Ethiopia) from 1952 to 1960, and forcibly annexed to Ethiopia from 1960 to 1991.

Eritrea is situated on the Red Sea and is bordered by Sudan, Ethiopia, and Djibouti. Its geographical areas covers 121, 370 sq. kms. Estimates of Eritrea's current total population range from 3.2 to 3.9 million, of whom about 0.5 million live in the capital city of Asmara. It is estimated that some 80% of the population live in rural areas, practicing a range of agricultural and pastoral activities depending on the ecological zone. Population densities vary considerably, from high densities in the central highlands (up to 200 persons/km^2), where about half of Eritrea's population lives, to low densities (sometimes less than 10 persons/km^2) in the coastal plains and parts of the western lowlands. The total population literacy level is estimated to be 58.6%. The literacy level for males is 69.9% and 47.6% for females. (CIA world factbook, 2003).

Figure 1.1 Map of the state of Eritrea

1.2.2 Historical overview of Eritrean education

Prior to Western colonization, the origin of Eritrea's educational system can be traced back to religious institutions (MOE 2002). In the country's highlands, the church was responsible for handling education matters. Students were first taught the *Geez* alphabet and numbers, followed by (reading) the First Epistle of St. John, the Acts. The Muslim population pursued its education via the Koran and related Islamic literature. The development and trajectory of Western education in Eritrea are explored further below.

Colonial education

The development of Western education in Eritrea cannot be fully understood without recognizing the role successive colonial governments played in the direction of education. Historically, the Eritrean education system was shaped by a blend of influences from such colonial forces as Italy, Great Britain, and Ethiopia.

Eritrea's exposure to Western education started in the late 1880's with the arrival of Italians (Trevaskis, 1960). The Italians brought their curriculum and established the A-B-C of the Eritrean education system. The curriculum included subjects like Italian language, Italian history, basic arithmetic, and hygiene. By decree, the highest level of formal education that a (Eritrean) student could pursue was up to fourth grade. The Italian curriculum was not intended to develop the country, but to train some Eritreans for their colonial administration. The standard of teaching was low and its scope was intentionally narrow. This was evident from a confidential memorandum circulated by the Italian director of education, *Signore Festa* to the then Italian headmasters (Trevaskis, 1960, p. 33).

> *"... The Eritrean student should be able to speak our language moderately well; he should know the four arithmetical operations within normal limits; he should be a convinced propagandist of the principles of hygiene; and of history, he should know only the names of those who have made Italy great."*

In 1941, after the defeat of Italy in World War II, Eritrea was placed under British military administration for ten years. The British expanded the education system fairly. They recruited teachers from Sudan as an initial step, and later established a Teacher Training Institute in 1943, which trained teachers for elementary schools. By 1950, 59 primary schools and one middle school had been set up. English was taught to the graduating primary students and institutionalized as the language of instruction thereafter. According to Trevaskis (1960), by the time the British left Eritrea, there were 100 primary schools, 14 middle schools, and 2 secondary schools enrolling 16,867 students.

Eritrea was federated with Ethiopia in 1952 through a UN resolution. The federation period was marked by substantial access to education for many Eritreans, and the establishment of higher education institutions such as the University of Asmara and the Technical College of Eritrea. Unfortunately, due to political unrest, this promising future was curtailed when Ethiopia unilaterally annexed Eritrea into its territory in 1962. Ethiopia suspended the Eritrean curriculum and destroyed all textbooks and other relevant curricular documents, and from then on the Ethiopian and Eritrean education systems were basically run as one and the same. The imperial Ethiopian curriculum in the early 1960s and late 1970s was heavily influenced by both British and American curricula. It was driven by the need to develop a scientifically versed manpower and emphasized disciplinary knowledge. In regard to the classroom practices of the 1970s, Wilcox (1972) reported that teaching and learning in Ethiopia was heavily stereotyped

with fixed patterns of teacher lecturing, passive students, and a prevalence of rote learning in most science classrooms. After the ousting of the imperial government in 1975, there have been reforms in the education system based upon the Education Sector Review and partly based on the military regime's socialist ideology (MOE, 1981). The military government achieved impressive improvements in primary and secondary education in terms of expansion and equity. However, the social turmoil, famine, and war that ravaged Ethiopia in the 1980s and 1990s reduced the educational system to a shambles, particularly in the northern regions (Eritrea) where the fighting raged.

1.2.3 Education after independence

At the time of liberation in 1991, the education system was characterized by utter neglect and decay (Saleh, 2002). Eritrea was in dire need of reconstruction and rehabilitation as the economy and infrastructure had collapsed. Because of this, the government has committed 9% of the national budget to education. This was about 4% of GNP, which was very high compared to most sub-Saharan nations (Newcombe, 2000). However, the macro-policy document identified education as a central element in steering the social and economic development of the nation. The document outlined the main objectives of the Eritrean education system as follows (Macro-Policy, 1994):

- to produce a population equipped with the necessary skills, knowledge, and culture for a self-reliant and modern economy;
- to instill self-reflection and motivation in the population to combat poverty, disease, and all the attendant causes of ignorance; and
- to make basic education available to all.

It is against this backdrop that the Ministry of Education carried out two waves of curriculum reforms that radically changed the Ethiopian curriculum in 1991 and 2003.

The first wave of curriculum reform (1991-2002)

The precursor of the curriculum introduced in 1991 can be traced back to the curriculum developed in 1978 for the Revolutionary school by the Eritrean People's Liberation Front (EPLF) during the armed struggle to educate fighters' and migrants' children (Saleh, 2003). This same curriculum was later reformed in 1982 to accommodate the needs of the increasing number of young students and illiterate adults, and was widely used in the liberated areas of Eritrea and refugee schools in Sudan until 1991. With some changes made to cater to the needs of the

larger population and emerging nation, Curriculum-1982 was introduced after the country's liberation in 1991, and completely changed the previous Ethiopian education system. What follows is an attempt to characterize curriculum 1991 in terms of the changes to the structure of the education system, science curriculum, implementation problems, its achievement, and what prompted its review and ushering in of a second curriculum in 2003.

Structure of the education system

The education system was structured into a 5-2-4 grade configuration for basic primary, junior secondary, and senior secondary levels, respectively (see Box 1.1). The duration of tertiary education varied according to the type of institute in which a student was enrolled. At the university level, a student stayed four to five years for a bachelor's degree, and for certificate and diploma programs, a student received a tertiary education of one to two years. English was introduced as the medium of instruction from the junior secondary level and all the way up to the level of higher education. *Tigrigna,* a language that was widely spoken in the country, was used first as the medium of instruction at the primary level. Later, however, a Mother tongue policy was introduced for the respective ethnic groups.

The Ministry of Education is responsible for developing and monitoring the national curriculum. In Eritrea, education at all public schools including higher education is almost completely financed by the government. There are a few private, missionary, and international schools that take a small share of the student population, but in general, the role of the private sector in education is very limited. At the end of each level, a student takes a standardized national examination prepared by the Consultancy, Training & Testing Center of the University of Asmara (CTTC). Students may join tertiary education after securing a passing GPA (Grade Point Average) in the secondary school and leave after the examination at the end of grade eleven. Performance on this examination determines the fate of the student's course of study in the higher institutes of education.

Box 1.1 Structure of the Eritrean education system (1991-2002)

Curriculum 1991		
Level	*Age cohort*	*Tertiary education*
Senior Secondary		⇧
		Secondary Education Certificate Examination
	17	Grade 11
	16	Grade 10
	15	Grade 9
	14	Grade 8
Junior secondary		⇧
		National examination
	13	Grade 7
	12	Grade 6
Basic primary		⇧
		National examination
	11	Grade 5
	10	Grade 4
	9	Grade 3
	8	Grade 2
	7	Grade 1
Pre school	5-6	I, II

The science curriculum: policy, organization and implementation

The policy regarding the science curriculum (MOE, 1998a) stresses that science education should be relevant for *personal needs*, *societal issues*, *career awareness,* and for the *academic preparation* of students. It recommends that the science curriculum be more *process-oriented and, learner-centered,* and discourages the literal memorization and passive learning of students, as well. The following were some of the curriculum of 1991's aims regarding science education at the secondary level (MOE, 1998a):

- to understand the basic facts, concepts, principles, laws, and theories of science;
- to develop science process skills in observing, gathering information, conducting experiments, recording, interpreting data, and drawing valid conclusions;
- to develop logical and critical thinking, as well as an innovative, creative, and inquisitive mind;
- to create awareness regarding the environment and environment-related problems, and provide basic techniques of problem-solving to instill self confidence, self reliance, and decision-making skills;
- to develop a positive attitude towards and the ability to understand science and technology.

Science is taught from the first grade onwards. It is offered as an integrated subject both at the primary and junior levels with an incremental scope and depth. Biology, chemistry and physics are offered at the senior secondary level. Specialized subjects begin at the senior secondary level (grade 9) where diversified curricula tracks like Science, Art, Technology, and Commerce are made available to students. It can be said that science is taught to all age groups (i.e. 11 years) except to those small groups of students joining the Commerce stream at the beginning of the upper secondary level.

It was originally expected that the changes outlined in Curriculum-1991 would be implemented within a few years, considering the strong national commitment to rebuild the nation. Nevertheless, science education in Eritrea, particularly the first four years, has been a bumpy ride with many implementation problems. To begin with, there was a dire shortage of qualified teachers, textbooks, and educators, along with poor educational infrastructures. The Ministry of Education went so far as recruit teachers for primary schools without formal training. The qualifications of the teaching force at the secondary level also left much to be desired. The teachers were introduced to the new curriculum with one-shot orientation workshops. And though the preparation and publishing of textbooks was finalized in 1995, it happened four years after the introduction of the curriculum. Given such circumstances it was hardly surprising that teacher-dominated practices still prevailed in science classrooms, in sharp contrast to what was stated in the policy of science curriculum documents.

In 1998, the Ministry of Education initiated a curriculum review study to identify the strengths and weaknesses of the system. Saleh (2002) explained that Curriculum-1991 had been generally successful from primary to junior secondary levels, but that senior secondary level was problematic. He summarized the milestone achievements of Curriculum-1991 as follows:

- extensive teacher training programs carried out to decrease the teacher-student ratio;
- increase in the number of schools from 200 to 980;
- increase in the gross enrollment ratio from 32% to 64%; and
- the promotion of adult education that won an award from UNESCO.

In regard to the senior secondary level, however, the curriculum wasted both government resources and student time (grade repeaters 20-30%), and did a poor job in preparing students for the labor market (MOE, 2002; Saleh, 2003). Apart from the few students who join the five comprehensive technical schools in the country,

the overwhelming majority of secondary school students take only academic subjects, which prepares them solely for tertiary education. In addition, this problem was exacerbated by the fact that less than 10% of the students who took the national matriculation exam (ESECE) managed to pass and gain access to a university education. The employment opportunities for those unable to go to higher institutions of learning were not high because the education system did not equip them with specific, employable skills. Because of this, the government initiated a second wave of curriculum reform to redress these problems and transform the education system (MOE, 2002).

The second wave of curriculum reform

With a budget of USD 200 million, the Ministry of Education established a five-year plan to bring about radical curriculum change at all levels. The ministry stated that a number of reasons prompted them to implement a new curriculum in the academic year 2003/2004. They argued that the education system must keep up with globalization and technological advancements. The Ministry of Education also stressed that the system could be enhanced by improving access to, and the equity of, education in Eritrea. Curriculum-2003 was heralded by the document 'Concept Paper for a rapid Transformation of the Eritrean Educational System' (MOE, 2002). This concept paper stated the main goals of the education system as follows:

- universal primary and middle school education for the whole school age population;
- a widely integrated high school education with both a core and an enrichment curriculum flexible enough to prepare students for University education as well as employment;
- a wide network of vocational schools and community colleges;
- a vision for up to eight universities located in various regions of the country, with a total enrollment of up to 20,000 students.

New structure of the education system

The new education system is structured in a 5-3-4 configuration. The primary level spans 5 years (as before), and the secondary level is extended by one more year. The secondary level is structured in such a way that it would accommodate twin objectives: offering a wider access to tertiary education while simultaneously ensuring acquisition of technical and vocational skills for those who need employment after high school (MOE, 2002). In this respect, all secondary school students will have both a core curriculum and an enrichment curriculum (elective subjects). The elective courses are primarily geared towards equipping students with practical skills for employment. The core subjects include Mathematics,

Science, Social studies, Proper Living, English Language and Communication skills, and Eritrean Language and Literature. Students can choose their electives from a wide range of fields including Agricultural Science and Technology Education; Business and Economics Education; Health Science and Technology education; Mechanical Technology Education; Electrical Technology Education; Construction Technology Education; Industrial Technology Education; Information Technology Education; Environmental Science Education; Visual Arts & Design Education; and Physical Education. Unlike the previous system, access to higher education will depend on the Secondary School final examination results as well as the student's performance throughout their years at the secondary level. Saleh (2003) explained that aside from changing the content of the curriculum, the teaching methods would also be improved as the new system of education was designed to make students more dynamic, interactive, and fully involved in the teaching-learning process.

The biology curriculum

The biology course is being taught to all students throughout the senior secondary school level. The content is organized into courses that are offered in four years as Bio 1, 2, 3, and 4. The biology syllabus clearly stated that in Curriculum-2003 there is a significant change in the teaching approach from "*teacher-centered to student-centered interactive pedagogy where the students will be empowered, have high levels of participation, share responsibility, and become creative and critical thinkers*" (Syllabus, 2003, pp. vii). It further specifies that in studying biology, students are expected to conduct field and laboratory investigations and make informed decisions. Students have to use scientific methods during field and laboratory investigations, and are expected to do the following:

- plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology;
- collect data and measure with precision;
- organize, analyze, evaluate, make inferences, and predict trends from data; and
- communicate valid conclusions.

With regard to using "critical thinking and scientific problem solving" skills while making informed decisions, students are expected to do the following:

- analyze, review, and critique explanations, including hypotheses and theories as to their strengths and weakness using scientific evidence;
- make responsible choices in selecting everyday products and services using scientific information;

- evaluate the impact of research on scientific thought, society, and the environment;
- describe the connection between environmental science and further careers; and
- research and describe the history of environmental science and the contribution of scientists.

1.2.4 Implications for the study

The second wave of reform in Eritrea entails considerable change in curriculum content with the introduction of many new subjects. It calls for more student participation in the learning process and improvement of the overall teaching approach. The biology curriculum, in particular, calls for significant change in the teaching approach toward "*student-centered interactive pedagogy,*" and as such biology teachers are expected to embrace it and change accordingly.

Nevertheless, implementing a new curriculum as ambitious as Curriculum-2003 and changing practices at the classroom level is not a simple process. As Fullan (2001) aptly outlined, curriculum implementation is affected by a number of factors related to characteristics of the change (*need, clarity, complexity, & practicality*), school context (*principal*, *teacher,* and *school environment*) and external factors (*government policies*, *etc.*). Of course, the realization of such changes in practice weighs heavily on the teachers: how can they make sense of the proposed changes, what do they do down the road of implementation, and the quality of professional development support they receive.

1.3 AIM OF THE STUDY AND RESEARCH QUESTIONS

The study investigated the potential of a professional development scenario for supporting biology teachers in implementing a student-centered approach within the context of a new curriculum. The central research question that guided the overall study is formulated as follows:

> *What are the characteristics of a professional development scenario that effectively supports biology teachers in Eritrea implementing a more student-centered approach?*

The study has been guided by three specific questions that provided an adequate platform for navigating the overall investigation. These questions were formulated in a way that facilitated context analysis, guided the review of relevant literature,

distilled the appropriate design guidelines, and directed the development and evaluation of the support scenario. They are as follows:

1. What are the contextual factors that influence the design and implementation of a professional development scenario for biology teachers in Eritrea?
2. What can be learned from the literature about promising professional development scenarios that adequately support teacher learning and classroom practice?
3. What is the practicality and effectiveness of the professional development scenario in supporting biology teachers' learning and classroom practice?

1.4 RESEARCH APPROACH

1.4.1 Development research

The study adopted a development research approach to guide the analysis, design, evaluation, and revision processes of the professional development scenario (intervention). Development research is a problem-oriented, interdisciplinary research methodology aimed at reducing the uncertainty of design decisions, generating concrete recommendations for quality improvement, testing general design principles, and stimulating the professional development of researchers and other professionals engaged in the educational intervention development (van den Akker, 2002b; van den Akker & Plomp, 1994). It is based on the premise that a systematic integration of research and design in cyclic and iterative ways play an important role in developing and testing the adequacy of interventions for ambitious policies in education where problems and needs are diverse and uncertainty about the effectiveness of interventions abounds (van den Akker, 1999). Van den Akker (2002a) asserts that this approach is particularly relevant and appropriate for educational development in developing countries because of its flexibility in emerging contexts, its potential impact on the professional development of participants, and its capacity building in general. Within a wider African context, the efficacy of the development research in enhancing the effectiveness of educational interventions has been explored in a number of studies and development projects. Reports coming out of such studies paint a promising picture that indicates its appropriateness in developing countries (Kitta, 2004; McKenney, 2001; Ottevanger, 2001; Thijs, 1999; Tilya, 2003; Stronkhorst, 2001).

1.4.2 Overall research design

The study's overall design was structured within the framework of development research. The development research activities were conducted in three stages: front-end analysis, prototyping, and formative evaluation of the professional development scenario. Figure 1.2 shows the stages and the research activities of the study.

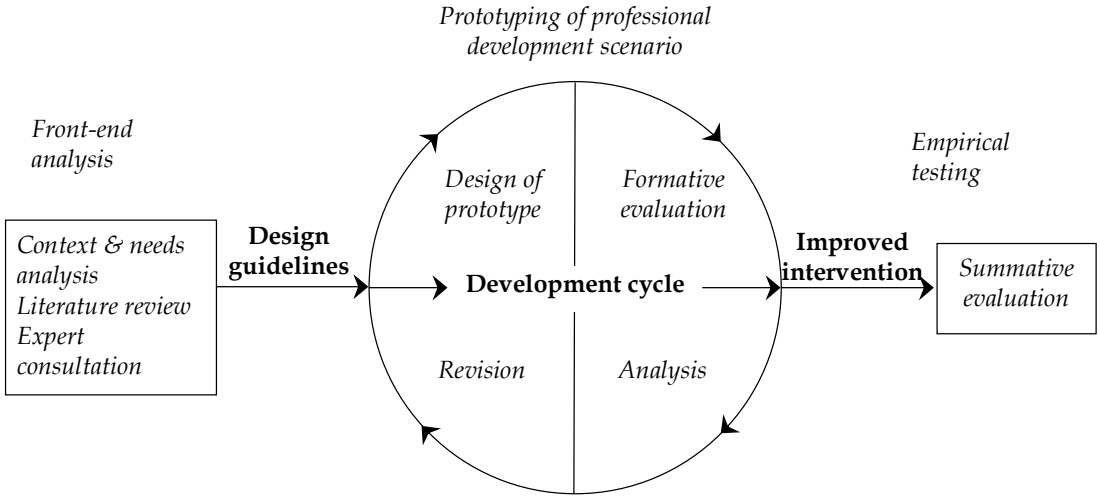


Figure 1.2 Stages of development research in the study

Front-end analysis

The three main activities that marked the front-end analysis of the study were a context and needs analysis, review of the relevant literature, and expert consultation. The context and needs analysis provided data on the contextual factors, professional development need, and the ultimate focus of the intervention. The study's extensive literature review focused on the knowledge base that supports the design of a professional development scenario. The overall front-end analysis culminated in a distillation of design guidelines for developing the professional development scenario.

Prototyping of professional development scenario

This stage of the study dealt primarily with the development and formative evaluation of the professional development scenario's successive prototypes. During the prototyping process of the study, a number of cyclic and iterative activities of *design-evaluation-analysis-revision* were undertaken to improve the validity and practicality of prototypes. In other words, the prototyping process entailed the use of a number of prototypes, a high degree of iteration, and the participation of potential users. The formative evaluation approach employed in the prototyping stage included expert appraisal, user appraisal, trial, and field-test.

Empirical testing

This stage of the study involved a summative evaluation of the professional development scenario. It was focused mainly on garnering empirical evidence on the professional development scenario's impact. A quasi-experimental design and Guskey's (2000) model of evaluation were employed for investigating the impact of the professional development scenario on teachers and students.

1.5 THE FOLLOWING CHAPTERS

The development research activities and findings of the study's three stages are presented in the following chapters. *Chapter 2* introduces the overall front-end analysis of the study and reports the detail of the context and needs analysis. *Chapter 3* presents a review of state-of-the-art literature for developing the study's professional development scenario. The first part of the literature review starts with an overview of the trends in science curriculum development and reform initiatives, along with the renewed focus on the professional development of teachers' implementation of reform initiatives. The second part focuses mainly on analysis of the current knowledge base that supports the design of professional development. The final part of the literature review is devoted to the implications drawn from it and the distillation of design guidelines. The prototyping stage of the study is reported in *chapters 4* and *5*. *Chapter 4* reports the design and formative evaluation activities of the study's exemplary curriculum materials. The design and formative evaluation of the professional development workshop, school follow-up, and supportive school environment is described in *chapter 5*. The summative evaluation of the professional development scenario is reported in both *chapters 6* and *7*, while the overall design of the summative evaluation is included in *chapter 6*. The results of the summative evaluation are described in *chapter 7*. *Chapter 8*, the final chapter, presents the discussion of the main findings, reflections on the research methodology, conclusions and recommendations warranted from the study, as well as direction for future research endeavors. Finally, the instruments used in chapters 2 and 4, the exemplary curriculum materials, and complete results of the formative evaluation activities are provided at http://projects.gw.utwente.nl/crc/ERpds/index.html

CHAPTER 2
Front-end analysis

The front-end analysis was carried out to become better orientated with the user context and knowledge base that could be used for developing the intervention. It was conducted through a context and needs analysis, and a review of relevant literature. The context and needs analysis study is presented in this chapter, while the literature review is discussed in chapter 3. Section 2.1 sketches the design of the front-end analysis in terms of its focus, research questions, and data collection instruments[1]. Section 2.2 is devoted primarily to the results of the context and needs analysis. It outlines biology teacher and student perceptions, classroom life, state-of-practice in biology education, and history of professional development. The final section 2.3 presents which implications can be drawn for designing the intervention of the study.

2.1 DESIGN OF THE CONTEXT AND NEEDS ANALYSIS

2.1.1 Research focus and questions

A recurring recommendation of professional development literature is that the user context requires serious consideration and particular focus on implementation conditions and strategies (Fullan, 2000, 2001; van den Akker & Plomp, 1994; Rogan & Grayson, 2003). Regardless of how sound a professional development might be, it appears that its impact is highly dependent upon the user context and implementation practices. London (1993) stressed that one of the most significant reasons for the failure of educational projects in developing countries is a lack of sufficient attention to harmonizing the project plan and contextual reality during the project's initial stages. Similarly, Loucks-Horsely, Hewson, Love, and Stiles (1998) suggest that developers should concentrate on a list of contextual factors, which are thought to ground the intended professional development plan in their own reality. Therefore, this study focuses on five contextual factors that have a potential stake in developing the professional development scenario. These factors are teachers, students, classroom life, state-of-practice in biology education, and

[1] The instruments are provided at http:// projects.gw.utwente.nl/crc/Erpds/FEAinstruments.pdf

history of professional development in Eritrea. The main research question that guided the context and needs analysis is formulated as follows:

> *What are the contextual factors that influence the design and implementation of professional development scenarios for biology teachers in Eritrea?*

Moreover, after consulting the literature and deliberating with experts, additional specific questions were derived in order to sharpen the focus of the analysis. The specific questions were as follows:

- How do teachers perceive their teaching approaches?
- What are the teachers' perceived problems and professional development needs?
- What are the students' perceptions of biology teaching and the learning process?
- What does a typical biology class look like?
- What is the current state-of-practice in biology education and professional development?

2.1.2 Characteristics of participants

The data collection process employed a purposive sampling strategy (Patton, 2002). A total of 11 schools from two administrative regions of Eritrea participated in this data collection. The participating public schools were also typical of the country. Table 2.1 displays the characteristics of the participating schools and biology teachers.

Table 2.1 *Characteristics of participant schools (N=11)*

School	**Sex**			**Qualification****		**Years of experience**	**School conditions*****						
	*n**	*M*	*F*	*Under*	*Qualified*	*Average*	*Lab*	*LabT*	*Eq*	*Ch*	*D*	*M*	*Class size*
A	4	2	2	1	3	16.5	+	+	+	+	+	+	52
B	5	3	2	3	2	17.2	+	+	+	–	+	+	45
C	4	3	1	–	4	7.75	+	+	+	+	+	+	59
D	6	5	1	–	6	8.5	+	–	+	+	+	+	56
E	4	3	1	2	2	10	+	+	+	+	+	+	55
F	4	4	-	1	3	4.5	+	+	+	+	+	+	54
G	3	3	-	–	3	15.7	+	–	+	+	+	+	50
H	5	4	1	1	4	7.6	+	+	+	+	+	+	71
I	7	6	1	2	5	17.1	+	+	+	+	+	+	55
K	4	4	-	–	4	6.3	+	–	+	+	+	+	55
L	3	2	1	1	2	16	+	–	+	+	+	+	60

Legend: * n = number of teachers; ** Under = teachers with a Diploma qualification; qualified = teachers with qualification of Bsc, Msc or Phd; *** Lab = laboratory, LabT = laboratory technician, Eq = equipment, Ch = chemicals, D = Desks or stools, M = biological models; +/– = indicates available or absent.

2.1.3 Data collection instruments and methods

Teacher questionnaire

The purpose of this questionnaire was to explore teachers' perception of their teaching approach, gather data about the school context, and identify teachers' perceived professional development needs. The questionnaire consisted of three sections: cover letter, general information about respondents, and eight items. The general information section asked teachers to provide data about their gender, qualification, teaching experience, and school context. The eight items were organized in a Likert scale form: open-ended items and ranking of professional development topics listed by the researcher. The items asked teachers to specifically indicate the following:

- frequently used teaching methods and activities in the form of a four-point scale (1=almost never, 2= sometimes, 3= often, 4= almost always);
- worries and problems related to content, practical work, teaching method, teaching materials, etc.;
- workshop topics which they think would improve their teaching and active student participation; and
- a ranking list of topics they wish to include in a professional development workshop.

A total of 53 teachers completed the teacher questionnaire. Both quantitative and qualitative data analysis procedures were applied for analyzing the data from the closed and open-ended items. Descriptive statistics (mean, standard deviation, etc.) were used to summarize the quantitative data of the questionnaire. The teachers' responses to the open-ended items were qualitatively summarized item by item.

Classroom observation

Three classroom observations were conducted to reveal the mode of instruction in biology classrooms and the nature of interaction between students and teachers. Two teachers from grade 9 and one teacher from grade 10 of the participant schools were observed without advance notice. The teachers were randomly selected and asked for their permission to be observed. The lessons were video-taped and transcribed for analysis. The video transcripts were analyzed qualitatively, and the extracted information was organized into four parts: general observation, start of lessons, body of lessons, and conclusion of lessons.

Student questionnaire

The student questionnaire consisted of six items. Four items asked students to mark their responses in a tabulated list of events or activities in a four-point Likert scale (1=almost never, 2= sometimes, 3= often, 4= almost always). These lists of events were meant to generate data pertaining to students' perceptions of and preferences for biology activities, teacher teaching strategies, and homework. The remaining two were open-ended items that asked students about textbooks and their experience with biology practical work.

A total of 125 students (from three classes) of those teachers observed had completed the student questionnaire. Quantitative data analysis was employed to analyze data from the items. The analysis involved computing descriptive statistics (both mean & standard deviation). The students' responses to the open-ended items were summarized item by item.

Interview plan

The purpose of the interview plan was to explore the Ministry of Education's in-service education policy as well as the experiences and constraints in organizing in-service education in Eritrea. The interview was organized around the following themes: role of the Ministry of Education, problem areas, experiences and constraints in organizing in-service education, and issues related to the evaluation of in-service Education in Eritrea.

The researcher conducted face-to-to face interviews with one in-serve educator and two officers at the Ministry of Education in Eritrea. The interview sessions were tape recorded and transcribed for analysis. The analysis of the interview transcripts involved summarizing participants' responses into two themes: policy on in-service education and constraints for organizing in-service education.

Document analysis

This involved analysis of relevant documents and publications of the Ministry of Education. The analysis focused on the policy of in-serve education and the state-of-practice of Eritrea's biology education.

2.2 RESULTS

2.2.1 Perceptions of the teaching practices of biology teachers

The teachers were asked to mark how frequently they use the tabulated teaching strategies/activities in their biology lessons. Table 2.2 displays an overview of the teachers' responses.

Table 2.2 *Perception of teachers about their teaching methods*

	N	M*	S.D
'Use of concept maps'**	53	3.6	0.60
Talk and chalk or lecturing method	53	3.5	0.73
Note giving	51	3.5	0.64
Questioning and answering	50	3.1	0.89
Teacher demonstration	53	2.9	2.90
Homework giving	53	2.7	0.84
Field trips/outdoor activities	52	2.7	0.93
Inquiry learning/teaching	53	2.5	0.67
Group work activities	53	2.1	0.74
Student practical work	53	2.0	0.64
Homework checking	51	1.9	0.78
Games	52	1.4	0.69
Whole class or small group discussion method	51	1.2	0.50

Legend: * 1 = almost never, 2 = sometimes, 3 = often, 4 = almost always; ** There appears to be misunderstanding about the meaning of concept mapping (cf. White & Gunstone, 1992).

The prevailing modus operandi of the biology teachers appeared to be concept mapping, talk and chalk, note-giving, and questioning and answering. Teacher demonstration, student practical work, and student group work activities were used occasionally. However, a large standard deviation (SD=2.9) indicates a wide variation regarding the use of a teacher demonstration. Group discussion and games were reported to be almost never used by teachers in biology lessons. The teachers indicated that their reasons for adhering to teacher-centered methods were class size, content press (a vast content), high teaching load, and lack of training in student practical work. One teacher noted the problem as follows:

> *"We frequently use the lecture method. Giving more information that they cannot understand. We know that this method is not effective but we do not have any option as the class size is the burden. It is very difficult for an audience of 80 students to make them discuss in a crowded room. We do not have materials that help us make use of a variety of teaching methods especially child centered. Lecture and demonstration are realistic with what we have in the school."*

Biology teachers were also asked to indicate how frequently they engage students with student-centered activities in their lessons (Table 2.3).

Table 2.3 *Teacher perceptions of their use of student-centered activities*

	N	M*	S.D
Asking guided questions to introduce the lesson/activity	53	3.6	0.77
Interacting equally with all groups in activity	53	3.5	0.64
Encouraging students to ask questions	53	3.4	0.87
Discussing students' homework results	53	3.3	0.63
Allowing students to draw their own conclusion(in group)	53	3.2	0.69
Encouraging students to explore the problem/topic in group or individually	53	3.1	0.66
Focusing students' attention on crucial observations or main points of a lesson	53	3.0	0.74
Finishing up the lesson by referring back to the introductory theory/objectives etc.	52	3.0	0.80
Guiding students to preliminary conclusion/ideas of the lesson	53	2.9	0.79
Providing general theoretical conclusion from activity	52	2.8	0.86
Asking students for their predictions	53	2.7	0.69
Drawing conclusions from the activity with the students	52	2.7	0.92
Asking students for their own ideas or using student ideas to illustrate lesson activity	53	2.4	0.72
Guiding students to understand discrepancies between predictions and observations	53	2.4	0.93
Encouraging student discussions with peers in their group	53	2.3	0.88

Legend: * 1 = almost never, 2 = sometimes, 3 = often, 4 = almost always.

Activities like asking students questions during introduction and encouraging them to ask questions were practiced most of the time. Nevertheless, asking students for their own ideas on lesson topics, as well as encouraging student discussions with peers was used only sometimes by the teachers.

Satisfaction with the status quo

Teachers were asked if they were comfortable with their teaching strategies. The majority (92.6%) of them reported dissatisfaction with the status quo and pointed out a need for improvement of their state-of-practices. Some teachers indicated satisfaction with their teaching; this satisfaction was related to their mastery of the routines of teacher-centered strategies and intrinsic motivations, as stated by one of the teachers.

> *"Yes, because I fulfill all the things needed in teaching strategies such as preparation of annual and weekly lesson plans, using oral questions before starting the new lessons to remember the main points, using charts of different diagrams, models, giving chance to students to ask questions on the points which are not clear discussing topics from simple to complex to motivate the students etc."*

The teachers who indicated dissatisfaction with the status quo were not articulate enough to suggest specific improvements as far as their teaching repertoire was concerned. Some teachers suggested a need for short courses to upgrade their subject matter knowledge with recent developments in science. Others indicated that any in-service education that could increase student participation or help them shift from teacher-dominated lessons into student-centered teaching approaches would be helpful.

Professional development needs

The biology teachers were asked to suggest specific workshop topics that would improve their teaching and active student involvement. Overall, 66% of them indicated topics in pedagogy, subject matter, and school administration.

Generic pedagogical topics or needs

- short term in-service education on updating teaching methodologies that increase student participation;
- workshops regarding innovative teaching methods, particularly those concerned with the student-centered approach;
- workshops on school management and student discipline;
- workshops on how to enhance student learning outcomes.

Biological content related topics or needs

- workshops on microbiology teaching, growth in plants, plant hormones, and tropism in plants; osmosis; different types of human systems and functions; sexual and asexual reproduction.

Specific professional development topics or needs

- how to use practical work, promote group works, and how to apply it to students' daily life;
- how to prepare simple teaching aids;
- an understanding of the general methodology of teaching learning process;
- workshops on a variety of teaching techniques (e.g. using discussion and game methods);
- an understanding of teaching methods that could be used for large class sizes.

The teachers were asked to indicate and rank topics they felt necessary for a professional development workshop. The outcome of their preference is listed as follows.

1. use of practical work (42%);
2. promoting group work activities or collaborative activities (34%);
3. conceptual learning with examples and applications to the daily life of students (32%);
4. whole class or small group discussion (19%);
5. use of Predict-Observe-Explain demonstrations (19%);
6. use of concept mapping (17%).

2.2.2 Student perceptions of biology teaching and learning

83.2% of the students who took part in the context and needs analysis reported having a biology textbook. The textbook was used for doing review exercises, studying (reading), and drawing diagrams. It appeared that student practical work was rarely done; 51% of the students indicated that they had never done practical work, and 18% of them reported having been involved in practical work only once during either grades 8, 9 or 10.

The students were asked to indicate the kinds of teaching strategies they encountered and how often activities were employed in the biology lessons. Analysis of students' responses showed that copying notes and listening passively were students' most frequent activities. In regard to teachers' activities, students indicated that sometimes the teacher spent half the period writing notes on the blackboard or the whole period explaining lessons. Teachers rarely used teacher demonstration, group work activities, and student practical work.

Students' preference regarding the biology activities

Students were asked to rank activities/strategies in biology lessons from one to seven according to their preferences: "1" for the activity they liked best and "7" for the activity they liked least. The results paint a very interesting picture about students' preference for the well established mode of instruction. Table 2.4 shows that the students were comfortable with and well conditioned to teacher-centered teaching and learning strategies. They have ranked the seven activities/strategies as follows: *listening to the teacher (1st)), copying notes, reading a text, doing assignments, discussing with classmates, doing practical work, doing group work (7th)*.

Table 2.4 *Students' rating of their favorite classroom activities in percentages*

Activities/strategies	Mean Rank *
Listening to the teacher (1)	2.98
Copying notes	3.06
Reading a text	3.55
Doing assignments	3.80
Discussing with classmates	4.20
Doing practical work	4.34
Doing group work (7)	4.34

Legend: * The lowest mean indicates the activity they liked most.

General observation

The observed classrooms were well ventilated, had electricity, had three to four rows of desks, and had a blackboard typical to any classroom in Eritrea. The majority of the students had textbooks and the nature of interaction between the teachers and students was unidirectional. The predominant activities of the teachers were talking, writing, and asking questions, while the students were passive most of the time except for lessons in which they actively responded to teacher's 'rhetoric' questions. The lessons observed were on *food preservation* (grade 8), *class Insecta* (grade 9) and the *Central nervous system* (grade 10). A summary of the lesson observations is organized as follows: introduction, body, and conclusion of lessons.

Lesson introductions

The lessons began with the teachers greeting the students and then hanging biological charts on the blackboard. One of the teachers reviewed what students learned in the previous lesson in the form of questioning and answering. He posed a question and randomly called students by name to come to the front of the class to identify *parts of the brain* on the biological chart. The other two lessons started with the teachers' review of the previous lessons and the introduction of what students were going to learn in the respective lessons. The lesson introductions lasted three to five minutes.

Body of the lessons

The body part of the lessons was heavily dominated by teachers' detailed explanation of lesson topics, and continuous writing of phrases and notes on the blackboard. In between the explanation, the teachers posed certain questions that they thought students should know from previous lessons. Such questions were meant to assess students' knowledge of prerequisite concepts and monitor if students were following them. The teachers appeared to be good presenters of factual information, stating the information precisely, and drawing good diagrams

on the blackboard. The dominant modes of instruction were explanation, as well as questioning and answering methods. The media and materials accompanying the lessons were chalk, blackboard, and some pictorial illustrations or biological charts. The role assumed by the teachers was as presenter of factual knowledge, while the students were passive for most of the lessons. The students listened, wrote down notes, and responded in chorus to some questions posed by the teacher. The body of the lessons lasted for 23 to 30 minutes.

Conclusion of the of lessons

The lessons' conclusion was characterized by students' copying what ever was written on the blackboard during the explanations. The students were given the opportunity to ask questions, but were reluctant to do so. There was no explicit attempt by teachers to summarize the lesson or make a link back to the introductory theory. Only one teacher used the questioning and answering method to wrap up the lesson.

2.2.4 The state-of-practice in biology education

The biology curriculum

The state-of-practice was one of the contextual factors influencing professional development for teachers. Loucks-Horsely et al. (1998) suggest four aspects of practice that require attention from professional development designers if science and mathematics education is to reach the desired ends. These are curriculum (what is being taught), instruction (how it is taught), assessment (how it is measured), and learning environment (the physical facilities and arrangements, as well as the culture within the classroom). The analysis of state-of-practice in biology education is organized within this framework in the proceeding texts.

The teachers who participated in the context and needs analysis were asked questions about the biology curriculum. They expressed their concerns and problems related to curriculum content, practical work, teaching method, and materials.

Most teachers pointed out that the content was too broad and theoretical. Many of them stressed that it was not practical. The topics were organized in a way that did not encourage teachers to conduct practical work. Besides, the teachers have also argued that the content was beyond the students' level of understanding, considering their language problem. Teacher support materials in terms of teacher guides and laboratory manuals were also scarce. Both teachers and students were so heavily dependent on the textbook that the biology curriculum was virtually identical to the textbook. The teachers indicated that content was not grounded in an Eritrean context, was outdated, and that the biology textbook had too large a

role in dictating their teaching approaches. This is reflected in the following quote from one of the teachers.

> *"The content of the text book is more theoretical and copied only from one outdated book i.e. 'fundamental concepts of modern biology'; the name of plants and animals given in the text book are not familiar to our country; it has no laboratory manual, for practical work, it only depends on the interest of the teachers…"*

Most of the teachers were aware of the importance of practical work for their respective grades. Nevertheless, students were not engaged in practical work for a number of reasons. The teachers reported that schools have insufficient laboratory apparatus and chemicals (sometimes outdated), a lack of practical manuals, unqualified technicians, large class sizes, and little emphasis of both the biology curriculum and the national examination on student practical work.

Focusing on the implemented curriculum shed light on how the biology curriculum was taught in Eritrea. It appeared that the reality of Eritrean science instruction classrooms was no different from those reported in the literature of other sub-Saharan countries (van den Akker, 1998; Prophet, 1990; Ottevanger, 2001; Tabulawa, 1997). A glimpse of the prevailing interaction between science teachers, students, and instruction was revealed in the following citation from the Science Methodology Training Manual (MOE, 1998a p. 1)

> *"…the teaching and learning process in our school is teacher dominated and is mainly focused on providing factual knowledge. Almost all biology, chemistry and physics teachers spend their time on writing notes…very limited time is given for explanation and discussion. Majorities of students are passive listeners… they neither ask questions nor involve in discussions. Practical activities are forgotten. As a result, the students are forced to memorize scientific facts, concepts and principles by heart and regurgitate them in exams"*

Similarly, in a study Habte (2001) conducted in Eritrean physics classrooms, it was reported that teachers spend as much as 53% of class time on lectures while students spend about 30% of class time copying notes. The teachers relied heavily on lecture method at the expense of more active student-centered methods.

As for assessment, the policy of continuous assessment was mandated for all schools (MOE, 1998a). Student performance was assessed over an extended period of time through quizzes, classwork, homework, 'projects', and tests. The teachers

were expected to measure the knowledge, skills, abilities and attitudes of students in all four domains. However, student assessment was mainly done through paper and pencil format to tap into students' factual knowledge. Assessment of student skills and attitude was not conducted at the secondary level on a regular basis.

Quality of the teaching force

Science teachers at the secondary level are considered qualified if they have the minimum qualification of a B.Sc. degree. Table 2.5 provides an overview of the qualification of teachers and student/teacher ratio for the whole country at the secondary level.

Table 2.5 *Teacher qualification and student/teacher ratio at secondary school level*

Academic	**8-11 grades (secondary level)**				
Year	*Total*	*Qualified*	*% of Qualified*	*Students*	*Student/Teacher Ratio*
1991/92	758	N/A*	N/A	27627	36
1992/93	905	431	47.6	31531	35
1993/94	1015	479	47.2	32756	32
1994/95	1081	507	46.9	36728	34
1995/96	1039	540	52.0	39188	38
1996/97	942	527	55.9	40594	43
1997/98	959	682	71.1	41615	43
1998/99	982	715	72.8	47533	49
1999/00	1047	729	69.6	57334	55
2000/01	1188	869	73.1	63951	54
2001/02	1419	1032	72.7	70183	50
2002/03	1277	870	68.1	70057	55

Legend: *N/A = not available.

It appeared that after independence there was a general increase in teachers' qualification at the secondary level. However, as shown in the student/teacher ratio, the production of qualified teachers is lagging behind the steady expansion of student numbers. Overall, 77.5% of biology teachers who participated in the context and needs analysis were qualified (B.Sc, Msc & Ph.D) and only 22.5% were under-qualified with a diploma degree (see Table 2.1).

School context

From the document analysis, it became clear that the school principal usually assumes the role of administrator whereas the vice-principal is more concerned with academic matters. The vice-principal is also called '*head of the pedagogic Unit*' of the school. He is involved in most of the academic duties: overseeing teachers' weekly lesson plans, supervising classrooms, and providing teachers with

pedagogic support. The vice principal often works closely with the department heads. Every school is mandated by the Ministry of Education to assign one hour per week to a 'departmental meeting' though this was not followed by a majority of the schools. Teachers are meant to use this meeting to discuss academic matters and cooperate with each other.

The teachers reported that all schools participating in the context and needs analysis do have a laboratory room; in some schools, one laboratory room was used for biology, chemistry, and physics subjects (see Table 2.1). The laboratory rooms were furnished with stools and desks, and many commercial models and charts displaying biological concepts. However, some laboratories lacked equipment, were stocked with outdated chemicals, or lacked the basic infrastructure for water supply. In all the schools, there was no specific period (one period is 40 minutes) devoted to practical work as teachers organized practical work according to their convenience. Four schools did not have a laboratory technician, and while the other schools did have one, their qualifications were often questionable. Some of the laboratory technicians' duties included photocopying exam papers, disciplining the students, and minding supplies.

The schools' class size was not uniform. Some schools had 42 students per class, while others had around 75 (see Table 2.1). The average class size in Eritrean secondary schools was 60 (Saleh, 2003). All schools worked in two shifts and the teachers' teaching load ranged between 24-36 periods per week. This left teachers little time to engage in collegial collaborations even though some schools indicated that teachers did have a one hour departmental meeting geared toward stimulating collaborations.

2.2.5 History of professional development

Policy on in-service education

Like many other developing countries, the professional development of teachers in Eritrea starts at teacher accreditation colleges or universities. The teachers were instilled with the idea that what they learned was enough to do the job. In-service education often consisted of one-shot workshops and seminars with no follow-up or support materials for implementation. In regard to science at the secondary level, teachers were sometimes invited to workshops organized by either the curriculum division, Zoba (i.e. regional) educational offices, or volunteer expatriates. At best, these workshops provided teachers information related to content, methodology, and new guidelines introduced by the Ministry of Education. Besides the small group discussions, however, teachers were rarely provided the opportunity to practice, let alone receive school support or follow-up assistance.

As outlined in the Science Methodology Training Manual (MOE, 1998a), a rather serious and deliberate in-service education for science teachers was attempted in the summer of 1998. This manual summarizes the Ministry of Education's policy on science in-service education. The manual was prefaced with the in-service program's purpose, need for improvement, in-service focus, and its duration and frequency. The manual's aim was to train science trainers who were supposed to run workshops for science teachers in their respective Zoba (region), sub-Zoba (sub region), or schools. The general approach adopted was a cascade model. The manual underscored that the existing teaching approach in science was far from desirable, and that the need to improve it was unquestionably clear. To improve the existing situation, the manual stressed that more emphasis must be given to *science process skills* and that science was best learned when presented in a practical way. An in-service education program of twice a year was recommended at the Zoba or sub-Zoba level by those who attended a six day national workshop in 1998. The aims of the Science Methodology Programme as outlined in the manual were as follows:

- to create a clear understanding of the aims of science education at the senior secondary school level;
- to upgrade science teachers' knowledge and understanding of various methods of science teaching at the secondary school level;
- to encourage science teachers to develop their skills by using their immediate environment in practical science teaching;
- to develop science teachers' capability in the preparation and implementation of lessons plans and methods of evaluation;
- to support potential science teachers who can work as science methodology trainers in their respective areas.

Nevertheless, before these proposed changes were implemented, they were eclipsed by other competing priorities such as the 'education sector review' and management of the internally displaced student population during the war with Ethiopia from 1998 to 2001.

Constraints for organizing in-service education

The main constraint in organizing in-service education was a lack of skilled trainers and a conceptual model for planning and implementing the professional development activities. All the interviewees stressed that much needed to be done to produce more qualified trainers and resource teachers. In regard to assessing the effect of the in-service activities, one interviewee pointed out the distinct lack of follow-up assistance. Teachers were not provided follow-up support to implement what they learned in those workshops. The interviewee also underscored that

trainers were overwhelmed with other activities and had no time to conduct impact evaluations.

2.3 IMPLICATIONS FOR THIS STUDY

Based upon the aforementioned results, the following implications are drawn for the design, evaluation, and implementation of the intervention:

1. The documents from the ministry of education (MOE, 1998; 2002) have thrown light on policies pertaining to science curriculum and in-service education in Eritrea. The methodology manual, in particular, has outlined the purpose, importance of improvement, and training focus of in-service education at the secondary level. Among other issues, the manual has emphasized the importance of science process skills, contending that science is best learned when presented in a practical way. Therefore, it is prudent that the study aligns and builds upon what was implied in these policies in order to maintain program coherence. Loucks-Horsely et al. (1998) noted that dismissing state policies can impede the progress of the intended professional development goals. A careful examination of local, state, and national policies that exert heavy influence on professional development design is crucial (Garet et al., 2002; Loucks-Horsely et al. 1998). Similarly, in the African context, Ogunniyi (1995) stressed that any curriculum innovation that ignores policy implications is bound for extinction. Therefore, the content of the professional development in this study has to reflect the topics, goals for student learning, and pedagogical methods emphasized in the Eritrean biology curriculum.
2. The teachers in the sample indicated a need for improving their state-of-practice. The majority of teachers (92.6%) were not satisfied with their own teaching strategies and student learning. They pointed out a need for in-service education that promotes student-centered teaching and learning, training that would improve student participation and understanding. The teachers prioritized their perceived training needs on teacher demonstrations, student practical work, and group work (section 2.2.1). This warrants consideration in the design of the professional development scenario intervention, and the best way to articulate such needs should be further explored in the literature.
3. The innovation capacity of the system to initiate and implement the intended improvements sounds promising. Around 70% of science teachers are qualified (Table 2.5), have adequate education, and expressed their readiness to engage in the process. The system's overall capacity to support the implementation of this study's intended professional activities looks adequate for startups.

CHAPTER 3
Towards a knowledge base for the intervention

This chapter presents a review of relevant literature carried out to outline a conceptual framework and design guidelines for developing the intervention. The first section sketches the trends in science curriculum development and reform initiatives from an international perspective. Section 3.2 looks at the limitations of traditional professional development approaches that spurred on the renewed focus on professional development in a systemic way. Section 3.3 examines the relevant knowledge base that supports the design of professional development programs. It explores what we know about learning and learners, teaching and teachers, the nature of science, change and the change process, and the characteristics of effective professional development. Moreover, the issue of embedding exemplary curriculum materials in professional development is examined in this section. Section 3.4 presents the implications drawn from the literature review. It discusses what is possible and what is not, in light of the context and needs analysis results presented in the previous chapter. This section concludes with a distillation of design guidelines that are employed for elaborating the professional development scenario of the study.

3.1 TRENDS IN SCIENCE CURRICULUM DEVELOPMENT AND REFORM INITIATIVES

The notion of reforming the science curriculum has been on the agenda of most countries across North America and Europe ever since the Sputnik launch in the late 1950s. The driving force of these endeavors had been the need to apply science and technology education to the modernization and development of their economies (Black & Atkin, 1996). In his review of science curriculum development, van den Akker (1998) has outlined two distinctive waves of science curriculum reforms and one emerging initiative worldwide, a systemic reform. The first wave of reform in science and mathematics curricula occurred in the late 1950s. It was characterized by large-scale curriculum development projects that emphasized on compartmentalization of academic subjects, science processes, and student practical work. In the early 1970s, the first wave of reform started to lose momentum, and the focus shifted onto evaluation of its impact, and was superseded by activities of the second wave (Fullan, 2000).

The second wave of reform had been initiated in North America due to the disappointing results of student learning outcomes, student participation, and societal awareness of science's side effects on the environment. The generic shift of emphasis in the science curriculum for the developed world is well illustrated by Ware (1992) in Table 3.1.

Table 3.1 *Trends on science reform initiatives (Ware, 1992)*

First wave*	**Second wave**
Preparation for a science career	Science for all students
Generation of science knowledge	Application of knowledge
Focus on the discipline	Focus on societal issues
Broad coverage of content	Less content = more learning
Science on the lab bench	Science in the community
Building of conceptual models	Personal decision-making
Mastery of content	'Ownership' of content
The teacher as lecturer	The teacher as manager
Class works as unit	Students work in groups

Legend: * not to be confused with the first and second wave of curriculum reforms in Eritrea.

With regard to developing countries, the precursor of present science education can be traced back to the first wave of curriculum reforms in the 1960s and 1970s (van den Akker, 1998; de Feiter, Macfarlane, Stoll, & van den Akker, 1998; Keeves & Aikenhead, 1995; Lewin, 1992). This was a time when most developing countries became independent and joined the faddish science reform initiatives of that time. The adoption of colonial curricula had been done with little contextualization, thereby undermining the indigenous culture of science learning and technology. In hindsight, this adoption sounds logical and heuristic considering the scarcity of context-specific empirical knowledge of curriculum change and the need for skilled manpower for the new nations. Such adoption, at best, has assisted in the achievement of the new national objectives, the establishment of curriculum development centers, and has provided a basis for ongoing revision of the education systems (Guthrie, 1986; Ogunniyi 1986). In the following decades, the need to reform science curriculum has been gaining prominence in developing countries for a number of concerns related to pedagogy, economic competitiveness and financial capacity to run academic science curricula (de Feiter et al., 1998).

These concerns are manifested in the launching of science curriculum development projects that are extensively reviewed in the literature of developing countries in general and sub-Saharan African countries in particularly by Guthrie (1986), Ogunniyi (1986), and Stoll, de Feiter, Vonk and van den Akker (1996).

In retrospect, these international shifts in the emphasis on science curricula initiated many reform efforts that have brought substantial change to science curricula in a number of ways. An exhaustive account of these reform efforts and their impact can be found in the reviews of van den Akker (1998), Keeves and Aikenhead (1995), Jenkins (1994), and Tamir (1991). However, at this point, it is sufficient to summarize the trends for improving science education across countries (van den Akker, 1998; Black & Atkin 1996; James et al., 1997). The trends are as follows:

- ephasis on student practical work;
- emphasis on experiential learning and application of knowledge across subject areas;
- more in depth understanding, inquiry, relevance to the real world, and problem solving;
- increased learner autonomy; and
- the changing role of the teacher.

Undoubtedly these trends are innovative, full of good ideas, and deserve a serious consideration in various contexts. The challenge is how to introduce them into educational systems that are staggering under ambitious science reform initiatives and contextual constraints. Research strongly indicates, however, the prospect of systemic reform as a plausible approach in bringing about the desired outcomes of educational innovations (van den Akker, 1998; Black & Atkin, 1996; de Feiter et al., 1998; Ware, 1992). Systemic reform addresses all elements of the education system and includes all the people and institutions which have any stake in the quality of education. As Ware (1992) aptly put it, in the long run, science education reform will achieve its more ambitious goals only through systemic reform. Van den Akker (1998) analyzed recent international initiatives and trends in improving science education world wide within the framework of systemic reform. He articulated these reform initiatives into seven themes–*national guidelines, meaningful content, scientific literacy, learning to learn, alignment of curriculum and assessment, ICT, and teacher professional development*. In this study more emphasis is paid to the last trend, the potential for teacher professional development utilizing curriculum materials as a vehicle for science reform initiatives.

3.2 THE RENEWED FOCUS ON PROFESSIONAL DEVELOPMENT

The dawn of a new century has brought many challenges to education systems. There is an explosive growth in the knowledge base of nearly all academic disciplines. The field of education, in particular, has been widely influenced by

new knowledge about teaching and learning. Schools and teachers are constantly subjected to overly ambitious and un-mapped reform initiatives aimed at improving student learning outcomes. (Ball, 1996). What is outlined in the preceding section is one example of such an unmapped initiative for teachers. It delineates the basic shifts in terms of what students have to learn and how they are taught science. If students are to achieve these innovative ideals, by default, teachers have to come into the equation since they must carry out the demands in the classroom. Most of the reform initiatives of the 1970s and 1980s were accompanied by professional development activities to facilitate teachers' implementation of these demands in their classrooms. However, the evaluation studies that documented the process of implementation and learning outcomes of the reform initiatives indicate a lack of contribution of professional development programs in giving teachers the support they need (Fullan, 2001).

There is a widespread recognition that most of the traditional approaches to professional development were not properly tuned to visions about teaching and learning as reflected in the reform initiatives (Guskey, 2000; Fullan, 2001). Professional development was viewed as a package of knowledge to be distributed to teachers in bite-sized pieces. This implies a limited conception of teacher learning, one that is out of step with current research and practice (Lieberman, 1996). The professional development experiences had been a series of disjointed activities that made little difference in the development of teachers' knowledge, skills, and reflective practices, and ultimately in the learning outcomes of students (Guskey, 2000). Many studies have attempted to reveal the problems and limitations of traditional approaches in an effort to improve the effectiveness of professional development for doing service to teachers and students. The following reasons and limitations were documented for the failure of these professional development programs (Darling-Hammond & McLaughlin, 1995; de Feiter et al., 1998; Fullan, 2001; Guskey, 1995, 2000):

- teacher professional development has been limited by lack of knowledge of how teachers learn;
- teaching has been described as a technical set of skills leaving little room for invention and the building of craft knowledge;
- professional development opportunities have often ignored the critical importance of the context within which teachers work. They hardly take into account the realities of many schools and students;
- strategies for change have often not considered the importance of support mechanisms and the necessity of learning over time;
- the theory of implementation and process of change has been inadequate. In-service programs rarely address individual concerns, and sometimes gloss over those concerns without adequate experiences themselves;

- one-shot workshops are too short to be effective. They are focused on faddish ideas and not based on well-documented research evidence. Topics are frequently selected by people other than those for whom the in-service is intended. Follow-up support for ideas and practices occurs in only minority of cases.

It is because of this backdrop and the aforementioned limitations that increased attention has been paid to the connection between curriculum reform and teacher professional development within the framework of systemic change (van den Akker 1998; Corcoran 1995; Garet, Porter, Desimone, Birman, & Yoon, 2002; Guskey, 2000). Among other requirements, sustainable impact and change in classroom practices would be carried out by addressing teachers' implementation problems and through meaningful professional growth. The next section (3.3) focuses on state-of-the-art-knowledge of professional development.

3.3 CURRENT KNOWLEDGE BASE THAT SUPPORTS PROFESSIONAL DEVELOPMENT

Dating back to the early 1990s, the literature on professional development comprises a body knowledge that is at the disposal of professional development designers. This body of knowledge is based on a consensus of views among experienced practitioners, case studies, and recently emerging, purely empirical data (cf. Garet et al., 2001). Loucks-Horsley et al. (1998) describe this knowledge base as the knowledge substantiated in research, literature, and in the wisdom of experienced professional developers. According to Loucks-Horsley et al. (1998) five distinct and interrelated bodies of knowledge are relevant for development designers. These are:

1. what we know about learners and learning;
2. what is known about teachers and teaching;
3. the nature of science;
4. change and the change process; and
5. characteristics of effective professional development.

The following section explores the knowledge base from these five areas in an effort to sharpen the focus of the study and to generate design guidelines for development of the professional development scenario.

3.3.1 Defining professional development

It appears that terms like professional development, INSET, staff development, and in-service education are sometimes used interchangeably in the literature, depending on the emphasis, duration, and scope of activities attached to them. Throughout this review, professional development is adopted as a generic term, broad enough to embrace the other terms and reflect certain attributes associated with each of them within the context of reform initiatives. According to the ERIC database, *professional development* refers to those activities that are purported to enhance professional career growth. Such activities may include individual development, continuing education, and in-service education, as well as curriculum writing, peer collaboration, study groups, and peer coaching or mentoring. Fullan (1991) defines professional development as the sum total of formal and informal learning experiences throughout one's career from pre-service teacher education to retirement. Loucks-Horsley et al. (1998) expand the definition of professional development to denote those opportunities offered to educators to develop knowledge skills, approaches, and dispositions to improve their effectiveness in their classrooms and organizations. Guskey (2000) elaborated the definition of professional development further. He referred to those processes and activities designed to enhance the professional knowledge, skills, beliefs and attitudes of educators so that they might in turn improve the learning of students. The following embraces Guskey's definition as a working definition because it captures the purpose of this study.

3.3.2 Conception of learners and learning

Recent research on learning has significantly changed the fundamental understandings of learning, learners, and how students learn best. Over the past decades conceptions of the learner have changed from individuals who receive and memorize information and practice skills to individuals who actively process information and construct understanding by relating it to what they already know (Blumenfeld, Marx, Krajcik, & Soloway, 1997). This shift in emphasis is influenced by learning theories of the times that attempted to make sense of learning. Broadly speaking, these learning theories could be subsumed under the umbrella of behaviorist and cognitive frameworks.

Behaviorism is one of the main theories that contributed to traditional approaches to learning and teaching. The behaviorist theory of learning focused on observable behaviors rather than mental operations, identified concepts like discrimination learning, generalization gradients, stimulus control, and fading as the operating mechanisms controlling learning. Learning is conceived of as a process of

conditioning observable learner behavior through selective reinforcement of learner responses to events that occur in the environment. The conception of the learner within such a framework is as passive recipient and *tabula rasa* (blank slate), malleable to direct instruction and prone to absorb scientific knowledge while listening to the teacher (Mestre, 1994; Murphy, 1997). There are at least two things absent from the aforementioned behaviorist conceptions of learning and learners. These are lack of interest in the cognitive mechanisms used by the individual and whether or not what is learned made sense to the learner.

Even though behaviorism explains many human behaviors and has a legitimate place in learning and teaching—as was demonstrated through the process-product studies—it is not sufficient to explain all the phenomena observed in learning situations. Several researchers argued that traditional behaviorist theories of learning could not adequately identify mechanisms accounting for student learning and why students develop misconceptions substantially different from the scientific concepts held by scientists (Blumenfeld et al., 1997; Duit & Treagust, 1997). To this end, cognitive psychology appears to offer a framework that could account for the mechanisms that take place in the mind of learners while learning. That is, within cognitive frameworks of learning, more emphasis is placed on the cognitive processes learners engage in as they learn. Blumenfeld et al. (1997) argued that these cognitive processes are important because they mediate between the instructional events organized by teachers and the ultimate learning students achieve. In other words, learning takes place not only because of what the teacher does during the lesson but because of the cognitive processes the learner uses. Learning is conceptualized as a student-mediated process that takes place when the learner imposes meaning and organization on experience by relating it to existing knowledge (Bransford, Brown, Donovan, & Pellegrino, 1999).

Following Piaget's seminal work on the cognitive development of children and the information processing theory of learning, great strides were made in cognitive research, paving the way for constructivist perspectives that renewed the centrality of the learner in theories of classroom learning (Prawat, 1989). Basically, constructivism means that as we experience something new, we internalize it through our past experiences or previously established knowledge constructs (Crowther, 1997). The constructivist view of learning and teaching has been a highly controversial approach in education, strongly criticized by some (Illman, 1998; Matthews, 2002; Phillips, 1995; Osborn, 1996) and vigorously defended by others (Duit & Treagust, 1997; von Glasersfeld, 1995; Lorsbach & Tobin, 1992). The literature is replete with many different sects of constructivism, which further compounds the confusion of readers to make sense of this learning theory. That said, at the heart of these differing constructivist views is the idea that conceptions held by each learner

guide understanding; knowledge is not transmitted but constructed as a result of cognitive processes within the human mind; and the development of understanding requires active engagement on the part of the learner (Bransford et al., 1999; Borko & Putnam, 1996; Duit & Treagust, 1997; Jenkins, 2000).

Constructivism stands in stark contrast to the conception of learning and learners in behaviorist frameworks. Constructivists view students as bringing to the classroom their own ideas, experiences, and beliefs, all of which affect how they understand and learn new material. Rather than receiving material in class as it is given, students restructure the new information to fit into their own cognitive frameworks. Although it is hard to ignore the popularity of constructivist theories of learning in science education, there is a cautious tendency in science education literature toward an inclusive view that harnesses the different theoretical orientations about learning and learners. The contemporary conception of learning and learners is best captured as a middle ground between traditional and constructivists approaches, although much skewed toward the latter. A synthesis of research on learners and learning (Alexander & Murphy, 1998; Bransford et al., 1999; Borko & Putnam, 1996; Loucks-Horsley et al., 1998) asserts that:

- learners' existing knowledge serves as a foundation of future learning by guiding organization and representations, by serving as a basis of association with new information, and by coloring and filtering new experiences;
- learners come to the classroom with preconceptions about how the world works;
- learners acquire new knowledge by constructing it for themselves, and this construction is as much a socially shared undertaking as it is personal and situated in a particular context;
- construction of knowledge is a process of change that includes addition, creation, modification, refinement, restructuring, and rejection. This process of change could be described by the quadriga "dissatisfaction-intelligible-plausible-fruitful" of the new ideas as compared to learner's prior knowledge;
- learning is a process that learners need to do for themselves. Learners' ability to reflect upon and regulate their thoughts and behaviors is essential to learning and development. That said, collaborative efforts can yield more learning than individual efforts.
- motivational or affective factors, such as intrinsic motivation, attributes for learning, and personal goals, along with the motivational characteristics of the learning tasks, play a significant role in the learning process;

3.3.3 Conception of teachers and teaching

The contemporary views of learning and learners portrayed in the preceding section demonstrate a redefinition of traditional conceptions of the teacher,

teaching, and teacher learning. There is a significant departure from behaviorist conceptions in that the teacher's role as dispenser of knowledge and skills is de-emphasized, and s/he is considered a guide and facilitator of student learning (Loucks-Horsley et al., 1998; Putnam & Borko, 1997). The teacher creates and orchestrates complex learning environments, engages students in appropriate instructional activities so that students can construct their own understanding of the material being studied, and works with students as partners in the learning process (Schuell, 1996). Broadly speaking, the current view of student learning is relevant to teacher learning as well (Bransford et al., 1999; Putnam and Borko, 1997). Borko and Putnam (1996) explained that the learning of individuals, including teachers, is a constructive and iterative process in which people interpret events on the basis of existing knowledge, beliefs, and dispositions. Thus, what and how teachers learn is shaped and filtered through the lenses of their existing knowledge, beliefs and practices.

By and large, these changes envisioned in current reform initiatives demand from teachers an awful lot of change in their roles, knowledge, and beliefs about teaching, learning, learners, and subject matter (Bransford et al. 1999; Putnam & Borko, 1997). Teachers must learn the required knowledge, learn complex skills, unlearn or reinterpret familiar skills, and change beliefs (Ball, 1996; de Feiter et. al., 1998). All these make learning to teach in new ways a complex and daunting task for teachers (Ball, 1996; Loucks-Horsley et al., 1998; Putnam & Borko, 1997). It goes without saying that helping teachers learn through professional development opportunities is critical if they are going to move successfully toward the new visions underscored in reform initiatives. Borko and Putnam (1996), from their comprehensive analysis of literature on learning to teach, suggest five features that facilitate teacher learning in professional development opportunities for practicing teachers. These five features are further expanded from current research on professional development (Hawley & Valli, 1999, 2000; Loucks-Horsley et al., 1998; Putnam & Borko, 1997, 2000). They are as follows:

- addressing teachers' pre-existing knowledge and beliefs;
- enhancing teachers' subject matter and pedagogical content knowledge;
- treating teachers as learners with an eye toward principles of adult learning;
- grounding teacher learning and reflection in classroom practice;
- time, support, and pressure.

1. Addressing teachers' pre-existing knowledge and beliefs

Teachers come to professional development opportunities with a number of expectations, knowledge, and beliefs that serve as a filter in their effort to learn new ways of teaching. According to Borko and Putnam (1996) this filtering of

learning experience occurs from the very general level of what learning teachers expect to get from educational opportunities to the much more specific aspects of their beliefs about the teaching and learning of particular topics. They have stressed that efforts to support teacher learning must recognize that teachers' knowledge and beliefs play a critical role in the development of the new understanding and practice. At the end of the day, it appears that what goes on in the classroom is a compromise of the intended knowledge and skills in light of teachers' preexisting knowledge and beliefs. Thus it is crucial that professional development opportunities explicitly address teachers' preexisting knowledge and beliefs. One way to do that is to enable teachers to reflect upon and make explicit their knowledge, beliefs, attitudes, and concerns about teaching, learning, learners, and the subject matter (Borko & Putnam, 1996). And it is equally valuable to assist teachers as they make their beliefs explicit. Teachers can be assisted by creating contexts in which they could examine and change their knowledge and beliefs.

2. Enhancing teachers' subject matter and pedagogical content knowledge

More often than not reform initiatives demand a strong conceptual understanding of the subject matter a teacher teaches. Teachers must have a rich and flexible understanding of the subject matter in order to teach in ways that are responsive to students' thinking and which foster learning with understanding (Borko & Putnam, 1996). The current view of the knowledge base for teaching underscores that, besides knowledge of subject matter, effective teachers need a pedagogical content knowledge that guides their actions in highly contextualized classroom settings (Bransford et al., 1999; Rowan, Schilling, Ball, & Miller, 2001).

According to Shulman (1986) this pedagogical content knowledge is described as a way of representing and formulating the subject that makes it comprehensible to others, and includes, among other things knowledge of how to represent and formulate content for student learning; knowledge of the common conceptions, misconceptions, and difficulties students encounter when learning particular content; and knowledge of specific instructional strategies and representations that can be used to address students' learning needs in particular classroom situations. Toward this end, Hawley and Valli (2000) argue that professional development needs to focus on the specific content that students are expected to learn, problems students might confront in learning the content, and instructional strategies that address anticipated problems. Teachers' should be provided with learning opportunities that help them deepen and expand their knowledge of the subject matter and pedagogical content (Borko & Putnam, 1996; Lucks-Horsley et al., 1998). Garet et al. (2001) provided empirical evidence of these assertions from a national

probability sample of teachers in the USA. They reported that those professional development programs with content focus have improved and deepened teachers' pedagogical content knowledge in mathematics and science. The use of curriculum materials specifically designed with teacher learning in mind is a case in point (van den Akker, 1988b; Ball & Cohen, 1996). Curriculum materials can provide teachers with content for teaching for understanding, specific instructional strategies, and representations for presenting content in ways that support learning with understanding and address student thinking and prior conceptions or misconceptions.

3. Treating teachers as learners with an eye toward principles of adult learning

Boko and Putnam (1996) argued that teachers should be treated as learners in a manner consistent with the program's vision of how teachers should treat students as learners. Most of the successful professional development projects they reviewed treated teachers as learners in ways that were consistent with the project's perspective on student learning. It is important that teachers experience learning environments where subject matter and learners are treated in new ways *before* they try to successfully translate them into their own classrooms (Borko & Putnam, 1996; Loucks-Horsley et al., 1998). That said, Putnam and Borko (1997) caution educators not to overlook the important differences between the settings and goals of student learning and teacher learning. First, as Putnam and Borko (1997) point out, simply providing the same learning activities for teachers and students wrongly assumes that teachers and students need to learn the same things and bring similar qualities to the learning setting. Second, professional development is a type of adult learning, and is affected by inherent adult characteristics. The literature on adult learning advocates that honoring adults' wisdom and autonomy is essential for the effectiveness of professional development programs. (Knowles, 1984; Bray, 2000; Smith, 1981; Zemke & Zemke, 1988). A synthesis of research on the principles of adult learning (Bray, 2000; Knowles, 1984; Smith, 1981) asserts that:

- adults are autonomous, goal-oriented, and self-directed. They like to have control of what they learn, how they learn, and how they use what they learn. They must see the reason for learning something, and it has to be applicable to their immediate situations;
- adults seem to get the greatest benefit from learning opportunities that help them process their experience through reflection, analysis, and critical examination;
- adults display distinctive learning styles with their routines and strategies for processing already established information. They have stronger conceptual control over their own cognitive processes than younger learners. They need time to reflect on how to apply their new knowledge and skills and review what did

and did not work. Professional development programs hold the interest of adults if they are problem-centered, task-oriented, and when there is time for reflection.

4. Grounding teacher learning and reflection in classroom practice

Teachers must have the opportunity to learn about and reflect on new instructional strategies and ideas in the context of their own classroom practice (Borko & Putnam, 1996). This principle is based on the premise that knowledge is situated in a particular context where it is acquired and used. However, there seems to be little consensus about the powerful context for conducting or situating teacher learning experiences—in- or out-of-school settings. Putnam and Borko (2000) argue that there is evidence that professional development programs can successfully address this issue by systematically incorporating *multiple contexts* for teacher learning. The use of multiple contexts could entail a combination of workshops introducing theoretical and research-based ideas. This would include ongoing school support as teachers attempt to integrate these ideas into their classroom practice. A professional development team could provide feedback, demonstration, and opportunities for reflection during visits to teacher classrooms, as well as organize follow-up workshops for further exploration of issues deemed necessary. Although the most appropriate context for professional development depends on the specific goal for teacher learning, Putnam and Borko (2000) suggest that a combination of approaches in a variety of contexts holds the best promise for fostering powerful, multidimensional changes in teacher thinking and practices.

5. Time, support, and pressure

There is robust consensus across the literature that at the early stages of implementation teachers must be provided with sustained time and support for learning complex skills and acting differently in classroom (van den Akker, 1988b; Borko & Putnam, 1996; Garet et al., 2001; Fullan, 2001; Guskey, 2000, 2002; Joyce & Showers, 1995). Guskey (2002) explained that, at the early stages of implementation, teacher problems are multiple, pervasive, and unanticipated. Teacher support coupled with pressure at this time is vital for continuation. Guskey (2002) further stated that such support should allow the teachers involved in the difficult processes of implementation to lessen the anxiety of fellow teachers concerning occasional failures. Moreover, as Borko and Putnam (1996) and Loucks-Horsley et al. (1998) asserted, teachers must be provided with ample time for practice, reflection, and collaboration with their colleagues. It is unfair to expect too much too soon from those involved in implementation. This is not much better than pulling a plant out of the ground each day to check its roots for growth (Guskey, 2000; Lucks-Horsley et al., 1987). Thus, professional development must be

seen as a process, not as an event. Garet et al. (2001) state that the duration of professional development activities is expected to be important in two ways:

- overtime activities are more likely to allow teachers to try out new practices in the classroom and obtain feedback on their teaching.
- longer activities are more likely to provide an opportunity for in-depth discussion of content, student conceptions and misconceptions, and pedagogical strategies.

Teacher support with pressure can be offered in a variety of ways. Support for change can take the form of exemplary curriculum materials systematically embedded in professional development scenarios (van den Akker, 1988b; van den Akker & Plomp, 1994; van den Berg, 1996; Roes, 1997). Reform-based and field-tested exemplary curriculum materials could support teacher learning and practice by providing teachers with information on the intended change, modeling how the indented change looks, and offering them the opportunity to experiment with the lessons to gain insight into what the change entails for their classroom practice and students.

Support for change could also take the form of coaching (Guskey, 2000). Coaching is the provision of on-site personal support and technical assistance for teachers following initial training (Showers & Joyce, 1996). Coaching, as for supporting teacher learning and practice, may involve providing teachers with technical feedback, helping them adapt new practices to their unique contextual conditions, helping them analyze the effects of their efforts, and urging them to continue, despite minor setbacks (Joyce & Showers, 1988, 1995). Besides, teachers could be involved in peer collaborations where they can interact and share ideas with one another following initial professional development experiences. Although such teacher collaboration is a promising strategy, teachers need to be trained how to do it, and as such, this makes it an innovation in itself (de Feiter et al., 1998; Thijs, 1999).

3.3.4 Conception of the nature of science

There is growing evidence that teachers need to be aware of the nature of science (Abd-el-khalick, Bell, & Lederman, 1998; Putnam & Borko, 1997). Putnam and Borko (1997) indicated that the overarching conception of the nature of a subject serves teachers as a conceptual map for making judgments and decisions about learning goals, instructional strategies, curriculum materials, and evaluation of student learning. It is worth noting that Loucks-Horsley et al. (1998) argued that professional development experiences for teachers need to be consistent with the current view of the nature of science.

Abd-el-khalick et al. (1998) noted that though there is no consensus about the nature of science, it can generally be characterized as the epistemology of science–science as a way of knowing or values and beliefs inherent to the development of scientific knowledge. Historically, the nature of science has been a bone of contention among scientists of different philosophical persuasions, scientists who attempted to influence science education. The traditional conception of the nature of science, which is informed by realism, viewed science as a body of established knowledge comprising facts that are true and that have been known for a long time. Loucks-Horsley et al. (1998) explained that this view represents a static conception of the discipline of science and offered an alternative view. They argued that we should not ask only "What do we know about science?" but also "How do we know it? What does it mean to do science," and "Where does our knowledge come from?" These questions are reflected well in the following summary about the contemporary conception of the nature of science (Abd-el-khalick et al., 1998; Bell, 2001; Lederman, 1992; Loucks-Horsley et al., 1998):

- science is a human pursuit—as much invention as discovery—with a long history of competing schools of thought, changing fashions, and some questions which may never be settled. The scientific enterprise provides scientists with processes by which they develop knowledge, make judgments regarding what is "good" knowledge, and equally advance arguments for their judgments or conclusions.
- scientific knowledge is tentative (subject to change); empirically based (based on and/or derived from observations of the natural world); replicable, probabilistic; humanistic (reflects human attempts to impose order on nature); public (shared); historic (past knowledge should be judged in its historical contexts and should not be compared to contemporary conceptions); and unique (has its own set of rules and values).

Practical work in science education

One of the hallmarks of the wave of science curriculum reforms was an emphasis on practical work in science learning. Practical work in science education has been said to promote the learning of some of the well-advocated science education goals such as understanding of science concepts, processes of science inquiry, development of science practical skills, and science attitudes and interests. However, lately, the role of practical work in science teaching and learning has been increasingly questioned (Lunetta, 1998; Hazel, 1995). A number of classroom-based studies showed that mismatches between goals, behavior, and learning outcomes of practical works have been limiting their effectiveness in science teaching (Lunetta, 1998; van den Berg & Giddings, 1992). Such studies clearly indicate that the role of traditional practical work in science education needs to be

reconsidered if it is going to bear fruit in its advocated role in science teaching and learning. Van den Berg and Giddings (1992) explained that an improved design of practical work through careful distinctions between the different learning objectives (e.g. concepts, processes, and skill) can improve the effectiveness of laboratory experiments.

In a similar vein, de Feiter et al. (1998) argue that simpler and more natural contexts can be more effective than traditional practical work for a skills-oriented approach, such as the one advocated in recent reforms (cf. Dekkers, 1997). They stated that for a thorough understanding of basic science concepts, a constructivist design of lessons intended to develop and challenge students' misconceptions can also be effectively accomplished with the use of teacher-led demonstrations. Besides, other cost-effective alternatives to laboratory works are science kits, thought practical work, interactive demonstration, video presentations, and excursions, if they are systematically incorporated in science teaching.

3.3.5 Change and the change process

There is a great deal of consensus among educators about the process of change. The resounding assertion across the literature is that change is a process, takes time, and is a complex and highly personal process (Fullan 2001; Hall & Hord, 2001; Horsley & Loucks-Horsley, 1998). A useful framework for understanding, describing, and predicting the probable behavior when people and organizations are engaged in change is provided by the Concerns-Based Adoption Model (Hall, Hord & Huling-Austin 1987). As Horsley and Loucks-Horsley (1998) aptly noted CBAM has proven itself a crucial tool for designing and continually evaluating change initiatives for more than two decades. It provides a conceptual framework for understanding what happens to teachers while experiencing change, what possible assistance could be structured in the professional development experience, and how the behavioral changes of teachers can be assessed. According to Hall and Hord (2001) there are three principal diagnostic dimensions of CBAM, namely:

- the stages of concern;
- levels of use; and
- innovation configurations.

The stages of concern describe the affective dimensions of change. It describes how teachers develop (*concern*) perceptions, feelings, and preoccupations as they are introduced to something new. It identifies seven stages of concern that teachers are assumed to go through when plugged into the change process. Teachers' concerns and questions evolve from self-oriented (*awareness* stage 0, *informational* stage 1, and *personal* stage 2) to task (*management* stage 3) and impact-oriented ones

(*consequence* stage 4, *collaboration* stage 5, and *refocusing* stage 6). Hall and Hoard (2001) succinctly outlined four guiding principles of concerns theory relevant to professional development programs.

- We all have personal concerns when first confronted with change. Rather than condemning someone who has a high level of personal concerns, we first need to be empathetic and work to determine why these concerns are so intense.
- When you find a teacher with impact concerns, be sure to take the time to encourage him or her.
- Collaboration concerns are very rare in any organization, including schools. A school where both collaboration concerns and consequence concerns are intense truly shows an interest in students and collegiality about teaching.
- Stages of concern can be applied to both individuals and to groups. Both interviews and the Stages of Concerns Questionnaire (SoCQ) can be used to assess individual and group concerns.

The levels of use address the behavioral dimension of change and depict how teachers act as they become more familiar with and more skilled in using the intended changes. There are three levels of use that define non-users (*non-use*, level 0, *orientation*, level 1, *preparation*, level 3) and five distinct Levels of use that characterize users (*mechanical*, level 3, *routine* and *refinement* level 4, *integration* level 5, and *renewal* level 6). The following guiding principles of levels of use are outlined by Hall and Hord (2001). These are relevant to developing and monitoring the implementation of change initiatives.

- With any innovation each person exhibits some kind of behavior and thus can be identified as being at a certain level of use.
- An interview is the only means by which to successfully and efficiently collect LoU information. A written format can not sufficiently account for this purpose. The only alternative to the LoU interview would be extensive classroom observations guided by an innovation profile.
- Informally gathered information about an individual's LoU can be used for facilitating implementation of change; more rigorously collected LoU data can be used for conducting research studies of changes and for evaluating the extent of implementation.
- The levels of use are presented in a logical sequence, but this sequence is not always followed by everyone.

Innovation configuration is nothing but the different ways teachers adapt the intended changes to their unique situations. It is sometimes referred to as Practice Profiles (Horsley & Loucks-Horsley, 1998). It entails professional developers

formally defining the intended change and how the change should look when it is used in the classroom.

Generally, the major implications of CBAM for professional development are as follows:

1. the importance of paying attention to where teachers are and structuring the appropriate assistance and support to address their concerns;
2. the conceptual framework for developing and evaluating the extent of implementation of the intended change;
3. the diagnostic instruments for assessing the stages of concern (SoCQ) and levels of use.

3.3.6 Characteristics of effective professional development for science education

The literature abounds with lists of the characteristics of effective professional development, stemming apparently from literature review, best practices, and synthesis of research studies across different domains. Guskey (2003) carried out an analysis of the well-known 13 lists of characteristics of effective professional development developed within the last decade. He noted that there appears to be little consensus among researchers regarding the indicators for effectiveness of professional development. For the most part, *effectiveness* has been judged by an index of participants' self-reports on the professional development features that help increase their knowledge and change their instructional practices; and or a consensus of the opinions of professional development writers and researchers. That said, Guskey (2003) suggests, although those lists of effective characteristics are valuable, that they provide only a starting point. At the end of the day, it is the unique feature of the context that shapes the quality of professional development programs and activities. In what follows, seven characteristics or principles of effective professional development are summarized in an effort to capture contemporary conceptions about effective professional development in science and mathematics education. These characteristics are primarily drawn from Birman, Desimone, Porter, & Garet (2000); Guskey (2000, 2002); Hawley & Valli (1999, 2000); and Loucks-Horsley et al. (1998). They are as follows:

1. *Effective professional development programs recognize change as both an individual and organizational process*. Success in any improvement effort of professional development hinges on improving both the knowledge and skills of individual teachers and principals, and incorporating organizational features and policies within the wider system.

2. *They are driven by a clear, well-defined image of effective learning and teaching*. This image includes, among other things, a sensitivity to the diverse learning needs of individuals and people; an emphasis on inquiry-based learning, problem-solving, student investigation and discovery, and application of knowledge; an approach to the understanding of mathematical and scientific knowledge, and skills that help students construct new understandings through experiences that extend and challenge what they already know; development of in-depth understanding of core concepts in science and mathematics, not just breadth of coverage.
3. *They are primarily school-based and integral to school operations*. This does not mean denying teachers' access to out-of-school learning experiences such as workshops, but to emphasize that the most powerful opportunities to learn are often job-embedded. That is, job-embedded learning opportunities, be they in school or workshop settings, should enable teachers to see new strategies modeled, practice them, engage in peer collaboration, and continuously assess the effects of newly learned knowledge and skills in their respective classroom.
4. *They provide teachers with opportunities to develop and enhance their subject matter and pedagogical content knowledge*. This process may include:
   - Engaging teachers in learning experiences that enhance their understanding of major science and mathematics concepts and pedagogy. Teachers need deep, thorough knowledge of the disciplines they intend to teach;
   - Strengthening teachers' knowledge of and beliefs about how students learn, what difficulties students of a particular age might encounter in learning a new skill or concept, and what misconceptions they might hold. They also need to be prepared to help students overcome their difficulties and to unravel misconceptions.
5. *They use instructional methods to promote learning for adults which mirror the methods to be used with students*. Good learning opportunities for teachers are:
   - build on the teachers' existing knowledge, skills, and attitudes;
   - allow teachers to construct their own knowledge;
   - provide teachers with opportunities to work in collaborative teams, to engage in discourse about science, mathematics, teaching, and learning, and to observe the modeling of relevant, effective teaching strategies;
   - give science and mathematics teachers adequate and ongoing opportunities to develop, practice, and reflect upon new knowledge and strategies. Deep learning takes time, and takes place over time;
   - plan and design for structured, continuous opportunities for follow-up.

6. *They incorporate systematic evaluation procedures and multiple sources for evidence on the effects of professional development activities*. This systematic investigation involves gathering and analyzing evidence of participants' reactions, learning, school organization and support, use of new knowledge and skills, and student learning outcomes. It must be non-threatening, conducted throughout various stages of implementation in ways that also contribute to improvement of the overall design of the professional development program.
7. *They foster coherence of professional development activities with policies and other professional experiences*. Coherent professional development is that which maintains:
   - connections with teacher learning goals and other activities;
   - alignment of content and pedagogy in the activities with state or district standards and assessments;
   - professional communication among teachers who are engaged in efforts to reform their teaching in similar ways.

3.3.7 Embedding exemplary curriculum materials in professional development

A curriculum material is a tool that helps the teacher implement the curriculum or innovation in the classroom. Ball and Cohen (1996) point out that unlike frameworks, objectives, assessments, and other mechanisms that seek to guide curriculum, curriculum materials are concrete and daily. They are the stuff of lessons and units, what teachers and students do, and have a uniquely intimate connection to teaching. It is this intimacy of curriculum materials to the classroom that offers support to teachers by illustrating exemplary practices in the context of educational change. Van den Akker (1988b) argued that exemplary curriculum materials could support the initial implementation efforts of teachers when they have neither the familiarity nor prior commitment to the new change. At this early stage, exemplary curriculum materials offer teachers a clearer understanding of how to translate curriculum ideas into classroom practice. They also offer a concrete foothold for the execution of lessons resembling the original intentions of designers, and stimulate reflection on one's own role, with the possibility of adjusting one's own attitude to the innovation. These potential functions of exemplary curriculum materials are explored widely in developed and developing countries (van den Akker 1988b; van den Berg, 1996; Roes, 1997; Ottevanger, 2001; Stoll et al., 1996; Stronkhorst, 2001; Thijs, 1999). The reports coming out of these studies indicate that curriculum materials with procedural specifications could help teachers overcome initial implementation problems and help them behave differently towards desirable changes. The same studies suggest that in order to

bolster the efficacy of exemplary materials, they have to be systematically embedded in professional development scenarios in ways that robustly facilitate change in teachers' beliefs and the reflections needed for transforming the intended change into classroom practice.

Van den Berg (1996) reported that the integration of exemplary materials into an in-service scenario inspires teachers to try new things and provides them with a successful first time experience that increases the opportunity for using the intended change in their classrooms. Exemplary curriculum materials, when systematically embedded in professional development, could strengthen some of the training components of the Joyce and Showers (1995) model and peer collaboration activities in school (Almekinders & Voogt, 2003; Ottevanger, 2001; Stronkhorst, 2001; Thijs, 1999). De Feiter et al. (1995) have articulated the potential benefits of integrating exemplary materials with the Joyce and Showers (1988, 1995) model, as follows. Exemplary material can be used to provide teachers with:

- a clear explanation of the ideas behind the intended change, e.g. the improvement of the teaching repertoire or curriculum innovation. The materials provide background information about the rationale behind the intended change(*theory exploration*);
- concrete examples of what these ideas look like in classroom practice, e.g. written exemplary lessons or video recordings. Exemplary lessons in the materials serve as demonstrations of the 'ideal' performance but also illustrate typical problems in practicing the lesson (*demonstration*);
- opportunities to practice during the in-service sessions, in the teachers' own classes. The materials can help teachers practice skills by means of the procedural specifications of teacher behaviors in lesson examples (*simulated practice*);
- opportunities for both structured feedback and informal exchange of experiences (*feedback*);
- follow-up support and coaching in adapting instructional materials or developing new ones (*coaching*).

Characteristics of exemplary curriculum materials

From the abovementioned functions of exemplary curriculum materials, the next logical question is what characteristics they should have in order to serve those functions. Van den Akker (1988a) explained that exemplary materials should support teachers with clear and concrete guidelines for dealing with anticipated problems during the initial phase of implementation of the new approach. He identified four frequent areas of implementation problems in primary science education that the materials need to proactively address. These are:

1. lesson preparation as a complex and time-consuming task;
2. insufficient knowledge of and confidence in subject matter;
3. difficulties in changing the teacher's role, especially with regard to more active and inquiry-oriented learning;
4. an unclear view on, and little realization of, learning effects in pupils.

For each of these problems, van den Akker (1988a) has formulated a set of potentially fruitful procedural specifications. This set of specifications for lesson planning and execution should focus on essential but vulnerable elements of the innovation:

- *Lesson preparation:*
  Estimation of time; list of resources and provisions; suggestions for task orientation; stimulation to study the lesson description actively.
- *Subject matter:*
  Concise and clear information about central elements; outlines of key-concepts and activities; possible questions and answers; suggestions about how to deal with knowledge.
- *Teaching pattern:*
  Suggestions for grouping and for the distribution of tasks and materials; sequence of activities, including suggestions for starting up, for the selection of topics, and for avoiding or solving learning problems; possible variations in the instructional process.
- *Learning effects:*
  Exemplary descriptions of potential learning effects in pupils; suggestions for assessing and evaluating those effects.

Similarly, in the USA, Wormstead et al. (2002), Singer et al. (2000), and Schneider and Krajcik (2002) reported on the characteristics of curriculum materials aimed at supporting teacher and student learning in innovative science approaches. For example, Schneider and Krajcik (2002) designed curriculum materials based on known challenges to inquiry-based curriculum and based on Ball and Cohen's (1996) five domains that need to be considered during the process of curriculum material development. These materials were designed as part of a professional development program for supporting teacher and student learning, and included the following features: (a) they addressed each area of knowledge necessary for exemplary practices—content knowledge, pedagogical knowledge, and pedagogical content knowledge (PCK), (b) they situated teacher learning by meshing the content of the support to lessons for students, (c) they linked different knowledge areas within lessons, (d) they made knowledge accessible to teachers by

including short scenarios in the language of teachers or students involved in the lesson to illustrate intended practice when possible, and (e) they addressed immediate needs for understanding as teachers plan lessons that will be enacted within a short time.

Van den Akker's (1988a) set of procedural specifications appear empirically rigorous. His set of procedural specifications has been validated and refined in several research and development projects in curriculum and courseware development in the Netherlands and Southern African countries (van den Berg, 1996; Roes, 1997; Ottevanger, 2001; Stronkhorst, 2001; Thijs, 1999).

3.4 CONCLUSION AND IMPLICATIONS

3.4.1 Conclusions

The context and needs analysis has identified a gap between the current state of practice and the visions of biology education set forth in the first and second waves of curriculum reforms in Eritrea (MOE, 1998a, 2000). It concluded, among other things, that comprehensive in-service education was an ameliorating solution to the existing situation in Eritrea. On the basis of this conclusion and deliberation with experts, this chapter endeavored to explore the relevant knowledge base supporting the design of a professional development scenario for the study. It examined the current conceptions about learning and learners, teachers and teaching, the nature of the science subject, change and the change process, and characteristics of effective professional development. Last but not least, this chapter has explored the integration of exemplary curriculum materials in professional development.

This chapter has yielded information and insights into what constitutes an effective professional development scenario for science education, the possible implementation problems, and the principles for implementing change and supporting teachers' learning and practice in the change process. The lessons learned indicate that the current conceptions of learning, learners, and teaching are very demanding, including Eritrean teachers. Considering the result reported in section 2.2, teachers have to adopt new roles, need to be well-versed with new understandings about learning, learners, subject matter, and pedagogical content knowledge. It appears that such change is a complex process and its implementation demands guiding teachers' through effective professional development scenarios that are well-informed by the aforementioned knowledge bases and adapted to the unique features of the user context, Eritrea. Thus, to tackle this challenge, it seems prudent for the study to employ strategies of workshops, exemplary curriculum materials, and follow-up coaching for supporting teachers'

learning and practice. These strategies could be systematically integrated in the professional development of the study in ways that develop teachers' awareness, enhance their knowledge bases for teaching, and help them to translate the new knowledge and practice into their classrooms.

Furthermore, the context and needs analysis has highlighted the needs, direction, and focus of the study. Biology teachers have pointed out a need for in-service education that promotes student-centered teaching and learning, particularly professional development that would improve student participation and learning for understanding. Teachers have prioritized their perceived professional development needs on interactive demonstrations, student practical work, and group work. Upon careful reflection and consideration of the literature, it appears that the intervention of the study should focus on engendering a more student-centered learning with a particular focus on *practically oriented biology lessons*. The main tenets of the practically-oriented lessons should be interactive demonstrations, student practical work, and managing group work activities in large class size.
In what follows, the relevant implications are presented in light of the context; that is what is promising and what may not work in designing the intervention.

3.4.2 Implications for the study

Guskey (1995) noted that literature reviews conducted by professional developers for the purpose of synthesizing evidence across studies that supports the design of their professional development program often tend to eliminate the effects of context or try to decontextualize the data. What works in one situation may not work in another. Guskey suggests that even though general principles may be applied throughout the contexts, most will need to be adapted at least in part to the unique characteristics of that context. Thus, such reviews must focus on finding the optimal mix of effective practices that will work best in a particular setting. Keeping this in mind, the following implications are drawn for the study.

Learning and learners

The contemporary conception of learning and learners asserts that knowledge can not be transmitted effectively from one individual to another. Rather, knowledge is constructed actively by the learner using his/her cognitive processes. The learner's process of constructing a new knowledge starts with a foundation of everything he or she already knows—he or she is not a tabula rasa. More often than not students come to science class with prior conceptions about the topic at hand,, and at times these conceptions contrast starkly with the current knowledge about

science. These things need to be considered in the design of the curriculum materials and professional development activities of the study. The following implications, in particular, are warranted.

First and foremost, it is crucial to understand what students already know when they embark on any learning experience. Without such assessment of students' prior conceptions, it is difficult to set realistic goals and offer meaningful learning experiences to students. The second implication is the issue of engaging students in active learning and putting them at the center of the learning process via a variety of student-centered instructional strategies.

Third, since new knowledge will be learned in the context of old knowledge, it is important to understand students' prior knowledge so that the new material can be organized and presented in a way most appropriately related to the old knowledge.

Finally, it is important to understand that some students bring to the classroom misconceptions that could interfere with their present or future learning. Simply telling the learner that some of their knowledge is wrong and attempting to provide them with the right knowledge, may or may not work. Thus, teachers should help challenge students to correct them themselves, and should be equally sensitive to those mechanisms known to contribute to the formation of misconceptions in particular concepts, and they should attempt to minimize their occurrence in the classroom.

Teachers, teaching, and their learning

Current views of teachers and teaching demand a lot of change in teacher roles, knowledge, and beliefs about learning, learners, and the nature of the subject they teach. The traditional role of teachers is extended to include facilitating and guiding students' learning process and knowledge constructions. Teachers must have a rich and flexible understanding of the subject matter in order to teach in ways that are responsive to student thinking and which foster learning with understanding. Knowledge of content and general pedagogical knowledge are not enough; teachers must have pedagogical content knowledge to teach in highly contextualized classrooms. Needless to say, learning to teach in ways consistent with the aforementioned views is a complex and daunting task. Teachers need to learn new roles, knowledge, and need to re-align their beliefs toward these ends through professional development and other support strategies. The following principles facilitate the teacher learning process and help guide their practices toward the desired ends, in terms of professional development activities.

- exploring and addressing teachers' pre-existing knowledge and beliefs about learning, teaching, students, and the subject matter;
- enhancing teachers' subject matter and pedagogical content knowledge;

- treating teachers as learners consistent with the principles of adult learning;
- grounding teacher learning and reflection in classroom practice; and
- providing teachers time and support coupled with pressure in their respective schools.

Towards the professional development scenario of the study

As Guskey (1995, 2003) aptly pointed out, there is no doubt today a clear vision of what would be the ideal characteristics of professional development. Most professional developers recognize that professional development must include organizational development as well as individual development. They also see that professional development must be built on principles of effective professional development. Moreover, they are becoming more serious about the issues of program evaluation. Nevertheless, the exact process by which this vision can be accomplished is still blurry and confusing. This is because the process is so highly contextualized. In other words, real-world contextual differences profoundly influence the characteristics of professional development (Guskey, 2003). Coming back to the study, it appears that the seven characteristics of effective professional development mentioned in section 3.4.6 are relevant and that the professional development scenario of the study should consider them across its components in light of the Eritrean context. This will be elaborated more in the next chapter.

It is, at this point, necessary to point out that some features of effective professional development might not be embraced to their fullest in the professional development scenario of the study because of contextual constraints. A case in point is the promotion of collegiality and collaboration among teachers, which is the most consistently noted characteristic of effective professional development (Guskey, 2003; Thijs, 1999). The contextual characteristics presented in Chapter 2 show that Eritrean teachers are over-stretched with teaching loads and that there is a lack of infrastructure and culture of collegiality for promoting professional collaboration in schools.

Secondly, the issues of duration and attending to the organizational development are too difficult to be influenced in ways that fully nurture the program in the study. In conclusion, the effectiveness of professional development could be greatly influenced by contextual characteristics. Nevertheless, as Guskey (1995) put it, professional development efforts should be designed with long term goals based on a grand vision of what is possible. Think big, but start small, should be the guiding maxim for the study.

The characteristics of the professional development scenario are laid down as follows.

Purpose of the professional development scenario

The overall purpose of the scenario should be promoting student-centered teaching in biology education, and in so doing, improve the learning outcomes of students. The scenario should strive to provide biology teachers clarity of and guidance for implementing *practically oriented biology lessons*, the opportunity to learn about and practice such lessons, school follow-ups, and a supportive school environment. More specifically, the scenario would be geared toward promoting a more student-centered approach by focusing on the following goals:

- developing teacher awareness on practically-oriented lessons;
- building teachers' knowledge, skills, and attitudes about practically-oriented lessons;
- supporting teachers' learning and their efforts for translating the new knowledge and skills into classrooms;
- providing teachers opportunities for reflection on their learning, and teaching practically-oriented lessons; and
- establishing a supportive school environment.

Structure of the professional development scenario

Needless to say, professional development comes in many forms depending on its main purpose and contextual characteristics. Birman et al. (2000) distinguished the different forms as traditional format and reform types of professional development. The traditional forms include workshops, institutes, courses, and seminars that are conduced outside the school. Study groups, mentoring, coaching, and others forms that take place in the school are considered reform types. It appears that the most widely criticized structure of professional development, by far, are workshops and variations thereof. They are criticized as being ineffective in providing teachers with insufficient time activities and content necessary for increasing their knowledge and fostering meaningful changes in their classroom practice (Loucks-Horsley et al., 1998). That said, Birman et al. (2000) and Garet et al. (2001) showed that the traditional workshop format can be effective as long as it exhibits appropriate duration, content focus, active learning, and coherences. The empirical results of Garet et al., (2001) indicate that the characteristics of the activities in the professional development matter, not the form. In the study, the inherent limitations of the workshop format should be strengthened with the Joyce and Showers (1988, 1995) model, which incorporates principles of effective professional development, curriculum materials and school follow-ups. The professional development scenario is structured as follows in ways that foster the goals of the program outlined earlier.

(i) A workshop that includes the following components of the training model
- exploration of the theoretical basis of practically-oriented biology teaching;
- demonstration;
- practice in a simulated setting;
- structured feedback and discussion of performance.

(ii) Exemplary curriculum materials (i.e., those which support the aforementioned training components and serve as a written-coach in school).

(iii) School follow up-support
   a. First school-based workshop
      - structured reflection sessions.
   b. Technical coaching
      - classroom observations;
      - structured individual feedback on practice.
   c. Concluding workshop
      - structured reflection session;
      - general feedback and discussion.

(iv) A supportive school environment.

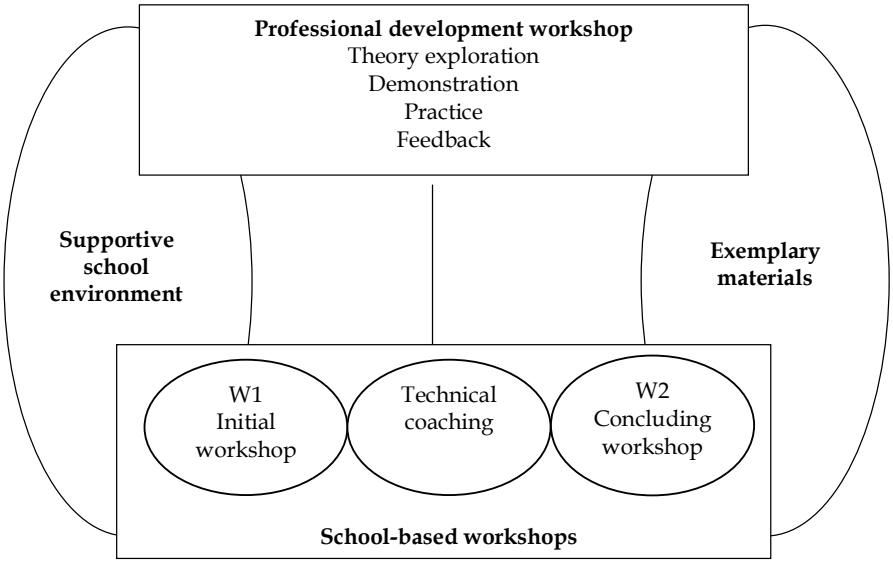


Figure 3.1 Structure of the professional development scenario

Design guidelines for elaborating the professional development scenario

The following design guidelines are considered for elaborating these components of professional development.

1. The professional development scenario should be built and nurtured on the principles of *effective professional development, adult learning, student learning, teaching science, and the change process* that pertains to implementing practically-oriented biology lessons. These principles need to be honed in such a way that they could mesh with the four components of the support scenario. Moreover, the study should strive to foster coherence of the professional development activities with national policies and components of the program, too.
2. The *professional development workshop* should focus on developing awareness and augmenting teachers' content and pedagogical content knowledge and skills in practically-oriented lessons, fostering the transformation of this knowledge and these skills into practice, and providing teachers with opportunities to reflect deeply on their learning and the practices of such lessons. The Joyce and Showers (1988, 1995) model (*theory, demonstration, practice, feedback, and follow-up coaching*) and exemplary curriculum materials should be instrumental in serving the purposes of the course within the Eritrean context. Toward these ends, the *professional development workshop* should be tuned up to provide teachers with opportunities to:
   - reflect upon and examine their knowledge, beliefs, attitudes, and concerns about practically-oriented lessons;
   - gain an understanding of the theories underlying the knowledge and skills of practically-oriented lessons;
   - observe a demonstration or model of what an exemplary biology lesson looks like in the classroom;
   - design a practically-oriented biology lesson under simulated conditions, e.g. designing a lesson on the basis of the exemplary curriculum materials; teaching such a lesson through microteaching.
   - get structured reflection and feedback.
3. Exemplary curriculum materials that have undergone a *cyclic and iterative* design and formative evaluation should be embedded in the professional development scenario. These exemplary materials need to effectively exemplify what *practically-oriented lessons* look like and support teachers' learning and practice about such lessons at workshops and later in the school. The exemplary curriculum materials that would be developed would have the following characteristics:
   - a clear *explanation* of the theories and rationales informing practically-oriented lessons;
   - concrete examples of what practically-oriented lessons look like in the classroom with procedural specifications. The specifications will focus on lesson preparation, subject matter and pedagogical content knowledge, and how to monitor and assess student learning effects;

- 4–6 *exemplary lessons* on topics that are closely linked to the textbook and which are taught right after the training workshop;
- standardized lay-out.

4. The follow-ups and exemplary curriculum materials should give teachers the necessary *pressure* and *support* to implement practically-oriented biology lessons. The type of coaching activities provided via *follow up support* should focus on assisting teachers in transferring the learning into classrooms right after the workshop. This should involve providing teachers with technical feedback, helping them adapt the new practices to their unique contextual conditions, helping them to reflect and analyze the effects of their efforts, and urging them to continue despite minor glitches. It also appears helpful to embrace the added value of the CBAM as a diagnostic tool for pinpointing *where teachers are and structuring appropriate assistance* during implementation in schools. Generally, the *school follow up scenario* will have the following characteristics.
   - It will be flexible enough to accommodate individual teacher's concerns. In other words, the kind of coaching forms provided should be dictated by the very nature of assistance needed by individual teachers;
   - It will consider the issue of *nonjudgmental feedback*; verbal feedback would only focus on salient, manageable issues that pertain to the basic tenets of the student-centered approach delineated in the study.
5. The professional development scenario should solicit as much *organizational support* as possible that would augment the process of implementation in schools.
6. There must be a mechanism in place to systematically assess the quality of the exemplary curriculum materials and the overall professional development scenario. The scenario should incorporate systematic evaluation procedures and multiple sources for evidence on the effects of the professional development activities. The professional development scenario evaluation would involve gathering and analyzing evidence of participants' reactions, learning, school organization and support, use of new knowledge and skills, and student learning outcomes. It must be non-threatening, conducted throughout various stages of implementation in ways that also contribute to the improvement of the overall design of the professional development scenario.

CHAPTER 4
Design and formative evaluation of exemplary material

This chapter presents the design and formative evaluation of exemplary curriculum materials embedded in the professional development scenario. Section 4.1 introduces the preliminary design of the scenario. Section 4.2 gives an overview of the design approach and formative evaluation of exemplary materials. The formative evaluation to improve the validity of the exemplary material on diffusion and osmosis is reported in section 4.3., while the formative evaluation to improve the practicality of the material is described in section 4.4. Section 4.5 reports the formative evaluation conducted to improve the effectiveness of the exemplary material. Finally, section 4.6 gives an overview of the final set up of the exemplary material.

4.1 INTRODUCTION

Chapter 3 has laid down the groundwork for the professional development scenario. Section 3.5, for example, revealed several relevant implications and preliminary design decisions about the scenario. Upon expert deliberation and the relevant professional development knowledge base, a decision was made to concentrate the scenario on promoting a student-centered approach with a focus on practically oriented biology lessons. The study recognizes that embracing practically oriented biology teaching is not an easy change for teachers because doing so requires treading on uncharted territory. The teachers have to assume new roles and understanding, and change related beliefs. Taking this into consideration, the study tackled these challenges with a professional development scenario that comprises exemplary curriculum materials, a professional development workshop, a school follow-up, and a supportive school environment. In this chapter, the design and formative evaluation of the exemplary curriculum materials is presented. The design and formative evaluation of the other components of the professional development scenario is reported in Chapter 5. Table 4.1 presents an outline of the four components of the professional development scenario.

Table 4.1 *Outline of the professional development scenario*

Components	Description
Professional development workshop	The workshop will be held for one day. It will be structured on the basis of Joyce and Showers' (1995) model that includes presentation of theory, demonstration, practice, and structured feedback. The teachers will be provided the following: ▪ opportunities to examine their concerns and prior conceptions; ▪ descriptive information on the basic tenets of practically oriented lessons and how they will affect them personally; ▪ a model of how the intended change will look like in classroom practice using video clips; ▪ opportunities for exploring and practicing the teaching of practically oriented lessons under a simulated condition (microteaching); and ▪ opportunities for plenary discussions, reflections, and feedback.
Curriculum materials	The exemplary materials will be integrated in ways that bolster the professional development workshop and the school follow-ups. The exemplary curriculum materials will be designed in ways that fulfill the following functions: ▪ clarifying the "what, why, and how" aspects of practically oriented lessons in ways that enhance subject matter and pedagogical content knowledge; ▪ exemplifying practically oriented lessons with concrete written lesson materials; ▪ providing teachers with support in lesson planning and execution; ▪ providing teachers an effective lesson format; ▪ providing teachers opportunities to practice during the workshop and in their own classes; ▪ providing 'written coaching' and opportunities for collaboration with fellow teachers.
School follow-up support	This component of the scenario will be carried out for 2-3 weeks at participant schools after the professional development workshop. It will involve organizing two school-based workshops and three cycles of classroom observations and feedback. The structure of the school follow-up was outlined as follows: *First school-based workshop* ▪ structured reflection and discussion sessions on practice; ▪ completion of Stages of Concern Questionnaire; ▪ planning for classroom observation. *Classroom observation* ▪ discussions on teacher concerns and implementation problems; ▪ lesson observations followed with individual feedback focused on matters pertaining to the basic tenets of practically oriented lessons. *Concluding school- based workshop* ▪ structured reflection and discussion sessions; ▪ overall feedback with special reference to researcher's classroom observations accompanied with vignettes or anecdotes.
A supportive school environment	The researcher will solicit school support that facilitates implementation of practically oriented lessons from the school principals.

4.2 APPROACH TO DESIGN AND FORMATIVE EVALUATION OF EXEMPLARY MATERIALS

The study employed the methodological guidelines of development research for designing exemplary curriculum materials as suggested by van den Akker and Plomp (1993) and refined in the studies of Ottevanger (2001) and Stronkhorst (2001). Among other details, this methodology also includes the following:

- selection of limited exemplary themes or topics;
- standardization of the structure and design of lessons;
- anticipation of potential implementation problems of teachers;
- provision of procedural specifications;
- systematic and efficient formative evaluation.

Considering the role of textbooks in Eritrean classrooms, topics selected for illustrating practically oriented biology lessons should be closely linked to the textbooks, perceived as challenging by the teachers, and taught immediately after the professional development workshop. On the basis of these criteria, the concepts of Diffusion and Osmosis and the Respiratory System from grades 9 and 10 biology textbooks were found to qualify for exemplification. The following five sets of procedural specifications were employed for writing the exemplary curriculum materials:

a. *Lesson preparation*
   An overview of the whole lesson and learning outcomes; estimation of time for each lesson component; list of resources and provisions including suggestions for other alternatives or substitutes; suggestions for task orientation; information on relevant pages of student textbook, background information and other reference.
b. *Pedagogical content knowledge*
   Information on students' learning difficulties, preconceptions, and misconceptions; suggestions on specific instructional strategies that would promote and support appropriate student learning; suggestions on specific representations, instructional strategies, and scenarios for addressing a particular content; suggestions on how to synthesize new knowledge.
c. *Subject matter*
   Concise and clear information about central elements; a list of instructional objectives that clearly specify the desired outcomes of a given lesson; outlines of key-concepts and activities; possible questions and answers.
d. *Teaching pattern*
   Suggestions for assessing students' prior conceptions; grouping and distribution of tasks and materials; sequence of activities, including suggestions

for selecting topics and solving learning problems; possible variations and responses within the instructional process; tips and advice on some critical aspects of a lesson: group work, discussion, demonstration, and practical work.

e. *Learning effects*
Exemplary descriptions of potential learning effects on students; suggestions for assessing and evaluating those effects; suggestions on how to conclude and summarize the lesson (i.e. possible follow-up questions or lesson-related homework assignments.)

4.2.1 Overview of the main parts of the exemplary curriculum materials

Explanation for the teacher

With particular focus on practically oriented lessons, this part of the exemplary materials introduces teachers to the theory and rationale underpinning the student-centered approach. It also outlines what the exemplary materials should achieve, prerequisite concepts, sequence of content, format of lessons, and symbols used throughout the lesson series.

Lesson series

The lesson series describes the exemplary lessons. It consisted of the following five lessons:

- Lesson one- *Diffusion in action*;
- Lesson two- *Demonstration of osmosis*;
- Lesson three- *Practical work on the effects of osmotic conditions on potato cylinders*;
- Lesson four- *Effects of osmotic conditions in living tissues*;
- Lesson five- *Concept identification game*.

Each lesson has a standardized structure that shows three distinct sections (see Appendix A1 for a sample lesson). The first section provides teachers with a lesson overview, instructional objectives, references, and a lesson plan. The second part focuses primarily on lesson preparation featuring subheadings like what to do before the class, required media and materials, expectations, and *tips*. The last section was devoted to the execution of a lesson. This section offers teachers with a variety of scenarios and suggestions for the introduction of a lesson, the lesson body, and the lesson conclusion. For the most part, the procedural specifications for the lesson preparation, pedagogical content knowledge, and teaching pattern were elaborated in this part of the exemplary materials. Tables 4.2 – 4.6 illustrate how the procedural specifications were elaborated throughout the of lesson series.

Background information

This section provides teachers information on the biological content, how to form groups, prerequisite concepts, the relationship between syllabus themes, and a concept map.

Assessment

This section of the exemplary materials offers teachers general information on lesson evaluation, guidelines for test construction, a marking scheme, and a bank of questions.

Table 4.2 *Description and examples of elaborations for lesson preparation*

Specifications	Examples from the materials
Lesson overview	*What the lesson looks like* This lesson is meant as a general introduction to the respiratory system. An important aim is to establish what the students already know and to provide them with an overview of what can be expected from this topic. Both this lesson and the following one focus on a mammal's respiratory system. The main activity will be the dissection of the respiratory system of a sheep or goat obtained from a butcher. We have chosen a demonstration because dissection skills are not required and the primary purpose of this activity is for students to view real life structures.
Estimation of time	**Lesson plan and timing** ***Activity*** — ***Approximate time(Mn.)*** Start of lesson — 10 Body of lesson (Demonstration & student activity) — 25 Conclusion of lesson — 5 Total — 40
Suggestions for task organization	*What to do before the class* ▪ Read about diffusion on innovation support (biological content pp. 11) ▪ Decide how you can arrange the desks so that the students can easily work on the activities in groups. (see appendix for arrangement suggestions) ▪ Assess what the students know about diffusion from physics and chemistry classes regarding concepts like kinetic energy and concentration gradient. You can do this by checking the syllabus and/or through discussions with fellow teachers. If you feel your students lack the necessary prerequisite concepts, then read the prerequisite concepts on page 4 and try to teach them.

Table 4.3 *Description and examples of elaborations for pedagogical content knowledge*

Specifications	Examples from the materials
Student learning difficulties	Students may experience some learning difficulties on this topic. These difficulties usually originate from the fact that students have to deal with explanations of phenomena on a molecular and cellular level, which are difficult to visualize. Therefore, to have a proper understanding of diffusion, students must be made aware of the fact that molecules in gases and liquids constantly move about at random. This concept of randomness can be simply demonstrated by …
Common student misconceptions	In regard to osmosis, students generally have little understanding of the issue of concentration. They often base their predictions regarding the overall direction of the osmosis on the concentration of the solute (e.g. with 70% sugar, 20% sugar, they think that the overall direction is from 70% to 20%). However, the scientific idea asserts that water concentration is the factor that determines the overall direction of osmosis, and H_2O concentrations are inversely proportional to solute concentrations (e.g. 30%H_2O, 80% H_2O).
Student thinking	Students think that energy is a thing and use the word energy and force interchangeably; they see it as being confined to a particular origin such as what we get from food or what the electric company sells.
Specific strategies supporting student thinking	The concept of energy is a fuzzy notion because we talk about it in terms of Newton-meters or joules. Students also have difficulty with abstract definitions in physics classes. It is a good strategy to stick to simple definitions like the ability to do or affect things, be it potential or kinetic energy. Try to elaborate this conception during the discussion with the student activity.
Representations of biology concepts	The understanding of concepts like turgor pressure, turgid cells, and plasmolysis can be facilitated by using the 'tyre' and 'cardboard box' analogies. When discussing turgor pressure and turgidity, one can refer to inflating a soft bicycle tyre. The tyre represents the firm cell wall, the floppy inner tube is like the cytoplasm, and the air inside is the vacuole liquid. If enough air is pumped in, it pushes the inner tube against the tyre (turgor pressure) and makes the tyre hard (turgid cell).

Table 4.4 *Description and examples of elaborations for subject matter*

Specifications	**Examples from the materials**
Instructional objectives that specify desired outcomes	*What you are trying to achieve in this lesson* By the end of this lesson students are expected to be able to do the following: ▪ recognize and explain some diffusion-related phenomena from their daily experience; ▪ define diffusion correctly, that is as: - the movement of molecules from a region of higher concentration to a region of lower concentration; - a process that results from the random motion of particles (ions or molecules).
Outline of student activity	 **Activity** 20 · Ask the students to form groups for the activitiies tio be done(to save time the groups can be assigned and arranged in advance) · Distribute the available resource materials for the activities and then let them do the experiment. That is the students can also watch diffusion taking place in a liquid by dropping a crystal of potassium permanganate/ink into a beaker of water. Tell them to make a careful observation of what is going on in their beakers.  · After you make sure that every group have done the activity, now you can come to the blackboard and should discuss with the groups how they explain what happened with their experiment. This could be followed by your explanation of the theoretical background of diffusion. This theoretical explanation might be illustrated by drawing on the blackboard what happened in the beakers with the crystals/ink drops. · Then you might ask the groups to discuss and write down some examples on diffusion-related phenomena out of their daily life experience. Let them bring their examples to the class. No wonder, they will come up with a large list & some other examples, which you might have not considered before.

Table 4.5 *Description and examples of elaborations for teaching pattern*

Specifications	Examples from the materials
student prior conceptions	*Assessing students' prior conceptions* You should have to assess what students know about the effect of osmosis from their daily life. The following questions might be helpful in eliciting their prior conceptions: ▪ How do we preserve food (e.g. meat) from getting bad? ▪ How does salting preserve food? ▪ What do they think about the fact that over-fertilization at times of low rainfall lead to wilting of plants? ▪ How do plants absorb water through their roots from the soil?
Scenarios for lesson start	*Start of lesson* You will have already brought some of the materials to be used in this period. You may start the class by asking students what they observed in their homework experiment. The following question may help you in discussing their observations: *What did you observe in your homework and why?* You might also tell them the results of soaking an egg in vinegar, and then ask them to predict the outcome of soaking it in pure water for some time. Listen to their predictions and allow them to observe the egg in pure water. Try to reconcile any conflict between their prediction and observations. After you have listened to some of the students' explanation on these matters, do the following: ▪ state the objectives to be achieved in this period. ▪ briefly introduce the concept of osmosis and tonicity
Grouping students for an activity	You will start the activity by distributing the materials (**see materials needed**) to each group. It is good to assign some groups a spring balance and others measuring rulers. While running the activity, help students operate the cork borer for making appropriate potato cylinders; Be patient. Group work takes more time, so you will have less time to cover things. There will also be students who are not fully up to the task. The main thing is not to give up the first time you try something and it does not work the way you intended.

Table 4.6 *Description and examples of elaborations for learning effects*

Specifications	Examples from the materials
Wrapping up a lesson 	*Conclusion of lesson* You will round off the lesson by giving the groups a chance to ask questions. Then you will summarize the main points of the lesson by making specific reference to the theory of diffusion and the groups' practical activity. You may use the following questions to help wind up the conclusion: 1. How do you explain diffusion? 2. What is the driving force behind the process of diffusion? *End of lesson* ▪ The next lesson is going to be a follow-up to this lesson. Students should have to analyze the class tables at home by answering the questions. They can start working on their home work if time allows. ▪ Remind students to read chapter one of their grade eight biology textbook (topic: *how do we study in biology*?). ▪ Collect the stop watches, rulers, and strings. ▪ Clean up the benches.
	

4.2.2 Overview of the formative evaluation approach

In this study, the term evaluation is defined as a systematic investigation of the worth or merit of an object (Joint Committee, 1994). It may take the form of formative or summative evaluation on the basis of its aim and the stage of maturity of the object being evaluated. The focus of the evaluation activities reported in this chapter was formative in nature because it aimed at improving the quality of the exemplary curriculum materials. The formative evaluation was bolstered further with an evolutionary prototyping approach, which the study adopted throughout the development of the exemplary materials. The prototyping approach entailed the use of several prototypes, a high degree of iteration through a cyclic development model, and participation of potential users (Maslowski & Visscher, 1999; Nieveen, 1999).

Furthermore, the quality of the study was delineated by the criteria of validity, practicality, and effectiveness. These criteria were all related to a typology of curriculum representations (see Table 4.7) expounded by Goodlad, Klein and Tye (1979) and later adapted by van den Akker (1998).

Table 4.7 *A typology of curriculum representations*

Curriculum representations		
Intended	Ideal	Reflects the original assumptions, visions, and intentions laid down in a curriculum document.
	Formal	Reflects the concrete curriculum documents such as student materials and teacher guides.
Implemented	Perceived	Represents the curriculum as interpreted by its users (especially teachers)
	Operational	Reflects the actual instructional process as it was realized in the classroom, guided by previous representations.
Achieved	Experiential	Reflect s the curriculum as the students experience it.
	Attained	Represents the learning results of the students

Quality exemplary materials must be valid, practical, and effective in supporting teachers for teaching practically oriented lessons. These criteria are defined in the following three paragraphs (Nieveen, 1999).

The first consideration of high quality exemplary materials boils down to its *validity*. Validity refers to answering specific questions: are the intended visions and intentions embodied in the material worthy of consideration? Are the components of the materials based on state-of-the-art knowledge? Are all components consistently linked to each other? If the exemplary material fulfills these demands it is considered valid.

A second characteristic of quality exemplary material is the aspect of *practicality*. Practicality designates the requirements for materials based on what teachers and other experts in practice consider or perceive to be usable. At the same time, it is possible for teachers and learners to carry out the lessons under normal circumstances. This means that consistency should exist between the intended and perceived curriculum, as well as the intended and operational curriculum (see Table 4.7). If both consistencies are in place, the material is deemed practical.

Finally, valid and practical exemplary materials should demonstrate *effectiveness*. Effectiveness is based on issues related to both students and developers: do students appreciate the lessons? Do the developer's intentions and assumptions with regard to desired learning outcomes take place? In other words, does an effective exemplary material consistency exist between the intended and implemented curriculum and the intended and achieved curriculum?

Overview of the formative evaluation strategies

The formative evaluation activities were geared toward improving the quality of the exemplary materials and instruments used throughout the prototyping process. The typology of curriculum representations provided a conceptual framework for elaborating the evaluation questions and deriving the evaluation trajectory shown in Figure 4.1. The central evaluation question guiding the overall prototyping of these materials was as follows:

> *What are the characteristics of high quality exemplary curriculum materials that adequately support teachers for teaching practically oriented lessons?*

In order to clarify and address this formative evaluation question, three additional sub-questions attuned towards the quality criteria and maturity of prototypes were also formulated. These were as follows:

1. What is the validity of the exemplary materials?
2. What is the practicality of the exemplary materials?
3. What is the effectiveness of the exemplary materials?

On the basis of these questions, the overall formative evaluation was designed to include several stages aimed at improving the quality of the exemplary materials before they are used in the professional development scenario. These stages were expert appraisal, user appraisal, trial, and field-test. Figure 4.1 shows the prototyping process of the exemplary curriculum material on diffusion and osmosis.

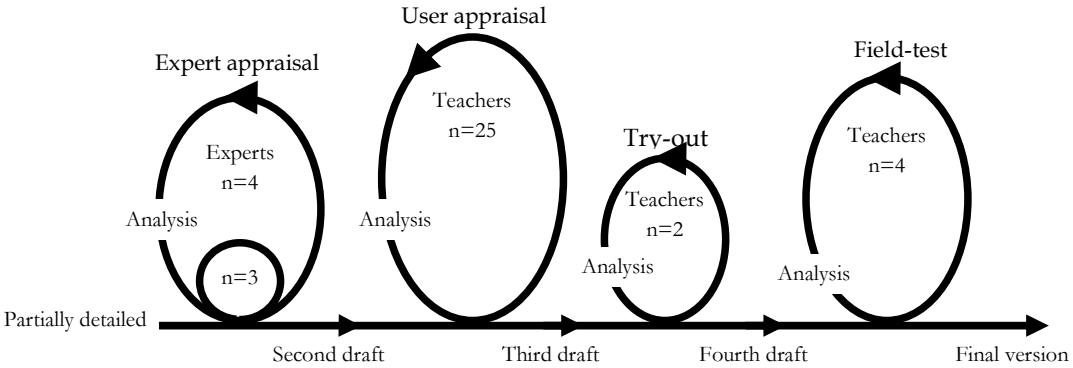


Figure 4.1 Itinerary of the prototyping of the materials

The report on the formative evaluation activities of the exemplary curriculum material on Respiratory System is provided at http://projects.gw.utwente.nl/crc/ERpds/FEva_RespiratorySyM.pdf. In the following sections, the formative evaluation activities conducted to improve the validity, practicality, and effectiveness of the exemplary curriculum material on diffusion and osmosis are presented.

4.3 FORMATIVE EVALUATION TO IMPROVE VALIDITY OF THE EXEMPLARY MATERIAL

Introduction

The expert and user appraisal activities were conducted to gain insight into the validity and initial practicality aspects of the material. These evaluation activities included consultation with experts on the initial design specifications of the material, two cycles of expert appraisals, and one user appraisal workshop in Eritrea. The data collection procedures involved asking the experts to walk through and comment on the partially detailed design specifications and complete prototypes of the exemplary curriculum materials. Moreover, in user appraisal workshops, teachers were asked to walk through the curriculum material and fill-out a questionnaire. The outcome of the expert appraisals is summarized in sections 4.3.1 and 4.3.2., while the user appraisal was presented in section 4.3.3.

4.3.1 The first cycle of expert appraisal

The first expert appraisal involved three subject matter and in-service education experts at Vrije Universiteit Amsterdam, the Netherlands. They were provided with a fully developed *lesson series* and design specifications for the remaining parts of the exemplary curriculum material (with an explanation for the teacher, background information, and assessment). The experts were asked to comment on the overall content, nature of support provided, and what they thought could be changed to improve the material.

Among other things, the experts commented that student objectives described in the lesson series were more conceptual and skill oriented in nature. They suggested that the lessons should also aim to instill students with positive attitudes and interest in science. Moreover, the experts suggested that teaching goals for the whole module must be stated at the introduction of the exemplary material. As for the layout and standardization of lessons, they recommended *PageMaker*. Finally, the experts pointed out that they needed a description of the user context to help them to see where the Eritrean context becomes explicit in the design process. These and other suggestions were considered in the next complete prototype of the material.

4.3.2 The second cycle of expert appraisal

The second expert appraisal (n=4) included an additional instructional design expert from Eritrea. This time the experts were provided with a complete prototype (including the explanation for the teacher, background information, and assessment) and description of the user context. The outcome of this appraisal is summarized in Table 4.8.

Table 4.8 *Overview of the revision decisions from 2nd expert appraisal*

Teacher guide part	Suggestions	Revision decisions
Lesson series	▪ More precise and concrete instructions on practical activities, organization, and materials;	▪ Rephrasing of instructions; some available materials were added and others omitted
	▪ It is good to try the demonstration and practical activities; it could be helpful for setting realistic time periods for lesson execution;	▪ The egg in vinegar demonstration was tried and time for the processes of osmosis adjusted; other practical work will also be tried out in the next evaluation activities
	▪ It is good to set aside five backup minutes out of the 40mn.	▪ Inclusion of backup minutes
Background information/ biological content	▪ Knowledge of the second law of thermodynamics is essential for understanding the concepts of diffusion and osmosis;	▪ Note on second law of thermodynamics was included
	▪ More pictures or diagrams should be used by teacher to explain process;	▪ Many scanned pictures were incorporated
	▪ More complete examples of what is happening in animal and plant cells (osmosis) would be helpful;	▪ A separate and detailed description was added with regard to plant and animal cells
	▪ More information for teachers who do not have the required resources is necessary;	▪ Alternative resources and scenarios are suggested when it is possible.
	▪ More information on prerequisite concepts, "read about… and ask fellow teachers about…" is not enough.	▪ Specific and clear notes on prerequisite concepts were included in the background information.

4.3.3 The user appraisal

The revision decisions reported in Table 4.8 were attended to in the second draft of the material. The second prototype was then finally subjected to user appraisal (n=25) in Eritrean workshops. The teachers were asked to walk through the material in groups and complete a questionnaire. Their group rating was quickly scored on a flip chart that was prepared in advance. During the plenary discussion, teachers were solicited for more clarification on the extreme scores on the items.

The overall, analysis of the questionnaire indicates that teachers' opinions of the material were positive [1]. They particularly appreciated the material for its support in the following:

- preparing and organizing practically oriented lessons;
- providing tips and the information on student misconceptions;
- offering clear structure of lessons (start of the lesson, lesson body, and conclusion); and
- providing a clear picture of biological content.

Some teachers were concerned about students' prior knowledge, particularly on the theory of the second law of thermodynamics. It appears that the students are taught this theory in grade 9 physics (i.e. in grade 10 of Curriculum-2003) so relating diffusion with the second law of thermodynamics in grade eight needs reconsideration. They further noted that this concept is also difficult for students to learn on their own. The participants also foresaw time problems, particularly in lessons two and three.

For the osmosis demonstration, they pointed out that using a pig's bladder could be offensive to Muslim students, and suggested that teachers use a goat's or bull's bladder instead if an osmo-meter was not available. In regard to the practically oriented teaching approach, some teachers were skeptical of its practicality. They noted that the physical set up of classrooms and the large class sizes make it difficult to run practical works or demonstrations as well as handle group work activities. These concerns and others were considered in the third prototype of the exemplary material before it was tried out in classrooms.

4.4 FORMATIVE EVALUATION TO IMPROVE PRACTICALITY OF EXEMPLARY MATERIAL

Introduction

The expert and user appraisal has been instrumental in improving the validity of the diffusion and osmosis exemplary material by generating valuable suggestions. For the most part, many of the suggestions were incorporated into the third prototype and few (e.g. time estimations) were considered during the trial. With the exception of lesson five, the remaining lessons were given a trial run during

[1] The complete result is presented at http://projects.gw.utwente.nl/crc/ERpds/InstrumentsforEvaofExempMaterials.pdf

this formative evaluation activity. Section 4.4.1 sketches the evaluation focus and questions for the trial. The description of participants and data collection instruments is presented in section 4.4.2. Section 4.4.3 provides the results of the trial. The revision suggestions generated from the trial are summarized in section 4.4.4. The conclusions of the trial are reported in section 4.4.5.

4.4.1 Evaluation focus and question

The aim of the trial study was to identify initial problems with the practicality of the material before it was used in a regular classroom setting. It was conducted under favorable situations similar to the practice setting. For this purpose, the central research question was specified as follows:

> *What aspects of the exemplary curriculum material should be changed to improve its practicality within the Eritrean classroom setting?*

A typology of curriculum representations was used for elaborating the sub-questions. The whole exemplary curriculum material was considered as the intended curriculum, and the formative evaluation activities were geared towards locating discrepancies between the intended curriculum and the other representations: perceived, operational, experiential, and attained. Therefore, to get an in-depth problem analysis and generate productive suggestions, the following sub-questions were studied throughout the trial and field-test.

Table 4.9 *Sub-questions derived from the curriculum representation*

Curriculum representations	**Sub-questions**
Perceived	What are the teachers' perceptions about the exemplary curriculum material?
Operational	How are the lessons executed with respect to the procedural specifications?
Experiential	How do the students experience the lessons?
Attained	What are the learning outcomes of the students?

4.4.2 Characteristics of participants and data collection instruments

The trial has employed a purposive sampling strategy for selecting the teachers (Patton, 2002). Two experienced volunteer teachers were selected from the capital city, Asmara. Both teachers tried four of the five lessons. They declined to use the lesson on 'concept identification game' because they felt that their students were not familiar with the concept-map. Table 4.10 shows the characteristics of the teachers and schools.

Table 4.10 *Profile of participant teachers and schools*

Participants	Sex	Qualification	Years of teaching experience	School context				
				Class size	*Teaching load*	**Lab.*	*Lab. Technician*	*School type*
Teacher A	M	Diploma	20	38	24	+	-	public
Teacher B	M	Bsc	8	72	36	-	-	private

Legend: * +/- shows presence or absence.

Overall, a total of five instruments were employed during the trial [2]. A description of the data collection instruments is presented in the following section.

Teacher logbook

The teacher logbook was designed to draw data on the perceptions about and experiences with the exemplary curriculum material. It is a questionnaire constructed in a way to solicit a teacher's perception of and experience with a given curriculum material or lesson. (Ottevanger, 2001). The teacher was asked to write down his or her impression of the lessons, problems encountered, teacher's role, and students' behavior during the lessons, reflections on information provided in the exemplary material, and additional suggestions to improve the material.

The teachers were asked to complete the logbook immediately after teaching a lesson. The logbook required a summary of key points and revision suggestions for each lesson on the revision decisions overview chart.

Curriculum profile-classroom observation instrument

A curriculum profile-classroom observation instrument was used to observe the execution of the lessons during the trial. A curriculum profile is a set of statements about the desirable (or undesirable) behaviors of teachers during lesson execution with respect to an intended curriculum (van den Akker & Voogt, 1994).

The classroom observation instrument was adapted from Ottevanger (2001)'s curriculum profile, which was used in a similar study in Namibia. The whole curriculum profile was divided into four parts: start of the lesson, body of the lesson, conclusion of the lesson, and overall impression. Moreover, within each part of the curriculum profile, statements were sorted into the following groups: basic teaching skills and classroom management, student-centered orientation, and subject matter.

[2] The instruments are provided at http://projects.gw.utwente.nl/crc/ERpds/TryoutResults.pdf

The curriculum profile was completed by scoring '1' for 'yes', '0' if a behavior was not observed, and 'n/a' for a statement that was not applicable for the observed lesson. The two teachers were observed with the curriculum profile-classroom observation instrument while teaching the four exemplary lessons. During observations, a video recorder was placed in the classroom and a running summary was kept. The observation instrument was completed partly during and following a classroom observation by the researcher.

A quantitative data analysis procedure was used to analyze the observations. Overall, analysis of the curriculum profile data involved counting the scores of individual statements in each part of a lesson. All the statements with a score '1' were counted and the total was divided by the total number of applicable statements from each part of a lesson. The practice profile scores were reported in percentages to gauge the extent of implementation of practically oriented biology teaching. The practice profile scores reflect the degree of actual implementation of the practically oriented biology lessons (cf. van den Akker & Voogt, 1994).

Teacher interview plan

This instrument was aimed at assessing teacher perceptions of and experiences with the exemplary lessons. The teacher interview plan consisted of 37 items that were organized into eight categories, namely general information (6 items), general impressions (7 items), lesson content (6 items), lesson innovation (4 items), lesson execution(8 items), lesson preparation(3 items), homework (3 items), and suggestion for improvements (6 items). Overall, the interview plan can be characterized as semi-structured (Krathwohl, 1998).

For practical reasons, the interview was only conducted with one of the teachers. The interview was audio taped and later transcribed for analysis. The analysis procedure involved clustering the interview data into similar themes (Mils & Huberman, 1994).

Student questionnaire

The data regarding students' experiences with exemplary lessons was collected with the help of a semi-structured questionnaire (Cohen, Manion, and Morrison, 2000). The questionnaire consisted of a rating scale and 11 items organized in the form of closed, dichotomous (Cohen et al, 2000), and open-ended items. Some of the items asked in the questionnaire include the following: what students liked and disliked about the lessons and for what reason; whether the lessons were different from the normal lessons; which lessons students liked best and least, and why; and what students felt they had learned from the lessons and how it could help them in their every day life.

The student questionnaire was completed by 55 students. The questionnaire was in English and as such it was not possible to get detailed responses for some of the open-ended items. The data analysis involved summarizing the responses of the open-ended and dichotomous items. The closed, rating items were expressed in percentages.

Student interview plan

The student interview plan solicited students' experiences with the four exemplary lessons. The student interview can be characterized as structured because it was focused mainly on specific lessons taught by their teachers; questions, as well as the order of the presentation were predetermined (Krathwohl, 1998). Questions featured in the interview plan included the following: did you like the lessons? Did you find the lessons difficult? Was there any difference between these lessons and your biology lessons? These questions were accompanied with follow-up questions that further probed students' yes/no answers.

The interview process involved a total of six students from the two schools. According to their respective teachers, the students represented three ability groups: outstanding, average, and poor. In each school one student was interviewed from each ability group. The interview process was conducted in the students' local language, and all the interviews were audio taped by the researcher. The transcribed interview data were aggregated into two themes: overall student experiences with the four lessons and their perceptions on how these lessons differed from their regular biology lessons.

4.4.3 Results of the trial

The results are reported in such a way that they would address the following questions formulated at the outset of the trial:

- What are the teachers' perceptions of the exemplary material?
- How are the lessons executed?
- How do the students experience the lessons?

4.4.3.1 Perceptions of the teachers

The results from the logbooks and interviews indicated that teachers' overall impressions were positive. The interviewed teachers, in particular, reported that the exemplary material provided them enough support to teach in a more student-centered fashion. However, that some teachers did feel that parts of the lesson could be difficult for students in regard to their background and language problems. For example, associating diffusion with physics (i.e. the second law of thermodynamics) was somewhat beyond their capabilities. They stressed that students were not taught this concept until grade 9, making it difficult to explain to grade 8 students.

In regard to the relevance of the lessons to students' daily life, teacher reported that the activities in lesson one and three were relevant and useful. Students mentioned many examples from their daily life: a smell from the cooking gas, or hazards associated with it was one of the typical examples students mentioned from their daily life. Teachers agreed that the exemplary lessons were the kind that they would like to have as a teacher. Their most notable experience teaching these lessons was observing students' curiosity, interest, and participation in "practical work" in comparison with the usual "theoretical" lessons.

Analysis of the logbooks of the two teachers indicated that they found the lessons useful. The teachers reported that they used the exemplary material as a general guide during the lessons and believed that they achieved more with the students than they normally do with their regular lessons. In all the lessons, the teachers explained their roles as a 'guide' to students.
In lesson one, the teachers reported that the theory of the second law of thermodynamics was very difficult for students to understand. Furthermore, the teachers suggested that for illustrating the diffusion of gases, other non-allergenic aromatic substances should be used. Two or three students were found to be allergic during the trial.

The teachers pointed out a number of problems in achieving the objectives of lesson two. The preparation was a bit complicated and the materials needed (e.g. pig's bladder and stands) were not easily prepared. The pig's bladder failed to show results, students could not compare their predictions in both classes, and the time allocation was not realistic. Finally, both teachers appreciated lesson three for its simplicity and the very clear way it illustrated the concept of osmosis to students.

4.4.3.2 Classroom observations

The classroom observations were conducted to explore how the exemplary lessons were executed. The analysis of curriculum profiles was organized along the three principal parts, namely the start, body, and conclusion of a lesson. The practice profile scores for each lesson were presented in Appendix A2. Tables 4.11 – 4.13 display a summary of scores at the start, body, and conclusion of all observed lessons.

Start of lesson

It appeared that both teachers followed the specific suggestions at the start of the lesson. The necessary resources for the given lesson were displayed and students were informed about the objectives. Both teachers introduced key concepts and tried to relate the activities to what was previously covered as well as to future

lessons. None of the teachers attempted to assess students' preconceptions about the lesson topic and none of them used students' ideas to illustrate a lesson. Table 4.11 shows the overall practice profile scores for the observed lessons.

Table 4.11 *Practice profile scores at start of the lessons*

		Teacher	
		A	*B*
Start of lesson	Basic teaching skills	62	75
	Student-centered orientation	76	69
	Subject matter	100	100
Average		79	81

Lesson body

For this part of the lesson, activities were introduced and the students were asked to form groups of different sizes and compositions. Both teachers took into consideration the composition of each group, but students were not explicitly told to make a division of roles. Table 4.12 displays the overall practice profile scores of the teachers for all observed lessons.

Table 4.12 *Practice profile scores at body of the lessons*

		Teacher	
		A	*B*
Body of lesson	Basic teaching skills	70	70
	Student-centered orientation	72	78
	Subject matter	100	88
Average		81	79

During the activities the teachers moved around the classroom interacting with groups, answering questions, and distributing materials. However, neither teacher was comfortable with group discussions. In lesson four, they did not challenge their students properly about the discrepancies in their results. Their students were unable to thoroughly discuss and argue the results with their classmates.

Lesson conclusion

Conclusions were drawn from each particular activity, and in some instances both teachers have attempted to provide students with general theoretical conclusions from the activity. Table 4.13 provides a summary of the practice profile scores of the teachers for all observed lessons.

Table 4.13 *Practice profile scores at the conclusion of the lessons*

		Teacher	
		A	*B*
Lesson conclusion	Basic teaching skills	65	69
	Student-centered orientation	50	70
	Subject matter	67	73
Average		61	71

Homework was given before the end of the lesson by both teachers. However, teacher A failed to do the conclusion during lesson 1 and 2; he almost ran out of time. Nevertheless, Teacher B prepared the homework in advance in posters and wrapped up lessons efficiently. This was found to be an efficient provision of the teacher, which was not part of the lesson specification.

4.4.3.3 Student experience

Student experience with exemplary lessons was measured by a questionnaire and interview. In addition, teacher logbooks were used to extract information regarding these experiences[3]. The following is a summary of student experiences based on these instruments and teacher logbooks.

The teachers described the behavior of students as active, interested, and a bit dependent. Throughout the trial, the students appeared very attentive and excited about being in the laboratory, and being asked to form and work in groups. The information extracted from the questionnaire indicated that students liked lesson three best (*practical work on the effects of osmotic conditions on potato tissues*), and lesson two least (*demonstration of osmosis*). Besides, it was found that students' attitudes toward the lessons were positive. Overall, two of the interviewees said that they found lesson two difficult because they did not see the results of the demonstration. Unequivocally students underscored that there was a difference between their regular biology lessons and the exemplary lessons, which they had experienced for a week. They noted that in the exemplary lessons there had been less emphasis on theory and more emphasis on group work, practical work, and relevance to their daily lives. The following quotes capture student perceptions about the lessons.

> *"We have done things by our self. It is more enjoyable when you do experiments in practice and saw the result in the next day".*

[3] The complete analysis of this questionnaire and interview data is presented at http://projects.gw.utwente.nl/crc/ERpds/FieldtestResults.pdf

"I think the practical we did was excellent. We liked it very well. One thing which I would like to mention is the connection between what we learn at school and do or try to improve things in our home. For example, we have seen the application of the lessons in preservation of food, how bacteria are prevented from spoiling our food. I think it is important sometimes to see the possible application what we learn in class into our life after we leave the school."

4.4.4 Revision decisions

The analysis of the five instruments provided rich data on teacher perceptions, teacher classroom practices, and student experience with the lessons. Furthermore, the results contributed to the revision and improvement of the instruments. The salience of problems and suggestions that emerged from analysis of the five instruments yielded the following revision decisions, reported in Table 4.14.

The revision decisions were incorporated in the fourth prototype of the exemplary material on diffusion and osmosis. Following these revision decisions, the exemplary material was redesigned to include only four lessons from the original five. Lesson two was removed and its content was reorganized. The fourth prototype consisted of the following lessons:

- Lesson one: Diffusion in Action.
- Lesson two: Osmosis practical work.
- Lesson three: Effect of osmosis in living organisms.
- Lesson four: Concept identification game.

Table 4.14 *Revision decisions overview chart of the trial study*

Cited section of the material	**Revision suggestions in concrete terms**	**Revision decisions**
Lesson one Second law of thermodynamics	▪ Both teachers suggested that this concept is difficult for students to comprehend. ▪ It is taught only in grade 9 physics.	The note was moved to the back-ground for teacher learning or reference. The concept of randomness was presented to students with simply analogies.
Lesson two Demonstration of osmosis	▪ The demonstration failed to yield results because of the problem with the pig's bladder. The pig's bladder needed a lot of processing and it consumed lots of time ▪ The demonstration took 3-4 hours to produce a result	The demonstration was removed.
Lesson three Time allotted Materials needed	▪ Both teachers said that time allocation in the lesson body was not realistic. They were overdue by 5-6 minutes. ▪ A cork borer was not easily available.	The time of the introduction was reduced to 5 minutes and that of the lesson body increased to 25 minutes. - Instead of a cork borer, a knife could be used and students could carefully prepare bars of potato slices.
Lesson four Handling group discussion	Neither teacher challenged students about the discrepancies of their results, other than saying this group was right and that group was wrong.	- More emphasis was put in this lesson on how teachers can handle the group discussion (reference to the background information). - The table in which students were supposed to fill and organize their results was improved.
Specifications on group work	Though students were working in groups, teachers did not explicitly tell them to make a division of roles. Some students simply sat in place crossing their hands or working on other things.	More emphasis on students' division of roles.
Using students' ideas	Neither teacher paid much attention to students' ideas and answers. During the start of the lessons neither teacher made an inventory of what students had already learned or knew about the concepts of the respective lesson.	More explicit specifications at the start of lesson for teachers to make an inventory of students' ideas or prior knowledge and how to make use of such ideas.
Instruments	The curriculum profile, student questionnaire, and teacher logbook have undergone some changes**.**	

4.4.5 In conclusion

It can be concluded that the overall opinion of teachers and students was positive. The trial generated data that indicates the practicality of the exemplary curriculum material. Both teachers found the lessons useful, and used the exemplary material as a general guide during their lesson preparations. The exemplary material gave them a clear idea of what each lesson looks like, and both teachers asserted that they achieved more with such students than they did in their regular lessons.

The practice profiles scores indicate that both teachers attempted to follow the procedural specifications at the start, body, and conclusion of their lessons. The results also show a number of improvements that should be made at the start, body, and conclusion of lessons. The teachers described their role as guide, assessor, and explainer, which was consistent with the innovation.

The results from the student questionnaire and interviews reveal that students liked doing practical work and working in groups. They liked lessons three, one, and four best, each of which involved practical and group work activities. Besides this, students liked the connection drawn between what they learned in these lessons and their daily lives. Finally, it should be noted that since the teachers did not try out lesson five, the aforementioned conclusions are solely based on four lessons. In this lesson, students played a concept identification game. They were expected to complete a blank concept map prepared by the teacher (or from those provided in the exemplary material) with flash cards.

4.5 FORMATIVE EVALUATION TO IMPROVE THE EFFECTIVENESS OF THE EXEMPLARY MATERIAL

4.5.1 Introduction

The field test was aimed at collecting data on the effectiveness of the fourth prototype before being embedded in the professional development workshop. It was conducted in four regions found to be typical representatives of the Eritrean school context. One school from each region participated in this field test. All schools agreed to use the lessons as part of the regular biology curriculum for teaching the concepts of diffusion and osmosis. Table 4.15 presents an overview of the characteristics of participant teachers and schools.

Table 4.15 *Profile of participant teachers and schools*

Partici-pants	Sex	Qualifi-cation	Teaching Experience (years)	School context				
				Class size	*Teaching load*	**Lab.*	*Lab. tech-nician*	*School type*
Teacher A	F	Bsc.	1	62	24	-	-	poorly equipped
Teacher B	M	Bsc.	1	54	36	+	+	modestly equipped
Teacher C	M	Bsc.	4	54	24	+	+	well equipped
Teacher D	M	Bsc.	4	48	24	+	+	well equipped

Legend: * +/- = indicates present/absent.

The central question and sub-questions that steered the overall field test are formulated as follows:

> *What aspects of the exemplary curriculum material should be changed to improve its effectiveness within Eritrean classroom settings?*

1. What are the perceptions of teachers about the exemplary material?
2. How are the lessons implemented?
3. How do students experience the lessons?
4. What are the student learning outcomes?

Section 4.5.2 presents the data collection instruments. The results of the field test are reported in section 4.5.3. The revision decisions are summarized in section 4.5.4. The conclusion from this field-test is provided in section 4.5.5.

4.5.2 Data collection instruments

In addition to the five instruments used during the trial, a student test—developed by the researcher—was administered. It consisted of 10 items that were organized in the form of multiple choice, open-ended, and true or false questions. Each item in the test was weighted one point; as such the maximum a student could achieve was ten points. This instrument was utilized with grade 9 students (N=198) for its reliability. The analysis of the 10 items resulted in Cronbach's □= 0.22, indicating an unacceptable reliability (De Vellis, 1991). For more insight into students' learning, an item analysis was conducted.

4.5.3 Results of the field-test

This section presents a summary of the data analysis of the six instruments employed in the field-test[4]. Triangulation of data sources and methods was used throughout the analysis. The result of the teacher interview and logbook are described in section 4.5.3.1. Section 4.5.3.2 presents the outcome of lesson implementation. Student learning experiences and outcomes are documented in section 4.5.3.3.

4.5.3.1 Perception of the teachers

The global opinion of teachers about the exemplary curriculum material was positive. They commended the exemplary material noting that it was good and well prepared. They reported that the exemplary material was useful for preparing and organizing their lessons. The teachers considered the exemplary material informative in providing them support on subject matter and pedagogical knowledge, organizing practical work, grouping students, and assessment of student prior conceptions. Moreover, they also expressed their 'disappointments' while implementing these lessons. Teacher C felt that even though he appreciated teaching these kinds of lessons, student reluctance to participate during discussions was frustrating. His students also dodged their homework because they figured out it was not marked. In the same vein, Teacher D mentioned that because of class size, it was hard to manage all groups, and as a result, some students were out of 'track'. Both Teacher A and B put their frustrations this way, respectively:

> *"….The disappointing things which I have encountered was the class size. Dividing them into manageable groups was not easy, students were so noisy, crowded and movement within the class was very hard to do it that is frustrating…."*
> *"…the difficulty or the problem was… the management of the groups. Students working in large groups are very difficult to manage and to overlook their group tasks properly…"*

The analysis of logbooks showed that the teachers considered the lessons useful. Overall the lessons were executed without many problems. However, time allocation seemed unrealistic for Teacher C; he indicated that there was limited time for teaching the exemplary lessons. The teachers reported that their preparation time was much higher than usual. As was evident from teacher logs, this was not why their lessons were complicated, but because they tried out the

[4] The complete result of the field-test is provided at http://projects.gw.utwente.nl/crc/ERpds/ExemplaryCurriculumMaterials.pdf

experiments and demonstrations before actually using them with students. It appeared that the teachers assumed many of the roles intended in the exemplary curriculum material--"guide", "assessor", "active participant", and "explainer"— while their students were "active", "discussants", and "group workers".

The teachers reported that the exemplary material helped them greatly in their lesson preparations. They indicated that they followed the specifications for teaching the exemplary lessons and believe that they achieved more with these lessons than their usual lessons.

4.5.3.2 Classroom observations

The classroom observations were conducted with the help of the curriculum profile-classroom observation instrument (see also section 4.4.2). Each teacher was observed teaching the four exemplary lessons. In this section, an overall summary of these observations is reported. The complete practice profile scores for each teacher and lesson are listed in Appendix A3.

Start of lesson

The majority of teachers appeared well prepared and ready to start. The resources needed for the lessons were displayed in the laboratory rooms. An explicit attempt was made at the start of the lessons to focus students by stating the instructional objectives. Teacher C and D, in particular, had written the lesson objectives on poster and blackboard in advance. Table 4.16 displays the practice profile scores for all observed lessons at the start of lessons.

Table 4.16 *Practice profile scores at the start of the lessons*

		Teachers			
		A	*B*	*C*	*D*
Start of lesson	Basic teaching skills	90	90	100	91
	Student-centered orientation	79	76	90	87
	Subject matter	88	100	100	100
	Average	85.7	88.7	96.7	92.7

The teachers introduced the key concepts using expository and demonstration methods. Students were asked to form groups, but none of the teachers attempted to organize these groups in advance, as was suggested in the exemplary material. In lesson one, in particular, a few minutes were lost when students attempted to group themselves in a disorganized way. Students were confused about how to group properly, although some of their confusion disappeared as the lesson went

on. Overall, only Teacher C tried to make an inventory of student preconceptions about diffusion. The rest of the teachers skipped this specification and simply proceeded to the body of their lessons.

The students were highly motivated to work in groups. In all classes, students formed five to seven groups of 8-10 students. As the teachers noted, students were a bit noisier than usual, a source of frustration for Teacher A and B. Generally, students appeared to know what they were expected to do at the start of the lessons. Teacher A and C were overdue by five minutes in lesson four, and Teacher B was overdue in lesson three by six minutes. Both Teachers C and D scored more at the start of the lesson, with student-centered orientation 90% and 87%, respectively. Teacher A's score on subject matter was relatively lower than the rest because she did not provide complete information.

Body of Lesson

The teachers made a conscious transition from the introduction to the body of their lessons, citing phrases like *"…do you have any question before we proceed to…, let's start to… etc."* In almost all the lessons, the teachers made resources ready and accessible for students. They introduced the activities and spent some time explaining the procedures, and at times demonstrated how to use resource materials and equipment. Table 4.17 shows the practice profile scores for all observed lessons.

Table 4.17 *Practice profile scores at body of the lessons*

		Teachers			
		A	*B*	*C*	*D*
Body of lesson	Basic teaching skills	72	91	100	97
	Student-centered orientation	91	88	100	98
	Subject matter	86	88	100	100
	Average	83	89	100	98.3

The students were observed working in large groups. For Teacher A and B this was a strange situation, students were noisy, and they felt uncomfortable with it. In particular, Teacher A was faced with teaching the four lessons inside a very crowded classroom. The rest of the teachers took students into relatively spacious laboratory rooms. None of the teachers explicitly assigned group roles to members, and as a result, some students in the groups simply sat back and did something else.

The teachers attempted to focus students at the outset by stating the aims of the activities and explaining mistakes done by other groups in a sort of plenary explanation. During the activities, teachers moved around the classroom interacting with groups, answering their questions, and distributing resources.

The teachers made different attempts to follow specifications in the exemplary material. From these observations, it seemed that Teacher A and B followed the specifications very closely. Most activities (and follow-ups), homework, and demonstrations were implemented according to suggestions laid down in the lessons. In addition, both teachers asked the researcher to clarify some issues before teaching each of the lessons. The other teachers sometimes abandoned specifications about homework or follow-ups (e.g. Teacher D). Teacher C improvised while teaching the exemplary lessons. As his practice profile scores showed, he outperformed the other teachers in getting maximum scores (100) for basic teaching skills, student-centered orientation, and subject matter. Some of the improvisations included:

- flip charts displaying diagrams and questions for group discussion.
- 'worksheets' for students' homework.
- showing students the results of his trial of the potato-experiment (this was given also as homework to students).

Overall, the teachers were not critical in probing the groups' wrong conclusions and incorrect measurements (e.g. Teacher A and D). Teacher C and B tried to sustain a group discussion in lesson three; nevertheless, the students in Teacher B's classroom were too reserved to participate. Only two or three outstanding students were observed answering and discussing the results of their group work. With regard to time, Teacher C and D were overdue by five minutes in lesson one and lesson four, respectively.

Conclusion of Lesson

For most of the observed lessons, conclusions were drawn from the activities. The teachers summarized the main points and, in some instances, the results of the experiment. It seems that they were more inclined to make teacher-based summaries than student-based ones. Table 4.18 summarizes the practice profiles of teachers for all observed lessons.

Table 4.18 *Practice profile scores at the conclusion of the lessons*

		Teachers			
		A	*B*	*C*	*D*
Conclusion of lesson	Basic teaching skills	85	85	84	74
	Student-centered orientation	63	76	86	100
	Subject matter	43	64	94	94
	Average	66.7	75	88	89.3

Homework was given before the end of the lessons, and except for Teacher D, all teachers executed the homework suggestions. Teacher A and C prepared the

homework in posters and worksheets, respectively. Overall, teachers were observed making hasty conclusions; the time they spent ranged between one to five minutes.

The teachers used a questioning and answering method to conclude lesson one. The students answered the questions individually and in concert. In lesson two, the conclusion was deferred until the next period. With the exception of Teacher A, the teachers attempted to challenge and help students understand discrepancies observed in their results. Teacher B, C, and D scored consistently high in the conclusion of lessons. Teacher A scored low in statements related to subject matter because she gave incorrect information in lesson one and incomplete information in one or two instances. In all the lessons, Teacher D referred back to the introductory theory and lesson objectives stated at the start of lesson.

4.5.3.3 Student learning experience

A test was administered to evaluate students' cognitive learning outcomes in the field test. Table 4.19 shows the results of the test at an item level.

Table 4.19 *A summary of the Item analysis of the test (N=198)*

			% of correct scores per class			
Items	**Content area**	**Cognitive Level**	*School A (n=62)*	*School B (n=54)*	*School C (n=34)*	*School D (n=48)*
1	Diffusion	Knowledge	59.7	74.1	85.3	83.3
2	Diffusion	Knowledge	90.3	88.9	94.1	87.5
3	Diffusion	Application	35.5	51.9	76.5	52.1
4	Concentration	Comprehension	43.6	20.4	23.5	43.6
5	Osmosis	Knowledge	82.3	75.9	70.6	83.3
6	Osmosis	Knowledge	1.6	72.2	35.3	58.3
7	Concentration	Knowledge	72.6	77.8	64.7	58.3
8	Osmosis	Knowledge	61.3	35.5	41.2	52.1
9	Osmosis	Knowledge	70.9	70.2	64.7	97.9
10	Osmosis	Application	43.6	38.9	50	58.3

Overall, with the exception of item 4, the result indicates a satisfactory mastery of the concepts of diffusion and osmosis on the part of the students. The students fared better on items that focused on knowledge rather than on comprehension and application. Item 2 appears to be the easiest question for the majority of students. It asked students to recognize the direction of molecules in a process of diffusion. However, most students were not able to answer item 4 correctly. This item measured students' understanding of the concept of concentration. The item had two parts: it asked students to choose a correct answer and a reason why they

selected that particular answer. Looking over the schools, it appears that School A scored low on items 3 and 6. With the exception of item 4, the result indicates that the students of School D fared better on items covering the concepts of diffusion and osmosis. This result seems consistent with the practice profile scores of Teacher D (see Tables - 4.18).

For evaluating student experience with the lessons, on the questionnaire students were asked to indicate which lesson(s) they especially liked during the course of the field test. Table 4.20 depicts students' responses to this particular item.

Table 4.20 *Percentage of students who especially liked particular lessons (N=157)*

	Lessons			
Sex	*1*	*2*	*3*	*4*
Male	30	40	14	33
Female	54	73	15	39
Mean	42	56	15	36

As shown in Table 4.20, lesson two (*osmosis practical work*) was especially liked by most students. The second and third rank was held by lesson one and lesson four, respectively. Lesson three (*Effect of osmosis in living organisms*) was least favored by the students. Students were further asked to give their reasons why they liked a particular lesson best. Overall, the students reported that they liked the lessons because the work was practical, they were involved in the teacher demonstration, and they worked on the activities in groups. The following quotes illustrate students' experiences with the exemplary lessons.

Lesson two because:

- *"…we have gone to the laboratory; we were working in group, discussed and the lesson was clear for me…"*
- *"…we worked in groups on osmotic conditions in potato cylinders. We tried out it also at home…"*
- *"…I was able to work with my friend…"*

Lesson one:

- *"…I like best lesson one because we did the activity in the class and we have seen diffusion by our eyes in the group work..."*
- *"…I observed many important things in this lesson; so I never forget this lesson in the future"*

Lesson four:

- *"…. we have learned it as a game so that I can understand it very easily"*

The students were also asked 'which lesson(s) they liked least and why?' They indicated that they liked lesson three and four the least.

Lesson three because:

- *"it is not clear to me like the other lessons"*
- *"…I have not understood it clearly and I am not sure the lesson is important"*

Lesson four because:

- *"…it is difficult"*
- *"I have done no observation …"*
- *"… I did not understand the concept identification game… the teacher did not correct our concept map"*

The questionnaire also explored students' attitudes towards the exemplary lessons. The results in Table 4.21 indicate that students' attitudes toward the lessons were quite positive.

Table 4.21 *Students' attitudes toward the four lessons in percentage (N=157)*

	I agree	I agree a bit	I disagree
I liked the lesson(s)	85	11	1
The lessons were interesting	64	23	5
I liked to work in group	83	10	2
I have learned something relevant to my every day life	54	28	10
I have learned to discuss my ideas with my classmates	75	15	5
I enjoyed doing the practical work(s)	67	20	6

Students were asked if there was a difference between these lessons and their regular biology lessons. Overall, 67% of them responded yes. The students noted some of the differences like working in groups, doing things by hands, and playing concept mapping game. The following quotes may illustrate the differences they experienced:

- *"… the lessons are very good and important for me because I have learned something relevant to my every day life"*
- *"The four lessons are very thrilling because we have learned with our hands & we worked in groups"*
- *"….in the previous lessons we listened to the teacher (i.e. it is only explanation) but with those exemplary lessons we did things by ourselves"*
- *"The difference is that we have done group work and concept mapping game in these lessons"*
- *"…there were more discussions with our classmates in these lessons than in the regular biology lessons"*

4.5.4 Revision decisions

The analysis of the six instruments provided data on the teacher perceptions, classroom practices, and student experience and performance of the lessons. The insights and suggestions for improvement that emerged from the field test are summarized in Table 4.22.

Table 4.22 *Revision decisions overview chart of the field-test study*

Cited section of the material	***Revision suggestions***	**Revision decisions**
Lesson two ▪ Table ▪ Time	- *labeling the solutions as "hypotonic" and "hypertonic" instead of solution A and B* - Time at the start of lesson was not enough to discuss homework and then introduce the lesson	- The table was edited - The time allotted at the start of lesson was increased to 10 minutes
Lesson three ▪ Student reluctance to participate in discussions	- *The teachers indicated that students have been shy to participate in the whole class discussion*	More structured specifications for teachers on how they might improve students' whole class discussion will be added.
Student group work ▪ Problems with assigning students different roles ; ▪ Teacher frustration with managing students working in large groups.	- The teacher failed to offer students explicit instructions for dividing roles in their groups. Some students sat back and did something else.	More emphasis and specification will be offered to help teachers deal with large groups.
Start of lesson ▪ Lack of questions to ask students ▪ Assessing student preconceptions	- One of the teachers indicated that there were not many questions at the start of lessons, and three teachers skipped the inventory of student preconceptions.	More questions will be added. The specification with regard to assessing students' preconceptions will be revisited.
Conclusion of lesson ▪ Done hastily	- The teachers, particularly teacher A, scored low in the conclusion phase of the lessons and all of them failed to make a logical closure to their lessons.	More emphasis will be placed on the conclusion phase of lessons.

4.5.5 Conclusions and implications for the study

The formative evaluation attempted to investigate and improve the quality of the exemplary material. The previous evaluation activities addressed the validity and practicality of the exemplary material. Similarly, the field test generated data pertaining to the effectiveness of the exemplary material within the Eritrean classroom settings. The data seem to suggest that there was a shift in both teacher and student behavior as compared to business as usual. The teachers assumed the role of guides to their students and active participants during the lessons. The item analysis provides indications of satisfactory student learning.

At the outset of the report it was indicated that in order to systematically address the main evaluation question, four sub-questions were formulated. The first question was related to the perceptions of teachers about the exemplary curriculum material. Teachers considered the exemplary material important and useful in providing them support on subject matter knowledge, lesson organizations, using concept maps, and handling group activities. The overall perception of teachers was positive, and they were optimistic enough to engage in such types of teaching approaches.
The second question focused on the implementation of the lessons. The teachers followed the specifications suggested at the introduction, body, and conclusion of lessons. At the start of lessons teachers tried to focus students via statement of lesson objectives and demonstrations. Only one teacher made an inventory of student preconceptions, thus implying that an elaborate specification was still needed in this regard. Two teachers were observed having problems with group work activities. Throughout the trial and field test the issue of time continued to be problematic. The teachers lagged behind the specified time, particularly during conclusions, and in most of the lessons, up to five minutes were lost when students moved from their classroom to the laboratory. The conclusions were hastily made and during some lessons not done properly.

The third and fourth questions dealt with student experiences and learning outcomes. Students' attitude toward the lessons was positive. The students reported that they liked lesson one, two, and four best. Lesson three was least favored lesson by students. The students reported their roles as group workers, active participants, and discussants. Clearly, as students underscored, there was a difference between these lessons and their regular lessons. The test analysis showed that the students mastered knowledge of diffusion and osmosis, but had more difficulty understanding and applying concepts.

4.6 OVERVIEW OF THE FINAL DESIGN OF THE EXEMPLARY CURRICULUM MATERIAL

Following the formative evaluation activities, the *background information* part of the exemplary materials was removed, and its content was integrated into other parts of the material. The biological content (subject matter) was moved into *the lesson series*, and the information related to pre-requisite concepts, relation of the topic to other themes in the syllabus, and concepts maps were incorporated into the *explanation for the teacher* part of the exemplary material.[5]
Table 4.23 provides an overview of the final material set up and changes in the lesson components within the lesson series.

Table 4.23 *Overview of the final material set up*

Part of the material	Overview of the changes
Explanation for the teacher	This part of the material was made to include the following additional headings: *Student practical work* ▪ Shows teachers how student practical work was interpreted in the study. It outlines information about when, why, and how to use practical work. *Prerequisite concepts* ▪ Provides teachers with information about the prerequisite concepts for learning the topics *Student prior conceptions* ▪ Provides teachers with information about the role of prior conception (misconceptions) on learning.
The lesson series	*Estimation of time* ▪ Optimization of the lesson plan and time for each lesson component *Start of a lesson* ▪ Specifications about making an inventory of students' prior conceptions ▪ Suggestion about how to assess students' prior conceptions (in the form of prior knowledge quizzes or questions) *Body of a lesson* ▪ Suggestions for grouping students and assigning division of roles. ▪ Suggestions about how to moderate classroom discussions ▪ Factual information about difficult biological ideas and phenomena. ▪ Possible student questions and answers
Assessment	This section was made to include: ▪ General information about lesson evaluation, ▪ Guidelines for test construction

[5] The final version of the exemplary curriculum materials is provided at http://projects.gw.utwente.nl/crc/ERpds

CHAPTER 5
Formative evaluation of the professional development scenario

This chapter reports the prototyping process of the professional development scenario. Section 5.1 gives an overview of the design and formative evaluation activities of the scenario. The design of the trial study of the professional development workshop is highlighted in section 5.2. Section 5.3 is devoted to results and conclusions drawn from the trial. The last section 5.4 presents the revision decisions and final design of the professional development scenario before it was implemented with a larger number of teachers.

5.1 OVERVIEW OF THE DESIGN AND FORMATIVE EVALUATION ACTIVITIES

The professional development scenario has made use of several formative evaluation activities. First, an outline of the professional development scenario (see Table 4.1) was vetted by experts. Based upon the outcome of an expert's appraisal, a preliminary design of the professional development components was developed. The design and formative evaluation of the exemplary curriculum materials is reported in chapter 4, and in this chapter the design and formative evaluation activities of the professional development workshop, school follow-up, and establishment of a supportive school environment are described. Figure 5.1 shows the itinerary of the prototyping of the scenario.

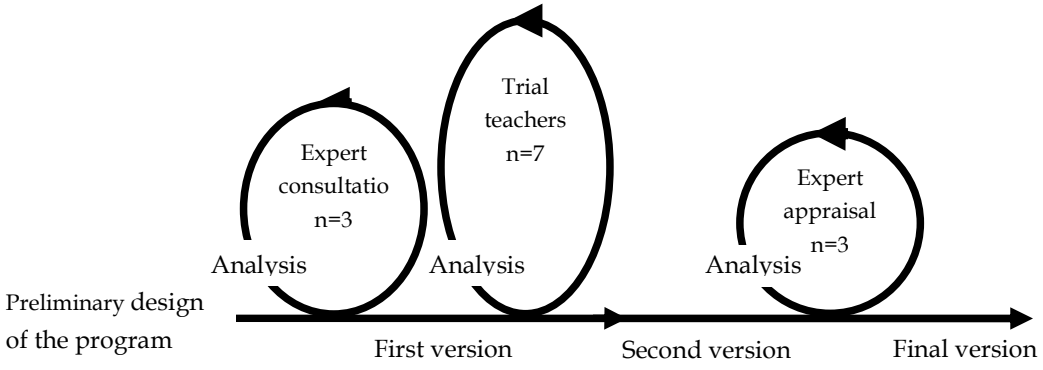


Figure 5.1 Itinerary of formative evaluation of the scenario

5.1.1 Expert consultation

A consultation with experts was undertaken for improving the validity of the professional development scenario as well as further elaboration of the components. Concerning the components of the professional scenario see Table 4.1 in Chapter 4. The consultation involved three experts in the field of curriculum and teacher professional development at the University of Twente and the Vrije University of Amsterdam. The experts were provided with an outline of the professional development scenario and the contextual characteristics of Eritrea.
The outcome of the expert consultation underscored that involving teachers in material development as part of the practice session could take a lot of the professional development workshop time. Instead, the experts suggested that teachers should be given the opportunity to explore the exemplary materials and prepare a lesson plan for microteaching. On top of that, the artificialness and degree of teacher involvement in a microteaching session should be considered. It was, in particular, indicated that the microteaching session may consume a substantial amount of the day. Regarding the demonstration session, the experts pointed out that video-clips should be carefully prepared if they are going to serve the purpose of demonstration. They underlined that issues of choreography related to running time, settings, and subtitling could affect the potential impact of a video-clip. The following were some of the general points that resulted from the initial consultation:

- comparing the design of the program with other African professional development programs (e.g. Ottevanger 2001; Thijs 1999; Stronkhorst, 2001);
- paying attention to the level of specificity or procedural specifications in exemplary materials;
- expanding the scope of coaching to embrace peer collaboration activities.

5.1.2 Preliminary design of the professional development scenario

Professional development workshop

Based upon the theoretical framework of the training model (Joyce & Showers, 1995), and the principles of effective professional development, the workshop was organized into three main sessions that could be delivered in a one day workshop. The following was a description of the workshop sessions.

Exploring the theory

The theoretical component of the training model was accentuated to provide teachers with a description of practically-oriented biology teaching, its theoretical basis, and the benefits and demands of embarking on it. It would address teachers' self-oriented concerns such as: What is it? How will it affect me? Etc.

At the start of this session, the teachers' prior conceptions about a student-centered approach would be explored. This would be followed by a researcher's presentation outlining the characteristics of the practically-oriented teaching approach and the rationale underpinning it. In addition to the presentation, teachers would be provided reading materials related to practically-oriented biology teaching.

Demonstration

The demonstration session was intended to provide teachers with an image of what a practically-oriented teaching approach looks like in classroom practice. The demonstration was done through a video-clip that exemplifies a practically-oriented biology lesson. The video clip had a running time of 20 minutes. At the end, the teachers were involved in a plenary discussion of the important aspects of the video clip.

Practice and feedback

The practice session was aimed at giving teachers the opportunity to practice the intended change under simulated conditions and to receive feedback. The practice and feedback activities were expected to address teachers' 'task' related concerns such as: How do I do it? Etc.

At the start of the practice session, there was a brief introduction to the exemplary materials, and then the teachers were given the opportunity to work in groups and prepare a lesson plan for teaching a practically-oriented biology lesson (i.e. microteaching). If teachers consented, the microteaching sessions would be recorded so that the clips could be played back to support the feedback process.

School follow-up support

The school follow-up was aimed at extending the support for teachers in schools after the initial professional development workshop. The follow-up was comprised of coaching activities and the exemplary curriculum materials. During the follow-up period, the CBAM's diagnostic tools were used for establishing where teachers are and structuring the appropriate support. The support scenario could be characterized as follows:

- Two school-based reflective workshops (meetings) to facilitate teachers' reflection process.
- Three sessions of technical coaching (Garmston, 1987). The researcher organized two to three observation sessions where concrete suggestions and tips from observations were shared with the teacher in a nonjudgmental manner.
- The existing peer collaboration activities in the schools were explored, and those that appeared relevant to the study were incorporated in the school follow-up.

Establishing a supportive school environment

This component of the scenario was focused on organizational changes that nurture teachers' efforts to teach practically-oriented biology lessons. As much as possible participating schools solicited school support that might augment the process of implementation. School support and change would encompass the principal's supportive leadership, administrative assistance, and the provision of resources from respective schools.

5.2 DESIGN OF THE TRIAL STUDY

As indicated in the preceding section, the professional development workshop was structured into three main sessions. Table 5.1 provides an overview of the workshop activities. The final version of the exemplary material on diffusion and osmosis was integrated into the professional development workshop. The other exemplary material on the respiratory system was used in the summative evaluation of the professional development scenario.

Table 5.1 *Overview of the workshop sessions and activities*

Workshop session	Activities	Duration
Theory exploration	*Introduction to the workshop* *Completing 'Teacher expectation questionnaire'* ▪ Participants' baseline data were collected at the start of the workshop ***Exploring participants' prior conceptions*** ▪ Participants were provided the opportunity to discuss issues pertaining to student-centered approaches in science education. ***Presenting the theory*** ▪ Brief discussion about student-centered education ▪ Presentation of the "what, why, and how" of practically-oriented teaching ***Reading materials*** ▪ Information about what student-centered education is, the rationale underpinning this approach, etc.	70Mn.
Demon-stration	***Video demonstration*** ▪ A video clip which demonstrates one exemplary lesson from the curriculum material ▪ Plenary discussion and reflection	60Mn.
Practice and feedback	*Introduction to the exemplary curriculum material* ***Microteaching*** ▪ The teachers walk through the exemplary material and develop a plan for teaching one lesson from those materials ▪ One teacher conducts a microteaching session with one class of students invited from a nearby school. The microteaching is video recorded and played back later during the feedback session ▪ Feedback and reflection on the microteaching	3 Hrs
Evaluation of the course	Teachers complete the evaluation questionnaire	15Mn.

5.2.1 Research focus and questions

The aim of the trial was to explore the practicality of the professional development workshop, particularly concerning design, content, and delivery, before it would be implemented on a larger scale. In addition, the trial also helped improve the data collection instruments (which will also be used in the summative evaluation study-- see chapter 6). For that reason, the data collection was focused on two levels of evaluating professional development, namely participants' reactions and learning (see also Guskey, 2000 & Chapter 6). According to Guskey, the data collection for a given teacher professional development at Level 1 was tuned to answer questions like: Did the participants like it? Will they consider it useful and relevant? Did the workshop material make sense to them and was their time well spent? Level 2 evaluation focused on answering whether participants gained the intended knowledge, skills, and hopefully attitudes.

Research question

The trial study was guided by the following research question:

> *What is the practicality of the professional development workshop for supporting teachers' learning and teaching of practically-oriented biology lessons in a simulated environment?*

Following this central question, specific questions were identified in order to focus the evaluation process, and to collect robust suggestions for improving the components of the professional development workshop. These are:

- How do teachers expect to benefit from the professional development workshop?
- What are teacher opinions regarding the usefulness and relevance of the sessions of the workshop?
- What is the degree of congruence between teacher expectations before and after the workshop?
- Did teachers acquire the knowledge, skills, and attitudes espoused in the workshop?
- What suggestions do teachers offer to improve the professional development workshop?

5.2.2 Characteristics of participants and data collection instruments

Characteristics of participants

In this trial, seven biology teachers were invited from one secondary school that has a reputation for organizing INSET workshops and seminars for teachers. It enjoys a patronage in terms of getting funds and expertise from the University of

Asmara and NGOs. Teachers of this school were motivated to attend workshops intended for their professional growth. Furthermore, the school had a relatively large number of biology teachers and was located nearby the workshop venue. Table 5.2 provides the basic information about the teachers.

Table 5.2 *Participants' background information*

Teacher	Qualifications			Years of experience	Gender	Age	Teaching load per week
	Diploma	*B.Sc.*	*PhD*				
A	√			27	F	45	28
B		√		2	M	25	29
C			√	11	M	35	30
D		√		5	M	29	30
E		√		17	M	45	30
F		√		9	M	31	42
G		√		4	M	26	29

Instruments and procedures

As indicated elsewhere, the design of the professional development scenario includes a professional development workshop, exemplary materials, and school follow-up strategies that are geared to facilitate the professional learning of teachers and implementation process of the intended changes in biology classrooms. Due to time constraints and the very aim of this trial, data collection instruments were developed for gathering data on the workshop only. The instruments employed during the workshop are presented in Table 5.3.

Table 5.3 *Overview of the research questions and instruments*

Research questions	Instruments
1. How do teachers expect to benefit from the workshop?	Teacher expectation questionnaire
2. What are the teachers' opinions regarding the usefulness, benefits, and relevance of the sessions?	Evaluation questionnaire
3. What is the degree of congruence between teachers' expectations before and after the workshop?	Teacher expectation questionnaire Evaluation questionnaire
4. Did teachers learn the knowledge, skills, and attitudes espoused in the workshop?	Evaluation questionnaire Curriculum profile-classroom observation instrument
5. What suggestions do teachers offer to improve the workshop?	Evaluation questionnaire

Teacher expectations questionnaire

The purpose of this questionnaire was to collect data on participants' background information and their expectations for attending the professional development workshop. The first part of the questionnaire asked participants to provide information like age, gender, qualifications, teaching experience, load per week, grade level taught, and previous workshop experiences. The second part consisted of two open-ended items that asked participants to write down their expectations. This questionnaire was completed by the participants (N=7) at the start of the workshop (see Appendix B1).

The data analysis of the instrument involved summarizing the responses on the open-ended items into similar themes that reflected participants' expectations. Moreover, the overall participant expectation was compared against a closed item in the evaluation questionnaire that asked whether their expectations had been met.

Evaluation questionnaire

The evaluation questionnaire was aimed at measuring initial satisfaction and the new knowledge, skills, and attitudes developed by participants from the workshop. Overall, this questionnaire consisted of two parts focused on assessing the first two Guskey levels of evaluating teacher professional development (see Appendix B2). The first part of the questionnaire asked participants to indicate their overall impressions of the workshop, their opinions about the components of the workshop and their perceptions regarding the usefulness and relevance of the learning opportunities in a five-point Likert scale. The second part of the questionnaire was focused on assessing the extent to which participants claimed to have gained the knowledge, skills, and attitudes intended by the professional development workshop. It asked participants to indicate to what degree the workshop had provided them with adequate information and helped them to develop a sound understanding, augmented their skills, and their conviction to try the intended changes in their respective classrooms. In addition, this part of the questionnaire also asked participants two open-ended items related to future use of the exemplary curriculum materials and their suggestions on how to improve the workshop in general.

The evaluation questionnaire was administered at the end of the workshop. Teacher responses to the open-ended items were summarized. These responses were examined for salient patterns and themes. A quantitative data analysis procedure was applied for computing descriptive statistics (mean & standard deviation).

Curriculum profile-classroom observation instrument

A curriculum profile-classroom observation instrument was used for collecting data on teacher performance during the microteaching session (see Appendix B7). The characteristics of this observation instrument, its scoring process, and analysis procedures are described in section 6.4.6. The maximum scores that a teacher could attain on each component of the lesson at the microteaching session are shown in Table 5.4.

Table 5.4 *Overview of the maximum scores at each component of a lesson*

Lesson component	Maximum scores	Threshold scores	Ideal scores	Unacceptable scores
Start of lesson	18	2	13	3
Body of lesson	20	2	15	3
Conclusion of lesson	11	1	8	2
Total score	49	5	36	8

Grade 10 students were invited from a nearby school for the microteaching lesson. One teacher taught an exemplary lesson and the rest of the teachers observed from a corner. The lesson was videotaped and the researcher later used the videotape to fill out the curriculum profile. The analysis of the instrument involved counting the scores for each statement and expressing them in percentages of the maximum score for the microteaching lesson.

5.3 RESULTS OF THE TRIAL

5.3.1 Participants' expectations

At the outset of the workshop teachers were asked to indicate how they expect to benefit from a course that intends to promote practically-oriented biology teaching. The participants formulated their expectations and the responses are summarized in Table 5.5.

Generally, the teachers expressed their expectations in terms of getting more information, skills, and activities regarding student-centered approaches. Specifically, they stated that they expect to get information on student-centered education, how to implement practical work, and how to improve their daily teacher-dominated lessons. They also expected to engage in activities that would help them develop skills and insights in organizing student practical work. (see Table 5.5). In addition, one teacher expected to get information related to adapting local material, which was not dealt with in the workshop.

Table 5.5 *Expectations of participants regarding the workshop (N =7)*

Expectation	N
Information on	
▪ how to use practical work in our school conditions	3
▪ the difference between teacher-centered and student-centered approaches.	
▪ how to use 'locally made materials ' in our class	
▪ to improve our lecturing or teacher-dominated approach	
Skill acquisition	2
▪ on how to teach student-centered lessons	
Activities that help us	2
▪ bridge the differences between what happens in our actual classes and what is required in student practical work	
▪ develop knowledge and insight about a student-centered approach in general and practical work in particular	

5.3.2 Participants' reactions

The first part of the evaluation questionnaire assessed participants' initial perceptions about their experience with the workshop. Table 5.6 shows that the overall impression of teachers about the professional development workshop was positive.

Table 5.6 *Participants overall impression of the workshop (N=7)*

	M*	SD
According to my expectations	4.1	0.64
Useful for my professional growth	4.6	0.49
Relevant to my teaching practice	4.0	0.53
Enhanced my understanding	4.4	0.73
The objectives are met	4.1	0.35

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree & 5 = strongly agree.

As shown in Table 5.6, the workshop satisfied teacher expectations with a mean score of 4.1 on a five-point Likert scale.

The participants were asked to indicate if they were going to use the exemplary curriculum material in their schools. Overall, 71% of the teachers responded that they would use the curriculum material, and 29% indicated that it would be difficult to do so for the following reasons:

- "… it will not work in our school and other schools because of the teaching load of teachers and the large class size."
- "… because of the vast portion to be covered within an academic year…. Student centered approach seems time consuming"

Furthermore, the teachers were asked for their opinions by rating certain statements focused on the sessions of the workshop. The analysis of these statements is summarized in Table 5.7. The overall opinion of teachers about the sessions was positive except for the video demonstration, which was rated just okay.

Table 5.7 *Participants' opinions regarding the components of the workshop (N=7)*

	M*	**SD**
Group discussion pertaining to practically-oriented lessons	4.1	0.64
Presentation of the "what, when, and how" practically-oriented lessons	4.0	0.64
Video demonstration	3.3	0.45
Practice session (designing lessons and microteaching)	4.4	0.49
Curriculum materials used	3.9	0.99
Organization	4.4	0.73

Legend: * 1 = very poor, 2 = poor, 3 = Just okay, 4 = good & 5 = excellent.

The video demonstration was appreciated less, with mean of 3.3 compared to the rest of the sessions. One of the teachers commented on the quality of capturing pictures and the short running time of the video clip. Results indicated that the activity on preparing a lesson plan and conducting microteaching was highly valued.

According to Guskey (2000), questions related to determining participants' reactions to teacher professional development could be classified into three categories related to the content, process, and context. In this trial, the teachers were further requested to indicate to what extent they agree with certain statements related to content, process, and context of the professional development workshop. Table 5.8 reports participants' reactions to these three categories.

Table 5.8 *Participants' perceptions about the content, process, and context (N=7)*

	*M	SD
Content		
The knowledge and skills explored in the workshop are useful for improving my teaching practices	4.7	0.45
My time in the workshop was well spent	4.9	0.35
Process		
The activities of the workshop are carefully planned and organized	4.3	0.45
The teacher guides are immediately useful for my classes	4.1	0.35
Sufficient time was provided for the completion of the activities	4.0	0.76
The presenter and organizers were well prepared	4.4	0.49
CONTEXT		
The facilities provided were conducive for learning	4.3	0.69
The workshop room was the right size	4.3	0.69
The tea, coffees were ready and hot	4.9	0.35
The lunch was fresh and tasty	4.9	0.35
The transportation/lunch allowance was fair and motivating	5.0	0.00

Legend: *1 = strongly disagree, 2 = disagree, 3 =neutral, 4 = agree & 5 = strongly agree.

Table 5.8 indicates that the teachers regarded the knowledge and skills explored during the workshop useful for improving their teaching practices and asserted that their time was well spent. Concerning the conduct and organization of the workshop (process), it appears that the average mean score on these items was 4.2. This indicates that teachers regarded the activities as well planned, the materials useful, and the time sufficient for completion of the activities.

The statements related to the setting (context) of the workshop were highly rated compared to the content and process questions. The results indicate teacher satisfaction with workshop facilities, refreshments, and allowance. The average mean score of these items was 4.7 on a five-point Likert scale.

5.3.3 Participants' learning

For assessing participants' learning, it was crucial to gather evidence on the new knowledge, skills, and dispositions that teachers claim to have gained as a result of their participation in the workshop. For this purpose, teachers were asked to indicate to what degree they agreed with statements related to their acquiring new knowledge, skills, and convictions for implementing the intended changes in their respective classrooms. Participants' responses regarding their perceived learning are provided in Table 5.9.

Table 5.9 *Overview of the participants' perceived learning from the workshop*

	M*	SD
After participating in this workshop my understanding about student-centered lessons is enlightened	4.6	0.49
The presentation about 'what, why, and how ' of using practical work provided me with much new information	4.1	0.64
After studying the exemplary lessons and practicing the design of such lessons, I am convinced that I can put them into practice in my own school	4.0	1.06
After attending this workshop I understand that in student-centered lessons the role of assessing students' prior conceptions is crucial	4.6	0.49
Eliciting students' prior conceptions about biology concepts is the optimum starting point for a lesson	4.4	0.49
After attending the microteaching conducted by a colleague I have the confidence to use practically-oriented lessons with students	4.3	0.69
It was difficult to provide an honest opinion about what I will change in my future teaching	3.3	1.30

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree & 5 = strongly agree.

Overall, as shown in Table 5.9, the teachers indicated having gained more information about the student-centered approach in general, and practically-oriented biology lessons in particular, and this has enlightened their understanding. However, the teachers varied in their opinions about how to put them into practice or change their way of teaching based upon their experience in the professional development workshop.

The teachers indicated that their confidence was enhanced after attending a microteaching session conducted by one colleague. In addition, the microteaching lesson was analyzed and the teacher's performance in simulated conditions looked satisfactory (see Table 5.10). He scored relatively low (64%) during the conclusion of the lesson. The teacher was not able to stick to the lesson timetable and was overdue by 15 minutes.

Table 5.10 *Summary of the scores from the microteaching session in percentages*

Lesson component	Maximum score	Score of the teacher
Start of lesson	18	83
Body of lesson	20	85
Conclusion of lesson	11	64

5.3.4 Participants' suggestions for improvement

Through an open-ended item, the teachers were asked to provide suggestions they thought would improve the overall design of the workshop. Their responses are summarized in Table 5.11.

Table 5.11 *Participants' suggestions for improvement of the workshop*

Sessions	Revision suggestions/problems
Theory exploration	▪ Time provided for group discussion was not enough ▪ The exemplary materials should be given to us few days before the workshop
Video demonstration	▪ The quality of capturing the pictures was not good particularly at the start of the lesson. There were a lot of vibrations, the recorder was not stable.
Practice and feedback	▪ Time given for developing a lesson plan was not enough, and it would have been good if we were provided with certain guidelines because we hardly had time to read the guides. ▪ Replaying the whole microteaching lesson was boring

5.3.5 Conclusions

At the outset of the report it was underlined that the intent of this formative evaluation activity was to improve the practicality of the professional development workshop and to improve the data collection instruments. To do so, a workshop was organized to test the workshop sessions (elements) with a small number of teachers in the user context. This evaluation study was focused primarily on the first two levels of evaluating teacher professional development: participants' reactions and learning (Guskey, 2000). This was guided by the fact that participants' initial satisfaction with, the perceived relevance of, and what they learned from the workshop at these two levels often affected their use of workshop ideas in practice.

The results indicated that the workshop had met teachers' expectations in providing them with sufficient information regarding student-centered approaches in general and practically-oriented lessons in particular. It can be concluded that participants were uniformly positive about the professional development workshop. The results further suggest that they acquired new knowledge, and that their learning experiences had enhanced their skills and convictions as far as student-centered approaches were concerned. In the next version of the professional development workshop, the following improvement suggestions were offered:

- Adjusting the time for the teachers' group discussion during the theory exploration
- Improving the video demonstration session, particularly the quality of the video clip.
- Improving items on the evaluation questionnaire and teacher expectation questionnaire. For example, improving the wording of the open-ended items in the expectation questionnaire and adding open ended-items to the evaluation questionnaire (e.g. giving participants the opportunity to describe what they learned in their own words).

5.4 REVISING THE OVERALL DESIGN OF THE PROFESSIONAL DEVELOPMENT SCENARIO

5.4.1 Expert appraisal

After appending the improvements that were warranted from the trial study, the professional development scenario was subjected to an expert appraisal. Three experts on curriculum and teacher professional development were involved from the Department of Curriculum, University of Twente. They were provided with a document that described the professional development scenario. They were also asked for suggestions and insights about improving the scenario before it could be implemented with more schools. Afterwards, the researcher held discussion sessions with two of the experts and the other expert e-mailed her feedback. The outcome of that expert appraisal was aggregated into the following two categories: generic and specific suggestions.

Generic suggestions that dealt with an additional clarification

- All the experts underscored the significance of embedding 'peer coaching' during the school follow-up, noting that in the study there seemed to be a lot of interaction between the researcher and individual teacher (i.e. technical coaching by researcher). This issue was clarified later with the experts that there are contextual constraints making it difficult to use in Eritrea. As such, technical coaching was deemed realistic considering the constraints and scope of the study.
- It was difficult to distinguish between cognitive and affective domains in assessing student learning outcomes. For insightful information, it was more realistic to focus on student experiences (how they enjoyed the lesson, were they able to conduct the practical work and group work, and was it relevant to them) and learning (focusing on skills and knowledge related to the lesson series).

Specific suggestions for improvement

Based on written comments, the researcher arranged discussion sessions to provide experts with additional clarifications (e.g. on peer coaching, etc) and further consolidation of the revision decisions. The experts suggested that it would be useful to integrate sample test questions in the lesson series instead of putting them in a separate section at the assessment part of the exemplary curriculum material. Pertaining to the professional development workshop, the experts suggested the following:

- Starting the theory exploration session with a participant group discussion that explores prior conceptions on practically-oriented lessons. The questions for this group discussion should attempt as much as possible to elicit what participants think about the basic tenets of practically-oriented lessons as espoused in the study. Later the introduction, presentation, and additional reading materials may follow.
- Making use of a participant observation or reflection form during the demonstration and microteaching sessions
- Regarding the technical/expert coaching, it would be useful if Glickman's (1990) model of developmental supervision was considered. On the basis of the classroom observation's outcome, providing feedback to teachers could take the form of directive informational, collaborative, and non-directive (Pajak, 1993).
- Involving school principals was indeed crucial for the success of implementing an innovation, particularly considering the situation in developing countries where school principals are quite far away from teachers and classrooms. Therefore, focusing more on heads of department was sensible and relevant for establishing a 'conducive school environment' (i.e. the fourth component of the scenario).

5.4.2 Revision decisions

The revision decisions that emerged from this expert appraisal were incorporated into the professional development scenario. In the following, a brief outline of the scenario shortly before it was implemented is offered.

The professional development workshop

The presentation of the 'theory of practically-oriented lessons' was delineated to include exploration of participants' prior knowledge, introduction to the workshop, and presentation of the researcher as to what constitutes a practically- oriented lesson as espoused in the study. The participants would be provided with reading materials that treat at depth the nature of the changes the study was promoting.

A sweeping change will be made in the video demonstration session of the workshop. The previous video clip had been less appealing to participants because of its short running time and the quality of capturing pictures. Following the outcome of this trial and expert appraisal, two video clips that demonstrate an exemplary practically-oriented biology lesson and another that shows a teacher-centered lesson will be used. The exemplary clip is going to be carefully choreographed and underscored with subtitles that indicate the main features of a practically-oriented lesson. Moreover, the participants will be provided with a reflection form and be asked to write down what they felt about each video clip. The participants will first be shown the ordinary lesson and later the exemplary video clip. At the end of each clip, there will be a plenary discussion and reflection on the salient features of the video clip. The rest of the revisions that were carried out on the professional development workshop are summarized in Table 5.12.

Table 5.12 *Structure of the professional development workshop*

Sessions	**Activities**
Theory exploration	**Welcoming participants and completing questionnaire** Participants are requested to complete the teacher *expectation questionnaire* at the start of the workshop. **Exploring participant's prior conceptions** Participants are provided the opportunity to discuss in groups issues pertaining to student-centered approach. The discussion will be guided by the following questions: 1. What do you think is the best approach for teaching biology? 2. What constitutes an effective biology lesson based on that 'approach'? 3. What would be your *concerns* for using that 'approach' in your biology lessons? **Introduction to the workshop** ▪ A brief introduction to the study. ▪ Statement of workshop objectives. **Presenting the theory** ▪ Brief discussion about participants' responses to the three questions ▪ Presentation of the "what, when, and how" of the practically-oriented biology teaching—what using it would mean personally, what they would give up, etc. **Reading materials** ▪ Information about what student-centered education is, the theory and rationale underpinning this approach, etc.

Table 5.12 *Structure of the professional development workshop (Continued)*

Sessions	Activities
Demon-stration	**Video observation** ▪ Participants watched two video clips that exemplify contrasting examples of a practically-oriented biology lessons. ▪ Participants were given a reflection form where they could note down their concerns or questions concerning the video clips. ▪ Plenary discussion on the video clips. The discussion was accompanied by a re-play of the exemplary video clip and a list of characteristics that are hard to miss from that clip.
Practice and feedback	**Introduction** ▪ The exemplary curriculum materials were introduced to participants. **Practice with lesson development** ▪ Participants formed groups and each group walked through the lessons and selected one exemplary lesson for preparing a plan for microteaching. **Microteaching** ▪ One teacher from each group did a microteaching with students invited from a nearby school. The microteaching lessons would be videotaped for completing *the curriculum profile-classroom observation instrument.* ▪ Feedback and reflection from the microteaching.
Course evaluation	**Evaluation** ▪ Planning for follow-up visits. ▪ Participants completed an evaluation questionnaire and the stages of concern questionnaire.

Establishing a supportive school environment

In order to establish a supportive school environment, the study attempted to garner as much support as possible from the school leadership. For this purpose, the school principal, vice principal, and department heads would be involved prior to and during implementation of the intervention of the study. The nature of the involvement of the school leadership would take the following form:

- providing orientation to the program and the specific assistance the school leadership could make available to teachers;
- handing out the exemplary curriculum materials; and
- an invitation for the workshop.

School follow-up support

Following the expert appraisal, technical coaching was made to embrace Glickman's (1990) model of developmental supervision (cf. Hall & Hord, 2001) that advocates provision of formative feedback to teachers for the purpose of helping

them improve their instruction, which, in this study happens to be teaching practically-oriented biology lessons. Glickman identifies three behavioral approaches available to supervisors: *directive informational, collaborative, and nondirective* for providing teachers with formative feedback following a classroom observation (Pajak, 1993). He suggested that in-service providers need to carefully assess teachers' level of concern and decide which supervisory approach to use with a particular teacher.

According to Glickman, a directive informational approach was recommended for inexperienced teachers, teachers who are confused, and those who are simply at loss for ideas concerning the innovation at hand. In this approach, the in-service provider represents the primary source of information and at times asks for and considers teacher feedback while allowing the teacher to choose from a range of alternative actions to improve practice.

A collaborative approach was most likely to be successful when used with experienced teachers who function at higher levels of development. This approach may also involve presenting information, problem solving, and negotiating a resolution with teachers.

The last approach was a nondirective model of supervision, and was considered appropriate given that teachers possess more knowledge and experience about the innovation at hand. This approach may entail listening, clarifying, encouraging, and reflecting on teachers' thoughts and practices.

The school support in the study was delivered with two school-based workshops, technical coaching, and exemplary curriculum materials. The following description may provide a picture of how the follow-up was implemented in the study.

a) The first school-based workshop

Following the initial professional development workshop the researcher conducted a workshop at the participant schools. This workshop lasted for 1.5 to 2.0 hours. The activities that marked the workshop were:

- introducing teachers with the follow-up scenario of the study;
- teachers' reflection on their teaching of practically oriented biology lessons after the professional development workshop. The teacher reflection was guided by four questions that focused on the role of the exemplary curriculum materials, use of practically oriented biology teaching and teachers' current concerns;
- completion of the stages of concerns questionnaire and preparation for the classroom-based (technical) coaching.

b) Technical coaching

The researcher worked on a one-to-one basis with the teachers for 2-3 weeks during the classroom-based coaching. It was organized in three cycles of classroom observations and feedback for each participating teacher. First the teachers were informed on objectives of the coaching activities, and were assured about confidentiality of the observations and feedback. The three classroom observations were carried out with out disruption of the schools' timetable. Later a discussion with the teachers was held during the free periods of teachers. In the third cycle of observation, the lessons were videotaped and the teachers were provided an opportunity to see their lesson during the feedback session. As noted earlier, Glickman's (1990) model of developmental supervision was employed in organizing the feedback sessions. In these secessions, concrete suggestions and tips from the observations were shared with the teachers in a nonjudgmental manner. Overall, the feedback was mainly focused on salient, manageable points that pertain to the basic tenets of practically oriented biology lessons.

c) The second school-based workshop

The concluding workshop was conducted at the end of the classroom-based coaching. Overall the workshop lasted for about 2-3 hours. In this workshop, the teachers were engaged in:

- a structured reflection (via three questions) on teaching practically oriented biology lessons;
- observed a short video-taped lesson from a classroom observation of a fellow teacher, and afterward made comments on it;
- the researcher provided an overall feedback on teachers' classroom practice with practically oriented biology teaching. The presentation was accompanied with particular vignettes or anecdotes from the classroom observations.

CHAPTER 6
Design of the summative evaluation study

This chapter presents the design of the summative evaluation of the intervention. Section 6.1 highlights the research focus and question of the summative evaluation. Section 6.2 discusses the five levels of evaluation and the indicators used for determining the impact of the professional development scenario. The research design is described in section 6.3. Section 6.4 is devoted to data collection instruments and procedures. The results of the summative evaluation are reported in Chapter 7.

6.1 RESEARCH FOCUS AND QUESTION

Chapter 1 underlined that the intervention was aimed at helping biology teachers teach practically-oriented biology lessons. The notion of practically-oriented biology teaching was operationalized in the study by applying interactive demonstrations, practical work, and managing group work activities in large classrooms. To enable teachers to use this approach, a professional development scenario, comprising a workshop, exemplary curriculum materials, school follow-up support, and a supportive school environment, was developed. A detailed description of the professional development scenario was described in chapter 5, and in section 6.3.1 a brief summary will be included.

Chapters 4 and 5 documented the formative evaluation activities that were conducted for improving the quality of the professional development scenario and focusing on its validity and practicality. The summative evaluation was focused on assessing the effectiveness of the scenario. The research question for the overall summative evaluation was specified as follows:

> *What is the impact of the professional development scenario in helping teachers teach practically-oriented biology lessons?*

For an in-depth investigation of this evaluation question, five levels of impact were identified on the basis of Guskey's (2000) model for evaluating teacher professional

development. This model of evaluation has provided a framework for formulating sub-questions, structuring instruments, and selecting data collection procedures. The five levels of evaluation are described in the subsequent section.

6.2 LEVELS OF EVALUATION

This section discusses the five levels of evaluation the study used for exploring the effectiveness of the professional development scenario. Included also are indicators for drawing valid inferences on program effectiveness in relation to this professional development at each level of evaluation (Guskey, 2000).

6.2.1 Teachers' reactions

Level 1 is the most common form of professional development evaluation. Evaluation at this level is focused on measuring teachers' initial reactions to or satisfaction with the professional development workshop. Overall the participants' reactions concentrated on the content, process, and context of the workshop. The main questions addressed at level 1 are: Did the workshop proceed according to teachers' expectations? Did they like it? Did they consider its content useful and relevant?

The data for level 1 were collected at the beginning and end of the professional development workshop with the help of the expectation questionnaire and evaluation questionnaire. Table 6.1 shows the indicators that were used to judge the effectiveness of the professional development workshop at level 1.

Table 6.1 *Indicators of teacher reactions*

Categories	Indicators
Expectations	▪ Teachers' contentment that the workshop met their expectations.
Content of the course	▪ Perceptions of teachers about the usefulness and relevance of teaching practically-oriented biology lessons.

6.2.2 Teachers' learning

Evaluation at level 2 is aimed at exploring what teachers thought they gained from the professional development workshop in terms of new information and understanding about practically-oriented teaching. The central question asked at this level was whether or not teachers acquired the intended learning. In this summative evaluation, teachers' self-reported understanding and the teaching skills they demonstrated in microteaching were used for sensing what they learned (see Table 6.2).

Table 6.2 *Indicators of teacher learning and understanding*

Categories	Indicators
Perceived knowledge and understanding	▪ Teachers' formulation of what they learned from the workshop in their own words. ▪ Teachers' attestation of what they gained in terms of new knowledge and enhanced understanding.
Demonstrated understanding	▪ Teachers' demonstration of understanding in a micro-teaching set up.

6.2.3 Nature of school support

Evaluation at level 3 is focused on the fourth component of the scenario, *supportive school environment*. It is aimed at gauging the extent to which the schools' facilitation and recognition of the teachers involved implementing practically-oriented biology teaching.

As Guskey (2000) underscored, evaluation at level 3 helps to document information related to those school conditions that accompany success or describe those that might explain the lack of significant improvement regarding the intended changes. In this study, the evaluation process was further narrowed down into the following aspects of support—measured by teacher self-reports:

- resources (time, personnel, materials, and technology);
- school culture and collegial support;
- school leadership and support.

Table 6.3 *Indicators for school support and change*

Categories	Indictors
Resources	▪ Teachers' opinion that materials, supplies, and physical conditions at the school were helpful for teaching practically-oriented lessons.
School culture and collegial support	▪ Teachers' perceptions of school culture and collegial support for teaching practically-oriented lessons.
School leadership and support	▪ Teachers' perceptions about the role of the principal and school administration in their efforts to implement practically-oriented teaching.

6.2.4 Teachers' use of new knowledge and skills

The purpose of evaluation at level 4 is to ascertain whether the teachers translated what they learned through a professional development experience change in their teaching practices. Guskey (2000) points out four evaluation challenges at this level. He suggests that evaluators need to identify appropriate indicators of use; specify dimensions of quantity and quality; determine if adequate time has been allowed

for relevant use to occur; and ascertain whether sufficient flexibility was allowed for contextual adaptations to take place.

For addressing the central question at level 4, Guskey (2000) further underscores that at least three major aspects of use or implementation need to be considered. The theoretical underpinnings for these aspects of use are derived from the Concerns Based Adoption Model of change (Hall & Hord, 2001) and from research linking professional development and student learning improvement (Guskey, 2000). These are as follows:

1. stages of concern;
2. levels of use;
3. differences in practice.

Stages of Concern

Stages of concern describes the affective dimension of change (Hall & Hord, 2001). That is, it portrays how teachers develop perceptions, feelings, and preoccupations when they are introduced to something new. The CBAM identifies seven developmental stages of concern that teachers are assumed to go through when plugged into the change process (Table 6.4). According to Hall and Hord (2001), participants' concerns and questions often evolve from self-oriented (*awareness*, *informational,* and *personal*) to task (*management*) and impact-oriented ones (*consequence*, *collaboration,* and *refocusing*).

Table 6.4 *Description of Stages of Concern (Hall & Hord, 2001)*

Category	**Stages of concerns**	**Description**
Awareness	0 *Awareness*	Little concern about or involvement with the innovation indicated.
Self	1 *Informational*	Focuses on learning more details about the innovation.
	2 *Personal*	Focuses on the demands of the innovation and one's adequacy in meeting those demands.
Task	3 *Management*	Focuses on the processes and tasks involved in applying the innovation and the best uses of information and resources.
Impact	4 *Consequences*	Focuses on how the innovation affects students.
	5 *Collaboration*	Focuses on coordinating and cooperating with others regarding the innovation.
	6 *Refocusing*	Focuses on exploring the broader benefits of the innovation, including the possibility of major alterations or adaptations.

Summative assessment of participants' concerns can help answer a number of questions related to use, partial use, or nonuse of newly acquired knowledge and skills. For example, an unattended or unresolved management concern or consequence concern may explain why many participants failed to incorporate what they learned into their regular practices, or why a lack of clear evidence of improvement in students' learning might lead teachers to abandon implementation efforts all together.

Level of use (LoU)

Level of use addresses the behavioral dimension of change (Hall & Hord, 2001), depicting how teachers act when they become more familiar with and more skilled in using the intended change. There are three levels of use that define nonusers (*nonuse* level 0, *orientation* level 1, *preparation* level 2) and five distinct levels of use that characterize users (*mechanical* level 3, *routine* and *refinement* level 4, *integration* level 5, and *renewal* level 6). These levels of use can be determined by specifically identifying teacher behaviors at each level as shown in Table 6.5.

Table 6.5 *Description of Levels of Use (Hall & Hord, 2001)*

Category	**Levels**	**Labels**	**Teacher behavior**
Nonuse	0	Nonuse	Has no involvement in and does nothing about becoming involved.
	1	Orientation	Seeks information and explores the personal resource requirements for use.
	2	Preparation	Prepares for the first opportunity for use.
Use	3	Mechanical	Focuses on day-to-day use, which tends to be disjointed and superficial, with little insight or reflection.
	4	Routine (4A)	Establishes an appropriate pattern of use with little preparation or thought given to improving its impact.
		Refinement(4B)	Varies use within the context to improve the impact on students.
	5	Integration	Makes deliberate efforts to coordinate with colleagues to achieve a stronger collective impact on students.
	6	Renewal	Reevaluates the quality of use and seeks major modifications to improve the impact on students.

Differences in practice

This is a third aspect of determining the use of the new knowledge and skills by those participating teachers who follow a professional development experience. It involves establishing and substantiating if an observed practice was truly different

from what participants used in the past or from what other teachers are using at the present (Guskey, 2000). This can either be established by explicitly asking the teachers about any changes in their practice or through measures of their practice collected before and after the professional development experience. In the study, differences in classroom practice were noted by observing the classroom practices of experimental teachers and comparing them to other teachers (control group teachers) who were not involved in the professional development of the study.
Table 6.6 presents a total of four sets of indicators of use that were formulated for exploring the impact of the professional development at level 4.

Table 6.6 *Indicators of use at level 4*

Categories	Indicators
1. Stages of concern	▪ Experimental teachers progress through the various stages of concern.
2. Levels of use	▪ Experimental teachers' levels of use of practically oriented biology teaching. ▪ Experimental teachers use or adapt exemplary materials for planning and executing lessons. ▪ The extent to which experimental students indicate teachers' use of practically-oriented activities.
3. Difference in classroom practice	▪ Experimental teachers structure their lessons differently in a way that reflects practically-oriented teaching. ▪ Experimental teachers function more as facilitators of students' learning. ▪ Experimental teachers assess students' prior conceptions as a starting point for teaching. ▪ Experimental teachers organize practically-oriented activities that promote active student participation. ▪ Students of the experimental teachers take active roles. ▪ Experimental teachers' higher classroom practice profile scores over a control group teachers

6.2.5 Student learning outcomes

Evaluation at level 5 attempts to link the professional development scenario and its effect on students' learning outcomes. In the summative evaluation, a link was established between the scenario and student learning outcomes with the help of an achievement test (for cognitive learning outcome) administered to grade 10 students of experimental and control teachers. For affective learning outcome, students' of the

experimental teachers were requested to complete a pre-test and post-test attitude questionnaire. Table 6.7 shows the indictors that were specified to connect the dots between the professional development and students' learning outcomes.

Table 6.7 *Indicators of student learning outcomes*

Categories	Indicators
Cognitive learning outcomes	▪ Student performance on the achievement test on Human Respiratory System.
Affective learning outcomes	▪ Student experience with practically-oriented biology teaching. ▪ Student attitudes toward practically-oriented biology teaching.

6.3 RESEARCH DESIGN

6.3.1 Quasi-experimental approach

A quasi-experimental *post-test-only nonequivalent control* group design was used for investigating the impact of the professional development scenario. This strategy enabled comparing at post-test two naturally existing groups of teachers, hereafter named as experimental and control groups. In this design, it was not possible to randomly assign teachers into experimental and control groups. Instead, a random selection and assignment of accessible schools into experimental and control groups was used (see section 6.3.3).

The post-test-only control group design offers protection for rival explanations stemming from testing effects and history (Cook & Campbell, 1979; Krathwohl, 1998). That noted, it is worth mentioning that such quasi-experimental design may not account for the differences in the groups prior to the treatment and other factors that may have contributed to a difference between the groups following treatment. Therefore, in the study, the following precautions were undertaken:

- selecting a group of schools that are reasonably comparable in terms of school resources, nature of student population, and teacher backgrounds (cf. Krathwohl, 1998), followed by random assignment the schools into experimental and control conditions;
- using multiple measures for assessing the impact of the professional development (cf. Guskey, 2000);
- conducting the summative evaluation at the same time in both groups of teachers.

The professional development scenario (treatment) was implemented for one semester (six months) in the experimental schools. All biology teachers at each experimental school were invited for a professional development workshop that was focused on developing awareness and augmenting teachers' content and pedagogical content knowledge about practically-oriented biology lessons. The workshop gave teachers the opportunity to reflect upon and examine their knowledge, beliefs, and concerns about practically-oriented lessons; gain an understanding of the theory underpinning the knowledge and skills of practically-oriented lessons (via presentation & exemplary materials); observe a demonstration of how an exemplary biology lesson looks like in classroom practice (via video tapes); practice design and teaching of practically-oriented biology lessons in a simulated condition (via microteaching & exemplary materials) ; and get structured reflection and feedback.

Following this workshop, the teachers were provided follow-up support for 2-3 weeks in their respective schools. The follow-up support involved two school-based workshops (reflective meetings) and three classroom-based coaching sessions. The teachers were then left alone to adapt and sustain practically-oriented biology teaching. However, the teachers at the control group schools did not get the aforementioned treatment. They taught the same biology curriculum in a way they used to teach biology. The summative evaluation took place 6-8 weeks after the school follow-up.

6.3.2 Characteristics of participants

Experimental and control group schools, teachers, and students

The researcher selected *Zoba Maakel* administrative region because it provides reasonably comparable schools and is accessible for conducting the research. Then, out of 15, a total of six public schools were randomly selected and assigned into experimental and control groups. In general, all the schools were located in the capital, and found to satisfy the sampling criteria: accessibility and reasonable comparability in terms of school resources, and the characteristics of teacher and student populations.

Information pertaining to the characteristics of the experimental group was collected with the help of an expectation questionnaire administered at the start of the professional development workshop. A teacher questionnaire completed during the context and needs analysis (see Chapter 2) was used to gather background information on the control group. The background information of the

control group was not greatly changed at the time of the summative evaluation study. Overall, as shown in Table 6.8, the two groups appear comparable in terms of teacher qualifications, years of teaching experience, and school conditions.

Table 6.8 *Characteristics of participant schools*

Variables		**Experimental group**			***Control group***		
School		*A*	*B*	*C*	*D*	*E*	F
Number of teachers involved		7	4	5	6	4	*4*
Gender	M	6	4	4	4	1	*3*
	F	1	-	1	2	3	*1*
Qualification	Dip	2	2	2	2	2	*1*
	Bsc	4	1	3	2	1	*2*
	Msc	-	1	-	1	1	*1*
	PhD	1	-	-	1	-	-
Years of experience	Mean	11	13.1	19.8	12.7	15.7	*12*
Teaching grade & Number of classless	9	11	10	8	10	7	*9*
	10	8	15	7	6	5	*6*
Laboratory Room	*+/-	+	+	+	+	+	+
Average class size		*55*	*54*	*56*	*51*	*44*	*57*

Legend: * +/- indicates present or absent.

A total of 20 experimental group teachers participated in the professional development workshop. However, throughout the implementation process only 16 biology teachers fully completed their participation in the summative evaluation study. With the control group, 14 biology teachers completed participation in the study.

As regards the students, random sampling was applied for selecting those who took part in the achievement test (N=304) and attitude questionnaire (N=103).The participating teachers provided, as a sampling frame, the name lists of all their students (N=1756). A proportional stratified sampling was applied for selecting those students to be taught by experimental and control group teachers. In selecting the students, the grade levels and number of classes taught by participating teachers were used as strata.

According to the Ministry of Education, the qualification of teachers who teach at senior secondary level is Bachelor's degree (Bsc) and higher. Nevertheless, in this summative evaluation, 36.6% of participants (i.e. 37.5% of them in the experimental schools and 35.7% in control schools) were Diploma holders, apparently under-qualified to teach at that level. The rest of the participants were qualified with Bsc, Msc, and PhD qualifications.

6.3.3 Triangulation

Triangulation is a procedure where researchers look for convergence of evidence among multiple and different sources of data, methods, and theories in an effort to overcome the inherent weaknesses of each of them and therefore minimize uncertainty in data interpretation in a given study (Creswell & Miller, 2000; Patton, 2002). Creswell and Miller (2000) underline that a researcher's lens is applied to strengthen the validity of findings in qualitative research. Denzin (1978) described three types of triangulation that can be appropriated to particular research designs:

a. data triangulation, using multiple sources of data across time, space, and persons;
b. method triangulation, using multiple methods; and
c. investigator triangulation, using multiple investigators.

Table 6.9 shows the *data sources and methods triangulations* that were used in the summative evaluation study. Because of contextual constraints investigator triangulation was not employed in the study.

Table 6.9 *Triangulation used in the study*

	Teachers							**Students**		
Evaluation level	*ExQ*	*EQ*	*SSQ*	*TFI*	*SoCQ*	*CP*	*LoUI*	*AQ*	*AT*	*SFI*
Participants' reactions	exp	exp								
Participants' learning	exp	exp				exp				
Nature of school support			exp	exp						
Participants' use of new knowledge and skills					exp	exp/ contr	exp/ contr			exp
Student learning outcomes								exp	exp/ contr	exp

Legend: ExQ = expectation questionnaire, EQ = evaluation questionnaire, SSQ = school support questionnaire, SoCQ = stages of concerns questionnaire, CP = curriculum profile-observation instrument, LoUI = level of use interview, AQ = student attitude questionnaire, AT = achievement test, SFI = student focus group interview; exp = experimental group, contr = control group.

6.4 DATA COLLECTION INSTRUMENTS AND PROCEDURES

The overall data collection process was organized into three stages that were conducted at different points in time. The first stage was geared toward gathering baseline data about participants; thus it was done before the implementation of the professional development scenario. The second stage was carried out during the implementation of the professional development workshop and school follow-up. The final stage of data collection was performed a few weeks after the end of the school follow-up. All in all, the evaluation study employed instruments and methods that were well-tuned for collecting data at each stage of implementation of the scenario. An overview of the data collection instruments used in this summative evaluation is provided in Table 6.10.

Table 6.10 *Stages of data collection and corresponding instruments*

Evaluation Level	**Stages of data collection**		
	Prior to intervention	*During intervention*	*After intervention*
Participants' reactions	▪ ExQ	▪ EQ	
Participants' learning		▪ CP ▪ EQ	
Nature of school support			▪ SSQ ▪ TFI
Participants' use of new knowledge and skills	▪ SoCQ	▪ SoCQ (2x)	▪ CP ▪ LoUI ▪ SFI
Students' learning outcomes	▪ Pre-test AQ		▪ Post-test AQ ▪ SFI ▪ AT

Legend: ExQ = expectation questionnaire, EQ = evaluation questionnaire, SSQ = school support questionnaire, SoCQ = stages of concerns questionnaire, CP = curriculum profile-observation instrument, LoUI = level of use interview, AQ = student attitude questionnaire, AT = achievement test, SFI = student focus group interview.

What follows is a description of the data collection instruments used in the summative evaluation study. The description includes the characteristics of the instruments, what was measured in relation to levels of evaluation, how the instruments were administered, to how many respondents, and the data analysis procedures.

6.4.1 Teacher expectation questionnaire

This instrument was developed first for the trial study of the professional development workshop (see Chapter 5). Following the trial, it was revised and

used again in this summative evaluation. The instrument is listed in Appendix B1 and its characteristics are described in Section 5.2.2.
At the start of the workshop the participants (N=20) were asked to fill out the expectation questionnaire. Responses to open-ended questions were organized and summarized into similar themes that reflect participants' expectations. Moreover, the overall participant expectation was compared against a closed item in the evaluation questionnaire that asked them if their expectations had been met.

6.4.2 Evaluation questionnaire

The evaluation questionnaire was developed for the trial study and later revised for the summative evaluation. The improved version of the instrument included an open-ended item that asked participants to formulate in their own words what they thought they learned from the professional development experience. The characteristics of the instrument are described in Section 5.2.2.
An analysis of the 40 items of the questionnaire resulted in a Cronbach's α=0.82, indicating a very good reliability (De Vellis, 1991). See Appendix B2 for this instrument.
A total of 18 participants completed the evaluation questionnaire at the end of the professional development workshop. Both quantitative and qualitative data analysis procedures were applied for analyzing data from the closed and open-ended items. Descriptive statistics were used to summarize the quantitative data of the evaluation questionnaire into tables. Participants' responses to the open-ended items have been summarized item by item into manageable parts or themes.

6.4.3 Stages of concern questionnaire (SoCQ)

The stages of concern questionnaire is a standardized instrument used for measuring the evolution of participants' concerns about teaching practically-oriented lessons. The reliability and validity of this instrument was established by the CBAM researchers (Hord, Rutherford, Huling-Austin, & Hall, 1987). Estimates of internal consistency (Cronbach's α) range from 0.64 to 0.83 with six of the seven coefficients being above 0.70 (see Appendix B3 for the α coefficients and instrument).
The SoCQ was constructed to apply to all educational innovations (Hall, George & Rutherford, 1998). The questionnaire items stay the same; the only thing that changes is the insertion of the name of a specific innovation on the cover page. The stages of concern questionnaire consists of 35 items that use a seven point semantic differential scale. The participants were asked to circle each item on a 0-7 scale (0= irrelevant; 1, 2= not true of me now; 3, 4= somewhat true of me now; 5, 6, 7= very true of me now) according to how truly the item describes a concern felt by the individual at that present time.

The participants were asked to complete the SoC questionnaire a few weeks before attending the professional development workshop. This same questionnaire was administered subsequently at the completion of the workshop, and 2-4 weeks after the professional development workshop, which is at the first school-based workshop. A quick scoring device in the form of an Excel spreadsheet and a manual of SoCQ was used for plotting the concern profiles of participants (Hall et al., 1998). The SoC questionnaire data are interpreted by examining both the *first highest stage of concern score* and *second highest stage score* for group data. See Appendix B3 for the instrument and the quick scoring device.

6.4.4 School support questionnaire

This instrument was intended to gauge the extent of school support for participant teachers during the course of the implementation (level 3). It consists of 20 items organized into a five-point Likert scale. These items focused on gleaning the relevant data on the aspects of organizational support, namely resources (8 items), school culture and collegiality (6 items), and school leadership (6 items). The internal consistency of this scale (20 items) was determined with Cronbach's alpha. The Cronbach's alpha for the overall scale was found to be α=0.90, indicating a very good reliability (De Vellis, 1991).

The questionnaire was administered after participants had implemented the intended innovation in their respective schools, and was completed by 17 teachers of the experimental schools (see Appendix B4). Quantitative data analysis was used to analyze the data from the school support questionnaire. The analysis included descriptive statistics (mean) and the percentage of teachers that agreed/strongly agreed for each closed item.

6.4.5 Teacher focus group interview scheme

Focus group interview is a structured group process used to obtain participants' perspectives on the various aspects of school support (Guskey, 2000). This method of data collection was employed to strengthen the school support questionnaire. The focus group interview was conducted with the help of 6 items that garnered additional information about the quantitative data extracted from the school support questionnaire. The instrument is available in Appendix B5.

The focus group interviews were moderated by the researcher in each of the experimental schools. First, the participants were provided a brief clarification on the purpose of this interview, and then they were asked to discuss the questions. The focus group interview was tape recorded and later transcribed for analysis. The analysis of the interview transcripts involved summarizing the responses into three themes related to participants' school resources, collegial and leadership supports.

6.4.6 Curriculum profile-classroom observation instrument

The classroom observation instrument was used for collecting data about teachers' learning during the microteaching session in the professional development workshop and for collecting data about the classroom practices of both experimental and control group teachers. A curriculum profile is a set of statements about the desirable (and undesirable) behaviors of teachers during classroom observation with respect to an intended innovation (van den Akker & Voogt, 1994). The classroom observation instrument was adapted from Ottevanger's (2001) curriculum profile used in a similar study in Namibia (see Appendix B6 for the instrument). It consists of three main parts of a lesson: start of lesson, body of lesson, and conclusion of lesson. Each part is operationalized into a number of lesson components and statements that can be distinguished as more or less acceptable (i.e. threshold statements), ideal statements (that can strengthen), or unacceptable statements (that can weaken) the degree of implementation of the innovation (see Table 6.11). The curriculum profile was completed by scoring '1' for 'yes', '0' if a behavior is not observed (or undesirable), and 'n/a' for a statement that was not applicable for each part of a lesson.
The analysis of the curriculum profile data involved counting the scores of individual statements in each part of a lesson. The total was then divided by the total number of applicable statements of each part of a lesson.

In this summative evaluation, a total of 30 classroom observations were conducted in the classes of both experimental and control group teachers. Each teacher was observed one time by the researcher, and the curriculum profile was completed partly during and following the classroom observation.

The practice profile scores are reported in the form of percentages for judging the extent of implementation of practically-oriented biology teaching. The maximum attainable or total practice profile score was considered 100%. The acceptable and ideal components were given a different weight—40% of the total score could be obtained by acceptable statements and the remaining 60% by ideal (and unacceptable) statements.
Descriptive statistics (mean and standard deviation) were used to calculate the practice profile scores of both experimental and control group teachers. For comparing the practice profile, mean scores of both groups, a non-parametric, Mann-Whitney test, and effect size (Cohen's d) were applied.

Table 6.11 *Example of curriculum profile statements for the start of a lesson*

	Score	
Threshold (Acceptable)	Yes	N/A
The teacher introduces the topic at hand	ρ	ρ
The teacher attempts to explore students' prior conceptions	ρ	ρ
Ideal	Yes	N/A
The teacher introduces the lesson with a short demonstration or simple practical activity	ρ	ρ
The teacher asks guided questions to introduces the lesson	ρ	ρ
The teacher uses prior knowledge quiz to assess students' prior conceptions	ρ	ρ
Unacceptable		
The teacher fails to state the instructional objectives	ρ	ρ
The teacher hardly explores students' prior conceptions about the topic (the unit) at hand	ρ	ρ
The teacher ignores students' wrong answers or ideas	ρ	ρ

As indicated earlier the curriculum profile-classroom observation instrument was also used to observe the microteaching lessons (Appendix B6*). At the start of the workshop, participating teachers formed three groups of 6-7 teachers each. The microteaching was organized in such a way that the teachers were able to practice planning and preparation of a practically-oriented biology lesson in their respective groups; one teacher from each group would teach it. For this purpose, around thirteen grade 10 students were invited from a nearby school, while the rest of the teachers observed the micro-teaching from a corner. The three lessons were video taped and later used to fill out the curriculum profile. The analysis of the instrument involved counting the scores for each statement and expressing them in percentages of a maximum score for each microteaching lesson. Moreover, each microteaching lesson was briefly described qualitatively.

6.4.7 Level of use interview scheme

This data collection instrument was intended to supplement the classroom observations, and hence it was focused on establishing the extent of participants' use of practically-oriented teaching. The level of use (LoU) attempts to document the different states of innovation user's behavior, and assign the interviewee at the various levels of use (Loucks, Newlove & Hall, 1998). The LoU interview plan is a standardized instrument where all the interviewees were asked the same questions in the same order (Hall & Hord, 2001; Patton, 2002). It consists of two main questions and four follow-up questions aimed at gathering data on practically-oriented lessons (see Appendix B7).

The researcher conducted face-to-face individual interviews with all the experimental and control group teachers. The interview sessions took 20-30 minutes and were tape recorded and transcribed for analysis with the help of the manual recommended by Loucks et al. (1998). The data analysis process entailed two main steps. The first step involved distinguishing between a nonuser and user of the innovation following an interviewee response to the first item ('yes'/' 'no'). The next step involved rating the overall level of Use of a participant on the basis of *decisions points* outlined in the *LoU chart* that was suggested by Loucks et al. (1998).

6.4.8 Student focus group interview scheme

It is sometimes true that indicators of change in a teacher's classroom practice may not be directly observable by one or two classroom observations (Guskey, 2000). For this purpose, a decision was made to triangulate data from the LoU interview and classroom observation with student perceptions about their teachers' use of practically-oriented teaching. The interview was semi-structured and consisted of 12 items designed to solicit data on teachers' use (level 4) and students' experience with learning practically-oriented lessons (level 5). A total of 22 experimental group students were involved in the interviews. Because of time constraints, the format was changed into a focus group interview at School B and C. At School A, the researcher made face-to-face interviews with individual students. The interview sessions took around 30 minutes and were audio taped and later transcribed for analysis. The interview transcripts were coded in a way that reflects the questions asked and levels of evaluation (level 4 & 5). All interviewee responses per item were pooled together and organized into four themes: general perceptions, perceptions of teacher's role as facilitator of student learning, assessment of student prior conceptions, and types of biology activities in which students were involved. The instrument is listed in Appendix B8.

6.4.9 Achievement test

The student test was developed by the researcher for comparing the cognitive learning outcomes between experimental and control group students (level 5). The measurement of cognitive learning was focused on concepts of the Human Respiratory System in grade 10. The concepts were used to exemplify practically-oriented biology teaching in one of the exemplary curriculum materials. The Human Respiratory System was taught to both experimental and control group students by their respective teachers.

The achievement test consisted of 10 items organized into a multiple choice format (see Appendix B9). It was tested with grade 10 students (N=304) for its reliability.

The reliability of this test was found to be Cronbach's α=0.45 indicating an unacceptable reliability (De Vellis, 1991).
The achievement test was administered to 304 grade 10 students (n= 158 experimental; n= 146 control group). Each item in the test weighed one point, meaning that the maximum score a student could attain was 10 points. The analysis involved computing descriptive statistics (mean and standard deviation), effect size (Cohen's d), and comparing items using a χ^2 Chi-Square.

6.4.10 Student attitude questionnaire

The questionnaire adapted from Russell and Hollander's (1975) and was used to gauge student attitudes toward biology. The questionnaire consisted of 13 items organized into one page on a five-point Likert scale. For improving its understandability, clarification in students' local language (*Tigrigna*) was included within the items (see Appendix B10). A Cronbach's alpha coefficient was calculated to determine the reliability of the 13 items of this questionnaire. Based on 103 responses from students and after a deletion of one item, the alpha coefficient was found to be 0.76, indicating a respectable reliability (De Vellis, 1991).

The pre-test was administered to grade 9 students of the experimental group at the start of the academic year, therefore prior to implementation of the program. The post-test measure was conducted with the same students towards the end of the academic semester in their respective schools. Quantitative data analysis was employed to analyze data from this instrument. The analysis involved computing descriptive statistics (mean & standard deviation), effect size (Cohen's d), and comparing means between pre-test and post-test scores with an independent-sample t-test.

CHAPTER 7
Results of the summative evaluation study

This chapter studies the effectiveness of the professional development scenario in helping biology teachers teach practically-oriented lessons. The first section presents teacher reactions to the professional development workshop in light of their expectations about and overall satisfaction with the workshop. Section 7.2 describes what the teachers learned from the professional development workshop. Section 7.3 explores the nature and extent of school support during classroom implementation of practically-oriented teaching. The effect of the professional development scenario on the classroom practice of teachers is reported in section 7.4. The impact of the scenario on student learning is described in section 7.5. The last section provides a summary of results and overall conclusions of the summative evaluation.

7.1 EXPERIMENTAL TEACHERS' REACTIONS

The measure of teachers' reactions was based on self-reported data gathered with the help of teacher expectation and evaluation questionnaires filled out at the beginning and end of the workshop. The following is the content analysis of the results organized into two sections.

7.1.1 Expectations

Teachers were asked two questions intended to explore their expectations of the professional development scenario. The first asked them to write down any previous in-service exposure with a student-centered approach (including its particular focus). The second asked them to specify how they expected to benefit from attending the professional development workshop of the study.

Examination of teachers' response to the first question showed that the majority (75%) had prior involvement in similar workshops on student-centered teaching. The workshops in which they participated covered a wide range of topics, from student-centered teaching to sex-education.

By and large, the respondents expressed their perceived benefits in terms of learning new information about and skills on how to teach biology in a 'student-centered' fashion.

The respondents' reactions can be summarized as follows:
Information on:
- different kinds of modern teaching methodology;
- practicality of student-centered teaching;
- the challenges a student-centered approach demands.

Acquiring skills:
- in helping implement the student-centered approach;
- in learning how to teach biology practical works;
- in making effective lesson plans;
- in teaching a hands-on approach.

7.1.2 Overall opinion and satisfaction

Table 7.1 shows that teachers' overall impression about the professional development workshop was positive (with mean scores of more than 4.0). At the end of the workshop they attested that the professional development experience had met their expectations with a mean score of 4.4.

Table 7.1 *Teachers' overall impression of the course (N=18)*

	M*	**SD**
According to my expectations	4.4	0.62
Useful for my professional growth	4.6	0.62
Relevant to my teaching practice	4.3	1.00
Enhanced my understanding	4.2	0.65
The objectives are met	4.2	0.62

Legend * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

In addition, the teachers were asked how much they valued the four sessions of the workshop. For this purpose, they were provided with a description of each session and then asked to rate that particular session. For example, for session-one, teachers were provided with the following description (*Theory exploration*):
- Brief introduction given at the start of the workshop.
- Group discussion about issues pertaining to a student-centered approach in science education.
- Presentation of the "when, what, and how" of practically-oriented lessons.
- Hand-out materials about what student-centered education is, the rationale underpinning this approach, etc.

Overall, Table 7 shows that teachers generally rated the sessions as *good*.

Table 7.2 *Teachers' opinions about the workshop sessions (N=18)*

	M*	**SD**
Theory exploration	4.2	0.50
Video demonstration and discussion	3.8	0.62
Practice with lesson planning	4.2	0.55
Micro-teaching and feedback	4.3	0.60

Legend: * 1 = very poor, 2 = poor, 3 = just okay, 4 = good, and 5 = excellent.

The teachers' were further asked whether they would use the exemplary materials introduced during the practice session, and what they thought about the most/least effective session(s) of the professional development workshop. With exception of one teacher, all of them (N=17) asserted that they were going to adapt the exemplary materials in their respective schools. Regarding the workshop sessions, it appeared that the least effective was the video demonstration. The microteaching session was viewed as the most effective and most highly valued. However, some teachers pointed out that there wasn't enough time for the microteaching session. One teacher put it this way:

> "*…there has been a rush to do the three microteaching lessons, with students so much that we did not have enough time for discussion afterwards*"

Teachers' reactions were also collected about the content of the professional development workshop, how it was delivered, and about the context. Table 7.3 presents their reactions to these three aspects of the workshop.

It appears that teachers regarded the content explored during the workshop useful and relevant to their teaching practices. Looking at how the workshop was conducted, the teachers indicated that there wasn't enough time for completion of the activities. Otherwise, the teachers seem to appreciate the organization and structure of the workshop as a whole. The following is a representative teacher comment:

> "*I have attended many biology workshops … we were simply lectured and had group discussions on the theme of the workshop. However, at this workshop I am impressed with the organization of the activities such as watching and comparing a student-centered video with a conventional lesson and doing microteaching with actual students* "

Table 7.3 *Teachers' reaction on the content, process, and context of the workshop (N=18)*

	M*	SD
Content		
The knowledge and skills explored in the workshop are useful for improving my teaching practices	4.7	0.46
My time in the workshop was well spent	4.4	0.50
Process		
The activities of the workshop are carefully planned and organized	4.4	0.50
The teacher guides are immediately useful for my classes	4.1	0.75
Sufficient time was provided for the completion of the activities	3.0	1.00
The presenter and organizers were well prepared	4.3	0.60
Context		
The facilities provided were conducive for learning	4.2	0.50
The workshop room was the right size	4.4	0.62
The tea, coffees were ready and hot	4.7	0.49
The lunch was fresh and tasty	4.8	0.43
The transportation/lunch allowance was fair and motivating	3.6	1.00

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

Regarding the workshop setting, teachers agreed that the facilities were conducive to learning, and they were very appreciative of the refreshments. However, they regarded the lunch and transportation allowance as less fair and motivating with a mean score of 3.6. Nevertheless, a large standard deviation (SD=1.00) for this item suggests that there was no strong consensus among the teachers.

7.1.3 Summary

The teachers indicated that the professional development workshop had met their expectations for learning new information and acquiring skills on how to teach biology in a more student-centered fashion. It appears that the teachers' overall impression about the workshop was positive. That is, they considered the workshop useful, relevant to their teaching practices, and they felt that their understanding about practically-oriented teaching was enhanced. The microteaching session, as it happens, was viewed as the most effective and highly valued, and the video demonstration as least effective. In addition, teachers' reactions about the content of the professional development workshop, its delivery, and its context were collected. The results show that the teachers found the content explored during the workshop useful to their teaching practice. They appreciated the organization and structure of the workshop, but they felt there wasn't enough time for the completion of the activities. Finally, the teachers agreed that the facilities at the workshop were conducive to learning.

7.2 EXPERIMENTAL TEACHERS' LEARNING

The extent of teacher learning was measured by teacher self-reports and demonstrations of understanding with microteaching lessons. The teachers were given the opportunity to describe in their own words what they thought they learned in the professional development workshop. In addition to the open-ended item, a total of 13 closed items were employed for exploring what teachers thought they had acquired after attending the workshop. The microteaching was carried out as part of the practice session that allowed teachers to practice lesson planning and teaching of a practically-oriented biology lesson on Diffusion & Osmosis and Respiratory System. The results of teacher learning are described in section 7.2.1 and 7.2.2.

7.2.1 Teachers' statements of learning

Teacher responses to the open-ended item were found to be shallow and, for some respondents, rather unfocused. The following are a sample of quotes pertaining to their perceived learning.

> *"I learned that student-centered education is the best way of teaching…"*
>
> *"Student-centered approach is not an easy task i.e. one has to plan, prepare, and practice before (prior) teaching; a teacher has to do a lot, be patient, etc"*
>
> *"I have learned how to teach students by doing different practical works, by grouping students to share their ideas and to make them attentive about the lesson. Generally, how to conduct a student- centered approach"*
>
> *"I have learned a lot from the workshop i.e. how to teach biology based on a student-centered way. It helped me a lot how to keep students to work themselves by seeing, hands-on and demonstrating things".*
>
> *"The lessons I have learned are: giving a chance to students to talk helps a lot in identifying misconceptions … a lesson must be supplemented by practical activities and make students think critically while acquiring the knowledge of the subject itself. Encouragement of students to ask and exchange ideas with their classmates enable them to build a skill of cooperation. In short, I found it is more practical and helpful".*

In addition, the teachers were offered the chance to indicate what they learned at the workshop with the help of closed items. Table 7.4 displays the teachers' responses. Overall, the teachers reported that the theory exploration and demonstration sessions of the professional development workshop had enhanced their awareness and understanding about practically-oriented biology teaching.

Table 7.4 *Teachers' learning from theory exploration and demonstration sessions (N=18)*

	M*	SD
The presentation about the 'what, why, and how' of practically-oriented lessons provided me with much new information.	3.9	0.76
After participating in this workshop my awareness and understanding of student-centered lessons was enlightened.	4.2	0.65
The video demonstration helped me identify important features of a practically-oriented lesson.	4.0	0.59
The video demonstration made me consider trying out practically-oriented lessons.	3.9	0.68

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

Impact of the practice session (i.e. with lesson planning and microteachings) on teacher learning was also assessed. The effect of this session on teacher learning is summarized in Table 7.5.

Table 7.5 *Teachers' learning from the practice session (N=18)*

	M*	SD
After attending this workshop I understand that in student-centered lessons the role of assessing students' prior conceptions is crucial	4.1	0.99
Eliciting students' prior conceptions about biology concepts is the optimum starting point for a lesson	3.8	0.64
The practice session has augmented my skills and knowledge of student-centered lessons	4.1	0.58
After studying the exemplary lessons and practicing the design of such lessons, I am convinced that Ican mange to put into practice such lessons in my own school	4.3	0.49
The microteaching and feedback session helped me become aware of my own teaching behavior and knowledge about alternatives	4.4	0.50
After attending the microteaching conducted by a colleague I have the confidence to use practically-oriented lessons with students	4.1	0.64
My opinion about practically-oriented lessons has changed as a result of the workshop	3.9	0.96
I will organize my biology lessons differently because of this workshop	3.7	1.02
It was easy to provide an honest opinion on what I will change in my future teaching	3.5	1.20

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

Table 7.6 shows that after the workshop the teachers reported that assessing students' prior conceptions was crucial in teaching biology. More specifically, after studying the exemplary materials and observing microteaching lessons, the teachers indicated that their confidence to try out the intended teaching was improved. This seems to influence teachers' previous opinions about practically-

oriented lessons. Even though there appears to be a wide range of opinions (SD=1.02 & 1.20), the teachers were more cautious when asked whether they would adapt or organize their biology lessons in line with the training provided at this workshop. This hesitancy was confirmed when they were pressed to indicate whether it was easy for them to provide an honest opinion on what they would change in future.

7.2.2 Teachers' understanding

The teachers' demonstration of understanding was measured by the three microteaching lessons conducted at the workshop. At the start of the workshop, the teachers formed three groups of 6-7 teachers each. Hereafter, the teachers (and groups) that performed the micro-teaching are referred to as A, B, and C. Table 7.6 provides an overview of their performance on the microteaching lessons; later, a summary of each lesson is highlighted.

Table 7.6 *Practice scores for microteaching lessons in percentage*

	Practice scores			
Group	*Start*	*Body*	*Conclusion*	***Whole lesson***
A	56	74	46	**58**
B	87	89	100	**92**
C	86	94	86	**88**

Legend: * the practice score for each lesson component = [score of the teacher]/[maximum score for that component] times 100%.

With the exception of group A (practice score =58%), the participants demonstrated an understanding of practically-oriented teaching with their planning and performance on the microteaching lessons. Both group B and C scored above 85%, which is a good indicator of the effectiveness of the start, body, and conclusion of the microteaching lessons. A brief analysis of each microteaching lesson will follow.

Microteaching lesson-group A

Group A decided to work on *diffusion in action*, which was lesson one of the exemplary material on diffusion and osmosis. For this lesson, the group was provided with necessary resource materials like dye, perfume, and posters. As can be seen in Table 7.6, the start and conclusion of the lesson scored low on the curriculum profile-classroom observation instrument. The teachers failed to execute properly the lesson specifications. The following is a summary of the microteaching lesson of Teacher A.

Start of lesson

Following the introduction of the lesson topic, Teacher A continued to ask students what they knew about diffusion. Apparently, this question was designed to assess students' prior understanding about the concept of diffusion. Two students responded to this question with very interesting answers. The response of the first appeared to reflect a familiar student misconception on diffusion. The student defined diffusion as follows: "*Diffusion is the mixing of substances".*

The teacher made a quick correction on this apparently flawed conception. In hindsight, he failed to probe the plausible sources for this particular response.

The second student answered in the following way:

> *"Diffusion is the transfer of molecules from a place of higher concentrations to lower concentration…"*

Regarding this response, the teacher told the whole class to use 'movement" rather than "transfer" in defining the concept of diffusion, but he did not offer a meaningful explanation. He then pressed the students to offer some examples of diffusion-related phenomena from their daily life. Nevertheless, despite their inherent shyness, two students at the back of the classroom offered some examples, and afterwards the teacher ran through an exhaustive list of possible examples of diffusion. According to the lesson specifications, this question was supposed to be discussed after students got some first hand experience (experiment) about diffusion.

Lesson body

For the most part, the lesson body was dominated by teacher demonstrations of diffusion. The teacher attempted to demonstrate the concept of diffusion with the help of a blue dye and a spraying of perfume. At the start of the demonstration, the teacher did not ask students to predict the direction of the diffusing molecules. He simply added the blue dye to a beaker of water and asked them to report what was going on in the beaker. Similarly, the teacher did the same demonstration with a spray of perfume for illustrating the diffusion of molecules in air.

In the remaining time, students were asked to repeat what he had already demonstrated. He provided each group with blue dye and a beaker of water to observe diffusion of molecules in liquid. One student from each group was responsible for describing what they had observed.

Conclusion of lesson

The teacher wrapped up the lesson too abruptly. He used a poster displaying a definition of diffusion and diagrams illustrating the process of diffusion (of dye molecules).

Microteaching lesson-group B

The second microteaching was conducted by group B. This group decided on *Practical work on osmosis* which was lesson two of the exemplary material. According to the specification, this lesson was supposed to be covered within two periods in such a way that students would first execute the experiment and then discussed the results in the second period. However, considering the workshop situation, this group prepared a '*thought-practical work*' that approximated the original potato practical work. This thought-practical work was focused on the effect of osmosis on the size of bean seeds. The group prepared a flow chart that described the experimental set up, procedures, and hypothetical results that students obtained while doing that experiment. This practical was taught by *teacher B*, and a brief description of that lesson is presented shortly.

Start of lesson

Teacher B opened the lesson with a brief introduction to the concepts of osmosis, solute, solutions, and concentration. He then went on to state the instructional objectives and sequence of activities that would be dealt with in that lesson. The teacher used a question and answer method for exploring students' prior conceptions by way of bringing up certain student life experiences and what the students think about them.

Body of lesson

The first half of the lesson body was spent on teacher explanation of the thought-practical in terms of its setup, procedures, treatments, and outcome (physical changes). A flow chart and diagrams were used for this purpose. The students were asked to work in groups on three *activity questions* that would be answered on the basis of that hypothetical experiment. The lesson body ended with one student reading out the answers of the group. While this was going on, the teacher asked the other group for their input on the same question.

Lesson conclusion

The teacher made an exemplary conclusion by discussing the discrepancies between students' answers and referring back to the main ideas of the lesson and objectives that he outlined on the blackboard at the outset of the microteaching.

Microteaching lesson-group C

The last microteaching was performed by group C on s*tructures of the respiratory system.* This group spent time working out the lesson plan and preparing a poster to display an unlabeled diagram of the respiratory system. Moreover, they

prepared as a class the activity questions (written into pieces of papers) that were used by students in group discussion. The lesson was taught by *teacher C* and the following is a summary of that lesson.

Start of lesson
The teacher kicked off the lesson with an introduction to the topic and a brief statement of the main lesson objectives. He attempted to assess students' prior conceptions of the topic by a questioning and answering session that set the stage for the student activity.

Body of lesson
The teacher spent some time introducing the student activity and explaining the procedures.
After this introduction, he engaged students in a problem solving exercise where they worked in groups to answer three questions. The students pursued the activity for 15 minutes, and afterwards, the teacher asked one of the groups to report their results. During this brief report, one student read straight through the group's answer for each question. The teacher made efforts to explore the perspectives of the other groups regarding the same question.

Lesson conclusion
The teacher concluded the lesson by revisiting the lesson objectives and providing students an overall summary of that lesson.

7.2.3 Summary

The teachers attested that the professional development workshop enlightened their awareness and understanding about practically-oriented teaching. They found the exemplary video helpful for identifying the important features of a practically-oriented lesson. In particular, the teachers indicated that their confidence to try out the intended teaching was improved after they studied the exemplary materials and observed the three microteachings. Moreover, most teachers demonstrated an understanding of practically-oriented teaching in their planning and teaching of lessons under a simulated environment.

7.3 NATURE OF SCHOOL SUPPORT FOR EXPERIMENTAL TEACHERS

The extent of school support was measured by a questionnaire and focus group interview administered at each school. The results are reported as follows.

7.3.1 Perceptions of teachers about the extent of resource support

A total of six closed items and two open-ended items were used to assess the provision of resources deemed necessary for teaching practically-oriented biology lessons. Looking at the overall results in Table 7.7, it appears that School A was in good shape in terms of resources (M= 3.6), School B was ranked second (M=3.5), and School C was reported as the least resourced school (M = 2.8).

Table 7.7 *The extent of resource support for teachers at each school (N=17)*

	School A N=7	**School B N=5**	**School C N=5**	**Average**
	*M**	*M*	*M*	*M*
The necessary materials are provided to me in a timely manner from the school	3.7	3.8	2.6	3.4
The necessary facilities of the school are made available to me at appropriate times	3.7	4.0	2.6	3.4
The physical conditions of the school (laboratory, supplies, classrooms, etc) are conducive to my implementation efforts	2.0	2.4	2.0	2.1
We have a quite place to plan and discuss important issues	4.3	3.8	3.0	3.7
I had sufficient time to prepare for implementing practically-oriented lessons into my regular classroom routines	4.0	3.4	3.4	3.6
I had ample time to reflect on my student-centered strategies and make appropriate adaptations	4.0	3.4	3.0	3.5
Average	3.6	3.5	2.8	3.3

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

All the teachers indicated that the physical conditions of the schools were not very conducive for their implementation efforts. Teachers at School C, in particular, asserted that the necessary materials and facilities of the school were not made available to them at the appropriate time. For the same items, School A and B agreed that materials and facilities were provided to them in a more timely manner. Finally, it appears that for teachers at schools B and C, time had not been on their side for lesson preparation and reflection (Ms= 3.0 & 3.4).

Moreover, the nature of resource support was explored during the focus group interviews. All the teachers reported that they had enough time for lesson preparation. This assertion seems to contradict slightly with what teachers at school B and C indicated on the questionnaire about having time problems for

preparation and reflection. Both teachers at School A and B noted that their schools were supportive at providing them materials and supplies in a timely manner. Teachers at school C reported that even though they had managed to get certain materials and supplies, it was not in a timely manner.

7.3.2 Perception of teachers about the school culture and extent of collegial support

A total of six closed items and three open-ended items focused on gleaning information about school culture and collegial support. The perceptions of teachers on these aspects of support are presented in Table 7.8.

As shown in Table 7.8 both Schools A and B encourage teachers to experiment with new strategies, and correspondingly, fellow teachers at these two schools are upfront in sharing their enthusiasm. School C, though, looks less conducive to experimenting with new teaching strategies. Furthermore, teachers at School C reported that the school administration was not open to suggestions for improving school practices, and that they were rarely ever engaged in conversations about ways to improve their teaching approaches.

Table 7.8 *The nature of collegial support and culture in the schools (N=17)*

	School A n=7	**School B n=5**	**School C n=5**	**Average**
	*M**	*M*	*M*	*M*
The school encourages experimenting with new strategies aimed at improving student learning outcomes	4.3	4.2	2.6	3.7
Fellow teachers share my enthusiasm for experimenting with new strategies for teaching	3.9	4.2	2.8	3.6
The school administration is open to suggestions for improvement in school practices	4.7	4.4	2.6	3.90
Your effort to improve is recognized by some fellow teachers	2.4	3.2	3.8	3.1
We frequently engage in conversations about ways to improve our teaching approach	4.1	4.0	2.8	3.6
I had the opportunity to visit the classrooms of fellow teachers and observe their teaching or the other way around.	3.7	1.8	2.2	2.57
Average	3.9	3.6	2.8	3.4

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 =agree and 5 = strongly agree.

Regarding peer observation, the results show that the teachers in Schools B and C did not have opportunities to visit the classrooms of peer teachers, while teachers at School A indicated that they had the opportunity to visit one another. Further analysis showed that four teachers in School A did 'peer observations' on different occasions prior to and during the course of the study. The head department considered his bi-annual classroom observation as peer observation.

During the focus group interview the teachers confirmed that the school administration encouraged them to experiment with new strategies aimed at improving student learning outcomes. School C reported that the school administration had a weekly schedule for departmental meetings but not in peer collaboration per se. Concerning the opportunities for peer classroom observation, the teachers noted that conditions at their respective schools did not allow that. Overall, the teachers described the impeding conditions in terms of time shortage, lack of structure, and fear of violating the 'classroom privacy' of colleagues. The following quotes illustrate teacher perceptions on the issue of peer observation:

- *"I did not have any opportunity to observe sessions of my fellows teachers. But this is not because I do not need, that's because such opportunity is not common in the school..."*.
- *"You do not prefer to spend your break time to observe others … such opportunity might be possible when there is a close intimacy among the fellows, otherwise, it is not simple to observe the fellow teacher's session with no care of what they feel…"*.
- *"… Because I did not have enough time to do so. I am very busy in the regular work: correcting, preparing, and writing three lesson plans etc. does not allow me to follow other teachers teaching"*.
- "*I could not get any opportunity where I could observe fellow teachers teaching formally; of course informally we talk or discuss things on the methods we teach in class among ourselves. Otherwise, it is really unfair to go and observe someone's way of teaching by going to one's class. He/she may not feel good to observe him or her*".

7.3.3 Perception of teachers about the school leadership

The nature of leadership at the schools was explored with the help of six closed items and one open-ended item. These items focused on the characteristics of the principal and school administration in general. A content analysis of school leadership items were summarized in Table 7.9.

Table 7.9 *The nature of leadership in the schools (N=17)*

	School A n=7	School B n=5	School C n=5	Average
	*M**	*M*	*M*	*M*
The principal is an active and enthusiastic learner	4.1	4.0	3.4	3.8
The principal encourages teachers to become involved in school wide decision making	4.3	4.2	2.8	3.8
The school administration encourages teachers to participate in workshops intended for their professional growth	4.3	4.6	2.8	3.9
You are encouraged to plan lessons collaboratively with your fellow department teachers	4.1	3.2	3.8	3.7
The principal recognizes and honors teachers' success with student achievement	4.4	4.6	3.6	4.2
The school administration offers schedules that allow you to collaboratively plan and discuss with fellow teachers	3.7	3.2	3.0	3.3
Average	4.2	4.0	3.2	3.8

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 =agree and 5 = strongly agree.

As can be seen in Table 7.9, the principals at both school A and B were viewed as active and enthusiastic learners as far as new innovations were concerned. The same teachers reported that their respective principals recognized and honored teachers' success with student achievement and encouraged them to be involved in school wide decision making. However, the principal and administration at School C were considered less supportive. Teachers there indicated that the school administration hardly encouraged them to participate in workshops intended for their professional growth. During the focus interviews at all the schools teachers indicated that they were not in a position to dispense information about their principals. One may surmise from this that the perceptions of teachers of School A and B about the school leadership from the questionnaire appear to be socially desirable reactions.

7.3.4 Summary

The extent of the school support teachers received was explored along the basis of resources, collegial support, and school leadership. Regarding resources, it was found that School A was in good shape and School C was reported as the least resourced. The teachers at School C reported that the necessary materials and facilities of the school were not made available to them at appropriate times.

Regarding the nature of school culture and collegial support, both Schools A and B encouraged teachers to experiment with new strategies, and fellow teachers were upfront in sharing their enthusiasm. However, teachers at School C reported that the school administration was not open to suggestions for improvement. Futhermore, as teachers they were not frequently engaged in conversations about ways to improve their teaching approaches. Similarly, the perceptions of teachers about the school leadership of School A and B were in sharp contrast with the perceptions of teachers in School C. The principal and administration of School C were viewed less supportive. The teachers indicated that the school administration hardly encouraged them to participate in workshops intended for their professional growth.

7.4 TEACHERS' USE OF THE NEW KNOWLEDGE AND SKILLS

Four methods were considered for exploring teachers' use of practically-oriented biology lessons. According to Guskey (2000), for addressing the issue of teachers' usage of an innovation, one ought to investigate teachers' evolving concerns, levels of use, and differences in practice. The results of the Stages of Concern Questionnaire, classroom observation, levels of use interviews, and student interviews are described in the subsequent sections.

7.4.1 Evolution of teachers' stages of concern

The Stages of Concern Questionnaire was administered three times with experimental teachers during the implementation of the professional development scenario. The three concern profiles were described and considered for re-constructing the evolution of their concerns in ways that offer insight into their usage of practically-oriented lessons. The three concern profiles of the experimental group are described in the following paragraphs.

A complete profile of individual teachers is available in Appendix C1. Table 7.10 and Figure 7.1 display stages of concern profiles for the group of teachers.

Table 7.10 *Mean percentile scores of stages of concern*

	Stages of concern						
	*0**	*1*	*2*	*3*	*4*	*5*	*6*
Before the start of workshop (N=17)	83	80	85	62	61	67	74
At the end of workshop (18)	74	79	75	50	51	71	72
At the start of school follow-up (15)	74	79	75	50	51	71	72

Legend: * 0 = Awareness 1 = Informational, 2 = Personal, 3 = Management, 4 = Consquence, 5 = Collaboration, 6 = Refocusing.

The data pooled from the questionnaires before the professional development workshop indicate that the teachers' concerns were high at stages 2, 0, 1, and 6 (see Table 7.10 & Figure 7.1).

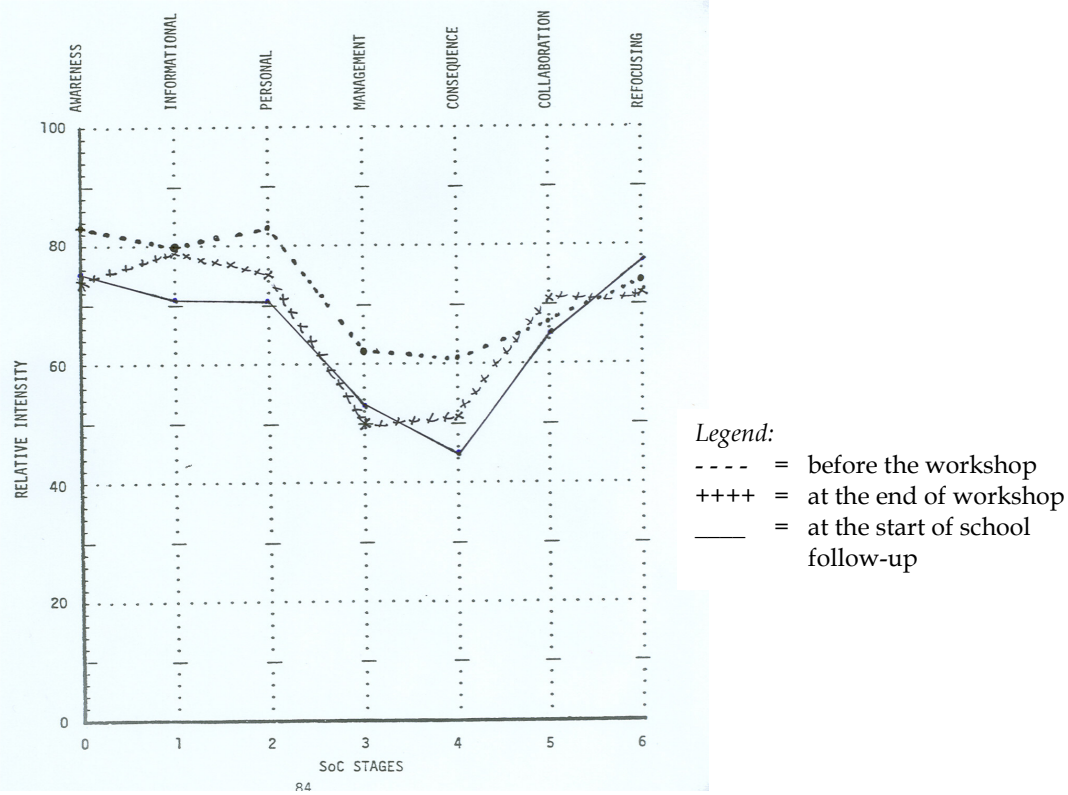


Figure 7.1 Stage of concern profile for three measurements

Overall, the concern profile generated before the workshop underscores that the teachers were aware of and concerned with practically-oriented teaching (stage 0). However, teachers' intensity of concern was slightly higher at stage 2 than stage 1. This might be considered an indication of a potential resistance to the intended change. When stage 2 concerns were equal to or more intense than stage 1, teachers' personal concerns overrode concerns about learning more about the innovation (Hall et al., 1998). The teachers seem to be more concerned about their personal well being in relation to the change than in learning more about practically oriented teaching. The valley in figure 7.1 suggests that at this point, the teachers were not much concerned about management (stage 3) issues and the effect (stage 4) of the innovation on students, which is consistent with their status as starters.

The second measurement was conducted at the end of the professional development workshop. This measurement was intended for keeping track of evolving concerns and making appropriate plans for school follow-up. The mean percentile scores

indicate that the teachers' intensity of concerns was still higher at stages 1, 2, and 0 (see Table 7.10 & Figure 7.1). This concern profile of the teachers indicates that teachers were aware of what the innovation was and yet wanted to get more information, even after attending the professional development workshop (cf. Hall et al., 1998).

The third measurement was aimed at assessing participants' immediate concerns while using practically-oriented biology lessons as well as in order to tailor the nature of the coaching for each individual teacher. Table 7.10 shows that at the start of the school follow-up the highest stages of concern of teachers were Stages 6 and 0. Additionally, teacher concerns about management and student learning were still very low.

According to Hall et al. (1998) a high score on stage 0 for users shows that the teachers as a group have low concerns, knowledge, attention, or interest regarding the innovation. Similarly, a high intensity of interest in stage 6 indicates that the teachers have ideas about how to improve the use of the innovation. Overall, the conspicuous upswing of stage 6 (refocusing), coupled with self-related concerns (stage 2), looks like a typical nonuser's concern profile as shown in the first measurement conducted before the teachers became involved in the professional development course (Hall et al., 1998).

7.4.2 Teachers' level of use of practically-oriented teaching

For investigating the level of use of practically-oriented teaching, the study conducted structured interviews. These interviews were conducted with both experimental and control group teachers in ways that enabled exploration of their usage and traced the differences in classroom practice between the two groups.

Experimental group teachers' levels of use

At the start of the school follow-up, one teacher reported that he was not using practically-oriented biology teaching. He further indicated that he had no plan to embrace the approach in the next academic semester. This teacher was later excluded from the coaching and summative evaluation. The rest of the teachers (N=16) reported that they were using practically-oriented teaching, and on the basis of the LoU interview, a modest attempt was made to place them at different levels (see Table 7.11). A summary of each experimental teachers' level of use and practice profile scores are available in Appendix C2. It should be noted that for rigorous placement, a longitudinal study on participants' level of use would have been more informative and decisive.

Table 7.11 *Percentage of experimental group teachers placed at different levels of use (N=16)*

Nonusers		**Users**
LoU II: Orientation	LoU III: Mechanical	LoU IVA: Routine
12.5 (2)	62.5 (10)	25 (4)

It appeared that most of the experimental teachers were users of practically-oriented teaching, though with different degree of usage. Only 12.5% (2) were placed at the level of use II (orientation) that distinguished them as nonusers. Despite their participation throughout the program these teachers failed to articulate their active usage of the innovation. Much of what they talked about with the researcher dwelt on self-related concerns about the innovation, and indicated that they would be using it in the coming semester.

The majority of the users (62.5% (10)) of practically-oriented biology teaching were placed at a mechanical level of use (LoU III). Almost all teachers at level of use III reported that they were actively and daily involved in reading, planning, and improvising materials for practically-oriented teaching (see Appendix C2). This active engagement was characterized by teachers' adaptation of the innovation to their peculiar classroom context and a general inefficiency in managing group work activities, time, and practical work. In part, the teachers blamed such inefficiency on a lack of resources, facilities, and content overload (i.e. grade 10), and students' reluctance to participate.

The teachers placed at level of use IVA asserted that they were making best of the professional development they received. This assertion seemed to be supported by their classroom practice profile scores (see section 7.4.3). Three teachers articulated their active engagement with the innovation by citing lessons or topics about students who did practical work or worked in groups, about how students liked particular lessons, and what misconceptions they identified, and what anecdotes of success and failure they could relate. Moreover, these teachers were able to relate what they were doing with the exemplary materials and reflective meetings that the research conducted during school follow-up.

Control group teachers' level of use

For ascertaining the effect of the professional development scenario on an experimental group's classroom practice, a decision was made to compare the observed practice to what other teachers (control group) were doing at that time (cf. Guskey, 2000). Thus the control teachers were first observed with the help of a curriculum profile-classroom observation instrument and later interviewed about their

use of practically-oriented teaching. A summary and overview of the analysis of data from the level of use interviews is presented in Table 7.12 (see also Appendix C2).

Table 7.12 *Percentage of control group teachers placed at different levels of use (N=14)*

Nonusers			**Users**	
Nonuse (LoU 0)	Orientation (LoU I)	Preparation (LoU II)	Mechanical (LoU III)	Routine (LoU IVA)
42.8 (6)	21.4 (3)	7.14 (1)	21.4 (3)	7.14 (1)

Analysis of the teachers' interview sessions shows that only 29% of the control group teachers were users of practically-oriented teaching. The rest of the teachers (71%) reported that they were not using the teaching approach at this time (see Table 7.12).

The teachers at LoU 0 (42.8% (6)) said that it was difficult to use practically-oriented teaching for a number of reasons, and indicated they were not personally committed to improving their practice. As can be seen in Table 7.12, around 28% (4) of the teachers were at the next levels of nonuse with respect to this innovation; that is, at orientation (LoU I) and preparation (LoU II). The three teachers at LoU I expressed their interest in practically-oriented teaching and indicated that they would like to learn about it. Teacher 4 was placed at LoU II (preparation) because he asserted that he was knowledgeable about the student-centered approaches and pointed out that he would be using such approaches next semester.
The teachers at LoU III and IVA asserted that they were using practically-oriented biology teaching. These teachers attempted to substantiate their usage by citing where students were involved in 'problem solving activities', 'laboratory work', and 'group discussions'.

7.4.3 Classroom implementation of practically-oriented teaching

The degree of implementation of individual teachers was determined by the curriculum profile-classroom observation instrument. The results are presented in Table 7.13. The results of the classroom practice of experimental and control group teachers are presented as follows, and they will subsequently be compared in order to explore differences in classroom practice.

The classroom practice profile of the experimental group

The total practice profile score was considered 100%--calculated by weighing 40% for the realization of the thresholds and 60% for ideals statements related to practically-oriented teaching (see chapter 6 section 6.4.6). Table 7.13 presents an overview of the experimental group teachers' classroom practice profiles.

Table 7.13 *Practice profile of experimental group teachers (N=16)*

	Threshold scores				Ideal – unacceptable scores				
Teacher	*Start*	*Body*	*Conclusion*	*40%*	*Start*	*Body*	*Conclusion*	*60%*	***Total****
A	83	100	33	29	50	77	33	32	61
B	83	100	33	29	90	71	20	36	65
C	67	40	33	19	57	33	0	18	37
D	80	40	0	16	50	29	0	17	33
E	100	100	100	40	92	97	100	58	98
F	100	100	100	40	100	97	100	59	99
G	83	100	100	38	83	93	80	51	89
H	100	100	100	40	83	89	83	51	91
I	83	70	67	29	67	33	100	40	69
J	57	60	0	16	64	46	0	22	38
K	100	100	100	40	85	97	100	56	96
L	100	60	100	35	75	40	75	39	74
M	67	100	0	22	42	57	50	30	52
N	100	100	100	40	100	97	86	56	96
O	60	67	100	30	75	46	100	44	74
P	67	60	100	30	58	63	67	38	68
Mean				30.8				40.4	71.2
SD				8.8				14.1	22.7

Legend: * The total= [threshold scores] + [ideal scores – unacceptable scores].

As shown in Table 7.13, the mean practice profile score for experimental group teachers was 71.2. With the exception of three teachers (Teacher C, D & J), the rest of the teachers scored largely above the threshold practice profile score, which was 40%.

Overview of classroom observations of experimental group

First, an overall impression of the lessons is discussed, followed by the salient details of what was observed at each component: start, body, and conclusion of the lesson. Finally, a condensed description of the lesson observations of particular teachers is presented for illustrating the three categories of use: orientation, mechanical, and routine users.

General impressions

Prior to the observations for the summative evaluation, the experimental teachers had already undergone three to four cycles of classroom observation over the course of the school follow-up. It is fair to note that despite their participation in the workshop, the first observation was characterized by teacher dominated factual presentations and a learning environment where students were largely subdued. Nevertheless, looking at their practice trajectories it is hard to miss the gradual

improvement of teachers' classroom performance in terms of structuring their classrooms, lessons, introductions, and organization of group work activities.

The teachers gave the impression that they were well aware how learning hinges on the active involvement of students. They were actually observed engaging their students in a Socratic style questioning, interactive demonstration, problem solving activities, and practical work. In 9 out of 16 lessons, the teachers re-arranged their classrooms in ways that enabled students to work in groups. The students were observed actively involved in groups of 6-7 working on activity questions and practical work. Despite the encouraging frequency of student group work, its quality leaves much to be desired. Another impression worth mentioning was that three teachers were observed explicitly assessing students' prior conception with the help of a quiz and oral questions. These same teachers seem to embrace the dictum that assessment of learner's prior conceptions is the starting point for teaching because they were observed doing it right from the time of follow-up observations. Regarding the overall roles of the teacher and student, it was observed that to some extent teachers appear to have relinquished their traditional dominance as knowledge dispensers. They enriched their roles as facilitators for student group work activities and as moderators during presentations. Students were observed to be actively involved in group discussions, activity questions, practical activities, and presenting results

Start of lesson

One pattern of lesson starting that stood out across all the lessons was a review of materials from the previous lesson. The teachers often began the class with a systematic review of the previous lesson in ways that warmed up the students and established a bridge to the day's topic. Another activity consistently observed by all teachers was a statement of instructional objectives. The teachers were observed attempting to garner and focus students' attention by writing learning materials in the corner of the black board or communicating them orally. More often than not the teachers wrapped up this section of the lesson by introducing the day's topic, and for some lessons, by instructing students to form groups.

> *The lesson that **Teacher F** taught was on animal kingdom. The lesson kicked off with the teacher's writing of the instructional objectives on the blackboard and posting two posters that displayed diagrams of Nematodes, Annelids, and mollusks. The teacher spent 10 minutes introducing the sequence of activities that would take place in this lesson and what students were expected to master by the end of the class. He briefly brought up the "reading homework" which students were asked to do on Nematodes, Annelids, and mollusks. Students were told to go to form their respective groups, and in the meantime he said that he would write down three activity questions on the black- board.*

Body of lesson

The majority of the tasks of a lesson were carried out in this section, be they interactive demonstrations, problem solving, or practical work activities. For those problem solving or practical work activities, teachers spent a few minutes at the start overlooking group formation and explaining the procedural aspects of that particular activity. In most of the lessons, it was observed that forming a total of 8-9 groups of 6-7 students appeared to be the norm. However, there were exceptions to this general rule, as when the whole class was divided into three big groups of 14-16 students each (e.g. Teacher G).

> ***Teacher N*** *spent few minutes introducing the student activity and how they would work on the activity. Students were provided with an unlabeled diagram of the male reproductive system and students were asked to identify the structure and describe its function. He asked students to form groups and start working on this 'problem solving' activity.*
> *Following the students' group activity the teacher moderated a whole class discussion about the structure and function of the male reproductive system. He solicited a particular response from each group on a male reproductive structure and at times interjected to provide additional explanation. The students were observed candidly responding to the teacher's questions and contesting the apparently wrong answers of certain groups.*

The types of lesson activities students performed were *problem solving exercises (in group)*, *practical work*, *interactive demonstrations,* and *presentations*. Out of the 16 lessons observed nine teachers engaged students in problem solving activities; one teacher started a lesson with an interactive demonstration; and one teacher engaged students in practical work. The remaining six teachers were observed employing very familiar teacher-centered teaching formula where they attempted to involve students as much as possible in question and answer and relating the concepts to students' daily life. By and large, the students seemed to enjoy presenting, working in groups, and doing practical work, but these activities consumed too much time to frustration of the teachers. The teachers were attempting to draw students into whole-class discussions but the students shied away from it.

Conclusion of lesson

The majority of teachers (n=12) recognized the significance of lesson conclusion. However, four teachers (Teacher B, D, J, and M) failed to do a proper lesson conclusion because of time constraints and poor organization. The student presentations/discussions or teacher explanations had to be abruptly stopped when the school bell rang. The rest of the teachers managed to end the lessons with a teacher-based or student-based summary in which questioning and answering was employed. It is worth noting that re-arranging the desks and cleaning the classrooms was a nuisance for incoming teachers.

> *The lesson that **Teacher L** taught was on phylum Coelenterate*
> *The teacher spent a few minutes recapitulating the main points about phylum coelenterates and finally provided students the opportunity to ask questions. One student asked if coelenterates were more advanced than poriferas. The teacher entertained the question very well by highlighting the salient indicators that qualify coelenterates as more developed than poriferas.*

A summary of individual teachers' classroom observation

The experimental teachers were differentiated into three groups on the basis of the level of use interview and classroom observation (see Table 7.12). The teachers in the first group were considered routine (LoU IVA) users of the innovation. The second group of teachers was placed at LoU III (mechanical), and the majority of participant teachers fell in this category. The last group was designated as nonusers at LoU II (orientation). The following is a summary of three classroom observations that illustrate these three categories of use and nonuse.

The teacher began the lesson with a review of the previous lesson. She conducted this review with an interactive demonstration of the difference between monocot and dicot plants. For this purpose the teacher brought forth a placard displaying a number of glued specimens of mono and di cot seeds and leafs. Four volunteer students were asked to come forward and identify the seeds/leafs. The teacher challenged the students to justify their identification of the particular seed and leaf as monocot and dicot. Before rectifying any incorrect answers, she gave the class the opportunity to provide a better explanation. The teacher wrapped up the start of the lesson with an introduction of the day's lesson topic (*Animal Kingdom)* and a statement of instructional objectives.

Student activity

The teacher spent some ten minutes explaining the main keys used to classify animals into different phyla and providing essential information students should follow in doing the problem solving activities in groups. The students were asked to go to their respective group and work on activity questions. The teacher prepared these activity questions on pieces of paper that were distributed to each group.

1. List any five animals that are familiar in your environment?
2. On the basis of the classification keys please discuss and sort them into the following categories.
    a. Vertebrate vs. invertebrate?
    b. Class in which they belong and why?

The classroom was rearranged swiftly to facilitate the work of 8 groups of 6-7 students each. The teacher appeared to have a good relationship with students; she managed to easily blend into groups and kept them engaged through out the discussions.

Group presentation

The teacher told the class she had time for only two group presentations; the other groups would be given the chance to present on other topics. The two groups presented the results of their problem solving activity. The teacher challenged them repeatedly and provided further clarification on what students presented. At times she deflected particularly contentious assertions to the whole class.

The teacher concluded the lesson by providing an overall summary of the lesson. She underscored that the classification keys are crucial for categorizing animals into their respective phyla and classes.

Figure 7.2 A lesson that illustrates a routine user (Teacher E)

The teacher began the lesson by revisiting the main concepts students had learned about bacteria. He underscored that in the previous three lessons they had discussed the structure of bacteria and in this lesson students would be working in groups on the economic significance of bacteria, i.e. beneficial and harmful bacteria. After spending a few minutes explaining the concept of economic importance, he told the class to form groups for the day's activity.

The body of the lesson started with students' chaotic group formation. The teacher attempted to reshuffle certain students from one group to another, and this took some minutes. That done, the teacher reminded the class that the previous day they were given a library reading assignment about beneficial and harmful bacteria. In today's lesson, he told them, students are going to "discuss and organize" what they have read in their respective group. He instructed some groups to focus on beneficial and others on harmful bacterial, and to that effect he managed the assignment.

Student activity
Students were observed working on the materials they had read from the library. They skimmed through the notes and read what they got from the library to their respective group. During the group discussion the teacher moved around monitoring and providing suggestions as to how students could best organize their results.

Group presentations
The teacher asked four groups to report the results of their discussion on the economic importance of bacterial. Two groups did their presentations on beneficial bacterial and the other two on harmful bacterial. During these presentations, the teacher was seen jotting down important points on the blackboard from the student who was presenting. The teacher managed to throw in some comments on each presentation and asked the class if they had anything to add or ask. The school bell rang when the last group was presenting, and the teacher informed that group to quickly wind up. The teacher ended the lesson without a proper conclusion or run-through of the points he outlined on the blackboard.

Figure 7.3 A lesson that illustrates a mechanical user (Teacher P)

At the start of the lesson the teacher outlined the objectives on the board. He told students that the day's lesson would be on the *endocrine system* and explicitly made clear to students why the lesson was important for them to learn. He spent some time checking the homework of each student and reprimanding those who failed to turn it in. The teacher engaged students in a questioning and answering session where he summarized the previous lesson material, even though it was hard to figure out how it would be related to the day's topic.

For the most part, the body of the lesson was dominated by the teacher's presentation. Judging by the flow of a presentation characterized by abrupt transition from one issue to the other, the teacher appeared less than organized. Initially the teacher engaged students in a question and answer session for reviewing the location of the endocrine glands from an ill-drawn diagram of the human body on the blackboard. He then went on to draw a very long and blank table in order to summarize the type of gland, location, hormone, function, and abnormality associated with that particular endocrine gland. The teacher spent an inordinate amount of time advising students how they could prepare such a table, the advantage of drawing such a table in a 'portrait or landscape' format, etc. The remainder of the lesson was spent explaining the location and abnormalities of the thyroid gland. Students were intermittently engaged with 'flier' questions to make sure they understood. Throughout the teacher's presentation, the majority of students were subdued and some were observed writing notes and others responding to teacher's low order questions.

When the bell rang the teacher told students to complete the table at home and advised them to do it on paper.

Figure 7.4 A lesson that illustrates a nonuser at orientation level of use (Teacher P)

Classroom practice profile of control group

Table 7.14 presents an overview of control teachers' practice profile scores. The mean practice profile score for control teachers was 56.6. All in all, three teachers (Teacher 1, 9 & 13) failed to realize an acceptable classroom practice.

Table 7. 14 *Practice profile scores of control group (N=14)*

	Threshold scores				Ideal – unacceptable scores				Total*
Teacher	*Start*	*Body*	*Conclusion*	*40%*	*Start*	*Body*	*Conclusion*	*60%*	*100*
1	50	20	33	14	28	29	50	22	36
2	60	20	100	24	30	29	75	27	51
3	67	50	100	29	40	40	100	36	58
4	60	60	33	20	50	50	14	23	43
5	100	100	100	40	91	100	100	58	98
6	80	60	0	19	69	39	40	29	48
7	100	75	92	37	87	75	80	49	86
8	67	75	50	26	58	36	75	34	60
9	50	60	0	15	72	46	0	23	38
10	50	40	100	25	37	27	20	17	42
11	71	100	100	36	71	94	100	53	89
12	50	100	0	20	46	86	57	38	58
13	50	60	0	15	29	7	0	7	22
14	50	60	67	24	58	39	100	40	64
Mean				24.6				32.6	56.6
SD				8.4				14.3	21.8

Legend: *Total = [threshold scores] + [ideal scores – unacceptable scores].

Overview of control group classroom observations

In this subsection, an overview of the classroom observations of control group teachers is presented in terms of the general impressions and patterns of teachers' practices at the start, body, and conclusion of a lesson.

General impressions

A closer look at the classroom observation data shows that this group of teachers consists of users and nonusers of practically-oriented biology teaching. At two of the classroom observations, students were seen actively working on problem solving activities and interactive demonstrations. In these lessons, the classroom was structured in ways that facilitated group work. By and large, the remaining 12 lessons were executed in a traditional classroom format where the teachers were observed heavily using expository methods. The only visible student activities were note-taking and responding to teacher questions. At best, students were purposefully engaged in a question and answer session at the start and conclusion of lessons in order to review the materials of a previous lesson and to summarize the day's lesson.

Start of lesson

At the start of the lesson, the teachers spent a few minutes revisiting materials covered in the previous lesson. In most of the lessons, students were involved in a question and answer session to review the materials. This was followed by an introduction of the topic(s) for that particular lesson and abrupt transitions to the lesson body. With the exception of one lesson (Teacher 7), almost all of the teachers failed to explore students' prior conceptions, and hardly stated the instructional objectives.

Body of lesson

This part of the lesson featured most of the teacher explanations, interactive demonstrations (e.g. Teacher 11) and problem solving activities (e.g. Teacher 12). Across the lessons, the teachers were consistently observed lecturing students with concept explanations. The students were occasionally engaged in 'flier questions' to ensure they were following the teacher. In some instances, the questions were simply answered by the teachers themselves without giving students adequate time or opportunity to think and answer. (Teacher 13, 10, and 6). This is not to say that there were no critical and challenging questions. For example, Teacher 7 used questions that challenged and helped students relate the topics to their daily lives.

The next major activity teachers were observed doing was note giving. For example, Teacher 2 first asked students to take the notes she wrote on the blackboard and only later offered an explanation for them. Five other teachers engaged in this note taking activity at the end of their lectures.

Lesson conclusion

The ways the observed lessons were wrapped up varied across the control group teachers. A total of six teachers used a question and answer session where both students and teacher summarized the lesson materials. As mentioned above, five teachers devoted this time to note giving while the remaining three abruptly concluded the lesson after the school bell.

7.4.4 Differences in classroom practice

In order to examine the differences in classroom practice of the experimental teachers, especially following their involvement in the professional development scenario, a decision was made to compare the observed practice of the teachers with what control teachers were doing at the time of the summative evaluation. This comparison was done on the basis of both groups' practice profile scores (threshold and total) and level of use results. Table 7.15 combines the threshold and total scores from the curriculum profile-classroom observation instrument.

Table 7.15 *Practice profile scores of experimental and control groups*

	Experimental (n=16)		Control(N=14)		Effect size	Mann-Whitney test	
	M	*SD*	*M*	*SD*	*d**	*Z*	*p*
Threshold scores	30.81	8.79	24.57	8.38	0.73	-2.03	0.043
Total scores	71.3	22.7	56.6	21.8	0.66	-3.89	0.00

Legend: * Cohen's d; small d = 0.2; medium d = 0.5; large d = 0.8.

The values of the effect size (d= 0.73 & 0.66) suggest that the difference in classroom practice scores between the experimental and control group teachers was medium. (cf. Cohen, 1988). A Mann-Whitney test was used to see whether this difference between the practice profile means was actually significant. The test showed that the difference in practice was significant (Z= -2.03 & -3.88, P= 0.043 & 0.00).

In addition to this, experimental teachers' perceptions about their levels of use of practically-oriented teaching were considered for determining the difference in classroom practice. That is, as shown in Table 7.16, the percentage of those teachers at different levels of use and nonuse was contrasted with the control group teachers.

Table 7.16 *Percentage of experimental and control teachers' level of use*

	Nonusers			Users	
	Nonuse (LoU 0)	*Orientation (LoU I)*	*Preparation (LoU II)*	*Mechanical (LoU III)*	*Routine (LoU IVA)*
Experimental (N=16)	–	–	12.5 (2)	62.5 (10)	25 (4)
Control (N=14)	42.8 (6)	21.43 (3)	7.14 (1)	21.42 (3)	7.14 (1)

It appears that only 12.5% of experimental teachers were considered nonusers as compared to the 70% of control teachers that make up those levels (i.e. LoU 0, I & II). Similarly, the percentage of experimental teachers at levels of use III and IVA was by far higher than that of the control teachers.

Comparing the experimental group teachers with the control group on these two measures (practice profile scores and levels of use) suggests that the professional development scenario of the study indeed contributed to the implementation of the practically-oriented biology teaching of the experimental teachers.

7.4.5 Student perceptions about teachers' classroom practice

General perceptions

The interviews started with general questions such as why student(s) choose the science/art stream, what subject(s) they study more than others, what activities of biology teaching students liked most and why, etc. It appears that, with exception of three students from the Art's stream, all (n=19) reported that they liked biology.

The students said that they enjoyed doing biology practicals and group work activities. One of the female students from the Art stream indicated that it makes her feel 'nervous' working in groups because such activities take too much time and she pointed out that in group work "rather than learning you share gossips".

Perception of teacher's role as facilitator of student learning

The students were asked if their biology teacher was good in creating an atmosphere where they could work comfortably on activities. They reported that their teacher was good in providing a learning environment best-suited for teaching the lessons. Regarding what this classroom atmosphere looked like students had many things to say. The following answers illustrate the student perceptions of the role of the teacher in facilitating student learning:

- *"because he takes us to the laboratory… The teacher discusses with us about our library or reading assignment."* [Teacher F];
- *" our teacher is a good explainer"* [Teacher M];
- *" because she makes us work in groups, and sometimes she takes and teaches us lessons outside the classroom in the school compound, for example when we are learning about the plant Kingdom"* [Teacher E];
- *"because he explains the concepts very well"* [Teacher N];
- *"the teacher teaches us in ways that we can understand the lesson easily"* [Teacher H];
- *"because he has a good sense of humor that accompanies the particular lesson"* [Teacher L];
- *"because we are not afraid for asking him questions inside or outside the classroom"* [Teacher D].

The students pointed out that teachers do frequently assist and interact with them during experiments and group activities. In addition, they were often encouraged to ask questions, to which their teachers responded positively.

Assessment of student prior conceptions

The students reported that their teachers did explore what they knew about a topic or concept at hand. However, from the follow-up question, it turned out that they often misunderstood prior conceptions from the review of previous materials routinely done by teachers. As such, it was not possible to gather much information on this issue from students. The following two quotes could sample students' responses in this regard.

- "*When we were learning about the pancreas gland, the teacher asked us about what diabetes is, its cause, symptoms etc.*"[Teacher D];
- "*At the start of every animal phylum the teacher had asked us what we knew about the animals: characteristics, habitat, feeding etc.* [Teacher L].

Types of biology activities in which students were involved

Six items were used for exploring the type and frequency of activities that students did in that particular semester. The students were directly asked whether they had done experiments, observed teacher demonstrations, and engaged in group work activities, and whether they found such activities meaningful or whether the teacher attempted to relate the learning materials to their daily lives.

It appears that the activities the students mentioned being involved in include practical work, demonstrations, group problem solving activities, library study, note-taking, and listening to teacher explanation. The students noted that the most frequent activities were teacher explanation, note-taking, and problem solving exercises done in the form of group work. The following quotes from the interview indicate the types and frequency of activities in which students were involved.

- *"… Most of the time the activities that we do are listening to the teacher's explanation and note-taking. Some times the teacher shows us a live demonstration"*[Teacher C);
- *"…we have done group work activity in male and female reproductive systems"* [Teacher N);
- *"We have never done any practical work. What we have been doing was group work and demonstrations. For example, recently we did one group work activity on the nervous system"*[Teacher H];
- *"We have done group discussion on economic importance of bacteria and vertebrate animals. Furthermore, we have conducted experiments in diffusion and osmosis"* [Teacher O].

Finally, the students explained that certain lesson activities were meaningful to them. It seems that the teachers were very explicit in this regard because students were able to cite interesting topics and circumstances where a particular teacher related a concept(s) to their daily life. The following quotations from the interviews may illustrate how participant teachers attempted to relate the activities to their daily life.

- *"…when we were learning about aerobic and anaerobic respiration, he tried to relate these with the production of a traditional sprit or drink (Sewa); in the Endocrine system for example he told us that if a diabetes's individual get fainted why do we give him sugar… in the nervous system he taught us why we involuntarily pull over our figures or legs the seconds that we touched a hot or sharp object…* etc" [Teacher D];
- "*for example relating to the digestive system…"*[Teacher H];
- "*… the teacher discussed in class how the use of antenna was developed from observations on animals…"*[Teacher L];
- *"… preservation of food with extra sugar or salt and how this practice is related to the process of osmosis.."*[Teacher K].

7.4.6 Summary

Experimental group teachers' use of practically-oriented teaching has been explored by examining the evolution of their stages of concern, level of use, direct observation, and perception of students. The level of use and classroom observation data were contrasted with control group teachers to see whether there was a difference in classroom practice. The following summary of results is organized in ways that reflect the aforementioned sequence.
It was assumed that as experimental group teachers were moving forward in using this innovation, their concerns would evolve from self-oriented (stage 0, 1, and 2) to task (stage 3), and then to impact-oriented concerns (stage 4, 5, and 6). Nevertheless, the concern profiles compiled at three points in time show that the teachers' concerns did not conform to this developmental process (figure 7.1). The overall nature of teachers' concern profile was found to revolve around self-related concerns (stage 0, 1, 2).

For measuring the degree and quality of the implementation of practically-oriented teaching classroom, observations were done with the help of a curriculum profile-classroom observation instrument. The analysis of the results from this instrument yielded a practice profile score per individual and group of teachers. It turned out that the mean practice profile score for the experimental group teachers was found to be 71.2 (N=16). With the exception of three teachers, the rest of the teachers have scored largely above the threshold practice profile score (40%).

The overall practice profile of experimental group teachers was compared to that of control group teachers (N=14) to see whether the observed practice could be attributed to the professional development scenario. It was found that the practice profile mean score of experimental group teachers for threshold and total scores was significantly higher than that of control group teachers. Furthermore, experimental group teachers' perceptions about their level of use of practically-oriented teaching was considered for determining the difference in classroom practice. That is, the percentage of those teachers at different levels of use and nonuse was contrasted with control group teachers. It appeared that only 12.5% of experimental teachers were considered nonusers as compared to the control group teachers who make up 70% of the three levels of nonuse (LoU 0, I & II). Similarly, the percentage of experimental group teachers at levels of use III and IVA was by far higher than that of control group teachers.

The data from the classroom observation and level of use interview were triangulated with students' perceptions about teachers' use of practically-oriented

teaching. The students reported that experimental group teachers provided a learning environment that was best suited for teaching the lessons. Regarding what this classroom atmosphere looked like, students related it to the type of activities teachers involved them in.

The students were directly asked to indicate whether they have done experiments, observed teacher demonstrations, done group work activities, and whether they found the activities meaningful to them or whether the teacher attempted to relate the learning materials to their daily lives. The activities the students mentioned include practical work, demonstrations, group problem solving activities, library study, note-taking, and listening to teacher's explanations. The students noted that the most frequent activities were teacher explanation, note taking, and problem solving exercises done in the form group work.
The students explained that certain lesson activities organized by teachers were meaningful to them. It seems that the teachers have been very explicit in this regard because students were able to cite interesting topics and circumstances where a particular teacher related a concept(s) to their daily lives.

7.5 STUDENT LEARNING OUTCOMES

The impact of the professional development scenario on student learning outcomes has been evaluated with the help of an achievement test and a pre-post attitude questionnaire. The achievement test was aimed at gauging the cognitive learning outcomes (i.e. knowledge and understanding) of experimental group students, and at the same time comparing their performance with control group students. The achievement test was administered with grade 10 students of both groups of schools towards the end of the academic semester, which was about 6-8 weeks after the Respiratory System was taught. The attitude questionnaire was only administered to students of the experimental group schools at the start and end of the academic semester for measuring the affective learning outcome associated with practically-oriented biology teaching. The results are presented in section 7.5.1 and 7.5.2.

7.5.1 Cognitive learning outcome

Performance of students on the achievement test

Table 7.17 displays the results of the test at an item level for both groups of students. The item analysis was reported in percentage of correct scores for each item.

Table 7.17 *Item analysis of the achievement test*

		% of correct scores			
Items	**Cognitive level ***	*Experimental (N=158)*	*Control (N=146)*	X^2	*P***
1	Comprehension	83	70.5	0.148	0.01
2	Knowledge	78.1	76	0.025	ns***
3	Application	82.5	52.7	0.319	0.00
4	Comprehension	80.6	70.5	0.118	0.04
5	Comprehension	39.7	58.1	0.184	0.00
6	Knowledge	38.9	34.2	0.091	ns
7	Knowledge	27.5	38.4	0.116	0.041
8	Knowledge	88.8	60.3	0.329	0.00
9	Knowledge	91.9	68.5	0.296	0.00
10	Analysis	29.6	56.2	0.269	0.00

Legend: * Characterization of the items was based on Bloom's taxonomy of intellectual outcomes; ** Significant $p<0.05$; *** ns = not significant.

Overall, the outcome of the item analysis of the achievement test reveals that five items showed significant differences in favor of the experimental group, three items in favor of the control group, and two items did not show significant differences in the mastery of content areas between the two groups. What follows is a description of the content areas that each group of students fared better in the achievement test.

Item level analysis of the achievement test

A content analysis of the items reveals that the items in which the experimental students fared better were focused on measuring students' *knowledge*, *comprehension* and *application* of concepts related to the human respiratory system (Bloom, Englehart, Furst, Hill & Krathwohl, 1956).

Item 1 was focused on the structure of the respiratory system. It measured students' understanding of the reason why a piece of lung tissue floats in a beaker of water. Table 7.21 shows that the experimental group students performed better on this item 1. The content areas related to the item were covered in *lesson one* of the exemplary curriculum material. The experimental group students were taught about structures (parts) of the respiratory system via a demonstration that involved observing a complete respiratory system specimen (pluck) of an animal, and working in groups on activity questions related to the demonstration.

Item 3 was the second item in which the experimental group students mastered the content areas better. This item measured students' ability to apply the knowledge they acquired about the different structures as well as assign roles to each structure in the respiratory system. It asked the students to find out the correct order or pathway of air entering the respiratory system.

Item 4 was the third item that showed the level of significance in favor of the experimental group students. The item measured students' comprehension about the 'mechanics of breathing'. The concepts regarding the mechanics of breathing were covered in l*esson three* of the exemplary curriculum material. In this lesson, the experimental group students conducted a practical work where they investigated the effect of physical activity (i.e. exercise) on the rate and depth of breathing.

The last two items the experimental group students fared better in were items 8 and 9. Both these items asked students to remember facts related to the structure of the respiratory system and cellular respiration. In particular, the concepts related to item 9 were addressed in *lesson six* (investigating cellular respiration) of the exemplary materials. The experimental group students worked on a 'thought-practical work' where they were provided with a description of a hypothetical experiment, and then asked to work in groups on activity questions related to this thought-practical work.

The items in the achievement test in which the control group students performed better were items 5, 7, and 10. Overall, the items focused on measuring students' *knowledge*, *comprehension,* and *analysis* of concepts related to the human respiratory system (Bloom et al., 1956).

Item 5 focused on measuring students' understanding about the processes of breathing and respiration. It asked students to identify the differences between these two biological processes. Item 7 measured overall student understanding of the different structures of the respiratory system and their role in the human breathing process. It asked students to identify from a diagram a particular structure and its role (function) in the process of breathing. Item 10 focused on measuring students' ability to identify elements of the scientific method and analyze data obtained from a thought-practical work in cellular respiration. The students were provided with a description of the thought-practical work and then asked to analyze tabulated data of that particular practical work.

The control group students learned the content areas covered in the achievement test by their respective teachers. The control students learned the content areas covered in Items 5 and 7 through expository methods that might have enabled them to remember and identify the differences between breathing and respiration better than the experimental group. The experimental students studied the same content areas through a practical work in which much emphasis was placed on science process skills.

7.5.2 Affective learning outcome

The overall attitude questionnaire was disaggregated into two categories in ways that reflect changing student perceptions about biology as a subject as well as about the activities featured in practically-oriented biology lessons. Table 7.18 provides an overview of the changing attitude of experimental group students.

Table 7.18 *Pre-test, post-test mean, d and t values for the attitude questionnaire*

	Descriptive statistics			**Effect size**	**t-test**		
Test	*N*	*M**	*SD*	*d***	*t*	*df*	*p****
Pre	103	3.74	0.55	0.33	-2.14	184	0.034
Post	83	3.91	0.49				

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree; ** Cohen's d; small d = 0.2; medium d = 0.5; large d = 0.8; *** Significant at p<0.05.

The value of the effect size suggests that there was a small improvement in students' attitude (d=0.33). An independent t-test has shown that the difference between pre-test and post-test means was significant (t=-2.14, p=0.034). Overall, this finding suggests that there was a positive change in students' attitude towards biology and practically-oriented biology teaching.

Furthermore, the change in students' attitude towards biology as well as towards practically-oriented biology lessons was analyzed separately. Table 7.19 presents an overview of experimental group students' attitude towards biology.

Table 7.19 *Students' attitude towards biology (N=83)*

	Descriptive statistics			**Effect size**	**t-test**	
		*M**	*SD*	*d***	*t*	
Biology is very *interesting* to me	Pretest	4.14	0.95	0.30	-1.95	0.054
	Posttest	4.40	0.76			
I have a good feeling toward biology	Pretest	3.63	1.21	0.35	-2.41	0.018
	Posttest	4.01	0.92			
I am very *curious* about doing activities in biology class	Pretest	3.86	1.01	0.20	-1.39	0.168
	Posttest	4.05	0.84			
Biology is the subject I *dislike* the most	Pretest	2.18	1.28	0.30	1.92	0.058
	Posttest	1.83	1.07			
I am always under a terrible *strain* in biology class	Pretest	2.23	1.14	0.08	0.542	0.589
	Posttest	2.13	1.24			
I feel more relaxed in biology class than in any other class	Pretest	3.52	1.20	0.06	-0.43	0.067
	Posttest	3.59	1.11			
Biology is fun	Pretest	3.77	1.06	0.18	1.23	0.222
	Posttest	3.58	1.07			

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree; ** Cohen's d; small d = 0.2; medium d = 0.5; large d = 0.8; *** statistically significant at p<0.05.

By and large, the values of the effect size suggest that there was a slight change in students' attitude towards biology. The students have developed a good feeling towards biology. An independent two-tailed t-test shows that there was a significant difference in student perceptions between the pre-test and post-test means for this item (d=0.35, t= -2.41, p=0.018).

The second categories of items that focused on practically-oriented activities were treated together and the results displayed in Table 7.20. Overall, the values of the effect size indicate that there was a small change in students' attitude towards practically-oriented biology teaching.

Table 7.20 *Students' attitude towards practically-oriented activities (N=83)*

		Descriptive statistics		**Effect size**	**t-test**	
		*M**	*SD*	*d***	*t*	*P****
I enjoy doing a biology experiment	Pretest	3.94	1.03	0.25	-1.7	0.091
	Posttest	4.18	0.85			
I enjoy doing more with my hands than listening to my biology teacher's explanation	Pretest	3.53	1.28	0.08	0.51	0.615
	Posttest	3.42	1.35			
I feel *at ease* working on biology group work activities	Pretest	3.93	1.05	0.36	-2.3	0.026
	Posttest	4.28	0.90			
It makes me nervous doing a biology experiment	Pretest	2.47	1.24	0.03	0.20	0.85
	Posttest	2.43	1.28			
It makes me *nervous* discussing and asking questions from our biology teacher	Pretest	2.86	1.25	0.34	2.13	0.036
	Posttest	2.43	1.29			
Doing group work activities with my classmates makes me feel uncomfortable and *impatient*	Pretest	2.24	1.20	0.28	1.73	0.088
	Posttest	1.93	0.99			

Legend: * 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree; ** Cohen's d; small d = 0.2; medium d = 0.5; large d = 0.8; ***statistically significant at p<0.05.

7.5.3 Summary

The impact of the professional development scenario on students was evaluated with the help of an achievement test and a pre-post attitude questionnaire. The item analysis did not show a clear pattern between the scores of the experimental and control group on the achievement test. What the analysis indicated was that five items showed significant difference in favor of the experimental group, three items in favor of control group and two items did not show significant difference in mastery of content areas between the two groups (p<0.05).

The pre-post attitude questionnaire was administered only with experimental group students. The analysis of the pre-test and post-test scores showed a positive change in students' attitudes towards practically-oriented biology teaching ($p < 0.05$).

7.6 OVERALL SUMMARY AND CONCLUSIONS

The summative evaluation study was aimed at investigating the effectiveness of the professional development scenario in helping teachers teach practically-oriented biology lessons. For this task, Guskey's (2000) model of evaluation has been used for gathering the relevant data in exploring the effectiveness of the scenario. The effectiveness of the professional development scenario was judged by participants' self-reports, classroom practice profile scores, student learning outcomes, and differences in practice between experimental and control group teachers. The following conclusions are drawn on the basis of the results gleaned at the five levels of evaluation the study embarked to investigate.

The results of this summative evaluation showed that the experimental group teachers' overall reaction to the professional development scenario was positive (level 1). The teachers considered the professional development workshop useful and relevant for their teaching practices. They are satisfied with the fact that the professional development workshop met their expectations for getting information about and skills for teaching practically-oriented teaching. Following their active involvement at the professional development workshop (i.e. through *demonstration, practice, and feedback*) the experimental group teachers' understanding about practically-oriented lessons was enhanced (level 2). The results underscore that the teachers found the exemplary video helpful for identifying the main features of a practically-oriented lesson. In particular, teachers indicated that after they studied the exemplary curriculum materials and observed (or taught) the microteaching lessons their confidence was improved, and they were encouraged to try out the innovation in their respective schools.

The extent of school support for experimental group teachers varied across the three schools (level 3). The results indicate that School C was perceived less resourced for teaching practically-oriented lessons. The camaraderie among the teachers in this school was reported to be less conducive for collegial support, and the school principal was considered less supportive. Comparatively, both school A and B were found to be in good shape in terms of resources and collegial support. The teachers in these two schools were upfront in experimenting with new

strategies and sharing their enthusiasm. The school principals and administrations at both schools were deemed supportive to teachers during the classroom implementation.

The summative evaluation study showed that experimental group teachers have been using practically-oriented teaching with varying quality and degrees in their respective classroom (level 4). This classroom implementation was triangulated with results from the evolution of participants' stages of concerns, level of use, practice profile scores, and perceptions of their students. The cumulative concern profiles compiled at three points in time depict that the teachers' stages of concerns were focused on self-oriented concerns.

The results of the interviews of experimental group teachers and their students reveal that the majority of teachers were users (LoU III and IV A) of practically-oriented teaching, while two teachers were placed as nonusers (at LoU II). The teachers at LoU III reported that they were actively using the innovation. This active engagement was characterized by the teachers' adaptations of the innovation to their peculiar classroom context and a general inefficiency in managing group work activities. The teachers at LoU IVA asserted that they were making the best of the professional development training they received.

The mean practice profile score for the experimental group teachers was calculated at 71.2 (N=16). The overall practice profile of experimental group teachers was compared to those of the control group teachers (N=14) to see whether the observed practice of experimental teachers was attributed to the professional development scenario. The comparison of the threshold and total mean scores of both groups showed that the observed practice profile of the experimental group teachers could be attributed to their involvement in this scenario.

The impact of the professional development scenario on experimental group students was positive. The analysis of the affective outcome showed a positive change of students' attitude towards practically-oriented biology teaching. Pertaining to cognitive learning outcome, the item analysis did not show a clear pattern between the scores of the experimental and control group on the achievement test. Time between teaching about the Human Respiratory System and administration of the achievement test was probably too long to identify difference in learning outcome.

CHAPTER 8
Discussion

The study aimed to explore the potential of a professional development scenario for helping biology teachers implement practically-oriented biology teaching and learning in Eritrea. This chapter presents a summary of the findings and a discussion of the academic journey. Section 8.1 recapitulates the research context, questions, and approach. The main findings of the summative evaluation study are discussed in section 8.2. The discussion in this section is structured along the five levels of evaluation that the study used to explore the effectiveness of the professional development scenario. Section 8.3 highlights the reflections on the research methodology of the study. The last section 8.4 presents the conclusions and recommendations for policy and research.

8.1 RECAPITULATION OF THE RESEARCH QUESTION AND APPROACH

8.1.1 Research context and question

Since independence, the Ministry of Education of Eritrea initiated two waves of curriculum reform that attempted to improve the quality and equity of education at all levels. The first reform effort, launched in 1991, introduced a structural and content change to the previous Ethiopian Education system. Among other things, the policy on science curriculum underscored that science education should be relevant for personal needs, societal issues, career awareness, and academic preparation of students (MOE, 1998a). It recommended the science curriculum to be more "process-oriented" and "learner-centered", and should discourage passive learning of students.

The implementation of Curriculum-1991 was confounded by many implementation problems. To begin with, there was a shortage of qualified teachers, textbooks, teacher educators, anda solid model of in-service education. At the secondary level, the qualifications of the teaching force left much to be desired. The preparation and publishing of textbooks was finalized in 1995, which was four years after the introduction of the Curriculum. The teachers were only introduced to the new Curriculum by orientation workshops, but these were mainly restricted to

information related to its content, methodology, and evaluation guidelines. Under such conditions, it is hardly surprising to observe a pervasive 'banking' education and teacher-dominated instructional practice that is in sharp contrast to what was intended in the policy. To ameliorate this reality of classroom practice, the Ministry of Education initiated in 1998 a curriculum review study that set the stage for a second wave of reform and the introduction of Curriculum-2003. This second wave of curriculum reform entailed a considerable change in content with the introduction of a number of new subjects. It called for better and more participation of students in the learning process, and improvement of the teaching approach. The biology curriculum, in particular, expects biology teachers to embrace "*student-centered interactive pedagogy"*and change accordingly (MOE, 2002).

It is within the context of a new Curriculum-2003 that the study has been undertaken to explore the potential of a professional development support scenario for biology teachers. The central research question of this study is formulated as follows:

> *What are the characteristics of a professional development scenario that effectively helps biology teachers in Eritrea with the implementation a more student-centered approach?*

To tackle this research question the study adopted a development research approach. The overall design of the study was structured within the framework of this research approach comprising the following three stages:

- front-end analysis;
- prototyping of the support scenario; and
- summative evaluation of the support scenario.

In addition to the aforementioned central research question, the study has been guided by three specific questions. These questions are formulated in ways that facilitate context and needs analysis; guide the review of relevant literature; distill the appropriate design guidelines; and direct the development and evaluation of the support scenario.

1. What are the contextual factors that influence the design and implementation of a professional development scenario for biology teachers in Eritrea?
2. What can be learned from the literature about the characteristics of promising professional development scenarios that adequately support teacher learning and classroom practice?
3. What is the practicality and effectiveness of the professional development scenario in supporting biology teachers' learning and classroom practice?

8.1.2 Front-end analysis

The front-and analysis of the study included two main components. As a first step toward a better orientation to the user context, a decision was made to conduct a context and needs analysis research in Spring 2002. The context and needs analysis focused on five contextual factors that have a potential stake in shaping the support scenario: state-of-practice in science education; teachers; students; school profile; and history of professional development in Eritrea (cf. Loucks-Horsley et al., 1998).

The outcome of the context and needs analysis has highlighted the needs, direction, and focus of the study. It showed that the current state-of-science education in Eritrea is far from desirable when examined against the visions of the science curriculum stated in the first and second waves of curriculum reform (MOE, 1998a, 2002). The majority of teachers are not satisfied with their own teaching strategies and student learning. They pointed out a need for in-service education that promotes student-centered teaching, particularly improving student participation and learning outcomes. The context and needs analysis concluded that even though there seems to be no silver bullet solution , an in-service education rooted in sound principles of professional development is a promising approach towards ameliorating the existing situation in Eritrea.

The second task of the front-end analysis of the study focused on review of relevant knowledge bases that support the development of the professional development scenario. Among other things the outcome of the literature study yielded valuable information and insights into what constitutes an effective professional development scenario, robust implementation strategies, principles for implementing change, and support for teachers' learning and practice in the change process. Based upon the results of the context and needs analysis and the literature review about professional development, a decision was made to concentrate the intervention on promoting a student-centered approach with a particular focus on practically-oriented biology teaching. The main tenets of this biology teaching are interactive teacher demonstration, practical work, and managing group work activities in a large class. The literature review culminated in the distillation of six design guidelines that helped to elaborate four components of the professional development scenario outlined in Box 8.1.

Box 8.1 *A summary of the professional development scenario*

Components of the professional development scenario
Professional development workshop The workshop was conducted in a one day. It consisted of the following three main sessions: ▪ discussion and presentation about the 'theory of practically-oriented biology lessons ' in which the teachers: – reflected upon and examined their prior knowledge, beliefs, and attitudes about student-centered approaches; – gained an understanding about practically-oriented biology lessons; ▪ demonstration of what a practically-oriented biology lesson looks like in classroom practice with the help of two contrasting videotaped lessons. ▪ practice and feedback about practically-oriented lessons where the teachers: – practiced lesson planning and teaching of practically-oriented biology lessons (i.e. microteaching); – received a structured feedback from the researcher and fellow teachers on their practices.
Exemplary curriculum materials The exemplary materials supported teacher learning and practice regarding practically-oriented biology lessons during the professional development workshop and later in the schools. The following are the main characteristics of the exemplary curriculum materials: ▪ standardized lay-out; ▪ concrete examples (4-6 lessons) of what practically-oriented lessons look like in classroom practice with procedural specifications. The specifications focused on lesson preparation, subject matter and pedagogical content knowledge, and how to monitor and assess students' learning effects; ▪ topics or themes selected for exemplification were closely linked to the textbook, and were taught right after in-service workshop.
School follow-up The school follow-up support took the form of reflective meetings, classroom coaching, and exemplary curriculum materials. It was conducted for 2-3 weeks in the schools following the professional development workshop. The main characteristics of the follow-up are summarized as follows: ▪ two school-based workshops organized in ways that facilitate teachers' reflection process; ▪ three coaching sessions. The researcher organized classroom observation sessions in which the teachers were provided with concrete feedback related to implementation of practically-oriented biology teaching.
Supportive school environment Establishing a supportive school environment involved soliciting as much support as possible from school principals. The school principals are: ▪ briefed about the overall scenario and the support they could provide; ▪ handed-out a copy of the exemplary curriculum materials and overall design of the scenario; ▪ invited to attend the professional development workshop.

8.1.3 Prototyping of the support scenario

This stage of the study dealt primarily with design, formative evaluation, and revision of the successive prototypes of the exemplary materials and professional development workshop. For addressing the validity and practicality of the professional development scenario, it was found prudent to employ evaluation

strategies of *expert* and *user appraisals* (i.e. for validity aspects), *trial* (i.e. for practicality), and *field-test* (i.e. for effectiveness of materials). The other two components of the scenario (i.e. school follow-up and establishment of a supportive school environment) were subjected to expert appraisal along with the initial design of the professional development scenario.

Formative evaluation of exemplary curriculum materials

The study selected topics of diffusion and osmosis from grade 9 and respiratory system from grade 10 biology curriculum for exemplifying the basic tenets of practically-oriented lessons. The exemplary material on diffusion and osmosis was developed first and embedded in the trial of the professional development course. The exemplary curriculum materials were embedded in the professional development scenario during its implementation. Figure 8.1 shows the itinerary of the prototyping process of the exemplary material on diffusion and osmosis.

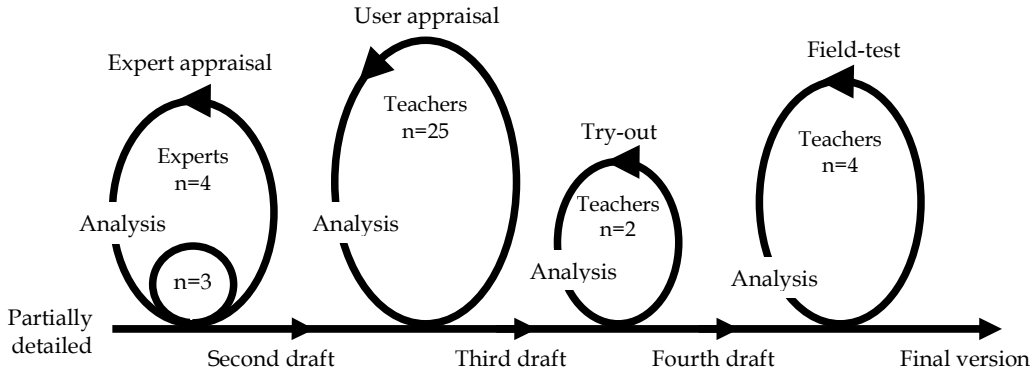


Figure 8.1 Itinerary of the prototyping of the materials

The results from the expert and user appraisals provided indications about the validity of the exemplary materials as well as concrete revision suggestions. The revision decisions were incorporated in a subsequent version of the exemplary materials. Following these appraisals, some lessons of the exemplary materials were tried out with experienced teachers. The trial was undertaken in order to identify some initial problems of materials practicality before they will be used in a regular classroom setting.

The results from the classroom observations, teacher and student questionnaires, and interviews showed that the overall opinion of the teachers and students was positive. The revision decisions generated from the trial study were used to improve the practicality of the exemplary materials.

Finally the exemplary materials were field-tested. This field-test was geared towards collecting more data on the effectiveness of the prototypes before embedding them in the professional development scenario. It was conducted in four regions of Eritrea found to be representative of the Eritrean school context. One school from each region participated in the field-test. All the schools agreed to execute the exemplary lessons as part of the regular biology curriculum for teaching the concepts of diffusion and osmosis as well as the respiratory system.

The field-test generated rich data pointing towards the effectiveness of the exemplary materials. The data suggested that there was a shift in both teacher and student behavior as compared to 'business as usual' while using the materials. The teachers acted more as guides to students than as transmitters of knowledge during. The student tests provided indications of satisfactory learning about diffusion, osmosis, and the respiratory system. In addition, students' attitudes toward the lessons were quite positive. They liked the lessons, and portrayed their roles as group workers, active participants, and discussants.

Formative evaluation of the professional development workshop

The workshop was structured into three main sessions dealing with the theory, demonstration, and practice of practically-oriented biology teaching using a student-centered approach (cf. Joyce & Showers, 1995). Regarding its formative evaluation trajectory, a preliminary design of the professional development scenario was first reviewed by experts, the outcome of which led to an elaboration of the first prototype of the workshop. Secondly, the professional development workshop was tried out in one school with biology teachers. The try out was aimed at investigating the practicality of the professional development workshop, particularly concerning the design, content and delivery, before it would be implemented on a larger scale. In addition, the try out also improved the data collection instruments to be used in the summative evaluation study.

Guskey's (2000) model of evaluation was employed in the try out (see Table 8.1). More emphasis was given to the first two of Guskey's levels of evaluation focusing on teachers' reactions and learning.

The results of this try out indicated that the workshop met teachers' expectations in providing them with sufficient information regarding the student-centered approaches in general and in practically-oriented lessons in particular. The initial reactions of the participants regarding to the workshop appeared positive. They considered the workshop useful, relevant, and believed that it enhanced their understanding of student-centered lessons.

Table 8.1 *The five levels of the Guskey (2000) model as used in the study*

1. Teachers' reactions	▪ Did the professional development workshop meet its expectations? Did they like it? Did they consider the content, process, and context of the workshop useful and relevant?
2. Teachers' learning	▪ Did teachers acquire the intended knowledge, skills, and attitudes about practically-oriented biology teaching?
3. Nature of school support	▪ Was the implementation of practically-oriented teaching supported by the respective schools?
4. Teachers' of the new knowledge and skills	▪ Did what teachers learned affect their classroom practices?
5. Student learning outcomes	▪ What is the impact of the professional development on student learning outcomes?

The trial also provided evidence of teachers' learning experiences from the activities of the workshop. The teachers attested that they gained new knowledge and experiences that augmented their skills regarding the student-centered approach. In the same vein, the results indicated that after studying the exemplary lessons, practicing the design of such lessons, and attending the microteaching session the teachers were convinced to try out the exemplary lessons in their respective classrooms. Overall, the trial study yielded suggestions for adjusting the time for group discussions during the theory exploration session and improving the quality of the video-clips. The trial study also resulted in changes in the evaluation questionnaire and teacher expectation questionnaire.

Finally, the second prototype of the workshop underwent another cycle appraisal with experts leading to an overall revision of the professional development scenario shortly before it was implemented.

8.1.4 Summative evaluation of the support scenario

The last stage of the study sought empirical evidence on the effectiveness of the professional development scenario in supporting teachers' learning and teaching of practically-oriented lessons. A quasi-experimental *post-test-only nonequivalent control* group design was used for investigating the impact of the professional development scenario.

The professional development scenario (treatment) was implemented for one semester at three experimental schools. Sixteen biology teachers from each experimental school attended the professional development workshop. Following this workshop, the experimental teachers were provided follow-up support for 2-3

weeks in their respective schools, and then they were left alone to adapt and sustain practically-oriented biology teaching. Fourteen biology teachers from the other three control schools did not get the aforementioned treatment. They taught the same biology curriculum they always taught.
The summative evaluation was conducted towards the end of the academic semester. Throughout the study, Guskey's model (2000) of evaluation was used to gather relevant evidence along the five levels (see Table 8.1). The discussion of the main findings of the summative evaluation is presented in the next section, 8.2.

8.2 DISCUSSION OF THE MAIN FINDINGS

The main findings of the summative study are discussed and structured along the five levels of evaluation in order to explore the effectiveness of the professional development scenario. The effectiveness was judged by participants' self-reports, classroom practice profile scores of experimental and control teachers, and student learning outcomes.

8.2.1 Positive impact on teacher reactions

From the findings of the summative evaluation study it can be concluded that the experimental teachers' overall reaction to the professional development workshop was positive. The teachers were satisfied that the workshop met their initial expectations for getting information on and skills pertaining to this innovation. Indeed the workshop appeared to satisfy the teachers' expectations by providing them exemplary materials, a forum for active discussion, the opportunity to observe exemplary practice, and a learning environment for practicing and augmenting the skills for teaching practically- oriented biology lessons (cf. Joyce & Showers, 1995; Locks-Horsley et al., 1998).
In addition, the findings reveal that experimental teachers highly appreciated the structure of the workshop and considered the content of the workshop useful and relevant for their teaching practices. These findings might be expected for several reasons. Firstly, professional development denotes a departure from their previous experience with one-shot professional activities in Eritrea. It involved the teachers with purposeful and intensive professional development activities both in the workshop setting and through the school-based follow-ups (cf. Guskey, 2000; Supovitz & Turner, 2000). Secondly, the teachers themselves identified the need and very focus of the scenario through the context and needs analysis at the start of the study. Thirdly, the activities of the workshop were organized on the basis of an effective in-service model (Joyce & Showers, 1988, 1995) that has strong

empirical support in the literature for skill acquisition and improvement of student performance (Hawley andValli, 1999; Sparks and Locks-Horsley, 1990).

Finally, the majority of experimental teachers reported that the exemplary materials were useful for planning and teaching practically-oriented biology lessons. The exemplary materials supported experimental teachers' learning by providing them with information on practically-oriented teaching, concrete examples of what such lessons look like in classroom practice, and enhancing their pedagogical content knowledge. This confirms the findings of van den Berg (1996), Stronkhorst (2001) andAlmekinders and Voogt (2003) that when these materials are systematically integrated into a professional development scenario they can provide teachers with a successful first time experience that has a fair chance of being used in the classroom.

8.2.2 Impact on teachers' learning

It was assumed that successful learning of experimental teachers about practically-oriented biology teaching is important for classroom implementation and improvement of student learning outcomes. Experimental teachers' indications and demonstrations of this learning are considered indicators of the effectiveness of the professional development scenario. The central question dealt with whether or not the teachers acquired the intended learning that would enable them to teach practically-oriented biology lessons. However, measuring this learning and coming up with a definitive answer has been daunting. This was because the context where the teachers' learning took place was not limited to the professional development workshop but also the exemplary curriculum materials and coaching sessions conducted during the school follow-ups. For this reason, a decision was made to explore the indicators of teacher learning by triangulating self-reported statements with a demonstration of their learning in microteaching sessions and classroom observations.

The experimental teachers reported that after the professional development workshop their awareness and knowledge of practically-oriented biology lessons was enhanced. Moreover, there are indications that demonstrate successful teacher learning from results of the microteaching sessions and classroom observations. By and large, the lesson preparations (i.e. plans and organization of materials) of experimental teachers gave the impression that they had followed the specific suggestions from the exemplary curriculum materials. The experimental teachers, in particular, were able to explore explicitly students' prior conceptions and engage them in practically-oriented biology activities. Furthermore, following the intensive classroom-based coaching, experimental teachers' classroom observations showed statistically higher practice profile scores than the control group teachers. It can be

concluded that there is concurrence of findings between the teachers' perceived and demonstrated learning from measures conducted in the workshop setting and actual classroom observations. These findings can be explained in light of the professional learning strategies this study employed (cf. Borko & Putnam, 1996; Locks-Horsley et al., 1998) and the opportunities experimental teachers received through the professional development workshop, exemplary curriculum materials, and school follow-ups.

The findings of the study agree with Garet et al. (2001). Garet et al. showed that professional development experiences aimed at deepening teachers' content knowledge, pedagogical content knowledge, active learning opportunities, and integrating them into the daily life of the school are related to teachers' perceptions of enhanced knowledge and skills (cf. Birman et al. 2000). More specifically, these initial indicators of learning are consistent with Joyce and Showers (1988, 1995) who showed that a systematic combination of the five training components (theory, demonstration, practice, feedback, and coaching) leads to effective teacher learning about an intended change and its transfer into classroom practice.

8.2.3 The extent of school support

This studyattempted to explore what experimental teachers thought about the school support they received from their respective schools in terms of resources, collegiality, and leadership. It was expected that through the involvement of school principals and administrations the implementation of practically-oriented teaching would be supported. Experimental teachers' positive perceptions of such support helped gauge the effectiveness of the professional development scenario.

School support for teachers varied across the schools. Teachers at one school reported that school resources, collegiality, and leadership support left much to be desired for implementing practically-oriented biology teaching. One might expect that such a characterization of that particular school's condition would have been reflected in the teachers' use of practically-oriented teaching. Nevertheless, the level of use and classroom practice profiles data show that this perceived implementation condition hardly affected their classroom implementation as compared to the rest of the experimental teachers. Interestingly enough, Supovitz and Turner (2000) had similar findings in their survey study on the effects of professional development on science teaching practices and classroom culture. They reported that neither school resources nor principal support had much influence on teachers' uses of inquiry based practices and investigative culture.

8.2.4 Impact on teachers' classroom teaching

Examination of experimental teachers' use of practically-oriented teaching was of central importance throughout the summative evaluation. The overarching question asked at this level of the evaluation was whether experimental teachers effectively translated the new knowledge and skills they had learned from the professional development scenario into their classrooms. This question was investigated by triangulating the teachers' stages of concern, level of use, classroom observation, and perceptions of students.

It was assumed that as experimental group teachers move forward with practically oriented lessons, their concern would evolve from *self*-oriented to *task* and *impact*-oriented concerns. In addition, if experimental teachers do not use this innovation, the measures of their stages of concern should look like the concern profile of a nonuser (Hall & Hord, 2001).
The concern profiles compiled at three points in time showed that the experimental teachers' concerns did not emerge sequentially and hardly conform to the developmental process. The overall teachers' concern profile was found to revolve around self-related concerns.
The teachers' lack of progress to the higher stages of concerns could be explained in terms of the measuring instrument and time taken for implementation of the intended change. The stage of concern questionnaire was developed and validated in an American context much different from Eritrea (cf. Hall et al., 1987). The cultural differences between these two contexts might have led to misunderstandings of some of the items as manifested in the lack of clearly focused concerns. Equally important was the fact that the time taken for the implementation of practically-oriented biology teaching was too short. After all, an education change as ambitious as this one is a complex process and it takes time (cf. Fullan, 2001).

From the concern profiles of the teachers a distinction can be made between users and nonusers of practically-oriented biology teaching in the study. The fact that the experimental teachers' intensity of concerns revolves around the informational and personal indicates their active engagement (not necessarily effective) in using-practically oriented biology teaching. In retrospect, an additional written assessment form and a fourth measure at the end of the follow-up support might have provided a more complete picture of the evolution of the participants' stages of concern.

It was assumed that experimental teachers' learning from the professional development workshop, exemplary curriculum materials, and classroom coaching would be translated into classroom practice that could be observed in terms of indicators of effective use. Similarly, the classroom practice profile scores were expected to show a noticeable difference from what other biology teachers (i.e. control group) were doing (cf. Guskey, 2000).

The convergence of results from level of use, classroom observation, and student interview indicated that the experimental group of teachers had been using practically-oriented teaching with varying quality and degrees of effectiveness in their respective classrooms. In addition, as shown before, experimental teachers' classroom observations showed statistically higher practice profile scores than the control group teachers. Even though this is evidence for the usage of this innovation, a closer examination of the results reveals that the majority of experimental teachers used only mechanically and only a few teachers demonstrated an effective use of practically-oriented teaching.

These findings are in line with the professional development literature that underscores how educational change is a gradual and difficult process for teachers. The early stage of implementation, in particular, is characterized by ambivalence, anxiety, and critical humps where teachers' proficiency at using a new approach goes down before it goes up (cf. Fullan, 2001; Guskey, 2002). This was apparent from the individual concerns and the initial cycle of classroom observations conducted at the start of school follow-ups. Despite participating in the professional development workshop, some experimental teachers early on inhabited a learning environment dominated by teacher's factual presentation and mostly subdued students. This contrasted starkly with what was advocated in the workshop. That said, it was hard to miss the gradual improvement of teachers' classroom practice after intensive classroom coaching. By and large, this finding reinforces previous empirical works and consensus about the critical role of school follow-up support for implementing change (cf. Fullan, 2001; Guskey, 2003; Harvey, 1999; Joyce & Showers, 1995). Finally, even though the impact of the school follow-up activities was encouraging, its transferability was arduous because of its labor intensive nature.

8.2.5 Impact on students' learning outcomes

It was assumed that the changes in participant teachers' knowledge and skills as well as in their classroom practice regarding practically-oriented biology teaching would lead to improvement in student learning outcomes.

At first glance, the logic of linking professional development to student learning captured the ultimate goal of any professional development. Nevertheless, in the study connecting the dots has been a daunting task. First and foremost, from a systemic perspective, professional development efforts alone can not produce student learning results unless the system in which it is embedded is supportive for teacher learning, classroom practice, and student learning (cf. Sykes, 1999). The study staked no claim in influencing the nature of school support that might have been more supportive for teachers' classroom practice and student learning. In addition, students' learning can be influenced through their activities outside the sphere of the school-- parents, peers, and the media (cf. Guskey, 2000; Ogunniyi, 1996). Secondly, it is extremely difficult in a complex social system of schools for rigorous experimental design to prove that professional development causes an increase in student achievement. That noted, as Guskey (2000) underscored, researchers should use multiple evidence of the impact on student learning in line with the specific goals of the professional development effort. Considering the complexity of measuring the direct impact of professional development on students, the study approached this challenge with a quasi-experimental design that enabled evaluating student learning through interview, attitude questionnaire, and achievement test.

Regarding the cognitive learning outcomes no clear difference was found between the experimental and control group students. In hindsight, considering retention of learning, the student achievement test should be administered shortly after the teaching of the unit in Human Respiratory System. The analysis of the attitude test showed a significant positive change of the experimental group students towards the practically-oriented biology teaching approach.

Evaluating the impact of the professional development scenario on student learning has been a complex task in the summative evaluation. Measuring the students' cognitive learning outcome, in particular, proved to be very challenging. Because of time constraints, the researcher was not able to do many pilot-tests of the achievement test that might have improved its validity and reliability. The achievement test was piloted once during the field-test of the exemplary curriculum material on the respiratory system. In retrospect, the time needed for a valid and reliable achievement test was underestimated in the study.

The findings of the study regarding the impact on student learning outcomes are consistent with Thompson's (2003) review of evidence-based research (i.e. Cohen and Hill, 2001; Kennedy, 1999; Porter and Garet, 2000) about the impact of science

and mathematics professional development on teacher practice and student learning. Thompson (2003) underscored that in science and mathematics professional development which reported the impact on both teacher practice and student learning, there was pervasive evidence both for a strong focus on subject matter and pedagogical content knowledge and opportunities for teachers to try out ways of teaching it, to get feedback on their practices, and to discuss their experiences.

8.3 REFLECTIONS ON THE RESEARCH METHODOLOGY

The study was carried out within the framework of development research. This research approach was chosen because of its pragmatic *structure* and focus on *design principles* considered helpful in navigating the uncertainties of design-decisions and the effectiveness of an intervention in the user context (cf. van den Akker, 1999). In the study, development research has provided the methodology for a stepwise analysis, development and evaluation process that contributed to a realization of a locally relevant professional development scenario. That is, a professional development scenario that supported biology teachers' learning and classroom implementation consistent with the policies of the education system and working conditions of participant teachers in Eritrea. That noted, however, the development research approach does bring with it certain methodological problems and dilemmas that researchers need to consider. The following are some reflections on the role of development research in the study.

8.3.1 The role of front-end analysis

Development research applied in the study involved three main stages that played a useful role in the realization of the professional development scenario. As a first step towards developing the scenario, a front-end analysis was done through a context and needs analysis, expert consultation, and review of the relevant literature. The outcome of the context and needs analysis has been instrumental in identifying the policies of the Ministry of Education on science curriculum and in-service education, in-service need, and local implementation conditions (and design constraints) serving as a basis for the preliminary design of the professional development scenario. In addition, this analysis has provided a direction where the literature review should be concentrated.

The extensive literature study and deliberations with experts have led to specifications for helping teachers teach practically-oriented biology lessons and for generating the preliminary design of the professional development scenario. Overall, findings of the context and needs analysis were helpful in reducing the

uncertainty of the international literature in designing the exemplary curriculum materials, professional development workshop, and school follow-up.

8.3.2 The role of the prototyping process

The prototyping stage primarily dealt with the design and formative evaluation of the successive prototypes of the professional development scenario. The hallmark of the prototyping process in the study has been the use of a number of prototypes, iteration, and participation of potential target users (cf. Nieveen, 1999). Overall, each prototyping cycle entailed the following activities: design of the prototype, formative evaluation, analysis, and revision or redesign of the prototype (see Figure 8.1).

Formative evaluation activities were integrated into a cyclic process of design, evaluation, and revision in naturally existing schools (cf. McKenney & van den Akker, 2004). For testing the practicality and effectiveness of curriculum materials and the professional development workshop, authentic research situations were used. The findings of the study attest that formative evaluation research and development has been productive in informing and supporting the design and revision decisions undertaken throughout the prototyping process. Such use of a cyclic (and iterative) design and formative evaluation in naturally existing test-beds has enabled the researcher to observe the main features of the prototypes in action and generate timely improvement suggestions.

Findings of the prototyping process also shed light on issues related to the number of iterations, the weight of revision suggestions, and collaborations in the course of developing the professional development scenario.

Overall, the prototyping process as used in the study indicated that as the expertise and insight of a developer sharpens, the number of iterations can be shortened without compromising the quality of the prototypes. In the study, many more rounds of iterations were applied to the development of the first exemplary curriculum material than the second one. The formative evaluation of exemplary material on diffusion and osmosis involved two cycles of expert appraisal, one of user appraisal, trial and field-test. However, as the researcher gained experience and insight in prototyping, the number of iterations was reduced in the design and formative evaluation of the second exemplary material. The formative evaluation trajectory of the exemplary material on respiratory system entailed one cycle of expert appraisal, trial and field-test. Moreover, during the trial, rather than focusing on all the lessons, the researcher tried out only one lesson of uncertain practicality.

Regarding revision suggestions or problems reported in the course of the prototyping stage,it has proved difficult to decide whetherto consider the

frequencies or salience of a given improvement suggestion or concerns expressed by the participants (cf. Nieveen, 1999). On this issue, while making the revision decisions, the researcher considered frequency, salience even if it was suggested by a single participant (e.g. a suggestion to use elements of Glickman's (1990)), and the very aim or focus of a particular evaluation activity (e.g. postponing a revision suggestion on lesson time during the user appraisal).

Furthermore, a collaborative design of the professional development scenario with potential users in various professional roles--teachers, principals, and policy makers--has paid off in this study. The involvement of policy makers and teachers throughout the study had the benefit of gradually accommodating their needs, improving the quality of the prototypes (i.e. validity, practicality & effectiveness), and professional learning of the researcher. For instance, a number of teachers and their students participated in the user appraisal, trials and field-test. The participation of teachers and students in these formative evaluation activities made it possible to identify unrealistic expectations, locate shortcomings, and generate as many ideas as possible for improvement of the prototypes. The policy makers were also involved in the context and needs analysis of the study. This interaction with policy makers helped identify the constraints for organizing in-service education in Eritrea, improving the 'public relation' of the study, and garnering full cooperation in schools. Overall, it can be concluded that the participation of the potential users and use of authentic research situations improved the ecological validity of the findings (cf. Bracht & Glass, 1968; Schmuckler, 2001).

8.3.3 Empirical testing

The prototyping process provided indications as to the validity and practicality of the professional development scenario. The summative stage mainly focused on gleaning empirical evidence on its effectiveness in helping biology teachers implement practically-oriented biology lessons. The professional development workshop was introduced in such a way that the teachers learned about and practicedteaching practically oriented biology lessons. Following the workshop, the teachers received follow-up support from the researcher and their respective schools.

The summative evaluation was conducted a few weeks after the completion of the school follow-up. A quasi-experimental design offered the opportunity to compare the experimental group teachers with control group teachers in naturally occurring test-beds. Considering the time taken for implementation (i.e. six months), this

design was a realistic and feasible choice in order to evaluate the effectiveness of the professional development scenario (treatment). Except for the treatment, both groups of teachers (and schools) were similar in most of the factors that could influence the intended outcomes of the scenario. Looking back, the conditions of comparison could have been enhanced by ensuring that the control group teachers received support (e.g. from their respective school, etc.) to improve their teaching practice or what they were doing ('conventional' teaching practice).

Both in the formative and summative evaluation of the professional development scenario, Guskey's (2000) model of evaluation has been helpful in formulating indicators, structuring the instruments, and selecting data collection procedures. This evaluation model has generated empirical evidence about teachers' reactions, learning, the nature of school support, classroom practice, and students' learning outcomes. By and large, the findings of the study indicate that Guskey's (2000) model of evaluation was a useful framework for determining and tracking the impact of the professional development scenario.

8.3.4 Methodological problems and dilemmas

Having discussed what the development research methodology contributed to the study, it is fair to say that certain methodological problems and dilemmas related to multiple researcher roles (cf. van den Akker, 1999), and the nature of formative research in a naturalist setting (cf. Walker, 1992) appeared.

It is hard to miss the roles assumed by the researcher during the prototyping and summative evaluation stages of the study. The researcher played multiple roles as designer, evaluator, implementer, and researcher which might have influenced the quality of the findings. Combining the four roles has been rewarding and at times challenging for keeping an objective distance from the subjects and data gathered. The researcher benefited in fine tuning his craft-skills related to designing professional development, and equally broadened his perspective and understanding of implementation. Moreover, as a sole designer and evaluator (researcher) during the prototyping stage, the researcher was able to make an evolutionary and insightful improvement in the prototypes because he was the one who established the overall conceptual framework and was intimately involved in developing the prototypes. Arguably, it could have been daunting for an external researcher to make insightful improvement without sharing the guiding perspectives of the designer. That said , this should not rule out a role that might have been played by an external evaluator with sharp objective eyes. As Walker

(1992) noted, if the formative evaluation researcher embraces the developer's values, or if for that matter the developer and researcher are one and the same, the research loses its power to identify whatever faulty assumptions the developer might make.
The study recognizes that while the designer and evaluator of the prototypes was the same person, the chances for interpretation bias may have increased. Yes, the designer may have neglected the perspectives and comments of teachers and students whose comments could have further improved the quality of the prototypes. For enhancing the validity of the findings and ensuring the credibility of their interpretation, the study employed a triangulation of data sources and methods. As much as possible the data collection instruments and analysis procedures were documented and made transparent in order to establish a chain of evidence throughout the research activities (cf. Yin, 1994).

Additionally, teachers and students may have reacted differently in the presence of the designer during the formative evaluation activities (cf. Krathwohl, 1998; Patton 2002; Walker, 1992). In hindsight, the researcher acknowledges that it would have been a good strategy to involve an external evaluator (researcher) both during the prototyping and summative evaluation stage, especially during data collection at the experimental schools. This strategy might have improved the internal validity and reliability of the findings.

Walker (1992) noted that one of the methodological concerns of formative research carried out in naturalistic setting is the generalizability problem. That is, the extent to which the findings are transferable from the situation being studied to situations not being studied (cf. Lincoln and Guba, 1985; Smaling, 2003). This was the case here because during the prototyping process, formative evaluation activities were integrated into the design process of the prototypes. Considering the lack of a statistical representation and the problem of restricting confounding variables in naturalistic situations (including the summative evaluation), making firm generalization from the findings of the study to a larger population or different contexts was difficult. Instead, in the study, readers of the research report are rather encouraged to invest in analytical forms of generalization (cf. Lincoln and Guba, 1985; Smaling, 2003). In order to help the readers determine whether the findings of the study are applicable to their own context or situations, the following matters were provided (cf. Miles and Huberman, 1994; Smaling, 2003; Walker and Bresler, 1993):

- a context-rich description of the research situation, design decisions, and formative (as well as summative) results;

- a description of the instrument characteristics, what was measured (e.g. in relation to levels of evaluation), how the instruments were administered and to how many respondents, and the data analysis procedures;
- the reasons used to make the choices for quality criteria, research designs, and research situations;
- the roles of the researcher in research activities.

8.4 CONCLUSIONS AND RECOMMENDATIONS

8.4.1 Conclusions

The study was initiated to explore the potential of a locally grounded professional development scenario for supporting Eritrean biology teachers within the context of a new Curriculum-2003. More specifically, the study sought to determine the characteristics of a professional development scenario that could effectively help teachers implement a morestudent-centered approach in Eritrea. The following conclusions are drawn from the findings of the study.

The study has shown that a professional development scenario combining a professional development workshop, exemplary curriculum materials, and follow-up support, has the potential to help teachers learn and implement practically-oriented teaching in their classrooms. When these three elements of the scenario are systematically integrated and extended overtime, they are more likely to bring about teacher awareness, learning, and improvement of classroom practice and student learning outcomes.

From the summative evaluation of this professional development scenario there is evidence that shows how effective it is for supporting teacher learning and use of practically-oriented biology lessons. The findings of the study indicate that the teachers who participated in the professional development scenario managed to use such lessons with varying quality and degrees of effectiveness in their respective classrooms. The study showed that the classroom practices of the experimental teachers differed from the control group teachers following the professional development workshop and intensive classroom coaching.

It is worthwhile to note that the experimental teachers' and students' learning took place in a complex social environment, one that cannot be surgically isolated or cannot contain the multiple variables that may have affected their behaviors or this outcome. Nevertheless, the convergence of quantitative and qualitative evidence

from different methods and data sources uphold that the observed differences in the practice of experimental teachers may be attributed to their involvement in this study. Overall, it can be concluded that a positive relationship exists between the professional development scenario and improvement in experimental teachers' classroom practice. It remains to be seen whether this difference in classroom practice is transient or sustainable considering the duration of time that this innovation is implemented. As Borko and Putnam (1996), Guskey (2000), and Loucks-Horsley et al. (1998) underscored, teachers must be allowed adequate time for relevant use to take place.

Finally, the study findings demonstrate that the characteristics of the activities matter more than the format of professional development for effective teacher learning (cf. Birman et al., 2000). A traditional format (workshop) can be effective as long as it has a follow-up, focus in subject matter and pedagogical content knowledge, opportunities for active learning, and integrates quality exemplary curriculum materials in ways that strengthen components of the training model.

8.4.2 Recommendations

For policy making in Eritrea

The Ministry of Education has embarked on a five year plan to bring a radical change to the education system with the introduction of Curriculum-2003. Nevertheless, lessons learned from educational reform initiatives worldwide indicate that implementing a new curriculum as ambitious as Curriculum-2003 is not a simple one-off event but rather a long and bumpy process (Fullan, 2001; Hargreaves, 2002). Here, it suffices to note that there is nothing wrong with ambitious aspirations--they are desirable for mobilizing resources and bringing direction to reform initiatives. That said, however, new curriculum ideas will not affect classroom processes until they take a systemic approach and teachers have had sufficient opportunity and support to internalize the teaching repertoire and beliefs associated with those actions (van den Akker, 1998). The study was undertaken on the premise that a professional development scenario in tandem with other elements of the system that support teacher learning, classroom practice, and student learning is desirable if the ideals of Curriculum-2003 are to be realized. Based on the findings of this study, the following two recommendations are considered relevant for policy considerations:

- The baseline information generated from the needs and context analysis of the study showed that the common practice and understanding of professional development in Eritrea is a series of topically unrelated one-shot "orientation"

workshops. At best, these workshops are restricted to providing teachers with information, and beyond small group discussions, teachers are hardly provided with the opportunity to practice let alone engage in school follow-ups. In contrast, the findings of the study demonstrate that the professional development scenario is a big step forward from past practice in Eritrea. After further empirical rigor, the professional development scenario should be considered a framework for development, implementation, and evaluation of the professional development of science teachers in Eritrea.

- In the study, a modest attempt has been made to establish a conducive school environment through involvement of school principals, administrators, and laboratory technicians. This was undertaken because the educational change process has both individual and organizational (school) dimensions (Guskey, 2003). Much of the professional development scenario hasfocused on individual teachers, and it should be noted that professional development efforts should also focus on school principals and improvement of the working environment of teachers. Therefore, the implementation process of Curriculum-2003 should take a systemic and holistic approach. That is, changes should take place simultaneously across the different elements of the education system so that in the final analysis a coherent, meaningful change will be brought about in classroom practice and improvement of student learning outcomes.

For professional development practitioners

The recommendations for future professional development endeavors should be based upon a critical deliberation of their particular context. Based on the findings of the study, the following recommendations are put forward:

- Professional development experience for science teachers should be based on their pressing needs. Whilst it is difficult to act upon every perceived need, professional development would be effective if these needs are linked to the goals of the particular educational system and concrete classroom practices of teachers.
- For supporting teachers' learning, the goals of the scenario should be tuned in ways that enable exploring and addressing teachers' pre-existing knowledge and beliefs; enhancing teachers' subject matter and pedagogical content knowledge; grounding teacher learning and reflection indaily practices; and providing teachers time and support coupled with pressure in their respective classrooms.
- Considering the situational nature of teacher learning (Putnam and Borko, 2000), professional development experience should be grounded in multiple contexts (outside the school, curriculum materials, inside the school, etc) and specific content of the curriculum the students study. Anchoring teacher learning

opportunities in content knowledge and pedagogical content knowledge of specific content (e.g. Diffusion andOsmosis, etc) could be relatedto improvement in teacher classroom practices and student learning outcomes (cf. Sykes, 1999). This anchorage could take place in a professional development workshop, school follow-ups, and exemplary curriculum materials where these three learning contexts are systematically honed to reinforce one another.

- The characteristics of the activities matter more than the format of professional development for effective teacher learning and improvement of classroom practice. For a professional development workshop to be effective, it shouldinclude school follow ups, should focus on subject matter and pedagogical content knowledge, should provide opportunities for active learning, and should integrate field-tested exemplary curriculum materials in ways that strengthen the exploration of *theory*, *demonstration,* and *practice* components of the training model (Joyce & Showers, 1995).
- The findings of this study indicate that school follow-ups have been instrumental in delivering the necessary pressure and support to participant teachers as per their particular classroom needs or concerns. The tailoring of follow-up support to the particular needs of teachers was made possible by the administration of Stages of Concerns Questionnaire (SoCQ). The follow-up support in the study took the form of reflective meetings, technical coaching, and exemplary curriculum materials.
- Considering the cost-effectiveness of scaling up and the sustainability of classroom-based coaching in Eritrea, effort should focus on building up the capacity of regional (Zoba) in-service cadres (i.e. a cascase model, e.g. Harvey, 1999) and improving school conditions for out-of-classroom peer collaborations (cf. Kitta, 2004; Thijs, 1999). As a part of the professional development scenario, a selected group of teachers and in-service providers can be trained on coaching and these cadre in turn replicate or provide the coaching within their respective schools or cluster of schools. In addition, considering Curriculum-2003's emphasis on Information and Communication Technology (ICT) and the introduction of computers in secondary schools, the potential of electronic support networks can be explored for peer collaboration (cf. Almekinders & Voogt, 2003).
- One of the challenges of development research with respect to evaluation methodology is the issue of determining the most relevant indicators of quality, success, and the impact of interventions (van den Akker, 1999). For this challenge, the findings of this study show that Guskey's (2000) model of evaluation offers a framework for determining critical indicators of impact of a professional development program along five levels of evaluations.

Further research

The findings of the study have provided evidence of the initial impact of the professional development scenario on teachers' classroom practice and student learning outcomes. Further research may examine its wider impact with many more samples taken and the long-term effect of this scenario on participant teachers' classroom practice and improvement in student learning considered. Additionally, it is high time in Eritrea to further test and articulate the design guidelines of the professional development scenario in different domains.

References

Abd-El-Khalick, F., Bell, R. L., & Lederman, N. G. (1998). The nature of science and instructional practice: Making the unnatural natural. *Science Education, 82*(4), 417-436.

Alexander, P. A., & Murphy, P. K. (1998). The research base for APA's learner-centered psychological principles. In N. M. Lambert, & B. L. McCombs (Eds.), *Issues in school reform: A sampler of psychological perspectives on learner-centered schools.* Washington, DC: APA.

Almekinders, M., & Voogt, J. (2003). The potential of ICT in rural schools. In J. Voogt, Y. Gorokhovatsky, & M. Almekinders (Eds.). *Information and communication technology in rural schools: Innovation didactics in physics teaching* (pp. 23-32). Enschede: University of Twente.

Ball, D. L. (1996). Teacher learning and the mathematics reforms: What we think we know and what we need to learn. *Phi Delta Kappan*, *76*(8), 500-508.

Ball, D. L., & Cohen, D. K. (1996). Reform by the book: what is - or might be - the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher*, *25*(9), 6-8.

Bell, R. (2001). Implicit instruction in technology integration and the nature of science: There's no such thing as a free lunch. *Contemporary Issues in Technology and Teacher Education*, *1*(4), 465-471.

Bloom, B. S., Englehart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives: The classification of educational goals, Handbook I: Cognitive Domain*. New York: David McKay.

Bracht, G., & Glass, G. (1968). The external validity of experiments. *American Educational Research Journal, 5*(4), 437-474.

Bray, B. (2000). Job-embedded staff development (Electronic version). *Today's school: Shared leadership in education, Fall Issue.* Peter Li Education Group.

Black, P., & Atkin, J. M. (Eds.) (1996). *Changing the subject: Innovations in science, mathematics and technology education*. London: Routledge.

Blumenfeld, P. C., Marx, R. W., Patrick, H., Krajcik, J., & Soloway E. (1997). Teaching for understanding. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers and teaching* (pp.819-878). Dordrecht: Kluwer.

Birman, B. F., Desimone, L., Porter, A. C., & Garet, M. S. (2000). Designing professional development that works. *Educational Leadership*, *57*(8), 28-33.

Borko, H., & Putnam, R. T. (1996). Learning to teach. In D. C. Berliner, & R. C. Calfree (Eds.), *Handbook of educational psychology* (pp. 673–708). New York: Macmillan.

Bransford, J. D., Brown, A. L., Donovan, M. S., & Pellegrino, J. S. (1999). *How people learn: Bridging research and practice*. Washington, DC: National Academy Press.

CIA, (2003). *World Fact Book*. Retrieved March 3, 2004, from http://www.cia.gov/cia/publications/factbook/geos/er.html

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillside, NJ: Erlbaum.

Cook, T., & Campbell, D. (1979). *Quasi-experimentation: Design and analysis issues for field settings*. Boston: Houghton Mifflin.

Corcoran, T. B. (1995). *Helping teachers teach well: Transforming professional development*. CPRE Briefs. Retrieved June 2004, from http://www.ed.gov/pubs/CPRE/t61/index.html

Creswell, J. W. & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice, 39*(3), 124-131.

Crowther, D. T. (1997). Editorial [Electronic version]. *Electronic Journal of Science Education* Retrieved May 10, 2004, from http://unr.edu/homepage/jcannon/ejse/ejsev2n2ed.html

Darling-Hammond, L., & McLaughlin, M. W. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappan*, *76*(8), 597-604.

Datnow, A. (2002). Can we transplant educational reform, and does it last? *Journal of Educational Change, 3*(3), 215-239.

de Feiter, L., Macfarlane, I. G., Stoll, C. J., & Akker, J. van den. (1998). *Teacher development as a key to science curriculum reform in southern Africa.* Paper presented at the Human Development Week at the World Bank. Washington, USA.

de Feiter, L., Vonk, H., & Van den Akker, J. (1995). *Towards more effective science teacher development in southern Africa.* Amsterdam: VU University Press.

de Vellis R. F. (1991). *Scale development, theory and applications*. Newbury Park: Sage.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, *23*(7), 5-12.

Fullan, M. (2000). The return of large-scale reform. *Journal of Educational Change, 1*(1), 5-28.

Fullan, M. (2001). *The new meaning of educational change*. New York: Teachers College Press.

Garet, M. S., Porter, A. C., Desimone, L. Birman, B., & Yoon, K. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.

Guskey, T.R. (1995). *Results-oriented professional development: In search of an optimal mix of effective practices.* NCREL. Retrieved August 8, 2004, from http://www.ncrel.org/sdrs/areas/rpl_esys/pdlitrev.htm

Guskey, T.R. (2000). *Evaluating professional development*. Thousand Oaks, CA: Corwin Press.

Guskey, T.R. (2003). Analyzing lists of the characteristics of effective professional development to promote visionary leadership. *NASSP Bulletin*, *87*(637), 38-54.

Guthrie, G. (1986). Current research in developing countries: The impact of curriculum reform on teaching. *Teaching and Teacher Education, 2*(1), 81-89.

Habte, G. (2001*). An evaluation of grade 10 physics practical work in five selected secondary schools in Eritrea*. Masters thesis. University of Western Cape.

Hall, G. E., George A. A., & Rutherford, W. L. (1998). *Measuring stages of concern about the innovation: A manual for use of the SoC questionnaire*. Austin, TX: Southwest Educational Development Laboratory.

Hall, G. E. & Hord, S. E. (2001). *Implementing change: patters, principles, and potholes*. Boston, MA: Allyn and Bacon.

Harvey, S. (1999). Phasing science INSET in developing countries: Reflections on the experience of the primary science programme in South Africa. *International Journal of Science Education, 21*(2), 595-610.

Hargreaves, A. (2002). Sustainability of educational change: The role of social geographies. *Journal of Educational Change, 3*(3), 189-214.

Hawley, W. D., & Valli, L. (1999). The essentials of effective professional development: A new consensus. In L. Darling-Hammond, & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 127-150). San Francisco: Jossey-Bass.

Hawley, W. D., & Valli, L. (2000). Learner-centered professional development. *Phi Delta Kappa Center for Evaluation, Development, and Research, 27(Aug.).* Retrieved March, 20, 2003, from http://www.pdkintl.org/edres/resbul27.htm

Hazel, E. (1995). Science laboratory Instruction. In T. Husén, & T.N. Postlethwaite (Eds.), *The international encyclopedia of education* (pp. 171-174). Oxford: Pergamon.

Horsley, D. L., & Loucks-Horsley, S. (1998). CBAM brings order to the tornado of change. *Journal of Staff Development*, *19*(4), 17-20.

Huberman, A. M., & Miles, M. B. (1984). *Innovation up close: How school improvement works*. New York: Plenum Press.

Illman, H. T. (1998). Constructivism and cooperation between scientists and educators: A reply to Crowther. *Electronic Journal of Science Education*, *2*(3). Retrieved February, 26, 2004, from http://unr.edu/homepage/jcannon/ejse/illman.html

James, E., Eijkelhof, H., Gaskell, J., Olson, J., Raizen, S., & Saez, M. (1997). Innovations in science, mathematics and technology education. *Journal of Curriculum Studies, 29*(4), 471-484.

Jenkins, E. W. (1994). History of science education. In T. Husén, & T. N. Postlethwaite (Eds.), *The international encyclopedia of education* (pp. 5324-5328). Oxford: Pergamon.

Jenkins, E. W. (2000). Constructivism in school science education: Powerful model or the most dangerous intellectual tendency? *Science & Education, 9*(6), 599-610.

Joyce, B., & Showers, B. (1988, 1995). *Student achievement through staff development*. 1st & 2nd ed. New York: Longman.

Keeves, J., & Aikenhead, G. (1995). Science curricula in a changing world. In B. Fraser, & H. J. Walberg (Eds.), *Improving science education* (pp. 13-45). Chicago: The University of Chicago Press.

Kitta, S. (2004). *Enhancing mathematics teachers' pedagogical content knowledge and skills in Tanzania*. Doctoral dissertation. Enschede: University of Twente.

Knowles, M. (1984). *Andragogy in action.* San Francisco: Jossey-Bass.

Lederman, N. G. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of Research in Science Teaching, 29*(4), 331-359.

Krathwohl, D. R. (1998). *Methods of educational social science research.* New York: Longman.

Lieberman, A. (1996). Practices that support teacher development. Transforming conceptions of professional learning. In M. W. McLaughlin, & I. Oberman (Eds.), *Teacher learning: New policies, new practices* (pp. 185–201). New York: Teachers College Press.

Lewin, K. (1992). *Science education in developing countries*: *Issue and perspectives for planners*. Paris: UNESCO/IIEP.

London, N. A. (1993). Why education projects in developing countries fail: A case study. *International Journal of Educational Development*, *13*(3), 265-275.

Lorsbach, A., & Tobin, K. (1992) Constructivism as a referent for science teaching. *NARST Newsletter, 30*, 5-7.

Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

Lunetta, V. (1998). The school science laboratory: Historical perspectives and contexts for contemporary teaching. In B. J. Fraser, & K. G. Tobin (Eds.), *The international handbook of science education* (pp. 249-262). Dordrecht: Kluwer Academic Publishers.

Maslowski, R., & Visscher, A. (1999). The potential of formative evaluation in program design models. In J. van den Akker, R. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 137-144). Dordrecht: Kluwer Academic Publishers.

Mathews, M. R. (2002). Constructivism and science education: A further appraisal. *Journal of Science Education and Technology, 11*(2), 121-134.

Mestre, J. P. (1994). Cognitive aspects of learning and teaching science. In S. J. Fitzsimmons, & L. C. Kerpelman (Eds.), *Teacher enhancement for elementary and secondary science and mathematics: Status, issues and problems* (pp. 3-1 – 3-53). Washington, DC: National Science Foundation .

McKenney, S. (2001). *Computer-based support for science education materials developers in Africa: Exploring potentials.* Doctoral dissertation. Enschede: University of Twente.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* London: Sage.

Ministry of Education. (1998a). S*cience methodology training manual for senior secondary school biology, chemistry and physics teachers*. Asmara: Department of General Education.

Ministry of Education Eritrea (1998b). *Education brief 1998*. Asmara: Department of Research and HRD.

Ministry of Education Eritrea (1999). *Education brief 1999*. Asmara: Department of Research and HRD.

Ministry of Education Eritrea (2002*). Concept paper for a rapid ransformation of the Eritrean rducation system*. Asmara: MOE.

Ministry of Education (2003). *Biology syllabus guide for high school*. Asmara: Department of General Education.

Ministry of Education Ethiopia (1981). Report on educational development in Ethiopia. Addis Ababa: MOE.

Murphy, E. (1997). *Constructivism from philosophy to practice*. Retrieved June 4, 2004, from http://www.stemnet.nf.ca./``elmurphy/emurphy/cle.html

Newcombe, C. (2000). *Secondary education in Eritrea (discussion paper).* Asmara: MOE.

Nieveen, N. (1999). Prototyping to reach product quality. In J. van den Akker, R. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 15-135). Dordrecht: Kluwer Academic Publishers.

Pajak, E. (1993). *Approaches to clinical supervision: Alternatives for improving instruction*. Norwood, MA: Christopher-Gordon Publishers.

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Prawat, R. S. (1989). Promoting access to knowledge, strategy, and disposition in students: A research synthesis. *Review of Educational Research, 58*(4), 1-41.

Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher*, *24*(7), 5-12.

Prophet, R. (1990a). Rhetoric and reality in science curriculum development in Botswana. *International Journal of Science Education, 12*(1), 13-23.

Putnam, R., & Borko, H. (1997). Teacher learning: implications of new views of cognition. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers & teaching* (pp. 1223-1296). Dordrecht: Kluwer Academic Publishers.

Putnam, R., & Borko, H. (2000). What do new views of knowledge say and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4-15.

Ogunniyi M. B. (1986). Two decades of science education in Africa. *Science Education, 70*, 111- 122.

Osborne, J. F. (1996). Beyond constructivism, *Science Education*, *80*(1), 53-82.

Ottevanger, W. (2001). *Teacher support materials as catalyst for science curriculum implementation in Namibia*. Doctoral dissertation. Enschede: University of Twente.

Roes, M. (1997). *Nascholing op basis van lesvoorbeelden in de context van curriculum-vernieuwing* [English summary]. Doctoral dissertation. Enschede: University of Twente.

Rogan, J. M., & Grayson, D. J. (2003). Towards a theory of curriculum implementation with particular reference to science education in developing countries. *International Journal of Science Education, 25*(10), 1171-1204.

Rowan, B., Schilling, S. G., Ball, D., & Miller, R (2001). *Measuring teachers' pedagogical content knowledge in surveys: An exploratory study*. Consortium for policy research in education. Ann Arbor: University of Michigan.

Russell, J., & Hollander, S. (1975). A biology attitude scale. *The American Biology Teacher, 37*(5), 270-273.

Saleh, O. (2002). *An interview with the Minster of education about the new educational system to be introduced in Eritrea*. Retrieved March 24, 2004 from http://shaebia.org/wwwboard/interviews/messages/44.html

Saleh, O. (2003). *Shaebia interview with Minister of Education.* Retrieved March 24, 2004, from http://www.shaebia.org/artman/publish/article_1838.html

Schell, T. J. (1996).Teaching and learning in classroom context. In D.C. Berliner & R. Calfee (Eds.), *Handbook on educational psychology* (pp. 725-764). New York: Macmillan.

Schneider, M. R., & Krajcik, J. (2002). Supporting science teacher learning: The role of educative curriculum materials. *Journal of Science Teacher Education*, *13*(3), 221-245.

Schmuckler, M. A. (2001). What is ecological validity? A dimensional analysis. *Infancy, 2*(4), 419-436.

Showers, B., & Joyce, B. (1996). The evolution of peer coaching. *Educational Leadership*, *53*(6), 12-16.

Shulman, S. L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.

Singer, J., Marx, W. R., & Kraijcik, J. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist*, *35*(3), 165-178.

Smaling, A. (2003). Inductive, analogical, and communicative generalization. *International Journal of Qualitative Methods, 2*(1), Article 5. Retrieved September 24, 2005, from http://www.ualberta.ca/~iiqm/backissues/2_1/pdf/smaling.pdf

Smith, M. R. (1981). *Learning to learn: Applied theory for adults*. Chicago: Follett Publishing Company.

Sparks, D., & Loucks-Horsley, S. (1990). Models of staff development. In W. R. Houston (Ed.), *Handbook of research on teacher education* (pp. 234-250). New York: Macmillan.

Stoll, C. (1996). Introduction. In C. Stoll, L. de Feiter, H. Vonk, & J. van den Akker (Eds.), *Improving science and mathematics teaching in Southern Africa: Effectiveness of interventions*. Proceedings of a regional conference, (pp. 9-19), Windhoek, Namibia, December 1995. Amsterdam: VU University Press.

Stronkhorst, R. (2001). *Improving science education in Swaziland: The role of in-service education*. Doctoral dissertation. Enschede: University of Twente.

Supovitz, J., & Turner, H. M. (2000). The effects of professional development on science teaching practice and classroom culture. *Journal of Research in Science Teaching, 37*(9), 963-980.

Sykes, G. (1999). Teacher and student learning: Strengthening their connection. In L. Darling-Hammond, & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 151-179). San Francisco: Jossey-Bass.

Tilya, F. N. (2003). *Teacher support for the use of MBL in activity-based physics teaching in Tanzania.* Doctoral dissertation. Enschede: University of Twente.

Tabulawa, R. (1996). Pedagogical classroom practice and the social context: The case of Botswana. *International Journal of Educational Development, 17*(2), 189-204.

Tecle, T. A. (1999). *The design of a teacher guide on diffusion and osmosis*. Msc. Thesis, Enschede: University of Twente.

The State of Eritrea (1994). *Macro-policy*. Asmara: GOE.

Thijs, A. (1999). *Supporting science curriculum reform in Botswana: The potential of peer coaching*. Doctoral dissertation. Enschede: University of Twente.

Thompson, C. L. (2003). *First in America special report: Research on professional development to improve student performance*. NC Education Research Council, April 2003.

Trevaskis, G. N. (1960). *Eritrea: A colony in transition, 1941 – 1952*. London: Oxford University Press.

van den Akker, J. J. H. (1988a). *Ontwerp en implementatie van natuuronderwijs* [Design and implementation of science education]. Lisse: Swets & Zeitlinger.

van den Akker, J. (1988b). The teacher as learner in curriculum implementation. *Journal of Curriculum Studies*, *20*(1), 47-55.

van den Akker, J., & Plomp, Tj. (1994). Educational development in developing countries. In M. M. Skutsch, J. M. Opdam, & N. G. Nordholt (Eds.), *Towards sustainable development* (pp.451-469). Enschede: University of Twente.

van den Akker, J. (1994). Designing innovations from an implementation perspective. In T. Husén, & T. N. Postlethwaite (Eds.), *The international encyclopedia of education* (pp. 1491-1494). Oxford: Pergamon Press.

van den Akker, J., & Voogt, J. (1994). The use of innovative and practice profile in the evaluation of curriculum implementation. *Studies in Education Evaluation, 20*(1), 503-512.

van den Akker, J. (1998). The science curriculum: Between ideals and outcomes. In B. Fraser, & K. Tobin (Eds.), *International handbook of science education* (pp. 421-447). Dordrecht: Kluwer Academic Publishers.

van den Akker, J. (1999). Principles and methods of development research. In J. van den Akker, R. Branch, K. Gustafson, N. Nieveen, & T. Plomp (Eds.), *Design approaches and tools in education and training* (pp. 1-14). Dordrecht: Kluwer Academic Publishers.

van den Akker, J. (2002a). The added value of development research for educational development in developing countries. In K. Osaki, W. Ottevanger, C. Uiso, & J. van den Akker (Eds.), *Science education research and teacher development in Tanzania* (pp. 51-67). Amsterdam: Vrije Universiteit.

van den Akker, J. (2002b). The potential of development research for improving the relation between curriculum research and curriculum development. In A. Fries, M. Rosenmund, & W. Heller (Eds.), *Comparing curriculum making processes* (pp. 37-53). Bern: Peter Lang.

van den Akker, J., & McKenney, S. (2004). *How can developmental research improve science curriculum policies and practices*? Poster session handout created for the annual NARST meeting, April 1-3, 2004, Vancouver, BC.

van den Berg, E. (1996). *Effects of in-service education on the implementation of elementary science*. Doctoral dissertation. Enschede: University of Twente.

van den Berg, E., & Giddings, G. (1992). *An alternative view of laboratory teaching*. Perth: Curtin University of Technology.

Verspoor, A. M. (1989). *Pathways to change: Improving the quality of education in developing countries*. Washington, DC: The World Bank.

von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. Steffe, & J. Gale (Eds.), *Constructivism in education* (p. 3-16). Hillsdale, NJ: Lawrence Erlbaum Associates.

Voogt, J. (1993). *Courseware for inquiry-based science curriculum*. An implementation perspective. Doctoral dissertation. Enschede: University of Twente.

Walker, D. (1992). Methodological issues in curriculum research. In P. Jackson (Ed.), *Handbook of research in curriculum* (pp. 98-118). New York: Macmillan.

Ware, S. (1992). *Secondary school science in developing countries: Status and issues*. Washington, DC: World Bank.

Wenglinski, H. (2002). How schools matter: The link between teacher classroom practices and student academic performance. [Electronic version]. *Education Policy Analysis Archives*, *10*(12).

Wilcox, R. (1972). *Effective teaching in Ethiopia schools*. Addis Ababa: Artistic Press.

White, R. & Gunstone, R. (1992). *Probing understanding*. London: The Falmer Press.

Wormstead, S. J., Becker, M. L., & Congalton, R. G. (2002). Tools for successful student-teacher-scientist partnerships. *Journal of Science Education and Technology*, *11*(3), 277-287.

Yin, R. (1994). *Case study research: Design and methods*. Beverly Hills, CA: Sage Publications.

Zemke, R., & Zemke, S. (1988). 30 Things we know for sure about adult learning. *Training, 25*(7), 57-61.

ENGLISH SUMMARY

The potential of a professional development scenario for supporting biology teachers in Eritrea

INTRODUCTION

Since independence, the Ministry of Education of Eritrea initiated two waves of curriculum reform in order to improve the quality and equity of education at all levels. The first reform effort, launched in 1991, introduced a structural and content change to the previous Ethiopian Education system. Among other things, the policy on science curriculum underscored that science education should be relevant for personal needs, societal issues, career awareness, and academic preparation of students (MOE, 1998a). It recommended that the science curriculum should be more process-oriented and learner-centered, and should discourage passive learning of students.

The implementation of Curriculum-1991 was confounded with many implementation problems. To begin with, there was a shortage of qualified teachers, textbooks, teacher educators, and a solid model of in-service education. Secondarily, the qualifications of the teaching force left much to be desired. The preparation and publication of textbooks was finalized in 1995, which was four years after the introduction of the Curriculum. The teachers were only introduced to the new Curriculum by means of orientation workshops that focused mainly on providing them with information related to its content, methodology, and evaluation guidelines. Under such conditions, it is hardly surprising to observe a pervasive teacher-dominated instructional practice that is in sharp contrast to what was intended in the policy (MOE, 1988a). For ameliorating this reality of classroom practice, the Ministry of Education initiated in 1998 a curriculum review study that set the stage for a second wave of reform, and a launching of Curriculum-2003.

With the introduction of Curriculum-2003, the Ministry of Education set out on a five-year plan to bring radical change to all levels of the education system. At the secondary school level, the second wave of reform entailed a considerable change

in the curriculum content and a number of new subjects. It called for better and more participation of students in the learning process, and improvement of the teaching approach. The Biology curriculum, in particular, expected from teachers a significant change in their teaching approaches. They were expected to embrace "student-centered interactive pedagogy" and change accordingly (MOE, 2002).

Nonetheless, the international literature on educational change asserts that implementing reform initiatives as ambitious as Curriculum-2003 and bringing forth change in practice at classroom level is not a simple event but rather a long and bumpy process (Fullan 2001; Hargreaves, 2002). For biology teachers, embracing the new teaching approaches is not easy because doing so will mean treading on uncharted grounds. The teachers have to adopt new roles, need to be well versed with new understandings about teaching, learning, learners, subject matter, and pedagogical content knowledge (Borko & Putnam, 1997; Fullan 2001; Loucks-Horsely et al. 1998). It appears that such change is a complex process and its implementation demands supporting teachers' through professional development experiences responsive to the unique features of the user context, Eritrea.

AIM AND RESEARCH QUESTIONS OF THE STUDY

The study was aimed at investigating the potential of a professional development scenario (intervention) for helping biology teachers implement a student-centered approach within the context of a new Curriculum. The central research question that guided the overall study has been formulated as follows:
What are the characteristics of a professional development scenario that effectively supports biology teachers in Eritrea with the implementation of a more student-centered approach?

This being the main research question, the study formulated three specific questions that provided an adequate platform for navigating the overall investigation. These were:

1. What are the contextual factors that influence the design and implementation of a professional development scenario for biology teachers in Eritrea?
2. What can be learned from the literature about the characteristics of promising professional development scenarios that adequately support teacher learning and classroom practice?
3. What is the practicality and effectiveness of the professional development scenario in supporting biology teachers' learning and classroom practice?

RESEARCH APPROACH AND DESIGN

A development research approach was adopted for addressing the research questions of the study. This research approach was chosen because of its pragmatic structure and focus on design principles that are helpful in realizing a series of small-scale examples of an intervention in interactive and collaborative ways. Development research is characterized by a cyclic and iterative design, evaluation, and revision process of an intervention, where problems and needs are diverse and the uncertainty of its effectiveness abounds in the user context (van den Akker, 1999; van den Akker & Plomp, 1994).

Front-end analysis

The overall design of the study was structured within the framework of this research approach. The development research activities were conducted in three stages. The first stage involved a front-end analysis. The three main activities that marked the front-end analysis were a context and needs analysis, expert consultation, and review of the relevant literature for developing the professional development scenario.

The outcome of the context and needs analysis has highlighted the needs, direction, and focus of the study. In addition, this analysis has provided a direction where the literature review should be concentrated. Among other things, a review of the international literature yielded valuable information and insights into what constitutes an effective professional development scenario, robust implementation strategies, principles for implementing change, and support for teachers' learning and practice in the change process.

Based upon the results of the context and needs analysis and the literature review, a decision was made to concentrate the intervention on promoting a student-centered approach, with a particular focus on practically-oriented biology teaching. The main tenets of this biology teaching are interactive teacher demonstration, practical work, and managing group work activities in large class size. The literature review culminated in the distillation of design guidelines that helped to elaborate the following components of the professional development scenario.

- Professional development workshop;
- Exemplary curriculum materials;
- School follow-up;
- Establishment of a supportive school environment.

Prototyping of the professional development scenario

It primarily dealt with the design and formative evaluation of the successive prototypes of the exemplary curriculum materials and the workshop. The prototyping process was characterized by the use of a number of prototypes, iteration, and the participation of potential users.

For addressing the validity and practicality of the curriculum materials and the workshop, it was found prudent to employ evaluation strategies of expert and user appraisals (i.e. for validity aspects), trial (i.e. for practicality), and field-test (i.e. for effectiveness of materials). The other two components of the scenario (i.e. school follow-up and establishment of a supportive school environment) were only subjected to expert appraisal along with the preliminary design of the professional development scenario.

Summative evaluation of the professional development scenario

The last stage of the study sought empirical evidence on the effectiveness of the professional development scenario in supporting teachers' learning and teaching of practically-oriented lessons. A quasi-experimental design was used for investigating the impact of the professional development scenario.

The professional development scenario (treatment) was implemented for one semester (six months) at three experimental schools. Sixteen biology teachers at the experimental schools were invited for a professional development workshop focused on developing awareness and augmenting teachers' content and pedagogical content knowledge about practically-oriented biology lessons. The workshop provided teachers the opportunity to reflect upon and examine their knowledge, beliefs, and concerns about practically-oriented biology lessons; gain an understanding of the theory underpinning the knowledge and skills of practically-oriented lessons (via presentation and exemplary curriculum materials); observe a demonstration of what an exemplary biology lesson looks like in classroom practice (via videotapes); practice design and teaching of practically-oriented biology lessons in a simulated condition (via microteaching and exemplary curriculum materials); and get structured reflection and feedback.

Following this workshop, the teachers were provided follow-up support for 2-3 weeks in their respective schools. The follow-up support involved two school-based workshops (reflective meetings) and three classroom-based coaching sessions. The teachers were then left alone to adapt and sustain practically-oriented biology teaching. Fourteen biology teachers at three schools were involved as a control group. These teachers did not get the aforementioned treatment, and were teaching the same biology curriculum they always taught.

The summative evaluation was conducted towards the end of the academic semester at both experimental and control group schools. Guskey's (2000) model of evaluation was used for gathering data along the five levels of evaluation: teachers' reactions, teachers' learning of new knowledge and skills, the nature of school support, teachers' use of new knowledge and skills, and, student learning outcomes. The data were collected through analysis of the teacher expectation questionnaire, evaluation questionnaire, Stages of Concern Questionnaire, school support questionnaire, teacher focus group interview, curriculum profile-classroom observation instrument, level of use interview, student focus group interview, student attitude questionnaire, and achievement test.

RESULTS

The effectiveness of the professional development scenario was judged by participants' self-reports, classroom practice profile scores of experimental and control school teachers, and student learning outcomes. The key findings of the summative evaluation are as follows:

- experimental group teachers' overall reaction to the professional development workshop was positive. The teachers considered the workshop useful and relevant for their teaching practice;
- following the professional development experience in the workshop, the experimental teachers' awareness and knowledge of practically-oriented biology lessons was enhanced. In addition, there are indications that teachers learned from the results of the microteaching sessions;
- after studying the exemplary materials and observing microteaching lessons, the teachers indicated that their confidence to try out the practically-oriented biology teaching was improved;
- the implementation of practically-oriented teaching was facilitated by the schools. The nature of school support made available for experimental teachers varied across the schools;
- the convergence of results from stages of concerns, level of use, classroom observation, and student interview indicated that the experimental group of teachers had been using practically-oriented teaching with varying quality and degrees of effectiveness in their respective classrooms. In addition, experimental teachers' classroom observations showed statistically higher practice profile scores than the control group teachers;

- there was a positive change of experimental students' attitudes towards practically-oriented biology teaching. Regarding cognitive learning outcomes, there is no statistically significant difference in the performance of both groups of students on the achievement test. Item analysis of the achievement test revealed that five items showed significant differences in favor of the experimental group, three items in favor of the control group, and two items did not show significant difference in the mastery of content areas between the two groups.

CONCLUSIONS

The study was initiated to explore the potential of a locally grounded professional development scenario for supporting Eritrean biology teachers within the context of Curriculum-2003. More specifically, the study sought to determine the characteristics of a professional development scenario that could effectively help teachers implement a more student-centered approach in Eritrea. The following conclusions are drawn from the findings of the study.

The study has shown that a professional development scenario that combines a professional development workshop, exemplary curriculum materials, and follow-up support, has the potential to help teachers learn and implement practically-oriented teaching in the classroom. When these three elements of the scenario are systematically integrated and extended overtime, they are more likely to bring forth teacher awareness, learning, and improvement of classroom practice and student learning outcomes.

From the summative evaluation of this professional development scenario there is evidence that shows its effectiveness for helping teachers learn and use practically-oriented biology lessons. The findings of the study indicate that the teachers who participated in the professional development scenario managed to use such lessons with varying quality and degrees of effectiveness in their respective classrooms. The study showed that the classroom practices of the experimental teachers differed from the control group teachers following the professional development workshop and intensive classroom coaching.

The study recognizes, though, that experimental teachers' and students' learning took place in a complex social environment where it is difficult to surgically isolate or contain the multiple variables that may have potentially affected their behaviors or this outcome. Nevertheless, the convergence of quantitative and qualitative evidence from different methods and data sources uphold that the observed difference in the practice of experimental teachers may be attributed to their

involvement in this study. Overall, it can be concluded that the study demonstrates that a positive relationship exists between the professional development scenario, improvement in experimental teachers' classroom practice, and students' learning outcomes. It remains to be seen whether this difference in classroom practice is transient or sustainable considering the duration of time that this innovation is implemented. As Borko and Putnam (1996), Guskey (2000), and Loucks-Horsley et al. (1998) underscored, teachers must be allowed adequate time for relevant use to take place.

Finally, the findings of the study demonstrate that the characteristics of the activities are more important than the format of professional development for effective teacher learning (cf. Birman et al., 2000). A traditional format (workshop) can be effective as long as it has a follow-up, focus in subject matter and pedagogical content knowledge, opportunities for active learning, and as long as it integrates quality exemplary curriculum materials in ways that strengthen the components of the training model.

APPENDIX A1

A practically oriented biology lesson from the exemplary curriculum materials

Lesson 2

Practical Work On Osmosis

What the Lesson Looks Like?

Resource materials which will be used in this lesson are availble in the class. You will briefly assess students' prior conceptions and then introduce the topic, and probably you may give a demonstration on how to prepare the potato cylinders using a knife. Students will work in groups and you may sketch the table on the board or hang a self-made poster that dispaly the table(pp 17.) that could help them to organize the results of their practical work for the next lesson.

What you are trying to achieve in this lesson?

The students should be able to :

- Define osmosis as the passage of water molecules from a region of their higher concentration to a region of their lower concentration through a semipermeable membrane
- Distinguishe betwen diffusion and osmosis
- Observe, measure, and record data while doing the practical work.

Relevant pages on the background information and students' textbook.

- Biology for grade eight: Chapter 2, pp35-37

Lesson plan and timing

Activity	*Approximate time (Mn)*
Start of lesson	10
Development (Explanation and practical work)	25
Conclusion	5
Total time	40

Lesson preparation

To do before the class

- Read about osmosis on the innovation support (biological content pp. 14-19), and if available refer to textbooks cited on the Reference
- Assess what the students already know about **solute**, **solvent**, **solution**, and **concentration**, from chemistry classes. If you feel your students lack the necessary prerequisite concepts then read the prerequisite concepts on page 4 and try to teach them

- Prepare/ buy some simple paper cups, and if you could not manage to find cork borer look for some other alternatives (e.g. Knife or local potato molder)

- If a lab. room is not available, try to look for a place where students work can be put for the next day.

- Read about osmosis on the innovation support (biological content pp.20-23),

- Poster that display the table on pp17.

✓ *Media and materials*

If available try to find the following items which will be needed for this lesson.

- Some amount of table sugar /salt (40% solutions)
- 10 beakers or test tubes
- some 5-6(depending the class size) large potatoes
- Paper cups (for holding the potato cylinders before treatment)
- knife or local potato molder
- Pencils
- Tap water, and sugar solution (40% sugar solution)
- Rulers(if possible spring balance).

✓ *What to expect and Tips*

- Concerning osmosis, students have some naïve idea on the issue of concentration. Often students base their predictions regarding the overall direction of the osmosis on the concentration of the solute (e.g. 70% sugar, 20% sugar, they think that the overall direction is from 70% to 20%). However, the scientific idea asserts that the concentration of water is the factor that determines the overall direction of osmosis, and H_2O concentrations are approximately inversely proportional to solute concentrations (e.g. 30%H_2O, 80% H_2O). Further more, on the issue of movement, students think those common solute molecules such as salt and sugar will diffuse through a semipermeable membrane. Nevertheless, we know that only water and other small, neutral molecules (such as oxygen and carbondioxid) can diffuse across a semipermeable membrane; sugar molecules and salt ions are too large and carry too much charge.

- Try to avoid the use of teleological explanations or explanations that originate from human behavior in relation to osmosis. From experience it appears that there is a tendency of teachers and students to use teleological explanations. Particularly students appear to believe in a strong drive (need or force), much like human drives, that provides the force, which moves the water molecules. Even learners who mention that there is a concentration gradient do not recognize that this gradient is the cause of movement and add that there is a drive toward obtaining equal concentrations.

- In case spring balance or ruler is not available students can make observation on the physical change which is quite conspicuous. More over in case a hypotonic condition, the potato cylinders get stacked in the test tube.

■ Be patient. Group work takes more time, you will have less time to cover things. There will be students who are not on task. The main thing is not to giveup the first time you try something and it does not work the way you planned it.

■ During the activity try to walk around make sure that the groups are on track and keep your self available to answer some of their questions.

■ One of the things that happens when you are running the activity is that you see things about your classroom that you would not have otherwise seen both good and bad things. When you ask students to start up, there is a lot of shuffling around as they get organized. So as everyone gets started on the activity the classroom is a buzz of noise. Initially, much of their attention focuses on things like figuring out what the groups needed to do.

■ Do not be caught up by the bell

Execution of lesson

10

Start of lesson

Assessing students' prior conceptions

You have already brought some of the materials for this period. You may start the class by asking students what they have observed in the experiment that you gave them as homework. These question may help you in discussing and assessing their observations:

- What is the difference between solute, solvent and solutions?
- What did you observe in your homework?
- In your observations, which one do you think move from its place of hight to low concentrations?

Introduction

The above discussion may be followed with what you have done with the "*venigar egg experiment*" . Tell them what you have got after you soaked an egg in a venger and ask them to predict, i.e. what do they think the outcome if you put it in a pure water for some time. Just listen for their predictions and then let them observe your egg that you have put it in a pure water. Try to reconcile any conflict between their prediction and observations.

After you have seen and entertained some of the students' explanation on these matters then:

- state the objectives that would be achieved in this period.
- you will briefly introduce the concept of osmosis and tonicity

25

Activity

You will start the activity by distributing the materials (**see materials needed**) to each group. It is good to assign some of the groups to use a spring balance and others measuring rulers. While running the activity, try to help students' in operating the cork borer for making appropriate potato cylinders.

Materials needed

10 beakers/ test tubes, some large potatoes, Paper cups, Cork borer/ knife or local potato molder, Pencils, Tap water and sugar solution, Spring balance and ruler.

NB: Some groups need to be given Spring balance and others rulers in measuring the effect of osmosis on potato tissues.

Procedures

- Push the cork borer into a large potato or use a knife to prepare potato cylinders
- push out the potato tissues out of the cork borer using a pencil. Prepare a number of potato cylinders in this way
- choose the two largest cylinders , and cut these two accurately to the same length
- Measure/ weight the cylinders very carefully and record your data. · Label two test tubes as A and B, & place a potato cylinder in each of them. Then fill or cover the potato in A with tape water and B with strong sugar solutions.

- Leave the test tubes for a day and record your predi-

5

Conclusion

You may round off the lesson by explaining students how they are going to organize and present the results of their practical work in the next lesson.

End of lesson

you can finish the lesson by asking the groups

- to clean up and return the materials used for the activity
- to copy down this table that could help them to organize their report for the next lesson

Page-17

Test tube	Initial Length / Weight	Treatment	Prediction	Observation		Explanation for observed change
				Final Length/ Weight	Physical appearance	
A		*Pure water*				
B		Concentrated solution				

Page-18

APPENDIX A2

A complete practice profile score for each lesson in the try-out study

The practice profile scores for Teacher A and B

Teacher *A*	**Profile elements**	**L-1**	**L-2**	**L-3**	**L-4**	**Total (%)**
Start of lesson	Basic teaching skills and classroom management	66.7	70	58.3	50	62
	Student-centered orientation	70	63.6	100	70	76
	Subject matter	100	100	100	100	100
Body of lesson	Basic teaching skills and classroom management	63.6	75	66.7	77.8	70
	Student-centered orientation	90	52.9	69.6	71.4	72
	Subject matter	100	100	100	100	100
conclusion	Basic teaching skills and classroom management	4	100	50	90	65
	Student-centered orientation	40	40	50	66.7	50
	Subject matter	66.7	50	50	100	67
Overall impression	Basic teaching skills and classroom management	71.4	60	66.7	54.5	64
	Student-centered orientation	83.3	60	50	50	61
	Subject matter	80	75	100	100	90
Total time:	Time allotted & actual time SL	10/**15**	10/**11**	10/**10**	5/**5**	
	Time allotted & actual time BL	15/**22**	20/**30**	20/**25**	20/**20**	
	Time allotted & actual time CL	5/**00**	5/**00**	5/**5**	5/**10**	

Teacher *B*	**Profile elements**	**L-1**	**L-2**	**L-3**	**L-4**	**Total (%)**
Start of lesson	Basic teaching skills	66.7	70	80	75	75
	Student-centered orientation	66.7	55.6	72.7	80	69
	Subject matter	100	100	100	100	100
Body of lesson	Basic teaching skills	72.7	75	58.3	77.8	70
	Student-centered orientation	78.9	37.5	90	95.2	78
	Subject matter	50	100	100	100	88
conclusion	Basic teaching skills	70	60	25	90	69
	Student-centered orientation	60	50	66.7	100	70
	Subject matter	50	50	100	100	73
Overall impression	Basic teaching skills	72.7	28.6	78.6	81.8	64
	Student-centered orientation	72.7	40	100	100	81
	Subject matter	100	80	100	100	95
*Time	Time allotted & actual time SL	10 /**10**	10/**5**	10/**6**	5/**5**	
	Time allotted & actual time BL	15 /**15**	20/**35**	20/**30**	20/**25**	
	Time allotted & actual time CL	5/**10**	5/**5**	5/**4**	5/**5**	

Note: * The bold denominator indicates the actual time.

APPENDIX A3

A complete practice profile score for individual teacher in the field-test

Teacher A	**Profile elements**	**L-1**	**L-2**	**L-3**	**L-4**	**Total(%)**
Start of lesson	Basic teaching skills	87.5	87.5	83.3	100	90
	Student-centered orientation	66.7	75	81.8	90	79
	Subject matter	50	100	100	100	88
Body of lesson	Basic teaching skills	62.5	70	62.5	87.7	72
	Student-centered orientation	76.5	82.2	100	100	91
	Subject matter	0	100	100	100	86
Conclusion	Basic teaching skills	100	50	100	60	85
	Student-centered orientation	50	50	80	66.7	63
	Subject matter	0	0	100	50	43
Overall impression	Basic teaching skills	90	87.5	100	88.9	92
	Student-centered orientation	66.7	100	66.7	100	81
	Subject matter	100	100	100	100	100
Total time:	Time allotted & actual time SL	5/**2**	5/**3**	5**/5**	5/9	
	Time allotted & actual time BL	20/**22**	25/**27**	25/24	20/18	
	Time allotted & actual time CL	10/**5**	5/**4**	5/5	0	

Teacher *B*	**Profile elements**	**L-1**	**L-2**	**L-3**	**L-4**	**Total (%)**
Start of lesson	Basic teaching skills	87.5	85.7	87.5	100	90
	Student-centered orientation	70	60	80	100	76
	Subject matter	100	100	100	100	100
Body of lesson	Basic teaching skills	77.8	88.9	100	100	91
	Student-centered orientation	76.2	84.2	94.7	100	88
	Subject matter	100	50	100	100	88
Conclusion	Basic teaching skills	100	75	66.7	100	85
	Student-centered orientation	66.7	100	50	100	76
	Subject matter	75	100	0	100	64
Overall impression	Basic teaching skills	76.9	88.9	81.8	90	84
	Student-centered orientation	100	100	100	100	100
	Subject matter	5/**5**	5/5	5/5	5/5	100
*Time	Time allotted & actual time SL	5/**5**	5/**5**	5/**11**	5/**5**	
	Time allotted & actual time BL	20/**15**	25/**26**	25/**19**	15/20	
	Time allotted & actual time CL	10/**15**	5/**5**	5/**5**	5/5	

Note: * The bold denominator indicates the actual time.

Teacher *C*	**Profile elements**	**L-1**	**L-2**	**L-3**	**L-4**	**Total(%)**
Start of lesson	Basic teaching skills	100	100	100	100	100
	Student-centered orientation	90.9	72.7	100	100	90
	Subject matter	100	100	100	100	100
Body of lesson	Basic teaching skills	100	100	100	100	100
	Student-centered orientation	100	100	100	100	100
	Subject matter	100	100	100	100	100
Conclusion	Basic teaching skills	77.8	100	100	40	84
	Student-centered orientation	100	100	100	50	86
	Subject matter	100	100	100	75	94
Overall impression	Basic teaching skills	100	91.7	100	100	98
	Student-centered orientation	100	100	100	100	100
	Subject matter	100	100	100	100	100
*Time	Time allotted & actual time SL	5/**4**	5/**9**	5/**2**	5/**10**	
	Time allotted & actual time BL	20/**26**	25/**22**	25/**27**	20/**20**	
	Time allotted & actual time CL	10/**2**	5/**4**	5/**2**	10/**1**	

Note: * The bold denominator indicates the actual time.

Teacher *D*	**Profile elements**	**L-1**	**L-2**	**L-3**	**L-4**	**Total (%)**
Start of lesson	Basic teaching skills	80	100	100	87.5	91
	Student-centered orientation	90.9	72.7	90	100	87
	Subject matter	100	100	100	100	100
Body of lesson	Basic teaching skills	100	100	100	88.9	97
	Student-centered orientation	100	93.8	100	100	98
	Subject matter	100	100	100	100	100
Conclusion	Basic teaching skills	55.6	100	56.6	100	74
	Student-centered orientation	100	100	100	100	100
	Subject matter	75	100	100	100	94
Overall impression	Basic teaching skills	90.9	100	90	83.3	90
	Student-centered orientation	100	100	100	100	100
	Subject matter	100	100	100	100	100
*Time	Time allotted & actual time SL	5/**3**	5/**13**	5/**5**	5/**7**	
	Time allotted & actual time BL	20/**20**	25/**25**	25/**25**	20/**27**	
	Time allotted & actual time CL	10/**5**	5/**5**	5/**3**	5/**5**	

Note: * The bold denominator indicates the actual time.

APPENDIX B1
Teacher expectations questionnaire (final version)

Dear teachers,
You are going to participate in the workshop that is intended to promote student centered approach by specifically focusing on practically oriented lessons. By means of this questionnaire I would like to have some of your background information; insight into your expectations with regard to the workshop; and your opinion on and experiences with student practical work. The information that you provide will be used to generate suggestions for improvement of the BICEPS in-service training program.

General information

Your age……..	Gender…….(M/F)	Grade you teach…….
Qualification……	Your school……	Position……
Major of study ……...(if not biology & chemistry)	Teaching load……	Teaching experience……

1. Have you ever participated in workshop(s) related to student centered approach? If yes, would you please write down what the focus of that workshop had been?

……
……
……
……
……

2. What do you expect to benefit from a workshop that focuses on practically oriented teaching for promoting student centered approach in biology?

……
……
……
……
……
……
……

Thank you for completing the questionnaire

APPENDIX B2
Evaluation questionnaire (final version)

Participants' reactions

1. What is your overall impression about the BICEPS workshop?

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
According to my expectations	1	2	3	4	5
Useful for my professional growth	1	2	3	4	5
Relevant to my teaching practice	1	2	3	4	5
Enhanced my understanding	1	2	3	4	5
The objectives are met	1	2	3	4	5

2. What is your opinion for the following aspects of the workshop?

	Very poor	**Poor**	**Just okay**	**Good**	**Excellent**
Group discussion pertaining to practically oriented lessons/student centered lessons	1	2	3	4	5
Presentation of the "what, when and how" of student practical work	1	2	3	4	5
Video demonstration	1	2	3	4	5
Practice session (designing lessons and microteaching)	1	2	3	4	5
Curriculum materials used	1	2	3	4	5
Organization	1	2	3	4	5

Remarks

_____

_____

_____

3. How do you value the usefulness of the following course sessions?

	Very poor	**Poor**	**Just okay**	**Good**	**Excellent**
Session one: Theory exploration					
▪ Brief introduction to the workshop ▪ The opportunity to discuss about issues pertaining to student centered approach in science education. ▪ Presentation of "when, what and how" of student practical work ▪ Reading materials about what student-centered education is, the rationale underpinning this approach etc.	1	2	3	4	5
Session two: Video demonstration and discussion					
▪ Video clips that demonstrate an exemplary lesson and a routine biology lesson(bad example) ▪ Plenary discussion and reflection on the clips**.**	1	2	3	4	5
Session three: Practice session					
▪ Introduction to the exemplary curriculum materials ▪ Practice with lesson	1	2	3	4	5
Session four: micro-teaching and feedback					
▪ A microteaching with small group of students conducted by fellow teacher. ▪ Feedback and reflection from the microteaching	1	2	3	4	5

Remarks

_____
_____
_____

4. What were the most effective sessions of this workshop?

_____
_____
_____

5. What were the least effective sessions of this workshop?

_____
_____
_____

6. Indicate for the following statements to what degree you agree with them or not.

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
My time in the workshop was well spent	1	2	3	4	5
The knowledge and skills explored in the workshop are useful for improving my teaching practices	1	2	3	4	5
The activities of the workshop are carefully planned and organized	1	2	3	4	5
The teacher guides are immediately useful for my classes	1	2	3	4	5
Sufficient time was provided for the completion of the activities	1	2	3	4	5
The presenter and organizers were well prepared	1	2	3	4	5
The facilities provided were conducive for learning	1	2	3	4	5
The workshop room was the right size	1	2	3	4	5
The tea/ coffees ready and hot	1	2	3	4	5
The refreshments and lunch were fresh and tasty	1	2	3	4	5
The transportation/lunch allowance was fair and motivating	1	2	3	4	5

Remarks

_____
_____
_____

Participants learning from BICEPS training workshop

7. Please indicate for the following statements to what degree you agree with them.

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
The presentation about 'what, why and how ' of using practical work provided me with much new information	1	2	3	4	5
After participating in this workshop my awareness and understanding about student centered lessons is enlightened	1	2	3	4	5
The video demonstration has helped me identify the important features of a practically oriented lesson	1	2	3	4	5
The demonstration made me consider trying out practically oriented lessons	1	2	3	4	5
The practice session has augmented my skills and knowledge of student centered lessons	1	2	3	4	5
After studying the exemplary lessons and practicing the design of such lessons, I am convinced that I can mange to put into practice such lessons in my own school	1	2	3	4	5
The microteaching and feedback session helped me get a considerable awareness of my own teaching behavior and knowledge about alternatives	1	2	3	4	5
After attending the microteaching conducted by a colleague I have got the confidence to use practically oriented lessons with students	1	2	3	4	5
After attending this workshop I understand that in student centered lessons the role of assessing students' prior conceptions is crucial	1	2	3	4	5
Eliciting students' prior conceptions about biology concept is the optimum starting point for a lesson					
My opinion about practically oriented lessons has changed as a result of the workshop	1	2	3	4	5
I will organize my biology lessons differently because of this workshop	1	2	3	4	5
It was difficult to provide an honest opinion on what I will change in future in my way of teaching	1	2	3	4	5

Remarks

_____
_____
_____

8. Do you think you are going to **use or adapt** the exemplary lessons of the Teacher guides in your own school?

μ Yes
μ No

If no, would you please explain why not? Be as specific as possible!

_____
_____
_____

9. What do you think you have learned from BICEPS workshop?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Thank you for completing the questionnaire!!

APPENDIX B3
Stages of Concern Questionnaire (SoCQ)

Name_____

Date completed_____

Purpose of the SoCQ

The intent of this questionnaire is to determine what people who are *using* or *thinking using* about various programs are *concerned about* at various times during the innovation adoption process.

Background of the SoCQ

The 35 items were developed from typical responses of the school and college teachers, who ranged from no knowledge at all about various programs to many years' experience using them. Therefore, *a good part of the items on this questionnaire may appear to be of little relevance or irrelevant to you at this time*. For the completely irrelevant items, please circle "0' on the scale. Other items will represent those concerns *you do have*, in varying degrees of intensity, and should be marked higher on the scale, according to the explanation at the top of each pages (Irrelevant, Not true of me now, somewhat true of me now, Very true of me now).

How to classify the varying degree of intensities

Statements of concerns	Irrelevant	Not true of me now		Somewhat true of me now		Very true of me now		
I would like to see the food menu for this workshop	0	1	2	3	4	5	6	7
	0	1	2	3	4	5	6	7
	0	1	2	3	4	5	6	7
	0	1	2	3	4	5	6	7

This statement is very true of me at this time	0	1	2	3	4	5	6	**7**
This statement is somewhat true of me now	0	1	2	3	**4**	5	6	7
This statement is not at all true of me at this	0	**1**	2	3	4	5	6	7
This statement is irrelevant to me	**0**	1	2	3	4	5	6	7

While responding

Please respond to the items in terms of **your present concerns**, or how you feel about your **involvement or potential involvement with practically oriented lessons.** Since this questionnaire is used for a variety of innovations, the name **practically oriented lessons** does not always appear. However, phrases such as "this approach" or "the innovation" or "the new system" refer to **practically oriented lessons**. Remember to respond to each item in terms of your **present concerns** about your involvement or potential involvement with practically oriented lessons.

Number of items and coefficients of internal reliability for the SoCQ (Hall et al., 1987)

Stages	*0	1	2	3	4	5	6
No. of items	5	5	5	5	5	5	5
Alphas	0.64	0.78	0.83	0.75	0.76	0.82	0.71

Legend * 0= awareness 1=Informational, 2=Personal, 3=Management, 4=Cconsquence, 5=Collaboration, 6=Refocusing

	Irrelevant	**Not true of me now**		**Somewhat true of me now**		**Very true of me now**		
1. I am concerned about students' attitude toward practically oriented lessons	0	1	2	3	4	5	6	7
2. I now know of some other approaches that might work better	0	1	2	3	4	5	6	7
3. I don't even know what the innovation is	0	1	2	3	4	5	6	7
4. I am concerned about not having enough time to organize myself each day	0	1	2	3	4	5	6	7
5. I would Like to help other teachers in their use practically oriented lessons	0	1	2	3	4	5	6	7
6. I have a very limited knowledge about the innovation	0	1	2	3	4	5	6	7
7. I would like to know the effect of reorganization on my professional status	0	1	2	3	4	5	6	7
8. I am concerned about conflict between my interests and my responsibilities.	0	1	2	3	4	5	6	7
9. I am concerned about revising my use of the innovation	0	1	2	3	4	5	6	7
10. I would like to develop working relationships with our biology department teachers and other using this innovation	0	1	2	3	4	5	6	7
11. I am concerned about how the innovation affects students	0	1	2	3	4	5	6	7
12. I am concerned about practically oriented lessons	0	1	2	3	4	5	6	7
13. I would like to know who will make the decisions in the new system	0	1	2	3	4	5	6	7
14. I would like to discuss the possibility of using the innovation	0	1	2	3	4	5	6	7
15. I would like to know what resources are available if we decide to adopt teaching practically oriented lessons	0	1	2	3	4	5	6	7
16. I am concerned about my inability to manage all what the innovation requires	0	1	2	3	4	5	6	7
17. I would like to know how my teaching is supposed to change	0	1	2	3	4	5	6	7

	Irrelevant	Not true of me now		Somewhat true of me now		Very true of me now		
18. I would like to familiarize other departments or persons with the progress of this new approach	0	1	2	3	4	5	6	7
19. I am concerned about evaluating my impact on students	0	1	2	3	4	5	6	7
20. I would like to revise the innovation's instructional approach	0	1	2	3	4	5	6	7
21. I am completely occupied with other things	0	1	2	3	4	5	6	7
22. I would like to modify our use of the innovation based on the experience of our students	0	1	2	3	4	5	6	7
23. Although I don't know about practically oriented lessons, I am concerned about other things in the area	0	1	2	3	4	5	6	7
24. I would like to excite my students about their part in this approach	0	1	2	3	4	5	6	7
25. I am concerned about my time spent working with nonacademic problems related to this innovation	0	1	2	3	4	5	6	7
26. I would like to know what the use of the innovation will require in the immediate future	0	1	2	3	4	5	6	7
27. I would like to coordinate my efforts with others to maximize the innovation's effects	0	1	2	3	4	5	6	7
28. I would like to have more information on time and energy commitments required by this innovation	0	1	2	3	4	5	6	7
29. I would like to know what other departments are doing in this area	0	1	2	3	4	5	6	7
30. At this time I am not interested in learning about the innovation	0	1	2	3	4	5	6	7
31. I would like to determine how to supplement, enhance or replace the innovation	0	1	2	3	4	5	6	7
32. I would like to use feedback from students to change the programme	0	1	2	3	4	5	6	7
33. I would like to know how many role will change when I am using the innovation	0	1	2	3	4	5	6	7
34. Coordination of tasks and people is taking too much of my time	0	1	2	3	4	5	6	7
35. I would like to know this innovation is better than what we have now	0	1	2	3	4	5	6	7

APPENDIX B4
School support questionnaire

Dear Teachers,
This questionnaire is focused on the fourth component of the BICEPS program termed as *supportive school environment*. It is aimed at gauging the extent of support provided to you by the school during implementation. It attempts to measure the degree to which school's supports facilitation, accommodation and recognition of those participants involved in the BICEPS project.

Instruction:
Please indicate the extent to which you agree or disagree with the following items.

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
The Teacher Guides provided me with relevant and useful information for planning and teaching practical oriented lessons	1	2	3	4	5
The necessary materials are provided to me in a timely manner from the school	1	2	3	4	5
The necessary facilities of the school are made available to me at appropriate times	1	2	3	4	5
The physical conditions of the school (laboratory, supplies, classrooms etc) infringed on my implementation efforts	1	2	3	4	5
We have a quite place to plan and discuss important issues	1	2	3	4	5
I had sufficient time to prepare for implementing practical oriented lesson into my regular classroom routines	1	2	3	4	5
I had ample time to reflect on my student centered strategies and make appropriate adaptations	1	2	3	4	5
The school encourages experimenting with new strategies aimed at improving student learning outcomes	1	2	3	4	5
Fellow teachers share my enthusiasm for experimenting with new strategies for teaching	1	2	3	4	5
The school administration is open to suggestions for improvement in school practices	1	2	3	4	5

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Your effort to improve belittled by certain fellow teachers	1	2	3	4	5
We frequently engage in conversations about ways to improve our teaching approach	1	2	3	4	5
I had the opportunities to visit the classroom of fellow teachers and observe their teaching or the other way around.	1	2	3	4	5
The principal is an active and enthusiastic learner	1	2	3	4	5
The principal encourages teachers to involve in school wide decision making	1	2	3	4	5
The school administration encourage teachers to participate in workshops intended for their professional growth	1	2	3	4	5
You are encouraged to plan lessons collaboratively with your fellow department teachers	1	2	3	4	5
The principal recognizes and honors teachers' success with student achievement	1	2	3	4	5
The school administration has schedules that allow you to collaboratively plan and discuss with fellow teachers	1	2	3	4	5
There are constant intrusions that divert your effort from concentrating on improving your teaching strategies	1	2	3	4	5

Thanks for completing the questionnaire!!

APPENDIX B5
Teacher focus group interview scheme

1. Was the school administration supportive in providing you the necessary resources, say materials, supplies etc that is needed for your lessons? On timely manner?
2. Did you get enough time to prepare on your lessons and also and reflect on them?
3. Does the school encourage you experimenting with new strategies aimed at improving student learning outcomes?
4. Did you organize opportunities where you could observe fellow teachers teaching or the vice versa?
5. Does the school administration have schedules that allow you to collaboratively plan and discuss with fellow teachers?
6. How could you describe your principal's supports in your efforts to improve students' learning outcomes?

APPENDIX B6
Curriculum profile-classroom observation instrument (final version)

Date: _____

Lesson topic: _____

School: _____

Teacher: _____

Observed by: _____

General Observations

Classroom layout

_____
_____
_____
_____

Teacher preparations and usage of the exemplary curriculum materials

_____
_____
_____
_____

Number of students in class: _____
Number of small groups: _____
Average number of members in a group: _____

Acceptable (Threshold) elements

	Score	
Start of lesson	*Yes*	*N/A*
1. The teacher introduces a topic at hand	ρ	ρ
2. The teacher explicitly assess students' prior conceptions about a topic at hand	ρ	ρ
3. Teacher clearly explicates the learning outcomes of the lesson	ρ	ρ
4. The teacher explains key concepts	ρ	ρ
5. The teacher shares with students essential information for conducting the activities	ρ	ρ
6. The teacher makes sure that lesson materials are easily accessible to students	ρ	ρ
7. Students respond to teacher's questions and ask questions and individually or in group	ρ	ρ
Lesson body/activity	*Yes*	*N/A*
1. The teacher introduces the activity	ρ	ρ
2. The teacher groups students for the lesson activity	ρ	ρ
3. Students execute activities based on procedures and equipment improvised by the teacher	ρ	ρ
4. Teacher engages students with interactive demonstration	ρ	ρ
5. Teacher makes lesson activities more meaningful to students' daily life	ρ	ρ
6. Students ask questions and respond to teacher's questions individually or in group	ρ	ρ
Lesson conclusion	*Yes*	*N/A*
1. The teacher spent some time discussing activity at the end of lesson	ρ	ρ
2. Conclusion is drawn from the activity	ρ	ρ
3. Homework is given before the end of the lesson	ρ	ρ

Ideal elements

	Score	
Start of lesson	*Yes*	*N/A*
Basic teaching skills and classroom management		
1. Teacher checks home work	ρ	ρ
2. Teacher asks/discusses/answers… homework questions	ρ	ρ
3. Teacher introduces the lesson series (If applicable)	ρ	ρ
4. Teacher relates activities to previous/future lessons	ρ	ρ
5. Teacher illustrates lesson topic using a demonstration	ρ	ρ
6. Teacher introduces/explains key concepts	ρ	ρ
7. Teacher makes use of classroom aids (blackboard etc.)	ρ	ρ
8. Teacher poses questions and waits for students' answers	ρ	ρ
Student- centered (practical) orientation		
1. Teacher assesses students' prior conceptions (through administering prior knowledge quizzes, giving them relevant reading assignments, etc.)	ρ	ρ
2. Teacher asks guided questions to introduce the lesson	ρ	ρ
3. Teacher introduces lessons with short demonstration or simple practical activities	ρ	ρ
4. Teacher encourages students to ask questions	ρ	ρ
5. Teacher responds to students ideas/questions	ρ	ρ
6. Teacher uses students' ideas to illustrates lesson/activity	ρ	ρ
7. Teacher asks students for their prediction and its justification	ρ	ρ
8. Teacher attempts to guide students to conclusions/ideas	ρ	ρ
9. Students discuss their results from homework	ρ	ρ
10. Students seem to have a sense of what is expected to do and start in a focused way	ρ	ρ

Unacceptable elements		
1. Teacher skips the introduction	ρ	ρ
2. Teacher does not assess student prior conceptions about a topic(a unit) at hand	ρ	ρ
3. Teacher hardly attempt to assess student prior knowledge	ρ	ρ
4. Teacher ignores students questions / wrong answers	ρ	ρ
5. Teacher provides answers promptly without giving enough time students to think	ρ	ρ
	Score	
Body of lesson	*Yes*	*N/A*
Basic teaching skills and classroom management		
1. Teacher makes smooth transition to the lesson body/activity	ρ	ρ
2. Teacher has lesson materials ready and organized	ρ	ρ
3. Teacher makes sure that materials are easily accessible to students	ρ	ρ
4. Teacher explains how to use materials/equipment	ρ	ρ
5. Teacher moves around classroom	ρ	ρ
6. Teacher stimulates less motivated groups	ρ	ρ
7. Teacher responds positively to student's questions/answers	ρ	ρ
8. Teacher maintains a positive learning environment	ρ	ρ
9. Teacher effectively handles discipline problems	ρ	ρ
10. Teacher effectively handles timing difficulties	ρ	ρ
Student- centered (practical) orientation		
1. Teacher creates a conducive classroom culture where students work comfortably	ρ	ρ
2. Teacher organizes practical work for students	ρ	ρ
3. Teacher organizes problem solving activities (activity questions) for students	ρ	ρ
4. Teacher establishes the relevance of activity to students' daily lives		
5. Teacher provides intellectual and emotional support for students	ρ	ρ
6. Teacher engages students with interactive demonstration	ρ	ρ
7. Students work in groups on the activities/practical work	ρ	ρ
8. Teacher assign appropriate number of students to each group	ρ	ρ
9. Teacher considers the member composition of each group	ρ	ρ
10. Teacher assigns various group roles to members	ρ	ρ
11. Teacher gives practical instructions (where applicable)	ρ	ρ
12. Teacher tells students what the objectives are for the activity/practical work	ρ	ρ
13. Students execute practical work/problem solving activity based on procedures and equipment improvised by the teacher	ρ	ρ
14. Teacher demonstration is visible for all students	ρ	ρ
15. Teacher makes sure students execute activity and use materials/equipment correctly	ρ	ρ
16. Teacher interacts with students during activities	ρ	ρ
17. Teacher interacts equally with all groups	ρ	ρ
18. Teacher assists students when necessary (but not immediately)	ρ	ρ
19. Teacher guides and challenges in a way that students discuss and argue their results	ρ	ρ
20. Teacher allows students to draw own conclusions in groups	ρ	ρ
21. Teacher encourages students to ask questions	ρ	ρ
22. Teacher discusses results problems/questions with a particular group	ρ	ρ
23. Students report and discuss their methods during activity (if applicable)	ρ	ρ
24. Students appear to listen to their class/group-mates questions, opinions, concerns etc.	ρ	ρ
25. All students in a group cooperate with each other	ρ	ρ

Unacceptable elements		
1. A learning environment where students are subdued	ρ	ρ
2. The only visible student activities are writing notes and responding to teacher low order questions in chorus	ρ	ρ
3. Teacher spent almost the whole period lecturing or explaining key concepts	ρ	ρ
4. The teacher does not make student work in groups or forms chaotic groups	ρ	ρ
5. Teacher make no effort to engaging students in practical work	ρ	ρ
6. Students are not asked about their prediction, and group results	ρ	ρ
7. The teacher provides quick answers to group activities	ρ	ρ
8. Teacher makes no attempt to relate the activity to students' daily lives	ρ	ρ
9. Students are not given enough time to complete the activities	ρ	ρ
10. Teacher correct students' wrong observations or discrepancies with out due explanation	ρ	ρ
11. All students of a group are not equally involved in the activity	ρ	ρ
12. Some students are diverting from the intended activity	ρ	ρ
	Score	
Conclusion of lesson	*Yes*	*N/A*
Basic teaching skills and classroom management		
1. Teacher summarizes the findings of the activity	ρ	ρ
2. Teacher gives specific homework	ρ	ρ
3. Teacher insures students' awareness of assignment (e.g. board)	ρ	ρ
4. Teacher explains homework clearly	ρ	ρ
5. Teacher/students clean-up classroom	ρ	ρ
Student- centered (practical) orientation		
1. Teacher asks each group to report their results to the class	ρ	ρ
2. Teacher asks groups for specific information/results	ρ	ρ
3. Teacher compares predictions with group outcomes/observations	ρ	ρ
4. Teacher guides students to understand discrepancies in their results	ρ	ρ
5. Teacher provides general theoretical conclusions from activity	ρ	ρ
6. Teacher draws conclusions with the student from the activity	ρ	ρ
7. Teacher responds to questions/answers from students	ρ	ρ
Unacceptable Elements		
1. Teachers skips conclusion of the lesson	ρ	ρ
2. Teacher does not spend enough time drawing conclusions	ρ	ρ
3. Teacher hardly brings into students' attention the discrepancies of their results	ρ	ρ
4. Teacher ignores questions/wrong answers of students	ρ	ρ
5. Teacher explains homework not clearly	ρ	ρ

APPENDIX B7
Level of use interview scheme

Description of the Level of Use

Level	Characteristic	Teacher behavior	
0	Nonuse	Takes no action with respect to the innovation	NONUERS
1	Orientation	Seeks information about the innovation	
2	Preparation	Prepares to sue the innovation	
3	Mechanical	Is poorly coordinated, making changes to better organize use of the innovation	USERS
4	Routine (4A)	Has established a pattern of use and is making few, if any, changes	
	Refinement(4B)	Assess impact and makes change to increase it	
5	Integration	Makes deliberate efforts to coordinate with others in using the innovation	
6	Renewal	Seeks more effective alternatives to the established use of the innovation	

Brief background

It is to be recalled that you are one of the participants of the BICEPS program that was aimed at promoting student centered approach in biology education. The program has been focused particularly on training teachers on how to teach practically oriented lessons (i.e. interactive teacher demonstrations, student practical work and group work activities). You have attended the training workshop(s) (that included presentation of theory, demonstration, practice and feedback), and you also got support with exemplary curriculum materials and in school follow up assistance. The following questions are intended to gauge the effect of the BICEPS program on those teachers who participated in this professional development program.

Thank you for your willingness to be interviewed.

A. Levels of Use that define nonusers

i. Are you using practically oriented lessons?

If No for (i)

Follow up questions

a) Are you looking for information about student practical work?
- No (Level 0 nonuse) or
- Yes (Level 1 orientation)

b) Did you intend to use practically oriented lessons sometime in the coming… in your classes?
- Yes and she/he specifies when to do so (Level 2, Preparation)

B. Levels of Use that define Users

If yes for (i)

Follow up questions

a) What kinds of activities are you engaging students or what are you doing regarding your use of practically oriented lessons?

- *Indicates that he/she is actively engaged with practically oriented lessons and is making adaptations in order to master use of such lessons in his classrooms.*
- *There is a day to day focus on planning and a general inefficiency in how to engage students in practical work.*
- *He/she is endeavoring to make the necessary change in terms of adapting the exemplary curriculum materials, managing time and other logistics*

Decisions: *He/she is can be categorized to be on* Level of Use 3, mechanical. *Teachers at this level may need assistance and support to iron out their daily classroom wrinkles through provision of curriculum materials and classroom assistance.*

- *Indicates that he/she thinks has established a regular way or pattern of teaching practically oriented lessons and does not need to make any effort to change or do adaptations*
- *Indicates his/her use of such lessons is stabilized and right now he/she thinks or sees no reason to make changes regarding his use of practically oriented lessons.*
- *Indicates he/she is doing impact assessment and making changes to improve it*

Decisions: He/she deserves applauds for achieving a *Routine use (Level 4a and b).*

ii. Are you coordinating your use of student *practical work / practically oriented lessons* with other users, including others in different departments?

Yes for (ii) , and if he/ she

- *indicates making adaptations for the benefit of students and this action was done together with one or more fellow teachers.*
- *points out some collaborative activities in the school where they carry out adaptations in their use of practically oriented lessons that deemed to benefit students*

Decision: He/she can be considered to be on L*evel of Use 5 integration* (impact-oriented). The possible assistance and support that could be considered is forging a realistically conducive conditions where for *fellow teachers* who wish to collaborate could do so.

Follow up question for (ii)

(a) Are you planning or exploring to make major modifications or replace student practical work/ practically oriented lessons that are promoted through BICEPS program?

Yes for (a), and if he/ she

- *indicates exploring some means to modify or replace in major ways or all together the use of student practical in such a way that it would benefit students*

Decisions: He/she can be labeled as in the *Level of Use 6 Renewal*. The teacher(s) deserves Kudos for achieving that and he may be asked to reflect and share experience with other teachers in that respect.

No for (a): Then he/she is on *Level of Use 5 integration*

APPENDIX B8
Student focus group interview scheme

General Questions

1. What is your name?
2. Why did you choose science stream?
3. Do you like biology?

Teacher's role as facilitator or guide of student learning

1. Do you think that your biology teacher has been good in creating conducive classroom culture where you have been working comfortably on the activities?
   If **yes**, in what ways could you explain how?
   If **no,** why not?

2. What are the usual activities that your biology teacher is engaged right from the time he/she enters the classroom until the bell rang?

3. Does your teacher assist you while doing the activities?
   If **yes**, in what ways could you explain how?
   If **no,** why not?

4. Does your biology teacher encourage you to ask questions?

5. Does the teacher interact with students and responds positively to their questions/answers?

Assessment of student prior knowledge

1. Do you think that your biology teacher often tries to find out what you already know a bout a topic at hand?
   If **yes**, could you explain how?
   If **no,** why not?

Types of activity students are engaged (practically oriented lessons)

1. Do you do biology practical work (execute *an experiment, observe teacher demonstration solve activities in-groups*)?
   If **yes**, could you explain the kind of activities you did?
   If **no,** what the usual activities that you are engaged with?

2. Did you find the activities meaningful to you, that is does the teacher relates the activities/ scientific concepts to your daily life?
   If **yes**, could you give me some examples, which can remember recently?

3. Did you do the practicals or activities in-groups?

4. Do you discuss about your answers/group results with the teacher and your classmates or other groups?

5. Did you feel you have been *actively learning*? (Explain to them roles that they may be having)

APPENDIX B9
Achievement test

Name_____Grade_____
Sex_____ School_____

1. If we put a piece of lung tissue in a beaker of water it usually floats. What do you think the reason?
   a) Because the piece of lung is very light in weight
   b) Because the lung tissue is made of sack like structures (alveoli) that are filled with air
   c) Because the water is heavier than that of the piece of lung
   d) If the lung is going to be submerged, it must be heavier in weight
   e) None of the above

2. Which one of the following is **False** about the respiratory system?
   a) The main function of the respiratory system is gaseous exchange (oxygen and carbon dioxide) between the air and the blood.
   b) During sleeping God controls our breathing
   c) The respiratory system is located in the chest cavity
   d) In alveoli the exchange of gases takes place between oxygen & carbon dioxide and blood
   e) None of the above

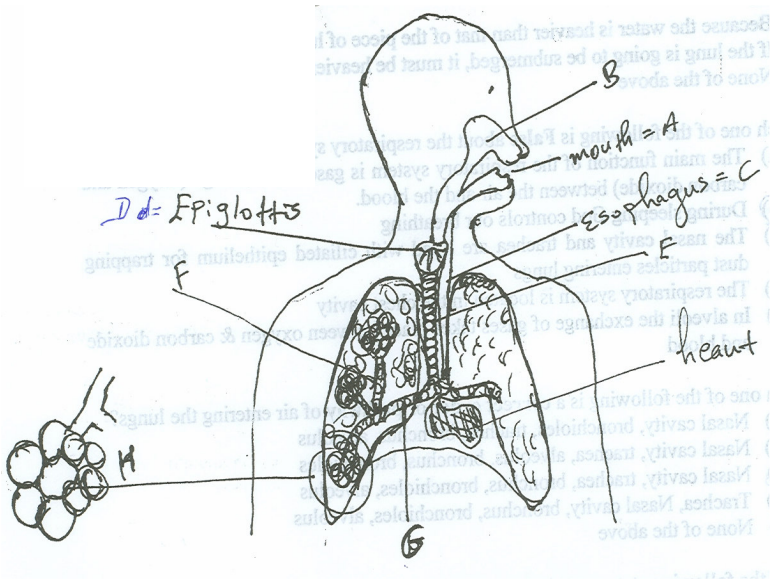
3. Which one of the following is a **correct order** or **pathway** of air entering the lungs?
   a) Nasal cavity, bronchioles, trachea, bronchus, alveolus
   b) Nasal cavity, trachea, alveolus, bronchus, bronchioles
   c) Nasal cavity, trachea, bronchus, bronchioles, alveolus
   d) Trachea, Nasal cavity, bronchus, bronchioles, alveolus
   e) None of the above

4. One of the following statements is **false** about the mechanics of breathing.
   a) The volume inside the thorax increase when we inhale air
   b) The depth of our breathing increases when we do exercise or heavy work
   c) The depth or rate our breathing is greater during sleeping than when we do exercise
   d) The rate of our hear beat remains constant when we do exercise
   e) C & D

5. The difference between breathing and respiration is
   a) Breathing is the process of inhaling and exhaling air in the lungs while respiration is exchange of gases inside cells
   b) Both breathing and respiration are involved in gaseous exchange in our body
   c) Breathing involves inhaling and exhaling of air in our body while respiration is the release of energy in cells or burning of food for energy production
   d) A & B are correct
   e) None of the above

6. Which one of the following structure of the respiratory system is **not** covered either by cilia or mucus membrane?
   a) Trachea
   b) Alveoli
   c) Nasal cavity
   d) Bronchus
   e) None of the above

7. Which of the following is a **false** statement?
   a) B represents the nasal cavity and its main function is warming the air and removing certain dust particles and bacteria
   b) Trachea is different from esophagus because it is lined with cartilaginous rings
   c) F represents the bronchus and it leads the filtered air into alveoli
   d) D represents the epiglottis and its main function is to prevent food from entering to the respiratory system
   e) None of the above



8. The structure of the lung where the exchange of oxygen and carbon dioxide between the respiratory system and blood take place.
   a) Alveoli
   b) Bronchioles
   c) Bronchus
   d) Larynx
   e) Epiglottis

9. The biological process that involves the release of energy from food inside the mitochondria of cells is called

   a) Reproduction
   b) Cellular respiration
   c) Excretion
   d) Digestion
   e) None of the above

10. A group of student performed the following experiment while studying about cellular respiration. In test tube A they have made a sugar solution with honey, and in test tube B they simply filled it with water. To both test A and B, they have added a small amount of commercial yeast. The students kept both test tubes in warm place for few days and observed the things that are summarized in the table below.

Test Tube	**Physical observation**	**Smell**
A	Bubble formation, push sound	Alcoholic
B	There was no change	No smell, only that of yeast

Which of the following statement is **false** concerning this experiment on cellular respiration.

a) One of the students' observation is that in the presence of yeast honey undergo fermentation
b) The students' problem is that yeas can only ferment sugar solution but not water
c) One of the possible conclusion of the students is that yeast convert through cellular respiration (fermentation) honey into alcohol, $C0_2$ and energy
d) The reason why there is no fermentation in test B is because of lack of oxygen
e) None of the above.

APPENDIX B10
Student attitude questionnaire

Dear students,
Your biology teacher is going to be involved in a training aimed to improve his biology teaching. Before and after the start of this training we would like to have your answers for the following statements in the table below.

Thank you very much for your cooperation!

Instructions:

Each statement on this questionnaire expresses an attitude toward biology. You are asked to indicate your extent of agreement between: **strongly disagree**, **disagree**, **neutral**, **agree** and **strongly agree**.

	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Biology is very *interesting* to me	1	2	3	4	5
I am very *curious* (• • • •) doing activities in biology class	1	2	3	4	5
Biology is fun	1	2	3	4	5
I am always under a terrible *strain* (• • •) in biology class	1	2	3	4	5
I have a good feeling toward biology	1	2	3	4	5
Biology is the subject that I dislike the most	1	2	3	4	5
I feel more relaxed in biology class than in any other class	1	2	3	4	5
It makes me *nervous* (• • • • / • • • • • •) discussing and asking questions for our biology teacher	1	2	3	4	5
I enjoy doing a biology experiment	1	2	3	4	5
It makes me nervous doing a biology experiment	1	2	3	4	5
I feel *at ease* (• • • •) working on biology group work activities	1	2	3	4	5
Doing group work activities with my class mates makes me feel uncomfortable and *impatient* (• • • •)	1	2	3	4	5
I enjoy doing more with my hands than listening to biology teacher's explanation	1	2	3	4	5

APPENDIX C1
Concern profile of experimental teachers

Before the workshop (N=17)

Teacher	Stages of concern percentile scores							
	0	*1*	*2*	*3*	*4*	*5*	*6*	
L	91	37	67	39	19	25	34	
P	53	88	87	71	59	72	57	
I	66	96	95	71	82	88	*96*	
J	81	90	85	27	90	98	87	
C	77	84	91	52	38	52	96	
M	96	90	91	71	92	52	60	
K	89	66	85	71	71	84	90	
E	96	93	96	69	96	80	94	
B	93	90	85	43	48	80	65	
G	77	80	88	39	86	87	57	
O	81	80	72	34	11	48	34	
H	77	72	91	65	82	59	87	
Q	77	69	76	77	63	22	90	
R	91	95	70	69	30	25	77	
F	93	99	97	80	90	98	97	
S	77	48	80	80	21	68	57	
N	93	80	85	88	43	95	77	
17	1408	1353	1441	1046	1021	1134	1255	
mean	83	80	85	62	61	67	74	

At end of the workshop (N=18)

Teacher	Stages of concern percentile scores							
	0	1	2	3	4	5	6	Total
L	60	40	21	39	27	80	65	
P	60	88	89	47	66	68	81	
I	86	75	85	65	54	48	69	
J	77	75	63	15	54	68	84	
C	86	80	70	27	33	64	34	
M	94	66	83	71	48	80	17	
K	93	93	92	85	71	76	99	
E	98	98	83	77	90	91	84	
B	89	95	87	47	54	88	94	
G	93	97	83	56	92	84	90	
O	23	63	72	11	7	48	34	
H	10	66	55	27	30	52	69	

Q	77	88	92	80	76	80	94	
R	72	63	55	52	16	48	77	
F	94	99	92	47	82	91	98	
S	77	88	92	80	76	80	94	
N	91	93	92	39	33	91	81	
M	53	57	48	27	13	36	30	
Total	1333	1424	1354	892	922	1273	1294	
Mean	74	79	75	50	51	71	72	

At the start of the school follow-up

SCHOOL A

	Stages of concern percentile scores							
Teacher	0	1	2	3	4	5	6	Total
L	89	80	83	97	82	97	98	
N	60	72	41	65	59	36	94	
O	23	60	59	9	9	40	38	
M	46	12	17	30	11	40	42	
K	84	91	72	23	76	97	92	
P	77	40	59	34	8	88	69	
J	89	80	85	65	54	64	73	
Total	468	435	416	325	299	462	506	
Mean	67	62	59	81	43	66	72	

SCHOOL B

	Stages of concern percentile scores							
Teacher	0	1	2	3	4	5	6	Total
C	94	57	76	80	63	55	81	
E	89	75	95	69	54	52	87	
D	81	90	55	80	8	12	47	
B	97	80	87	69	63	52	69	
Total	361	302	313	298	188	171	284	
Mean	90	76	78	75	47	43	71	

Barka secondary school (SCHOOL C)

	Stages of concern percentile scores							
Teacher	0	1	2	3	4	5	6	Total
H	53	48	63	34	24	84	90	
F	91	99	89	11	82	98	97	
I	86	88	85	47	33	76	87	
G	81	90	92	60	54	80	96	
	311	325	329	152	193	338	370	
Mean	78	81	82	38	48	85	93	

APPENDIX C2
Levels of use of teachers

Experimental group

Experimental teachers at level of use II (nonusers)

Teacher	Practice profile	Level of use	Teacher's behavior
C	37	LoU II: Orientation	▪ Reported that he is using practically oriented teaching but failed to articulate his usage. What he noted doing was demonstration of concepts with charts and models. He indicated that next year he would be better organized for doing it. ▪ The teacher was observed consistently using expository and questioning answering methods. He was a champion of using low-order questions.
I	69	LoU II: Orientation	▪ The teacher indicated that he did not feel fully used what he learned in the professional development course. He said that because of time shortage it was not possible to use group work and take students to the laboratory. Next semester he would be considering using practically oriented teaching. ▪ He was observed heavily depending on explanation and questioning and answering methods. For the most part students were passively listening and responding to his pointed questions.

Experimental teachers at Level of use III (mechanical users)

Teacher	Practice profile	Level of use	Teacher's behavior
A	61	LoU III: Mechanical	▪ The teacher reported that he is using practical work. He noted that as a matter of fact recently his students have done practical work on 'yeast fermentation'. His biggest challenge while utilizing practically oriented teaching was time shortage and lack of students' participation. ▪ The teacher was observed teaching 'the female reproductive system" where students discussed on a couple of questions with the help of A4 posters that he distributed to each group. Following this discussion, the teacher explored the answers for each group, and later spent much of the lesson time on explanation.
B	65	LoU III: Mechanical	▪ Indicated that he is doing his best to involve and engage students 'hands on' activity. He dwelt much on lack of resources and time to use practically oriented lessons. ▪ Observed making poor management of students' group work and presentation.
D	33	LoU III: Mechanical	▪ Indicated that he was spending inordinate amount of time for lesson preparation and this would be improved next semester. He frequently uses group work and as such he had permanent groups each consisting 6 members. ▪ Observed engaging students in group work and relating the topic to their daily life. He appeared to have problem with lesson time management so much that the lesson was abruptly stopped to let leave students for the next teacher.
G	89	LoU III: Mechanical	▪ The teacher reported implementing what he learned from the course and school follow up. He appeared disappointed regarding his students' reluctance to embrace 'this new approach', and expressed his optimism for next semester to tackle the range of obstacles he outlined for teaching practically oriented teaching. ▪ The teacher was observed teaching a lesson where students worked and discussed in groups. Though superficial, the teacher attempted to explore students' prior knowledge on the topic at hand. The teacher appeared awkward managing students working in large groups and keeping the lesson time.
H	91	LoU III: Mechanical	▪ Reported that he is using practically oriented lessons. However, he pointed out that he is overwhelmed with the vast content of grade ten Curriculum so much that he hardly actively engaged students in group work/ practical work for the last few weeks. Moreover, he said that there is always so much work to do with other school related assignments. ▪ The teacher was observed teaching a follow up lesson where the groups were reporting their results. The lesson was punctuated with group presentations and intermittent teacher comments and corrections on points reported by particular group.

Teacher	Practice profile	Level of use	Teacher's behavior
J	38	LoU III: Mechanical	▪ This teacher indicated that he is using practically oriented lessons when the circumstances allowed. Particularly he noted using student group work and demonstration in 'food-test' and 'reproduction system'. Moreover, he pointed out that it had been challenging to do some group works because it takes too much time with students. If the content of grade ten Curriculum is not adjusted next year he has no choice but resort to teacher-centered methodologies. ▪ He was observed teaching a lesson where he dominated most of the period, and students were intermittently called for to indicate their understanding before he moved to the next concept.
L	74	LoU III: Mechanical	▪ He reported that he is doing 'practical work and interactive demonstration' with students. As a matter of fact he mentioned those lessons where the researcher observed during school follow up. This teacher indicated certain logistical and time management problems while using the approach. ▪ The teacher was observed teaching an interactive demonstration for teaching phylum porifera. He used specimen of corals and sponges, and attempted to relate to certain national TV programs which students are familiar with.
M	52	LoU III: Mechanical	▪ The teacher indicated that most of the time students are involved in group activities, and he only did two practical work in this semester. He considered these practical activities as challenging because he has to do a lot of reading, preparation and worksheets for students. ▪ This teacher was observed in a double-period lesson where he spent the first 30 minutes doing explanation on male reproductive system, and on the remaining period he asked students to make their respective groups and work on activity questions. The activities questions were mainly focused on what he lectured them the previous 30 minutes and as such were not demanding.
O	74	LoU III: Mechanical	▪ She indicated that she is made students work in group in doing practical work and 'project' assignments. She described the practical work that students did with 'bread molds' and diffusion. The teacher has expressed her frustration in managing large groups and particularly evaluating individual contribution in activities done by groups. ▪ The teacher was observed teaching 'life cycle of bryophytes'. For the most part of the lesson she used expository and questioning and answering methods to explain the structure and life cycle of these plans. Students remained passive and were only involved towards the end of the lesson when she asked them to compare and contrast what they learned to other life cycle of plants.

Teacher	Practice profile	Level of use	Teacher's behavior
P	68	LoU III: Mechanical	▪ The teacher reported using practically oriented lessons. He attempted to substantiate this by citing lessons where students have done group assignments and practical work. The teacher noted that his students are not doing their share of responsibilities so much that he is lagging behind other teachers covering the content for the final exam. ▪ This teacher was observed teaching a lesson on 'Economic importance of bacteria' where students were given library assignment the previous week. The lesson's activity centered on students' group discussion and presentation. Students formed very chaotic groups that entailed loss of some minutes for reshuffling them from one group to another. Time for the lesson was up in during one group's presentation and the teacher closed the lesson abruptly with out proper conclusion

Experimental teachers at Level of use IVA (routine users)

Teacher	Practice profile	Level of use	Teacher's behavior
E	98	LoU IVA: Routine	▪ Reported that she is using practically oriented teaching and was happy that her students liked the lessons. She will be using the 'same approach' next semester with out much change. ▪ She was observed doing an exemplary interactive demonstration and problem solving activities. Students were working in groups on activity questions that she prepared for each group on piece of papers.
F	99	LoU IVA: Routine	▪ This teacher pointed out that he is using interactive demonstration, group work and practical work activities. He was able to articulate what he was doing by citing particular topics that he used practically oriented lessons and how his students reacted about the lessons. ▪ The teachers was observed teaching exemplary lessons where he - rearranged the classroom to facilitate student interactions; - explored student prior conceptions, - executed a lesson smoothly in which students were actively engaged in a problem solving activity
K	96	LoU IVA: Routine	▪ The teacher reported that he is making best of the professional development training. He managed to articulate what he was doing regarding practically oriented teaching by citing lessons where students were taught with such lessons. ▪ He was observed teaching smoothly a practical work in 'dichotomous key' where he designed a rich context that students used this keying for classifying he organisms he improvised.
N	96	LoU IVA: Routine	▪ The teacher pointed out that he frequently uses demonstration and group work. The students only worked in the laboratory with 'food-test' only. He argued that the content of grade ten Curriculum does not lend itself for frequent practical works. The teacher cited some of his improvisations for maximizing students' participation and learning. ▪ This teacher has established a satisfactory pattern of teaching and was observed to:- - explicitly states why the lesson is important to them; - created a rich context where students worked in group on problem solving activity - moderated smoothly group presentation and whole class discussion

Control group teachers

Control teachers at LoU 0 (nonuse)

Teacher	Practice profile	Level of use	Teacher's behavior
1	36	LoU 0: Nonuse	▪ The teacher indicated that he is not using 'student centered lessons. He believes that to do so he outlined a number of preconditions that need to be met, and as such not interested for information regarding this innovation. ▪ This teacher was observed teaching a lesson on 'carbohydrates' where he taught for the entire lesson via a 'Socratic' questioning and answering method.
2	51	LoU 0: Nonuse	▪ The teacher reported that this was her first year of teaching experience and to date she has not used demonstration/practical work or group work activities. She indicated that she would not mind getting information ▪ She was observed teaching a lesson on 'structure of DNA. The first 20 minutes of the lesson was spent on writing the note on the backboard and then this was followed with her explanation.
3	58	LoU 0: Nonuse	▪ The teacher indicated that he was not fully using practically oriented teaching. Sometimes, he shows students 'demonstration' and project that students do it in group. ▪ Was observed teaching a lesson on 'root system' that for the most part dominated by him and the majority of students subdued.
8	60	LoU 0: Nonuse	▪ The teachers responded that she is not using 'student centered' approach because of class size, load and logistical problems. She indicated that she has been to a number of workshops in India, and as such not short of knowledge regarding the approach. What she needs was improvement of the abovementioned constraints. ▪ She was observed teaching a lesson on 'xerophytes' that was dominated with her talk and jotting down of hyphenated phrases in the black board.
9	38	LoU 0: Nonuse	▪ This teacher reported that he is not using 'student centered' approach all the time. He said that it is difficult to embrace the approach in its fullest sense considering the problems they had at the school. He indicated that sometimes he uses demonstration and brain storming to spice up his "talk and chalks". ▪ The teacher was observed teaching a lesson in 'homeostasis' where he first defined the concept and later exhausted its manifestation in humans and animal adaptations. The teacher presentation was punctuated with intermittent teacher questions. The lesson finally abruptly stopped when the bell rang.
14	64	LoU 0: Nonuse	▪ This teacher indicated that she does not believe that she is using student centered approach. That said however she has been trying to improve students involvement by asking them critical questions during the lesson and 'project work' which they do it in group.

Teacher	Practice profile	Level of use	Teacher's behavior
			▪ The teacher was observed teaching a lesson on 'respiration'. She attempted first student prior knowledge about respiration before delving to her presentation. The presentation of dominated for the most part with her explanation and intermittent questions.

Control teachers at Orientation and preparation level

Teacher	Practice profile	Level of use	Teacher's behavior
6	48	LoU 1: Orientation	▪ The teacher reported that she is attempting to use 'student-centered' teaching approaches. Nevertheless, class size and lack of student interest have been the stumbling blocks in the school. She indicated that she is interested to have more information and training for properly use practically oriented teaching in the coming semester. ▪ She was observed teaching a lesson on 'Flowers'. At the start of the lesson the teacher spent some time exploring the different perceptions of students about flowers. The rest of the lesson involved a detailed explanation on each the floral structure and its role.
10	42	LoU 1: Orientation	▪ The teacher pointed out that teaching 'student centered' lessons is not possible considering the class size and facilities they had in the school. He indicated that he would be happy for information and materials that are deemed helpful in this regard. ▪ This teacher was observed teaching a lesson on 'adaptation of plants'. The lesson was characterized with teacher's monotonous explanation and low order questions that he kept on answering them himself.
13	22	LoU1: Orientation	▪ The teacher reported that he is not using practically oriented teaching. He exhausted a list of obstacles for not doing so that ranged from lack of resource and facilities to in-service training. He noted that he would be happy to have materials and training that would assist him to improve his teaching approach. ▪ The teacher was visited teaching a lesson on 'stem system' and 'flowers'. The teacher used up almost the whole lesson time lecturing on the structure and function of stems and flowers.
4	43	LoU 2: Preparation	▪ This teacher said that at this time he is not a committed user of practically oriented lessons. He indicated that he had enough information on how to do it because of his involvement in 'training of trainer' conduced by the ministry of Education last summer. He will start using such lessons next semester. ▪ He was observed teaching a lesson on 'plant tissue' where he lectured students for two third of the lesson, and the reaming lesson time was spent on writing notes on the blackboard.

Control teachers at mechanical and routine use

Teacher	Practice profile	Level of use	Teacher's behavior
5	98	LoU 3: Mechanical	▪ The teacher reported that he uses frequently 'demonstration' and 'problem solving' activities that students perform individually or in groups. He said that he involved students in practically work in osmosis and food test. ▪ This teacher was observed teaching a lesson on 'food test' that focused on the theoretical and procedural aspects of doing the experiment for the next lesson.
11	89	LoU 3: Mechanical	▪ The teacher reported that she has been using 'laboratory work' and 'demonstration'. She explained this semester her students did lab work on 'diffusion and osmosis', 'how to use the microscope' and 'food test'. ▪ The teacher was observed teaching a demonstration on 'protein test'. This interactive demonstration was done in the laboratory where students organized into three big groups to make the observations and write a report. The teacher made students to make predication and later carried out the demonstration.
12	58	LoU 3: Mechanical	▪ This teacher asserted that that she is using 'student centered approach'. She reported that frequently she involves students in ''practice questions', 'real demonstration and 'group discussion'. The teacher substantiated using such methods by citing topics where students done the practice questions, demonstration and group work. ▪ The teacher was observed teaching a lesson in 'plant adaptation'. In this lesson students worked in group to tackle four questions that set the stage for the teacher presentation and whole class discussion.
7	86	LoU 4A: Routine	▪ This teacher reported that she frequently uses teaching methodologies that maximize students' understanding and participation for a topic at hand. She said that at the start of the semester she managed to make permanent groups that work together in assignments and laboratory works. She cited instances or lessons where she involved students in lab works and group activities. ▪ The teacher was observed teaching a lesson on 'Lipids'. The teacher has established a satisfactory patter of teaching practically oriented lessons where she attempted to - Explore students' prior /misconceptions, - Garner students' attention to the topic citing a local anecdotes about obesity, - Involve almost the majority of the class with high order questions - Relate the ideas to students' daily life etc.