EXPLORING STRATEGIES AND APPROACHES GRADE TEN LEARNERS IN ERITREA USE WHEN STUDYING A GIVEN MATHEMATICAL MODEL

By

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Submitted in partial fulfilment of the requirements for the degree of MPhil. in the Faculty of Education, University of the Western Cape.

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DECLARATION

I declare that *Exploring strategies and approaches grade ten students in Eritrea use when studying a given mathematical model* is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

Yohannes Kibreab **August 2001**

Signed: ___________

Abstract

This study explores the strategies and approaches grade ten learners in Eritrea use when studying a given mathematical model.

In this study, ten learners selected from a grade ten mathematics class had been presented with a mathematical modelling task. The study has two different parts. Firstly, the observable behavior of learners when they studied a given model is discussed and analyzed. The model that was given to them was a module dealing with the "human development index". It was an excerpt from 1994 human development report. In this part, learners became familiarized with the whole process of modelling, which could help them to solve other related modelling problems. Secondly, observable behavior of learners, when they were engaged in constructing a similar model was analyzed. In this part, learners were asked to develop a *community development index.*

Two methods of data collection were used:

1. Participant observation with the help of videotaping
2. Interviews which were recorded on audio tape

Analysis was embedded in the *conceptual model of activity system* as proposed by Engestrom. Results of analysis of this study show that the main difference between the traditional and emerging activity systems of teaching-learning mathematics lies in the main components of the system – the tools, the rules, the division of labour and the object as well as the outcome of the system.

Based on this study, the following recommendations to improve the quality of teaching-learning strategies of mathematics in Eritrean secondary schools are made:

- A variety of approaches and strategies of teaching-learning mathematics in general, and of mathematical modelling in particular, must be incorporated into the new curriculum design.
- Mathematical modelling problems should integrate many of the necessary skills, which allow learners to explore strategies of their own.
- Mathematical modelling problems could be introduced and tested in grade ten mathematics classrooms in the form of projects already required in the syllabus.

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Chapter One

Introduction and Motivation

1.1 Back ground of the study

Modern formal education in Eritrea was first introduced during the Italian colonial period (1890 – 1941). Like the majority of the African countries which were under the colonial administrations, the purpose of education during this period was to serve colonisers as troops, clerks, interpreters and machine operators. The language of instruction during this colonial period was Italian. The main goal of teaching the Eritrean child during this period was " to inform the native child of Italy's ancient and present glory and greatness so that the child might become a conscious militiaman under the Italian flag" (Distefano, 1998; 71). Even with these colonial objectives, the educational opportunity for Eritreans was very limited. According to Distefano, there were only 523 Eritrean students enrolled in colonial schools in 1923. These students were being accommodated in only five government schools, while there were 25 secondary schools to accommodate the Italians (Ertzgaard, 1995; 17).

The school curriculum during this period indicates that subjects like arts, crafts, hygiene, history, geography and arithmetic were part of the Italian school program. The Eritrean student was confined to four years of schooling and his academic achievements were restricted to the limit of knowing the four arithmetical operations, to speak the Italian language moderately, know the principles of hygiene and know the history of the great nation, Italy. The change of the colonial power from Italian to British in 1941 had brought a great change to the Eritrean education. Local communities started to play an active role in establishing new schools and financing its administration by paying the teacher's salary. The school syllabus had both theoretical and practical contents. Some of the practical subjects include - shoe-making, metal work, knitting and gardening (Ertzgaard, 1995; 18). The medium of instruction was Tigrigna, Arabic and Kunama at primary level and English at the middle level. The goal of British educational structure was to train Eritreans as functionaries in the administration with the main objective of reducing management costs. Thus, according to Distefano, one of the main goals of British colonial education was "to force Eritreans into wage economy and to help break up tribal solidarity" (Distefano, 1998; 71). It was during the federation period from 1952 to 1962 that education expanded dramatically in Eritrea. This expansion was particularly evidenced during the first half of the period. "The federation brought the right of education to all Eritrean citizens" (Ertzgaard, 1995; 19). But, starting from the second half of the federation period, the influence of the Ethiopian government was becoming increasingly evident. During this period, the school system of Eritrea adopted the three levels of schooling existing at present - the primary level, the middle level and the secondary level.

During the first years of annexation, education continued to develop. The number of both private and governmental schools showed surprising increments. Eritreans were fully aware of the importance of education. But soon after the outbreak of the Ethiopian revolution in 1974, and the emergence of the Ethiopian military government (Dergue), educational progress started to deteriorate in Eritrea. As a result of the civil war, which followed the outbreak of the revolution, educational projects were hampered, teachers and students were persecuted and tortured and most of them fled the country or joined the struggle. After independence in 1991, Eritrea entered a new and different era. The government of Eritrea had declared education to be a right of all citizens in accordance with the UN declaration (Woldemicael, 1992; 3). Some of the general objectives of the education system after independence include:

- To produce a population equipped with necessary skills, knowledge and culture for a self-reliant and modern economy.

- To make the basic education available to all.
  (Ministry of Education, 1998; 1)

In planning of a national curriculum, under the department of education, one of the general principles underlined was that "educational content should be rooted in the social, cultural and economical environment of the country" (Ertzgaard, 1995; 22).

The current emphasis placed on mathematics education in general and the incorporation of mathematical modelling and applications into the secondary school curriculum in particular, cannot be viewed in isolation from the above general policies and principles of education in Eritrea. Some goals of mathematics education in Eritrea, according to Ministry of Education (2001; 1), include:

- To develop mathematical skill among students, which will enable them to function in all practical affairs of life;
- To deepen their appreciation of the importance and role of mathematics in the society;
- To develop in pupils positive attitude towards the subject and thus enjoy learning it;
- To enable everyone to master mathematics in accordance with his/her abilities and prepare the capable ones for higher education;
- To provide pupils with mathematical tools which they can use in other subjects.

In this study, learners' potential knowledge acquired from school and outside the school was used to explore the existing strategies and approaches they use when they study a given mathematical model. The study had been conducted with minimum possible external interventions. These interventions were in some special occasions where guidance was needed. The motivation behind such an approach, according to Edwards and Hamson (1996; vii), is to direct learners towards building up necessary skills in a systematic way. Through the given mathematical model, "human development index", different strategies and approaches of modelling were discussed. After all these discussions and sharing of experiences, a similar exercise on mathematical modelling was given. Learners' task on this exercise was to develop a "community development index" using their own strategies and approaches and with the help of the experiences they gained from the given example.

1.2 Statement of the problem

One of the aims of teaching mathematics in Eritrean secondary schools is "to acquire basic knowledge of and to master skills combined with an ability to apply them efficiently and accurately in real situations... " (Ministry of Education, 2001; 1). To this end, some basic mathematical structures that lend themselves to modelling like graphs, equations and inequalities, index numbers, numerical-tables etc. are included in the content of the Eritrean secondary school syllabus. However, besides this inclusion and the general policies and principles of education in Eritrea, little success has been accomplished in involving learners actively with mathematical modelling activities. In line with this issue, the existing strategies and approaches learners use when studying a given mathematical model must be explored before designing different approaches of teaching modelling in a classroom. Under this general objective, the researcher will specifically deal with grade ten learners to explore what approaches and strategies they use when they study a given model.

Studying a given model can help learners in many different ways. They can use it as a "framework" to solve for themselves other unrelated problems of a similar difficulty. Besides this, through understanding of the given model, they can learn how to tune and adjust a given model and analyze the assumptions made. Besides all this, studying an existing model can help them to explore new situations where mathematical modelling can be used.

Increasingly over the past few years, and specifically after the independence of Eritrea, more emphasis has been given to root the educational contents in the social, cultural and economical environment of the country. Thus, the goals of mathematics education had being changing with time. At this time, acquiring basic knowledge combined with an ability to apply them efficiently in real situations and prepare learners for the work place and future education has become one of the main objectives of education.

In preparing learners for the work place, one usually needs more than algebra or geometry alone. Teaching or including mathematical modelling integrates mathematics with the real world. In doing so, it has the nature of cross connecting various subjects. Some of the burning questions that arise from this feature of mathematical modelling are:

Is there any possibility to include mathematical modelling in our secondary school curriculum? If yes, how can mathematical modelling be taught in class?

The purpose of this study is to explore the strategies and approaches learners of grade ten use when they study a given mathematical model and to initiate other researchers who might have interest to conduct further studies on the same issue.

1.3 Significance of the study

Globally, there has been a shift over the recent years, from perceiving mathematics as an abstract and theoretical body of knowledge; to a subject that has utility and relevance in real life (Mogari, 2001; 204). In this view, learning mathematics should involve argumentation, justification and negotiations rather than memorizing a set of procedures.

However, students of our secondary schools are used to study mathematical concepts and formulas by remembering and memorizing strings of words and mathematical symbols without really understanding what they mean. From my experience as a secondary school mathematics teacher for the last fifteen years, mathematics has been considered as a difficult subject by majority of the students. One of the reasons that might contribute to this belief could be that mathematics in a classroom had been given without any association to the outside world experiences and without letting students know the interrelations in their own natural reasoning powers. Even after they complete the high school level, with exception of some, the majority does not know how to apply their knowledge learnt in classrooms to solve any real world problems.

If learners are required to be productive citizens, they must acquire experiences in solving a variety of extended and none routine problems while they are still in schools. To achieve this goal, the researcher believes that the inclusion of mathematical modelling and applications in classroom practices could play an important role. To this end, the mini-thesis has the following goals:

- To explore the strategies and approaches learners of grade ten use when studying a given mathematical model;

- To let learners be aware of and explore some social practices where mathematical modelling can be applied;

- To remind the concerned departments of Education to initiate further research projects on the possibilities of incorporating mathematical modelling and applications in our secondary school curriculum.

1.4 The scope of the study

The nature of my research requires close survey and observations of subjects involved in the study. Ten grade ten learners of Semaetat secondary school located at Asmara, the capital city of Eritrea, have been selected as participants of the study. I used to teach in the above-mentioned secondary school for fourteen years. This helped me to gain the required staff co-operation and access to facilitate my study smoothly.

After necessary introductions had been made, the ten selected participants formed two randomly chosen groups. Each group had equal number of members. One member from each group was chosen as a group leader. To facilitate observation and interviewing, two videotapes and one audiotape recorders were used.

As a nationwide rule, all secondary school learners in Eritrea go to school either in the morning or in the afternoon shifts depending on the particular arrangements made by the administration of each school. All participants of this study were taken from the morning shift. For this reason, I used some of the afternoon shifts and most of the weekends as convenient time for meeting and discussion sessions. The entire time spent for collecting data was one month and the total contact time was around twelve hours for each group.

1.5 Limitation of the study

The study had the following drawbacks:

- The study was limited to one secondary school and the number of participants in this study was small. As a result, it cannot be taken as a true picture of the situation as a whole. The study area and the samples taken may not be taken as representative of all secondary schools. Thus the findings of the study cannot be generalised.

- Selection of participants was based on their previous year grade records. Ten students with the best average mark were selected for the purpose of the study.

This could also be another limiting factor to generalize the findings of the study.

- Most of the times, participants were using convenient and co-operative kind of settings. Usually, they were holding round table discussions in the compound of the school. In this setting sometimes, for technical reasons, I had used only one videotape recorder instead of two. As a result, it was difficult to record the entire atmosphere at a time. In such situations, some activities of participants were not recorded properly.

- Even though its effect to the continuity and progress of the study was not significant, there were two absenteeisms and three late comings by some individual participants during the entire period of the study. In fact, some special arrangements had been made to solve the problem. However, since the semester examination period was approaching, the problem was not solved completely.

1.6 Organization of the study

The paper is organized in five chapters in the following manner:

Chapter one includes the background and the motivation behind the study.

In chapter two, a review of the relevant literature on different approaches and strategies of teaching-learning mathematical modelling and the procedures of analysis are dealt with.

Chapter three discusses the research methodology. Two methods, which complement each other, were chosen as means of collecting data. Participant observation was made on both groups while they were discussing and writing. After this, two individuals from each group were chosen for further person-to-person interviews. The interviews are recorded on audiotape. Finally, each group had submitted its final findings in a report form.

In chapter four, the collected data is analyzed with the help of the literature review.

In chapter five, findings of the study are discussed. This chapter also includes the conclusion of the study with some recommendations.

Chapter Two

The Literature Review

2.1 Mathematical modelling - an overview

> ...the application of mathematics to problems of natural science, of technology and commerce is so powerful that mathematics appears as one of the most, perhaps the most, highly developed mental tools available to us for dealing with our physical environment.
>
> (Skemp, 1979; 17)

Most people consider mathematics as a self-sufficient field of knowledge that does not rely on other areas of science or other disciplines. This view is reinforced by the majority of the problems that we see in our school mathematics, which tend to be well structured and have unique solutions. According to Cross and Moscardini (1985; 15), each problem we solve as students in class is complete in itself; it contains only the necessary information and requires, at worst, a modification of a routine application of mathematical techniques to obtain the only correct answer. If for instance, we look at the nature of the word problems, which dominate our school textbooks, most of them are mathematical problems masked in words but not affixed in any sort of reality. These are types of problems, which Pollak (1969; 397) calls these problems "pure whimsy problems". They are puzzle like mathematical tasks, which require mere application of routine mathematical techniques.

A study made by two Belgians and one Northern Irish researchers (Verschaffel et. al 2000; 17), provides us with an informative issue within the content of word problems in mathematics education. Their findings point out that students often perceive word problems as "artificial, puzzle-like tasks, which have to be solved algorithmically by selecting the obviously required operation with numbers given without taking into account the conditions of the problem text. However, in real life applications, such tidy state of affairs occurs or manifests itself rarely. As de Lange et al (1993; 8) point out, "the traditional image of mathematics as a structure that is finished and well defined – where the truth plays the leading role and dullness reigns – is slowly being replaced by the picture of a dynamic, ever improving and exciting science....". Subjects like mathematical modelling and other topics, which are closely related to daily life, have a great contribution in changing public impressions on mathematics. In the following paragraphs, the discussion will focus on the meaning of "model" and "mathematical modelling".

Aris (1979; 1) defined a model as being derived from "modus" (a measure). The term "model" according to his definition implies a "change of scale in its representations" and only later in its history did it acquire the meaning of " a type of design". However, the word model (without its adjective mathematical) has been and is still used in a number of different senses by many philosophers as well as scientists. Aris (1979, 1), defined mathematical model in the following way: "the term mathematical model will be used for any complete and consistent set of mathematical equations which is thought to correspond some other entity, its prototype." In this definition, the term prototype represents any physical biological, social psychological or conceptual entity. It may also represent another mathematical model. Having this in mind, let's see how different authors view mathematical modelling.

Mathematical modelling, according to Cross and Moscardini (1985; 15), is "an activity which requires rather more than one ability just to solve complex sets of equations, difficult though this may be". In these authors' view, mathematical modelling comprises an attempt to develop a coherent representation of the behavior of some system or process, from a mass of largely irrelevant disordered data.

In this context, mathematical modelling can be viewed as a process of "problem reduction" which involves the transformation of some idealized form of the real-world situation into mathematical terms. It utilizes an analogy to help understand the nature of complex systems. Thus "a mathematical model is a mathematical structure that approximates the features of a phenomenon; and the process of devising a mathematical model is called mathematical modelling" (Swetz and Hartzler, 1991; 1).

Niss and Blum (1991; 11) defined the notion of mathematical modelling as part of the process in problem solving. According to these authors, problem solving has four steps of which the process of mathematical modelling comprises the first two. As a first step, the situation has to be simplified, idealized and structured with appropriate conditions and assumptions. In the second step, its data, concepts, relations, conditions and assumptions are to be translated into mathematics. This is what Niss and Blum (1991; 11) have phrased as "the real model has to be mathematised". These were, according to Niss and Blum, the two major steps in modelling. In Niss and Blum's view, the process of mathematical modelling doesn't include the third and the fourth steps of problem solving; which are "the choice of suitable mathematics and work within it" as well as the "interpretation".

Niss and Blum (1991; 11) have clearly distinguished between the following three terms: Mathematising, Modelling and Problem solving. Later in this chapter, I will try to discuss other authors' opinion on the non-existence of these clearly distinguished marks between these three terms and how these authors' have outlined the hierarchical stages of mathematical modelling in a different way. The following paragraph will discuss some of the purposes of mathematical modelling and the distinguishing features of models from reality.

Mathematical modelling can help us to understand complicated systems and to make predictions or generalizations about the whole system or subsystems. As Cross and Moscardini (1985; 16) point out, we continually use simplified representations and idealizations to enhance our understanding of systems and make predictions about their behavior. Usually models of a given system may not be very precise representations of the actual system. Models are not exact replicas of reality but contain only some of its essential elements. They are partial and never represent the entire system. In Cross and Moscardini's view, modelling is an activity which is fundamental to a scientific method. Each model merely reflects mathematical description of a hypothesis concerning the behavior of some physical process or other. At this point it is important to make a distinction between models and reality, because lack of distinction between them may have severe negative consequences. Once a successful model is accepted by majority and is confused with reality, it will take time and great effort to discard or modify the model after it is discredited or whenever it requires modifications. As Cross & Moscardini (1985; 17) stated, people tend to refuse accepting a new model if it merely contradicts with their old beliefs or faith even if scientific facts approve it. In this sense models, if confused with reality, may play a negative role in the history of progress of mankind

The fact that models never replicate a system leads us to another fact that models are not unique representations of a given system. This means as Cross and Moscardini (1995; 17) put, models represent different things to different people. One's environment, background and objectives heavily influence one's conceptual view of a given model. The same is also true when we deal with mathematical modelling. In this sense mathematical modelling is an art, which involves experiences and intuitions of individuals in addition to the basic mathematical modelling skills.

Thus taking into consideration, the restricted link between mathematics and reality on one hand, and the intentions of the modeler on the other, the choice of an appropriate model is really an art, which requires skill and experience to master some of its fundamental techniques. In the following paragraph, the processes of mathematical modelling will be discussed.

In the process of mathematical modelling, besides the problem of adopting a suitable framework, the choice of an appropriate mathematical model is also not an easy task. There is no ready-made theory, which can foretell which model is suitable under a given situation. It requires skill and experience. Some authors argue that the ability of choosing an appropriate model is more or less an art. According to Davis and Herish, cited by Niss and Blum (1991; 12), " the resulting model depends on the intentions of the modeler, whether it is a question of description, of prediction, or of prescription". From the above arguments, it can be stated that different experiences and intuitions plus the intention of individual modelers have certain influences in the process of mathematical modelling. However, despite these different experiences and conceptual views of individuals to a given model, the stages for the process of modelling as stated by many authors are more or less similar. The following paragraph will discuss some basic and typical hierarchical stages in the process of mathematical modelling.

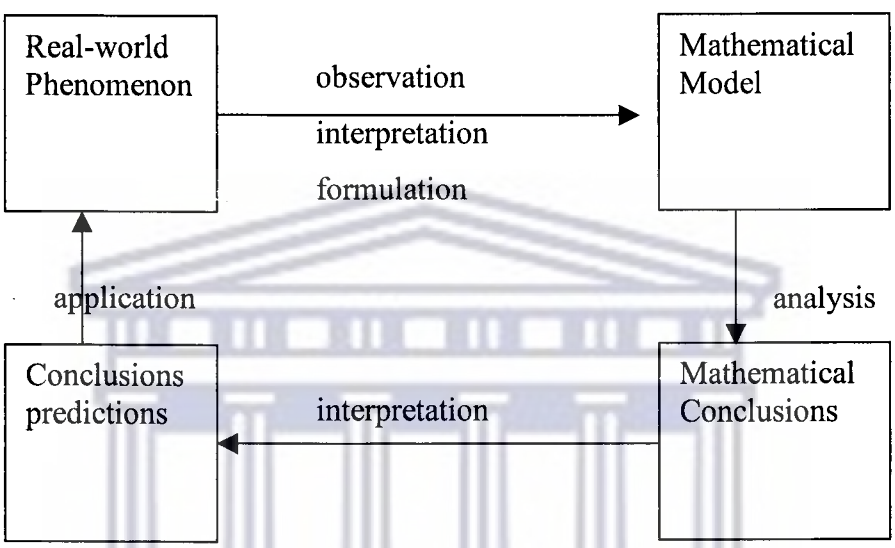
The National Council of Teachers of Mathematics (NCTM) has outlined hierarchical stages for the process of modelling, which with some modifications provides a basic framework for conducting a research on mathematical modelling in mathematics education. The NCTM (Swetz and Hartzler, 1991; 3) identified four main stages:

1. Observing phenomena; delineating the problem situation inherent in the phenomenon and discerning the important factors/parameters that affect the problem.
2. Conjecturing the relationships among factors and interpreting them mathematically to obtain a model for the phenomenon.
3. Applying appropriate mathematical analysis to the model obtaining results and interpreting them in the context of the phenomenon under

study and drawing conclusions.

4. Obtaining results and interpreting them in the context of the phenomena under study and drawing conclusions.

These stages can be schematically represented in the form of a closed cycle as follows:



The above modelling process is not the only complete process. It can be modified or some more stages can be added. For instance, the testing and refinement of the model can be included as a fifth stage and so on. But, the main objective in modelling is not to formulate complicated stages that will produce refined results. According to Fowkes and Mahony (1994; 2), "the main challenge in modelling is not to produce the most comprehensive descriptive model but to produce the simplest possible model that incorporate the major features of the phenomenon of interest."

Research can be conducted at each stage of the process, and each level can be taken as a unit of analysis or the entire system can be taken as the unit of analysis.

Finally, I would like to close this topic by mentioning some of the reasons suggested by Cross and Moscardini (1985; 20), why we should apply mathematical models in all economic, social and management activities:

1. Mathematical models are less expensive than physical models
2. Mathematical models have a potential to identify sources of any problem on the process and when the problem is traced, modifications to the design can be implemented and tested quickly.
3. The effects of optimizing a system with respect to a production rate, quality, cost etc. may be assessed fairly and readily.
4. Economic models may be used in assessing various budget options to control the economy.

Since mathematical modelling is so vital in solving various real world problems, it is worth teaching its techniques to our students. The main problem concerning this issue is how to deal with mathematical modelling problems in classroom situation. Addressing this issue, Swetz (1991), comments that mathematical modelling should be taught as a process.

Certainly, mathematical modelling involves a problem, but it should not be seen merely as a collection of problems and their solutions. More important, according to Swetz (1991), "modelling is a multistage process that evolves from the identification and mathematical articulation of a problem through its eventual solution and the testing of that solution in the original problem situation". In this multistage process which may demand creativity and innovation, acquiring the basic skills and applying them effectively is the main objective of studying a given mathematical model in schools.

2.2 Mathematical modelling skills

The process of solving problems with the help of mathematical modelling is by its very nature a practical and creative activity involving different stages, which demand a variety of skills. For variety of reasons we need to know what mathematical modelling abilities or skills our learners develop when they are given a mathematical modelling problem.

Questions, like why we need to incorporate mathematical modelling into the secondary school curriculum and how do we deal with it, depends mainly on the number of skills mathematical modelling is intended to develop in our students.

But before specifying some basic skills of mathematical modelling, let's first consider some general abilities expected from a mathematics student as described by McLone (1984). McLone, in his attempt to answer the question "can mathematical modelling be taught?" pointed out four central abilities (skills) for the mathematics student. These are the *technical knowledge, discovery, criticism* and *communication*. He further clarified them as follows:

- Technical knowledge;
  -The acquisition of basic techniques and theory,
  -Use of techniques to solve standard problems,
  -Use of existing techniques in unfamiliar situation.

- Discovery;
  -Improvisations of new techniques when the existing ones are inadequate,
  -Abstraction of a unifying principle from a class of situations,
  -Formulation of a problem in mathematical terms.

- Criticism;
  -Organization of material (from books, papers, etc.),
  -Assessment of suitability of different mathematical models,
  -Asking of pertinent questions in a mathematical situation leading to criticizing of (a) own and (b) others work.

- Communication;

  -Communication of ideas, results, in mathematical form,

  -Communication of mathematical results to non-mathematicians,

  -Work effectively in a group.

(McLone, 1984; 480)

More or less the above mathematical abilities are skills that we are trying to achieve from mathematical modelling by incorporating it into the school curriculum. According to Cross and Moscardini (1985; 76), by learning the basic art of mathematical modelling it is meant that, by the end of the course, students should:

I. Have the confidence to attempt to make sense of an ill-posed problem with a large amount of mostly irrelevant data;

II. Be able to rationalize the ill-posed problem into an unambiguous question to be answered that utilizes a subset of the data available;

III. Be able to develop a mathematical description of the system that will enable a valid answer to be generated to the above question;

IV. Be able to solve the resulting set of equations and substantiate the validity of the model;

V. Be able to make predictions using the model which answer the question posed in II above;

VI. Be able to prepare a written report on the modelling exercise, including recommendations, and in addition make a verbal presentation defending the model and its predictions.

In these authors' view, the good modeler must be able to do rather more than merely formulate set of equations and solve them mathematically.

To sum up, from the above arguments, one can understand that abilities and skills can be highlighted when mathematical modelling is incorporated with the school curriculum. Mathematical modelling is of course much wider than just mathematics or just education. In addition to the skills gained as de Lange et al. (1993; 56) commented, it also implies "a vitality to look for more innovative solutions to life's problems". In these writers' view, mathematical modelling also implies basically optimistic, rational, exploratory and forward-looking form of life.

According to Swetz and Harzler (1991; 2), mathematical modelling is also a type of problem solving because, it shares characteristics like computation, interpretation and finding answers and all other skills required by problem solving, but it is also distinctly different. Frequently, in a mathematical modelling situation, a phenomenon that is seemingly non-mathematical in context must be modelled. Thus mathematical modelling is a systematic process that draws on many skills and, as suggested by Swetz and Hartzler (1991; 2), it employs the higher cognitive activities, of interpretation, analysis, and synthesis. The next topic deals with how these problem-solving and modelling activities can be carried out in classrooms.

2.3 Varieties of teaching mathematical modelling

In trying to identify the different ways of teaching mathematical modelling and applications, the main problem I faced was, that most modelling books, mathematical modelling journals, and papers written on the art of mathematical modelling praise its virtues and give smart definitions in terms of its use, but, say very little about how it can be taught successfully. The following discussion on the varieties of teaching mathematical modeling is therefore based on some authors' way of presenting the topic in their respective books.

One of these approaches views the whole modelling process as a closed system. In this approach, a given mathematical model is studied step by step following an outlined set of procedures. In other words, learners use models as objects of learning. These models serve as realistic illustrations of the actual use of mathematics. Various steps in the development of the model are studied with the help of illustrations by discussing some real world problems.

In this approach, contexts mainly emerge from outside-of-mathematics. This method of studying a given mathematical model with the help of illustrations can help learners to understand the whole notion of modelling and its wide applications. Learners in this approach are not passive participants, they are supposed to understand the different assumptions taken at each step and need to justify or oppose them. In other words, according to this approach, mathematical modelling is viewed as a process and it must be taught as a process (Swetz; 1991). This framework then may be used as a basis for learners to solve for themselves other unrelated problems of similar difficulty. In a classroom situation, learners may be given similar mathematical modelling activities as a group task after studying a given mathematical model.

At this time studying a given mathematical model is a widely used approach and it has began to be offered separately from the ordinary mathematics courses. An evidence for this could be the book written by Edwards and Hamson (1996) which is mainly designed to be used as introductory course in mathematical modelling, whether in scientific context or business environment. A good deal of the material on which such courses are based stems from many newly published case collections (Niss; 1985). Part of the study made in this research follows this approach in exploring learners' strategies and approaches when studying a given mathematical model. Learners involved in this study will be given a model as an "object of learning".

Another way of teaching mathematical modelling is a complete immersion of participants (learners). This method can be applied with a couple of lectures on the basic principles of, and a systematic approach to, mathematical modelling. According to Cross and Moscardini (1985; 55), this featured some detailed discussion of modelling structure, which indicated the successful transfer of real world problem to a suitable mathematical model. In this approach, learners are assigned into groups to work on a given model problem. Model problems in this approach may develop from simple to complex, to illustrate the process of mathematical modelling. Essentially, they might involve building of models in solving the problem. One big difference of this approach, from the above discussed one is that, here, learners should not be presented with models as an objects of learning, but should arrive at them as a result of their own efforts. Studies done by Cross and Moscardini (1985; 57), indicate that, with this approach, learners express an interest in solving more realistic problems rather than fictitious ones.

In a classroom situation, the role of a teacher in this approach is to identify mathematical modelling tasks that build the students ability to reason, process information, speculate and think critically. He/she is supposed to give learners more opportunity and freedom in acquiring the ability to activate mathematics themselves when dealing with the given problems and situations. At school level, the problem situations should not be too extensive, or one that lead to more complicated or sophisticated models. As Niss (1987), pointed out, the problem situations at issue had to be "open-ended", which means, that the questions asked, whether explicit or implicit, are - as are also the answers -fuzzy, ill-defined, and accessible to learners' own influence.

One main advantage of this teaching strategy is that it helps learners prepare for more professional activities. One common impediment in using this approach, as described by Cross and Moscardini (1985; 75), is that learners find construction of modelling and its use as disturbing because of the open-ended nature of the problems and the lack of a "unique" solution to a given problem.

Another issue, worth mentioning here, concerning the problem of teaching mathematical modelling is the complexity or simplicity of the school mathematics in dealing with modelling and applications that have socio-cultural context. To bypass this problem of mathematical content, some educators suggest using very simplified arithmetic calculations. Concerning this issue, Smith (1996; 14), recommends for kinds of problems, which require simplified arithmetic calculations and more of common-sense knowledge. Some scholars criticize this approach for being " extremely unhealthy long-term mathematical diet" (Breen as cited by Julie; 1998). On the other hand, scholars, who promote this approach, claim that it encourages and pave ways for the majority of the average students who might find problems in mathematical modelling as disturbing or annoying.

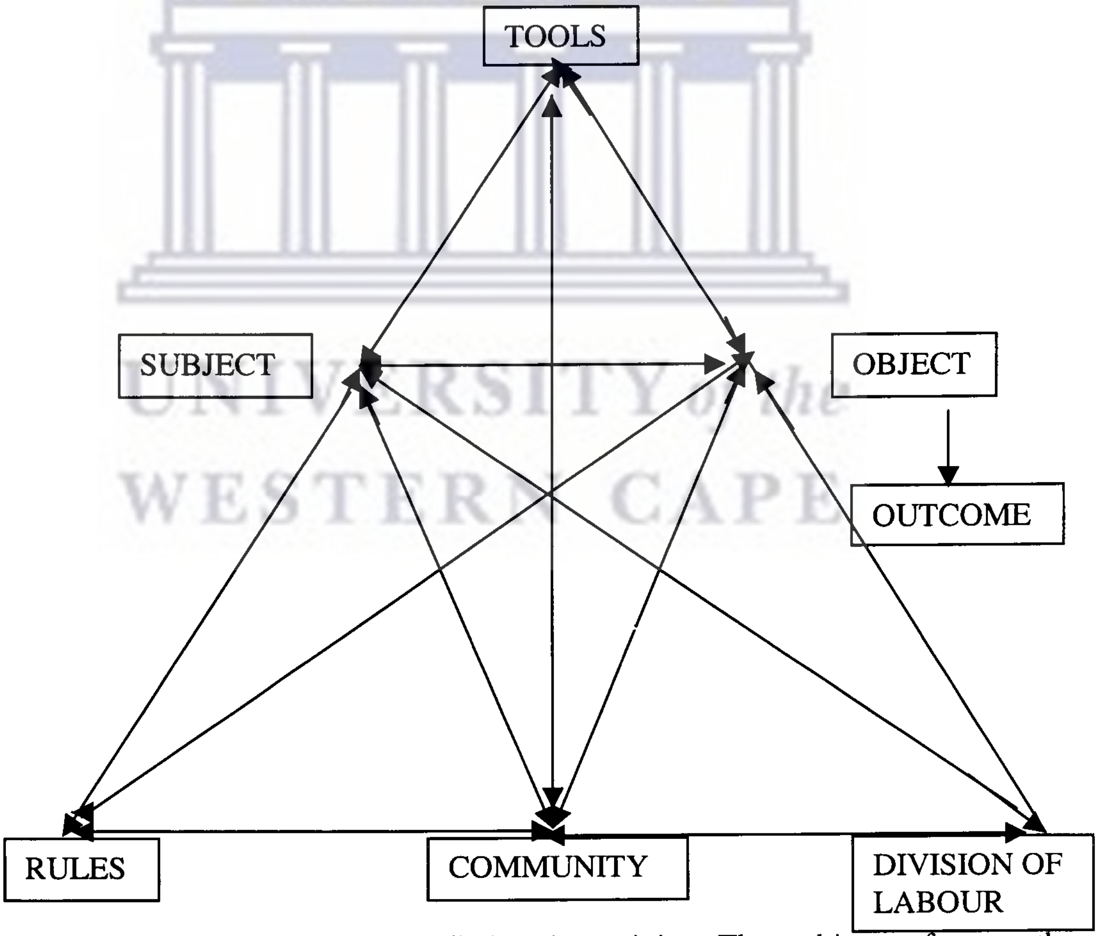
In contrast to the above two extremes, Julie (1998; 114), suggests presenting the problems in such an open-ended way so that learners at various levels of mathematical development can engage with the problems at their level of mathematical expertise". In this notion, Julie (1998; 115) is suggesting that "mathematical modelling should be treated as a distinct, separate section of the school mathematics curricula in the same sense that algebra, geometry and trigonometry are dealt with". It could also be treated in the school mathematics curricula in the form of project work (Abrantes; 1993).

2.4 Analytic framework – Activity system

Analysis of this study is based on the conceptual model of an *activity system.* Activities in this context can be defined as "social practices oriented at objects" (Engestrom, 1996; 380). Objects are entities, which determines the horizon of possible goals and actions that function as the motive force deriving the activity forward. Thus "an entity becomes an object of activity when it meets a human need" (Engestrom, 1996; 380).

The subject constructs the object, and "singles out those properties that prove to be essential for developing social practice" (Lektorsky as cited by Engestrom 1996; 380). Goals and objectives can be understood in relation to the objective and motive of the collective activity. Activity systems evolve through "long historical cycles in which clear beginning and ending are difficult to determine" (Engestrom, 1996; 381). Activity systems constantly generate actions through which the object of the activity is enacted and reconstructed in specific forms and contents; but being a horizon, the object is never fully realized. In an activity, objects are not to be confused with goals (Engestrom, 1996; 381). Objects are constructed both mentally and physically. This means that the object of activity is not fixed and clearly defined, but constantly evolving. In this study, the studied activity of learners is the task when "studying of a given model" and "designing of a similar one".

The analysis of this activity is made through a conceptual model of the activity system depicted below.



The model shows multiple mediation in activity. The subject refers to the individual group whose point of view is adopted in analysis. In this research, subjects are the two groups of learners whose point of view is adopted in the analysis. The object in the activity system refers to the "problem area" to which the activity is directed. For instance in the traditional (existing) activity system of learning mathematics, one object of the system could be to "memorize set of procedures" towards an outcome of "passing an examination" or "test". Thus the object of the activity is oriented towards a particular goal and is transmitted to produce outcomes with the help of mediating instruments. These mediating instruments are the tools, signs and all other representations that occur within the school environment. Learners in the traditional activity system could use – recording devices, recall devices, and processing devices as instruments.

The model of an activity system can help to describe the relation between subject and community in learning activity. A learner or a group of learners can be observed as subjects. Community in this notion signifies all other classmates at similar performance level who share the same object. Division of labour refers to the distribution of tasks between members and may also refer to the vertical division of power and status (between teacher and learner). Rules refer to the implicit and explicit regulations that constrain actions, and to the written and unwritten rules.

From the activity theoretical point of view, (Engestrom, 1993a; 65), there are three basic principles that need to be analyzed.

The first one is to take the collective activity system as a unit of analysis, given context and meaning to seemingly random individual events. In the second principle, the activity system and its components can be understood historically. As a the third principle, the inner contradictions of the activity system can be analyzed as a source of disruption, innovation, change, and development of the whole system in general with its individual participants.

In this study, in analyzing the learning behavior of subjects, the entire activity system is taken as the unit of analysis. Any learning activity emerging as deviation from the traditional activity system of learning mathematics will be the core of discussion and analysis. In other words, new elements, which may enter in to the existing system from outside, as a result of learning mathematical modelling, will be identified. These new elements may create contradictions in the system. This contradiction may lead to change. In this situation, the entire activity system may change or reorganize itself.

Engestrom (1996; 134-135) described activity system as follows:

> Activity system periodically faces situations in which their internal contradictions are aggravated and demand a qualitative reorganization, re-mediation, of the entire activity. When an activity system - a work place, for example - goes through such reorganization and constructs a historically new mode of practice for itself, it learns something that there was not there at the outset, something that no authority was able to transmit and teach. This is collective learning in which internalization and externalization, appropriation and creation, routinization and innovation take place as parallel and intertwined process. It is a type of learning that is systematically neglected in standard learning theories.

Change that may occur as a result of contradictions between elements of the system may require construction of new objects and new motives. From an activity system point of view, collaborative learning in a group can be analyzed as "object formation" i.e. expansion of the "object and motive" of the activity system. This is what Engestrom has named as "expansive learning". Engestrom (1996; 382), described the initial stage of expansive learning cycle as follows, "in an expansive learning cycle, the initial simple idea is transformed into complex object, a new form of practice".

In chapter four, activities of learners will be studied and analyzed using the concept of "activity system" discussed above. Deviations of activity that might appear when learners study and design a model will be compared against the "traditional activity system". By "traditional", I mean the existing activity system.

2.5 Summary

Mathematical modelling has been defined as an activity, which requires active involvement of participants. As Burghes and Borrie (1978; 41) point out, it is important that learners "not only see how mathematics is used, but also participate in the process of modelling". Different authors on mathematical modelling suggest the importance of class participation in learning mathematical modelling. I agree with these authors' idea, but the question is how far should this be taken? Should learning take place on an individual basis or be taken as a group activity? etc. Such questions lead us to investigate different ways of teaching-learning mathematical modelling. Unfortunately, most authors on mathematical modelling say very little on how mathematical modelling can be taught successfully. The following variety of ways of teaching are therefore suggested based on some authors' approaches when they deal with mathematical modelling problems. These are:

1. study a given mathematical model,
2. guided exploration of a given model,
3. complete immersion

Classification of these three different approaches is mainly based on the "object of learning". In the first two approaches, models are given to learners as "objects" of learning; but in the complete immersion approach, learners are expected to construct models as a result of their own efforts.

Finally, the chapter discussed the "conceptual model of an activity system" which will be used as a framework of analysis in identifying the learning behavior of subjects involved in the study.

Chapter Three

Methodology

3.1 Exploratory research

The question of "what research methodology to employ?" is one of the most important choices to be made by a researcher. The choice of methodology depends on the research question itself. Once the methodology of a research is selected, it tends to govern other choices such as how the data will be collected, how it will be analyzed and how results will be reported as well as the nature of the conclusions that may reasonably be drawn from the results.

In a broad sense, this study has an objective of exploring strategies and approaches learners use when they study a given mathematical model as well as observing their behavior when they are engaged in developing a similar one. It is a kind of study, which requires an in-depth observation of the qualities of the following particular strategies and activities.

- How do learners study a given mathematical model?
- What kind of strategies and approaches do they use?
- In what particular activities do they engage?

These questions are subjective in nature; hence, they seek qualitative research techniques and procedures in the process of data gathering and analysis.

Having the above broad objectives in mind, the specific or main focus of this study will be to explore the strategies and approaches grade ten learners in Eritrea use when studying a given mathematical model. The study requires considerations of the individual's own perceptions and subjective understanding.

As far as the researcher knows, no study has been made on mathematical modelling in the Eritrean secondary school context. Therefore, the study made on this area is an exploratory type of qualitative research. Exploratory research is a particular type of descriptive study (Bless and Higon-Smith, 1995; 41). The purpose of exploratory research, as Bless and Higon-Smith (1995; 42), pointed out, is "to gain insight into a situation, phenomena, community or person".

This research, being exploratory in nature, might be used or serve as an initial step for further deep researches that ought to be conducted to explore the strategies and approaches used by Eritrean secondary school learners when they study a given mathematical model.

3.2 What is qualitative research?

As Berg (2001; 6) pointed out, qualitative research properly seeks answers to questions by examining various social setting and the individuals who inhabit these settings. Qualitative researchers, then are most interested in how humans arrange themselves and their setting and how inhabitants of these setting make sense of their surroundings, through "symbols, rituals, social structure, social roles, and so forth" (Berg, 2001; 6).

3.2.1 Common features of qualitative research

The following common features of qualitative research stated by Robert Bardon and Sari Knopp cited by Fraenkel and Wallen (1993; 380), were taken as a guiding points for all major activities of this study.

- The natural setting is the direct source of data and the research is the key instrument in qualitative research.

The researcher of this study made direct observations with the help of videotaping and conducted interviews with an intention of capturing views on a broad range. This was done by going to the school of the subjects under study.

- Qualitative data are collected in the form of words or pictures rather than numbers.

Data collected in this study includes: videotape recordings, interview transcripts, task reports and personal comments etc. Every detailed action, movements and even hand gestures, jokes … are recorded to grasp ideas in their original form. Actual words of subjects and their actions are also recorded and used as source for the data analysis.

- Qualitative researchers are concerned with process as well as with product.

One of the main tasks of the researcher in this study was to make observation of learners' interactions, their responses to every question raised including their manner, comments, facial expressions etc.

- Qualitative researchers tend to analyze their data inductively through observation and interviewing.

One objective of the researcher was to formulate a whole picture of the study as it happened. Original and first hand data had been collected from the natural setting before any research question was considered.

- How people make sense out of their lives is major concern to qualitative researches.

In this study, one main focus of the researcher was to capture what participants think about the task they were doing from their perspective. In other words, recording and reporting ideas, comments and responses in the participants' point of view was one of the main concerns of the researcher.

3.3 Data collection

Techniques of data gathering used in qualitative researches vary depending on the nature of the study, the subjects under study, the selected setting etc. Some of these data gathering techniques include – observation (participant and non-participant), interviewing, and role-playing.

In this study the following techniques had been used as a means of data gathering.

1. Interviewing
2. Participant observation

3.3.1 Interviewing

In research, the interview is defined as "a two person conversation initiated by the interviewer for the specific purpose of obtaining research relevant information, and focused by him on content specified by research objectives of a systematic descriptions, predictions, or explanation" (Cohen and Manion, 1989; 307-8). In short, as stated by Berg (2001; 66), interviewing is defined simply as "a conversation with a purpose". One main purpose of interviewing in research is to gather information through direct verbal interactions. It is believed that in an interpersonal encounter, people are more likely to disclose aspects of themselves, their thoughts, their feeling and values, than they would in a less human situation (Cohen and Manion, 1989; 319).

Data gathering through interview has its own advantages as well as disadvantages. Some of the advantages of interview as a research technique include:

- ***Interviewing allows for an in-depth verbal interaction***. When compared to other methods of data collection, interviewing allows for greater depth of communication with interviewee. Issues, which might had been not clear in the process can be discussed with more detailed and more focused manner in an interview conducted afterwards. In the process of conducting qualitative research, statements might be interpreted wrongly and actions might be perceived incorrectly. These wrong interpretations and perceptions, which might have negative influence on the results of the whole research, will have to be corrected through direct verbal interactivity with interviewee.

- ***Extensive opportunity for asking***. In an interview, the researcher does have great opportunity to ask whatever question he or she thinks will be relevant to his/her research analysis. This opportunity is limited in other methods of data collection.

- ***Relative magnitude of data is great because of the use of coding***. Responses gathered through interview can be reduced to manageable categories with the help of coding.

- ***Opportunities for probing are also better when compared to other data collection techniques.***

Some disadvantages of interviewing include:

- ***The overall reliability is limited.*** This is mainly because the number of respondents in an interview is relatively small or limited.

- ***It has relatively large source of error.*** Some of the main sources of error in an interview are the interviewer, the instrument, the coding and the sample taken.

- ***It is relatively expensive.*** One major expense of interviewing could be the payment to the interviewers.
- ***Typically, the numbers of respondents who can be reached are small.***

3.3.1.1 Types of interview

In research, identifying and acknowledging of the type or structure of interview chosen is very important. According to Berg (2001; 68), "no consideration of interviewing would be compete with out at least some acknowledgment of the major interview structures". Interview, as a research process, can be either formal or informal; either structured or unstructured. In research, at least three major categories of interviewing may be identified. These are:

1. The formal or structured interview
2. The informal or unstructured interview
3. The guided or semi-structured interview

In this study, the informal or unstructured interview had been implemented. I found this technique to be more suitable to my study, because, it offered me the immediate opportunity of generating questions and probing the interviewee. In an informal or unstructured interview, as Schwartz and Jacobs cited by Berg (2001; 70), pointed out, "interviews must develop, adapt, and generate questions and follow up probes appropriate to the given situation and the central purpose of the investigation".

Unstructured interviewing is very helpful in exploratory research (Bless and Higon-Smith 1995; 110). It helps to clarify concepts and problems. It also allows the interviewer for discovery of new aspects of the problem by investigating in detail some explanations given by respondents. In unstructured interviews, the wealth and quality of data gathered are strongly dependent on the skill of the interviewers, the confidence they are able to awaken in respondents, the type of questions which are asked and the encouraging comments which are made at the correct moment.

The weakness of unstructured interviews lies partly, in the fact that if the interviewers are not competent, they may introduce many biases. In particular, recording the comment of participants is a delicate matter because of the great variety of answers and their complexity. Moreover, such interviews as discussed earlier, are time consuming and thus expensive.

Usually I was conducting unstructured interviews with particular participants, at the end of the day's task and sometimes during the observational periods, depending on the necessity for more clarifications and elaboration of some issues under discussion. This helped me to a great extent in gaining additional information and clarifications about various phenomena I observed during the process of studying the given model and the process of developing a similar one. (For the original Tigrigna copy of the interview, refer appendix B)

3.3.2 Observation

In research, observational studies are made to collect data from a specific setting. The oxford dictionary meaning of the word *observation* is "watching carefully". In research, it has more or less similar meaning. In observational studies, Dallen et al (1979; 162), researchers collect data on the current status of entities by watching them and listening to them rather than asking questions about them. According to Dallen et al (1979; 163), observation may be "controlled or uncontrolled, scheduled or unscheduled, visible or concealed, participant or non-participant".

In this study, I chose the observation to be controlled, scheduled, visible and participatory. No attempt was made to observe subjects by assuming a role of unidentified participant observer, or to conceal the true purpose of the research. By participating actively in a group, Dallen et al (1979; 163), one may gain insights into a subculture and obtain sources of information that are not accessible in any other way. But of course, one should have to be careful, because in doing so one may lose objectivity.

Considering the above advantages and disadvantages, I decided to reveal the true purpose of the research and convinced both groups to assure their cooperation.

During the observation period I followed the following three steps:

1. Make sitting arrangements convenient to the group and the videotape recording
2. Jot down some interesting statements and phrases while the group were conducting discussions
3. Write the full notes immediately before I start to forget some important events

I used both direct observations (by choosing a place suitable for observation) as well as videotape recording one after the other. Sometimes I had to call some of my colleagues to assist me technically.

3.3.2.1 Participant observation

In this study participant observation was used as one technique of data collection. Participant observation, as Bless and Higon-Smith (1995; 43) point out, requires that the researcher "join the group of people who are being studied in order to observe and understand their behavior, feelings, attitudes or beliefs better".

Participant observation has its own weaknesses and strengths. The following are some among many:

Advantages:

- Develops a more intimate and informal relationship,
- The investigator is able to discern on going behavior as it occurs,
- It is superior to surveys and questionnaires when data are being collected on non-verbal behavior.

Disadvantages:

- Costly,
- Biases due to subjectivity of the observer
- Time consuming,
- Can not be applied to many aspects of social life.

(Bless and Higon-Smith, 1995; 106; Cohen and Manion, 1989; 128-9)

Joining the group under study allowed me to access more information that could not be possible through any other means. At the beginning, it was not very easy to create such an easy and free atmosphere. But through more adaptation the problem was solved. Learners were able to express their feelings and beliefs more openly.

3.4 Data presentation and data analysis methods

Janice, Morse cited by Berg (2001; 102) commented, "…despite the proliferation of qualitative research methodology texts, the process of data analysis remains fairly poorly described". This part of a research is the part, which requires more of personal techniques along with some general principles of analysis.

3.4.1 Personal data presentation

After gathering of relevant data for analysis, the next steps followed were to transcribe and translate it to the English version. Both groups used *Tigrigna,* one of the Eritrean local languages, as a means of communication. I didn't try to interfere or encourage them to use the English language because, by doing so, I thought, I might hinder the free flow and exchange of ideas. One main obstacle that I faced in the process of translation was the problem of getting English words or phrases, which translate the correct meaning and sense of some of the local and cultural expressions. Of course, the required effort had been made to minimize its negative effects through consultation of the "English- Tigrigna" dictionary.

The next following step was concerning the development of the codes and categories of the translated data. In this process, my first step was, to assign some initial codes for each phrase or statement of the interviewer questions and the interviewee's responses. Then, by going through all the codes that I gave for each phrase, I tried to group similar codes together. In other words, all related codes, which, I thought had common features and meaning were grouped and categorized.

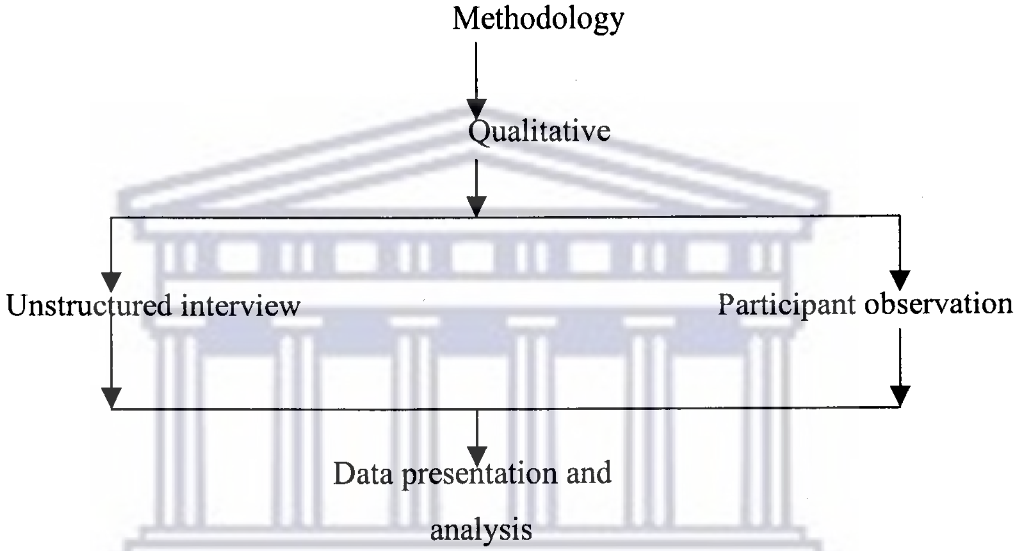
In this study, data was analyzed from the viewpoint of *the entire activity system and its contradictions.* The activity setting chosen was "Semaetat secondary school" located in Asmara, the capital city of Eritrea. The ten students, who were taken as subjects of this study, are grade ten students of this secondary school.

The following were personal research analysis procedures that I have passed through:

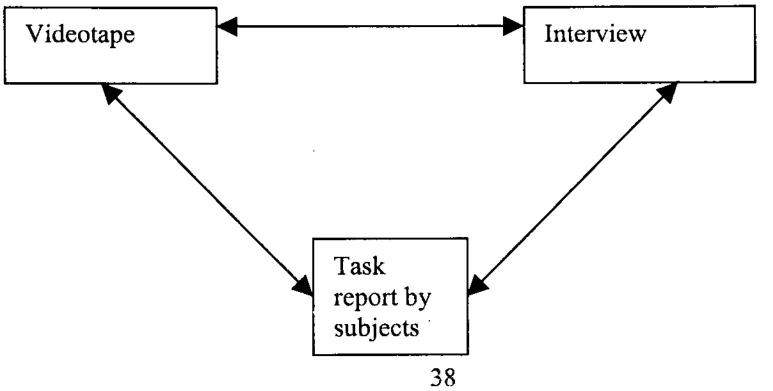
1. Use of codes for identifying key elements of interest.
2. Examination for possible patterns and findings.
3. Construction of *new emerging activity system* from the findings.

4. Compare the *new emerged activity system* with the *traditional* one.
5. Discuss similarities and differences of the *new activity system* with the traditional activity system.
6. Conclusions and recommendations.

Flow chart of methodology that had been dealt with is depicted below:



The collection of data for analysis that had been dealt with is depicted below:



Chapter Four

Presentation and Analysis of Data

4.1 Presentation of data

As mentioned in the introduction and methodology, the nature of this study required close observation of subjects under study. For this reason, I have conducted my study of both groups using videotaping and participant observation. Further interviews were also conducted to clarify some of the ambiguities and controversies. In general I can say learners had participated actively and the problem given to them was done properly. I have used their final work report and videotape copies as a basis for the format of the analysis in this chapter.

For the sake of simplicity, results of the analysis are presented at two different levels:

1. Observable behavior of learners when they are studying a given mathematical model
2. Observable behavior of learners when they are engaged in developing a similar model

In the first section, the observable behavior of learners, when they explore a given mathematical model was analyzed. The model that was given to them dealt with *the human development index* (HDI) model. It is an excerpt from the 1994 human development report. (Refer appendix C). After a brief orientation, each member of the group was given a copy of the HDI activity. I didn't inform them that I was recording the starting and the ending time of readings and discussions. My intention was to create free atmosphere as much as possible, suitable for free exchange of views, by minimizing any external influences.

Besides keeping a time record of each activity, in this section, I did the following:

- Observe and record how discussions began and proceeded.
- Record any progress made any intervention or any other barriers.
- Record any activity done, movement made and materials used in facilitating the task.

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The second level of the analysis deals with analyzing the observable behavior of learners when they are engaged in construction of their own model. In this part, learners were asked to develop a *community development index.*

4.2 Observable behavior of learners when they are studying a given mathematical model

In this discussion,

- S11, S12, … represent the 1st, 2nd, … members of group one.
- . S21, S22, … represent the 1st, 2nd, … members of group two.
- Q represents questions asked by the researcher.
- Uncompleted statements are represented by…(three dots)
- The key issue of discussion is the given HDI model. (see appendix C)
- Each student of group one and group two had a notebook and a pen of his/her own. There was one calculator on the table of group one.

When I distributed the HDI report to each member of the group, at first there was a silent reading with very few occasions of attempting to ask questions. Reading the given report in silence continued for nearly fifteen minutes. All of them were very serious and the atmosphere was very quiet. After fifteen minutes they started to discuss in a very low voices.

I think some of the reasons why there was very slow progress at this initial stage of the group work might be attributed either to the fact that they were not familiar with each other or/and to the unfamiliar approach of learning used in the study. Then suddenly they started a discussion. The following is an excerpt taken from group one's discussion.

S11: Why don't we first see some of the examples given in the report?

S12: Yes, let's see how it is done

S11: I tried to see how the life expectancy index is computed, but the answer I got is quite different from the answer given in this report

S12: How did you start?

(S11 began to explain. He was referring to a piece of paper on the table; there were some mathematical calculations on this piece of paper)

S13: I really don't understand the kind of relationship that exists between life expectancy at birth, as given in the report, and the life expectancy index.

Then there was a pause for about two minutes. All of them seem to have no idea about what the next step should be. So they began to re-read the given report again. Then S11 broke the silence by saying, "I think it would be better if we first test one factor, for instance – the factor knowledge." He pointed his pen towards the paper on his hand, in helping his colleagues locate the paragraph he was talking about. All of them agreed to his suggestion by nodding their heads. They agreed to first understand the steps of calculating the index of the component knowledge as shown in the given model before deciding what the next step will be. After this, the group began to work by rearranging themselves into two sub-groups.

After some time, S12 called the attention of all members in his group by knocking the table using the pen in his hand, and said, " I think we all should check the value of education index of Norway as given in the report through re-computing the process in our own way". They all began to turn to the page, which S12 was referring to.

Members of group two were still discussing together. The approach followed by them was very similar to that of group one. They first began to recheck some values in the table. The following is an excerpt from their conversation:

S24: Should we first try the life expectancy index?

S25: Yes we can try any one of the factors

S24: Let's then try the life expectancy index

S22: Did anyone have any idea?

(No body responded immediately)

S24: let's see

(He was jotting some numbers on his notebook)

From the above discussions and conversations made, it becomes clear that both groups started verifying the given model through re-computing the index values. For instance, when members of group two were verifying the index value of education, nobody raises any issue outside the mathematical part of the report. They didn't raise questions such as why the adult literacy was given more weight (2/3) when compared to mean years of schooling (weight 1/3). They didn't even ask why only these two components are included to measure the knowledge of human beings and no other factors.

In fact, when S13 asked the question regarding the relationships that may exist between life expectancy at birth and life expectancy index, the group did start to reread the report again; but her question was dismissed from further debating by S11. In this first day of meeting, the discussion remained confined to mere computational checkups, with very rare occasions of shifting to the main content of the problem which, discusses the development factors of a given country.

4.2.1 Analysis of learners' discussion on the mathematical aspect of the given model

As mentioned earlier, at the beginning, most of the learners' discussions were confined to the mathematical aspect of the given model. The discussion of group one on this part begins when S12 suggested for re-computation of the Education index of Norway. In the given report, knowledge is measured through the combination of adult literacy (two-third weight) and mean years of schooling (one-third weight). Moreover, the education index of Norway was given to be 0.9667. The intention of the group was then to check whether this value is correct or not. The checking process proceeded as follows:

S11 began to read paragraph two of the given report loudly. This paragraph states the weights given to each component that constitute knowledge. S12 was jotting the given data in his notebook. At the same time, he was feeding the calculator with in-puts from the same notebook. Finally they came with an equation of the form 2/3(99)+1/3(92). 99-refers to adult literacy rate in percentage of Norway in 1995, and 92 refers to the combined first, second and third level of gross enrollment ratio in percentage of Norway in 1995. (For detailed work, see appendix A).

At the beginning, there were some difficulties in identifying the years of schooling in percentage (92%) from the table. This was because there was some change of terminology used in the table. Initially, they were not able to identify the value of the mean years of schooling in the table. But after some time all members of the group came to the same level of understanding with more guidance of S11 and S12. With the help of the calculator, the answer for the above equation was found to be 0.9666… ≅ 0.9667. And this was exactly the same as the value given in the HDI report. Satisfied with this correct answer, they agreed to recheck the validity of the method used but now by taking the case of Eritrea as a checking example.

Their answer was again in complete agreement with the value given in the table.

A problem emerged when they faced some difficulties in the calculation of the "life expectancy index." When computing the "life expectancy index", they were not able to get the same result as given in the table of the report. They re-read the information given in the report, in search of some clues that might help them to reach the same answer as given in the report.

What follows is the mathematical problem they faced and solution they provided. Members of group one were trying to compute the "life expectancy index" of Canada". The following information was given in the report:

<u>Given</u>

Maximum life expectancy = 85

Minimum life expectancy = 25

Life expectancy of Norway = 77.6

Given the above information they formed the following equations:

Maxi. Life expectancy = 85 ⟶ index = 1

Norway's life expectancy = 77.6 ⟶ index = x

$$X = \frac{77.6 \times 1}{85} \Longrightarrow X = 0.91$$

This was quite different from the answer given in the table. They tried again and again to get the same result, as given in the table of the HDI report, by interchanging the places of some figures in the equation. Still they didn't come to the same answer. Finally they decided to compute some other countries' life expectancy index, e.g. the Canadian and the Eritrean one, to check the validity of their original method. The result obtained did not coincide with that given in the table. Then different opinions began to be generated and rejected at the same time until S11, while he was re-reading the report, discovered one important assumption made in the report, that had not been given the required attention at the beginning of their reading. What follows is an excerpt from the dialogue conducted by members of group one regarding this issue:

S12: There is something wrong. We better read the report again

S11: Here it is, we are committing a mistake by ignoring one very important assumption

S12: Which assumption?

S11: The assumption that says the minimum for life expectancy is 25 years

S13: Where is it?

S11: Here it is in page one paragraph…

(Everybody turned his HDI report paper, trying to locate the statement under discussion)

S13: Now I understand... we were not supposed to correspond the age 85 to index 1

S11: Exactly! First we must subtract 25 from it

S14: Why?

S11: Because the minimum age is not 0

The discussion continued in a similar fashion. Finally, after they put this important assumption into consideration, they were able to get the same result as given in the report. Then, they redid the calculation in the following manner:

Maximum life expectancy = 85, Minimum life expectancy = 25, Life expectancy of Norway = 77.6:

<u>Norway:</u>

Max. $85 - 25 = 60 \longrightarrow$ index = 1

Norw. $77.6 - 25 = 52.6 \longrightarrow$ index = x

$$\Longrightarrow \quad x = \frac{52.6 \times 1}{60} \quad \Longrightarrow \quad x = 0.877$$

Canada:

Max. 85 –25 = 60 ⟶ index = 1

Can. 79.1-25 = 54.1 ⟶ index = y

$$\Rightarrow x = \frac{54.1 \times 1}{60} \Rightarrow x = 0.902$$

Eritrea:

Max. 85 – 25 = 60 ⟶ index = 1

Eri. 50.2 – 25 = 25.2 ⟶ index = z

$$\Rightarrow z = \frac{25.2 \times 1}{60} \Rightarrow z = 0.42$$

Two things are clear from the above discussions.

1. Learners' main concern was to verify the index values of each component.
2. After obtaining results that did not coincide with values given in the given table, they began to understand the effects of certain assumptions made in the report.

Finally, before they concluded the work of the day, the researcher intervened by requesting them to take some of their time for discussing of some questions on the given model. They all agreed. The following questions taken from the report were presented for discussion.

Q. In the paragraph headed "how to combine indicators measured in different units?", it is stated that 'the score for the three dimensions are then averaged in an overall index.' Verify this statement.

They all at once came to read the indicated paragraph. After a while, S11 began to answer the question and all of them agreed with his answer by nodding their heads.

His answer was as follows:

> First we compute the index of each component by expressing all units between 0 and 1. There are three components all together. Finally we get the average of these three components by adding the individual indexes and then divide them by three to get the HDI value.

After verifying all values given in the table, they were more confident with the computations followed. In addition to this, they all were familiar with the term "over all average". Hence, as it was evident from the above response, they were very confident in their answer. The second question was non-mathematical. And it was stated as follows:

Q. In "why only three components?" it is stated that "the ideal would be to reflect all aspects of human experience". Say that you want to include the aspect "satisfaction with the government of the day" in a revised HDI,

How would you go about to measure and normalize this aspect?

Concerning this question, there were three different opinions. These different opinions are presented below to show how individuals differ in their views on the same issue before they made any compromises.

S11: I think satisfaction is mostly associated with standard of living. Most people are simply satisfied or dissatisfied with the policy of their government mainly because of economic reasons. So, I would rather say this component is already included within the component of the GDP.

S12: I don't think we can measure human satisfaction easily, whatever the cause may be. Therefore, I would drop this component from inclusion…because there is no way of measuring satisfaction or dissatisfaction of human being

S13: I don't know, ...may be, I need more time to think.

S14: I would ask different people found in different level of standard of living. And then I would determine their level of satisfaction.

S15: I have the same idea as S12.

The above responses indicate that learners didn't find it easy or necessary to measure human satisfaction with government of the day.

According to my observation, at some occasional times, learners were discussing emotionally with full attention and enthusiasm. Since the model presented for this study had included situations outside the classroom context in which learners were required to make use of mathematics they have learnt in school, they were really enjoying it and have benefited in a number of ways. This has been reflected in S11's response, when he was asked to express his opinion concerning this approach of teaching. He said, "...if it is given as a group task, you can share the task, you can share activities among individuals...and I think it would have been one of the lessons that one couldn't forget soon after class".

4.2.2 Major findings Summary of section 4.2

- **Computational security:** Both groups started their initial discussions with the mathematical part of the given report. After reading the report individually for some time, they quickly turned their attention to some mathematical checkups. This is an approach they have used for years when dealing with mathematics or physics problems. S11, from group one, for instance, began his explanation by showing them some of his successful attempts of calculation. Even in the discussions that followed, there was no sign or any clue, which indicate any further discussion beyond the mathematical aspect of the given activity. S24, from group two, also began his discussion by suggesting the computation of the life expectancy index.

- **Individual initiatives:** the same individuals were proposing solutions to the problems faced. For instance, on one situation when there was stagnation at one point for a bit longer time, S11 suggested a solution by saying "I think it will be easy if we first test one factor, for instance the factor-Knowledge". This statement reduced the tension and paved a way. All of them agreed to first understand the steps followed when calculating the index of the component knowledge as shown in the HDI model, and then to decide on the next step on the basis of the experience gained. The same event had happened repeatedly. Observing most of the discussions made by group one, S12 had an initiative and directive role. S11 and S13 were confronting him frequently and S14 and S15 had a tendency of being passive in most of the discussions conducted. But if we compare their academic achievements, as seen from last year's record, S14 leads them in the overall average score. S12, S11, S13 and S15 stood behind him in their respective order.

- **Ignoring given assumptions:** In some instances, they were arguing a lot without paying full attention to some necessary information given in the problem or they were ignoring vital piece of information without considering all consequences it might have. For example, in one instance, when computing the life expectancy index, they were not able to get the right answer because they had missed a piece of necessary information. It was after S11 brought to their attention that they were committing a mistake by ignoring one important assumption made in that report that they were able to get the answer. The assumption that they didn't pay full attention at the beginning was the piece of information, which says, " the minimum for life expectancy is 25 years".

- **Competitive individuals:** In this section, each student was doing his best to be the first in finding the solution before anyone could get it before him.

This behavior was particularly manifested when they were dealing with mathematical calculations. They were working fast and competitive.

- **Variation in views:** The variety of answers given to the question " how would you go about to measure and normalize the aspect satisfaction with the government of the day in a revised HDI", suggest that learners did not found easy to measure human satisfaction. As a result, it can be argued that the context did not really drive them to construct another model.

4.3 Observable behavior of learners when developing a similar Model

As indicated earlier, the second section of my analysis deals with the observable behavior of learners when they are engaged in construction of a similar model. The following mathematical modelling problem was given to both groups:

> *Based on your experience with HDI, you are required to develop a community development index (CDI). Each group should discuss and decide on which part of our community and which basic components/indicators of development be included in the study. Group members can also decide for themselves on how each member is assigned and share the task. Finally, you are expected to come up with your own CDI model and write a report that explains and defends your model.*

Reasons behind selection of the above problem include:

1. Learners had studied a similar model.
2. It reflects a realistic situation.
3. It can lead them to a modelling situation.
4. It can be tackled with more or less of the learners' existing level of

mathematical skills.

Learners started to discuss the above given problem in their respective groups. Videotaping was used for close observation of events. But here, I would like to inform readers that some part/s of the assignment was being done individually by learners. In addition to this, learners were engaging themselves in some informal meeting to discuss some difficulties concerning the given task. This is simply to indicate readers that every activity might not have been recorded or observed entirely. I am afraid that some events might have missed from being recorded or observed. Of course, further interviews had been made to fill this gap as much as possible, but still the problem remains worth mentioning.

Both groups were using Tigrigna, one of the local languages in Eritrea, as a means of communication. The following data records were used for the purpose of analysis in this section.

- Videotape records
- Observation notes
- Group task reports
- Interviews

4.3.1 Data records from videotaping, observation and group task reports

4.3.1.1 Constructing a problem

Group one members started to discuss the problem by raising some aspects of the given question. First they discussed the meaning of "community". After few minutes of discussion (which included the researcher in guiding some initial steps), they agreed to interpret community as one district (part) of the city of Asmara. In further discussions, they took " Gejeret" as one community of Asmara, to be the target of their study. When they were asked why they chose "Gejeret", they all gave very similar reasons and it can be summarized in one statement as "it is a district, which is familiar to most of us". I thought it was a very wise choice because; familiar contexts can facilitate group tasks. According to Niss (1991; 39), "… modelling in contexts not understood by the students is likely to be a waste of time".

Gejeret is one out of nearly 40 sub-zones (districts) of the city Asmara -the Capital City of Eritrea. In fact, Gejeret is further divided in to two sub communities (the big and the small Gejeret). This study refers to the small Gejeret whenever it mentions the name Gejeret.

After they reached agreement concerning the specific community as target of their study, S12 raised two main issues of discussion. First he called to have an agreement on factors, which could indicate the development of a given community. And second, to talk about how these factors will measure the development of the community under study. The following excerpt represents part of their discussions:

S11: I think, the three main development factors are education, health and communication.

S12: Availability and conditions of the infrastructures like transportation, water supply and electricity are also determinant factors of development.

S13: Well, income is also another major factor.

S11: What about including the beauty of buildings and sanitation mechanisms in addition to the above components.

S13: But, can't we combine some of the factors? Say for instance, health with education?

S11: No, I think both are quite different and major components of development, we should treat them separately.

The rest of the group expressed their support to S11's idea by nodding their heads. The process of rejecting and accepting of different opinions and new ideas continued until they reached agreement on selection of the basic development factors.

At the end, all agreed to include the following components as factors of measuring development of the community "Gejeret". Education, Health, Income, Electricity, Water supply, Sanitation, Communication and Transportation. All of them jot these factors on their notebooks. After a brief silence, S13 suggested for a break, but S11 commented that they are almost through the work of the day. Their conversation continued in the following manner:

S11: I think we need some additional information to proceed from this point. Why don't we discuss now on how to share the task of collecting data and meet next Saturday?

Majority of the group accepted his comment, but S15 suggested as follows:

S15: We all have no idea as to which kind of data we need to collect; neither the means of obtaining it so, it will be helpful for us if we discuss the issue a bit further.

The group considered this idea and finally decided to meet again after ten minutes of break.

After break, they continued to discuss the issue of "data collection techniques". Here follows some part of their discussion:

S15: On the factor health, I think we should consider the number of clinics in the given community and compare it with some other communities of

Asmara.

S11: Do you mean we should count all clinics?

S15: Yes, if possible, if not we may use estimation.

S11: Why only clinics? What about hospitals and pharmacies? Don't you think these are also important factors?

S12: Yes, but we have very few hospitals in Asmara when compared to the number of clinics and pharmacies. Besides this, their service is open to every body. I don't think we need to include hospitals. But we can include pharmacies though I have no idea on how we can.

S13: Ok, let's not go into more complications. I think it will be enough if we include clinics and pharmacies.

S12: I agree with S13. We need to know which part of Asmara has got the highest and the lowest number of pharmacies and clinics. This will help us to determine the maximum and the minimum points.

S11: Then, we can apply techniques used in the HDI.

S12: Yes

Then S13 mentioned one part of Asmara, which she thinks, has the highest number of clinics and pharmacies. She said, the central city, (named as Kebabi Cathedral), must be in this category. All members of the group seemed to agree with her comment. Then she said, (she was counting using her finger), " I think if I am not wrong, there are eight pharmacies in Kebabi Cathedral." But, most of them didn't agree with the idea of counting at this time and agreed to postpone the process of counting for next week.

Two things can be observed from the above conversations:

1. Learners were omitting or avoiding some indicators for instance, "hospital", from inclusion, simply because they want to avoid complications. This was evident from S13's statement when he said, "let's not go into more complications".

2. They were imitating the approach used in the HDI model. For instance, when they decided to determine parts of Asmara that have the highest and the lowest number of pharmacies, they were imitating the maximum and the minimum notion of the HDI model.

In the discussion that followed, they agreed to measure education through the available number of high schools, junior (middle school), elementary and kindergarten in the given community and then make comparisons. Then S12, who was keeping minute up to this time, reminded them to postpone discussions of the other issues for the next meeting. In addition to this, he commented, " instead of sharing the task of data collection, I think, it would be better if every one of us take the responsibility of collecting what ever valuable data we may get, and then, bring it for group discussion". All of them support his idea and the work of the day was dismissed.

Discussions were being conducted in both groups in a similar fashion. Group II chose the community of "Setanta-oto", one district in Asmara, as the target of their study. Factors, they chose as indicators of development, include, the infrastructure, and sanitation. They further divide the factor infrastructure in to two components - building and transportation. These factors were the bases of discussions for group two. The following excerpt can be taken as a typical representative of the discussions made by group two regarding the issue of selecting development factors:

S24: I think, we need three major factors.

S22: Why only three?

S24: Well, we can add more, but I think we should not make them too many…

S22: Ok, I will say the first one must be education.

S25: Health is also another one.

What was very peculiar in group two's discussion, when compared to group one, was the following:

1. They didn't raise the factor "income" for discussion, while it was one of the main issues of discussion in-group one.
2. They raised and discussed whether the factor "culture" is one indicator of development or not.

The factor "culture" was of course rejected finally. As is evident from the following excerpt, almost all members of group two had different opinions with regard to the issue of culture:

S25: Can't we include culture as one factor?

S24: What do you mean by culture?

S25: The way we eat, we dress, we dance…etc.

S24: Do you think these can measure development?

S25: Yes, why not?

S22: But the way we eat, we dance, we get married…etc are also affected by other factors, for instance, the religion we follow, education…etc.

S24: Yes, but religion is also part of culture.

S24: Do you mean, then, religion can measure development?

S25: Well …in this case…

S22: I think we are involving ourselves into quite complex issues. Why don't we simply drop this component?

As can be observed from the above conversations, controversial issues like culture had been raised and discussed. Such issues were only excluded mainly to avoid complications.

On their third day of meeting, one member from group one came ten minutes late. Two members of group two were half an hour late. As I came to understand later, there was a bit confusion in the time of the appointments made on the previous week. Anyhow after some time, the discussion resumed smoothly. They started to discuss each factor at a time. Group one started their discussion on the factor "education".

4.3.1.2 Education

Group one started their discussion immediately. They raised the factor "education" as the first agenda of their debate. Based on the rough assessments they made, they agreed to measure development of education of a given community by taking "the number of schools" in its vicinity in to account. One of the assumptions they made regarding the issue of education includes:

All levels of education have equal contribution in the development of a given community. In other words, they assigned equal weight of ¼ for each level of education (i.e. high school ¼, middle school ¼, elementary school ¼ and kindergarten ¼.).

All members of the group were convinced that there was only one high school in Gejeret, but none of them was so sure about parts of Asmara that do have the maximum or the minimum number of high schools. The group couldn't reach agreement or the same level of understanding regarding the issues of " the location of a given high school" and "the communities that get service from it". The location of a given high school refers to the place where the high school is built; and the communities that get service from it refer to the number of districts around that given high school. According to their argument, in some instances, one high school might be located in a certain district, but it might render service to other district or districts. They argued a lot without convincing one another. But finally, through negotiation, they decided to take the "service rendering" and not the "location" as the main factor of measuring access to education.

In this notion, they chose the district with the highest number of high schools, as having five secondary schools under its vicinity. They also conclude that there are some districts in Asmara, which do not own any high school under their vicinity. These districts, according to their argument, might possibly get service from schools, which are built to render service to other neighboring districts.

The following computations show how the education index was obtained. As usual, S12 was jotting down and the others were actively participating.

Secondary high school: Maximum number of high schools = 5, index = 1
Minimum number of high schools = 0, index = 0
Number of high schools in Gejeret = 1, index = ?

$$5 \longrightarrow 1$$

$$1 \longrightarrow X$$

$$X \Longrightarrow \frac{1 \times 1}{5} \Longrightarrow \underline{X = 0.2}$$

Here, the HDI type of calculation influences the way the calculation is done.

In a similar way, they discuss on determining the maximum and minimum numbers of middle schools, elementary schools and kindergartens. The results obtained as indexes were, 0.5, 0.67 and 0.4 respectively. (See appendix A)

The education index was then computed as follows:

$$\text{Education index} = 1/4(0.2) + 1/4(0.5) + 1/4(0.67) + 1/4(0.4)$$
$$\cong \underline{0.4425}$$

4.3.1.3 Health

The second factor of debate for group one was health. In some instances, group members had differences in views with regard to some issues under discussion. This was evident in the following excerpt:

S12: I think we can measure health only through counting the number of clinics and pharmacies.

S11: We had already agreed on that last week. We should decide now on how much weight should we give to each of them

S13: I think we better give them equal weight.

S12: I don't think this will be fair. I think clinics play more important role in communities' health condition. Though pharmacies are also important, most of them are open to everybody. Moreover, I don't think one can say this particular pharmacy belongs to this community and that pharmacy belongs to another.

S11: Yes more weight, in my opinion 2/3, should be given to clinics and 1/3 weight to pharmacies.

S15: …but pharmacies are also very important indicators of development, you can't get for instance any pharmacy in the far disadvantaged areas, while there are more than enough around the center.

S13: Yes… but in our case, I think clinics must be given more weight. We are measuring how one community gets health service. Health service doesn't mean mere selling of drugs. It includes so many other things.

Finally all of them agreed in S11's suggestion of giving weight 2/3 to clinics and weight 1/3 to pharmacies.

The above excerpt suggests that some decisions made on behalf of the group may not necessary represent or reflects every individual's opinion. For instance, S15 had shown a deviation in his opinion regarding the weight that must be given to clinics and pharmacies. He was not totally convinced by the idea of his colleagues. Despite this situation, a decision had passed in favor of the majority.

Later, in break, when I asked S15 why finally he decided to agree, his response was "well, one must agree with majority". The final average index was computed as follows:

Health index = 1/3(0.25) + 2/3(0.2)

= 0.216

(See appendix A)

The procedures followed by group one when computing the rest of the factors were similar and does imitating the CDI type of calculating do all.

In their final work, the result of the factor income was not included. The group had decided to drop this factor as a result of, according to them, "the complex nature of the factor". We will see later how and why they decided to drop this factor as one means of measuring development of a community.

4.3.1.4 Water Supply

Before deciding how to measure water supply, group one's first attempt was to assess and discuss all water supply means of a given community. After this, they decided to measure this factor on the basis of weekly service. According to the rough assessments they made, there are some districts in Asmara, which get water tap service six days a week. On the other hand, there are also some districts of Asmara, which get water tap service only two days a week. Gejeret, according to the information from S11 and S12 as residents of this district, gets on average five days a week. Having this data as a base, the calculation proceeded as follows:

Water supply → Maximum 6 days a week → index = 1

Minimum 2 days a week → index = 0

Gejeret 5 days a week → index = ?

6 – 2 = 4 → index = 1

$5 - 2 = 3 \longrightarrow \text{index} = X$

$X = 3 \times 1 / 4 = 0.75$

Water supply index = 0.75.

4.3.1.5 Sanitation

Sometimes learners were discussing some issues by taking instances from very familiar contexts. The following excerpt is an evidence of this:

S11: I think the center of the city, around the Cathedral, must be the part of Asmara, which has the best sanitation. It has clean roads, clean public toilets, adequate waste containers (vans), sanitation workers… etc. so, we must take this area as our maximum point.

S14: *Abashawl* must then be an area with the minimum sanitation. (All of them laughed by his comment)

*Abashaw*l is part of Asmara with a lot of slum houses and poor sanitation. Moreover, it is part of Asmara where most local drinks are sold. A lot of people live in a very crowded small area. Residents of Asmara, especially from the old generation, used to call this area as "Abashawl Ade Dika" which means – Abashawl the mother of the poor. *Abashwl* of course is not only known for its poor sanitation. It has a lot of comparably cheap restaurants, and tearooms. Moreover, *Abashawl* is well known in its crowded "Siwa and Me-ess" houses. Siwa is the typical traditional beer in Eritrea. As most of the day labourers and the disadvantaged people live in this area, it seems logical that the students relate this area with poor sanitation. The discussion continued as follows:

S12: If we select these two areas, as our maximum and minimum points, how do we then put these points in a scale between 0 and 1.

S11: Why don't we assign 100% to the maximum point for places around

Cathedral and 0% to the minimum point, may be for Abashawl.

S14: Even in Abashawl, we can find public toilets and waste containers. This area also gets some sanitation services from the municipality of Asmara. In addition to this, residents of Abashawl do have the experience of launching public sanitation campaigns at a given interval of time. So we can't say in general Abashwl has got 0% sanitation services.

S12: you must have come from Abashawl to know all these. (Laugh…. In fact, the researcher came to understand later that S14 lives in Abashawl).

S11: So, why don't we decrease the maximum percentage from 100% to 85% and increase the minimum from 0% to 25%. Gejeret in my opinion has an average sanitation service and it will be fair if we assign 60% to this area.

After all these discussions, they started to compute the sanitation index of Gejeret. As before the techniques of calculation used were imitated from the HDI model.

From the above discussions, we can see how familiarity with contexts helped them to have common understanding and hence facilitate the group task.

4.3.1.6 Income

At first, all of them thought this factor would constitute the main part of their computation. But none of them was able to produce any idea, which could convince the whole group. The following is part of their discussions:

S11: As we all may know, in a given area, there are rich merchants, average government workers and poor labourers.

S13: Yes, but…

S11: Let me finish, For instance in Gejeret, there are some merchants whose monthly income exceeds 20,000 Nakfa. There are also day labourers or housemaids who earn monthly less than 400 Nakfa.

(Nakfa is the legal paper money in Eritrea, it is usually denoted as Nfa)

S13: Let me show you something I have tried at home…

Then S13, By referring to her notebook, tried to show them how she managed to divide the residents of Gejeret according to their income. The following was taken from her notebook:

Residents of Gejeret	Average monthly income in Nakfa
Merchants	3000-5000
Government workers	700, 800, 2500, 3000 (four stratification)
Daily laborers and housemaids	200-500

Before she proceeded to show them how she had obtained the average income, S11 interrupted her. And their conversation continued in the following manner:

S11: Do you have similar data of the areas that we should take as maximum and minimum?

S13: No.

S11: So obtaining the average income of Gejeret alone is meaningless.

S13: Ok, but we can also…

S11: I don't think this factor will have simple measuring mechanism. For instance, if we take the 20,000 Nakfa as maximum income, how many persons do you think earn such income monthly? In different case, one who owns factory at the center of the city might live in Gejeret. So how do you think we can address such complicated issues?

S12: Yes, income is a very complicated factor. We may need more additional time and information even to have very rough estimation.

The dialogue continued, but they never came to a common point, neither did they find "income" easy to measure, as is evident form the following excerpt:

S13: Why don't we take 50,000 Nakfa as the maximum income of an individual in Asmara?

S11: How? We cannot base our work on blind estimation.

S12: Well, suppose a person who owns one big plant lives in Gejeret, do you think then this person would represent any part of the community of Gejeret?

S11: I don't think so.

S13: Ok, why then don't we see the majority?

S11: What do you mean?

S13: As we all may know, most residents of Gejeret are government workers so we can estimate the average income of these people and compare it with other community's average income.

S11: Do you think this will be easy?

S15: How about asking randomly the income of some people from the communities we selected as maximum and minimum, and then take these samples for comparison.

S12: But, how would we know whether these people represent the entire population of the given community?

At this stage the group divided into two, some of them suggest to drop the income factor from the list. Others suggest for some additional time of study. S11, S12, and S15 call for dropping the issue altogether. The following is an excerpt from their conversation:

S11: Our exam is approaching, I don't think we will be able to come with different new ideas next time, so I think it will be easier if we drop the factor "income" from our list.

S15: Estimating the income of a given community is not an easy task; it is very complicated issue.

S12: Yeah, I think everyone of us have understood that there is no easy way of getting complete information. So, I think, it will be enough for us if we take the other factors to complete our assignment.

Finally, the other two members, S13 and S14 also came to agree with this idea and they decided to exclude the factor income from the list.

From the above excerpt, one can understand that "time" was one constraint factor in the completion of the task given. Besides this, one can also understand how learners were expecting readily available information. They were after an "easy way" of getting information.

Procedures and ways of argument of group one and group two were very similar. This paper mainly narrates the work of group one. The same assignment was given to both groups. The following tables give information about tasks of group one and group two.

	Group one	Group two
Given assignment	CDI	CDI
Community taken as target of study	Gejeret	Setanta-oto
Number of components considered	7	4
City	Asmara	Asmara
CDI value obtained	0.5337	0.3900

Table 4.1 contrasts the works of group one and group two.

Comm unity	Educat ion	Healt h	Water supply	Sanitat ion	Commu nication	Transp ortation	Electric supply	**CDI**
Gejeret	0.4425	0.216	0.75	0.5833	0.625	0.2727	0.875	**0.5377**

Table 4.2 the CDI result of group one.

Infrastructure %		Health %		Educ Ation	Health	Infrastru cture	Sanitat ion	Overall CDI
Buil ding	Transp ortation	Clinic	Phar macy	0.33	0.23	0.35	0.66	0.39
50	20	33	20					

Table 4.3 the CDI result of group two.

4.3.2 Data records from interviews

The following discussion is based on the interviews conducted with group one.
Q represents questions by the interviewer.
A-1 and A-2 refer to responses given by student one and student two of group one respectively.

Q: Ok, when you are asked to develop CDI, you tried to measure development using seven indicators or components, why did you choose these indicators?

A-1: We choose these indicators because we thought by using these components; we can complete our task without being involved into more complications.

A-2: In choosing these seven indicators, the first two things we put into consideration were, how easily can data be collected? And how smoothly can we apply mathematical operations to compute these data?

Q: From your explanations, isn't that seems you were interested in the success of collecting data more than any other task? Have you faced any problem in that area?

A-2: Yes, for instance, we tried to include "income" as one component, but soon we faced with the big problem of not getting adequate and enough information.

Q: Why didn't you include the literacy factor of knowledge in computing the index of education?

A-1: We didn't put this factor into consideration. We only consider the contribution of schools as important.

From the above excerpt, we can see that students had some difficulties in collecting data. They were more concerned on "how easily" will the data be collected. This notion had certain influences in the process of selecting community development factors.

On the other hand, most of their mathematical work was based on the HDI's type of calculation. Once they understood how the calculations were done with HDI, they tried to imitate and perform their calculation following the same procedure and strategy. The following excerpt elaborates how rigorously they were imitating the HDI type of calculation.

Q: Let's come back to the computational part, how did you come to measure and compute the community water supply as an indicator of development?

A-2: We tried to measure water supply on the basis of weekly service. How many days a week does a given district gets water supply service? There are some districts in Asmara, which gets taps water only two days a week. On the other hand, there are also some other districts that get the same service for six days a week. By taking these two extremes as maximum and minimum points in a scale, we tried to get an index of the "Gejeret" community, which gets water tap service five days a week.

Q: Ok, you had seven factors of development in your study, and all of them had different units of measurements. How did you then combine these different units?

A-2: We tried to measure each factor in terms of percentages or indexes (between 0 and 1), then the scores of each factor were averaged to get an overall index.

Q: Let's come to evaluate the overall task. When you try to overview the whole picture, where do you think you have started? What have you done? And finally where did you end up you think?

A-2: First a real world problem was given in the form of a word problem. Then, with the help of some strategies we studied earlier, we tried to set up different criteria and made different assumptions, which lead us to the computation of the CDI value. Finally, coming back to the reality we came to understand where Gejeret stands in its way of development in relation to the other communities of Asmara

Q: Ok, what new experience do you think you get from this approach of learning mathematics?

A-1: Yes, for instance, by setting maximum and minimum points for each factor chosen as component of development, and by estimating the exact position of the target community in the range, you can determine its approximate development index. This was a new technique for us. Besides this, the teamwork and the discussions conducted were also new for us.

Q: Where did you get this new method of computation that you have mentioned? I mean about the maximum and minimum?

A-2: Yeah, we got it from the given HDI report.

In most of the cases, decisions were being made on the basis of general group agreements. As it is evident from the following excerpt, "consensus with reasons" had been one of the main tools in resolving disagreements.

Q: Ok, my second question is concerning the sanitation. You took the number 85 as maximum and 25 as minimum, what does these numbers stand for?

A-1: The number 85 is in percentile. We didn't take100 as a maximum score because we thought 100% sanitation is quite impossible or is just an imagination. By the same token, 0% sanitation is also meaningless.

Therefore we agreed to take 85% as a maximum score and 25% as minimum.

Q: Ok, what obstacles did you face while collecting this information and while conducting your task in general?

A-2: Yes, we had certain problems in collecting data. "Where from" was our biggest problem. To solve this main problem, we were being forced to be engaged in long discussions and reach some agreements as means of resolving tensions.

Q: Let me take you back to one of the factors - Education, when you dealt with education as one factor of development, you took four levels: the kindergarten, elementary school, middle school and secondary school by giving each component equal weight of ¼ each. How is this?

A-2: We assumed that each level has equal contribution in educating the child. In a kindergarten, the child learns his first social life, which might have significant influence in his future development. In elementary school, the child gets the basic skills for his future life. The middle and the secondary schools are places, where he can develop his full personality and they are levels of transition for higher education. So we conclude that all levels have equal and important contributions.

Q: Ok, what kinds of sources or equipment do you think would improve or refine your task results?

A-2: This issue was one of the main reasons, which led us to conclude that our work is not reliable enough to be taken as a base for further studies on this area. For instance, when we were trying to investigate the sources of information for electric and water supply, we were not able to find reliable documents that possess the information we need. So we had to agree on the basis of our own assumptions in measuring these factors.

The expectation of readily available information was one of the main sources of frustration. In many occasions, statements like, " I don't think we can find enough sources", " I think every one of us has understood that there is no easy way of getting complete information" etc., indicates how they were expecting readily available sources of information. The following excerpt elaborates the situation more clearly:

Q: Ok, what obstacles did you face while collecting this information and while conducting your task in general?

A-1: Yes, one of the main obstacles was that we were not able to find any written documents, which can give us necessary information or data. This was really a frustrating problem.

Q: Let's go back to your work procedures, what were the actual procedures you followed in collecting data? Was it an individual or teamwork?

A-2: Due to the scarcity of available data, all of us agreed to bring any information or data we could, instead of dividing the task among us. Of course, there was individual sharing of certain tasks. But mostly it was a group task.

Most results of their computation were based on their own assumptions. Some of the assumptions had concrete basis, but some had not. For instance, assumptions like, " In Asmara the number of pharmacies is more than the number of clinics", "Most residences of Asmara use public transportation services" etc… are almost dead sure facts or at least they are reasonable assumptions. On the other hand, if we see some of the assumptions they took, for instance, "The illiteracy rate in Asmara is 0%", they are neither reasonable nor justifiable assumptions. In some instances, learners were using such misleading assumptions. Moreover they were also trying to defend and justify their own assumptions even if they knew they were wrong. Some of the reasons behind such acts could be, to simplify tasks and mathematical operations as much as possible by taking suitable assumptions. This is evident from the following excerpt:

Q: … so, it seems your assumption lacks one important ingredient of knowledge - the literacy. What do you think the effect on the final result would be, had you put this factor into consideration?

A-2: Look, if you see, we took the city of Asmara as our target of study; and we assumed that illiteracy rate in Asmara is almost zero. Even if it is not, it will make insignificant difference. I have no doubt about that.

Q: Therefore your work is done on the base of the assumption that literacy rate in Asmara is 100%?

A-1: Yes

Some of the learners were aware that they were doing or applying classroom learned mathematics. But, for some of them nothing of it was mathematics. This is evident from the following excerpts:

Q: After collecting and sorting out your data, you have used some mathematical calculations. Have you used any mathematics you have learnt in grade ten or lessons of before in your calculations?

A-2: Yes, for instance, we frequently applied the percentile calculations that we had learnt in grade six or seven.

Q: What about in taking the ratios and computing the final CDI's?

A-1: Yes in the final process, while we were computing the overall average of the ratios with different weights, we used some mathematical computations that we still apply them in class.

Q: In your response given earlier, you said the task was given in the form of a word problem. Does it have any similarity with the types of word problems found in your grade ten textbook?

A-2: Well, here the problem is given in the form of statements without any numbers in it. Numbers are included at last in the form of data. But in our text, word problems are given with numbers in them. Our task is simply to add, subtract or multiply these given numbers and come up with an answer.

The following conversation with S24 from group two, which was conducted at break, shows how applying the school-learned mathematics often goes unnoticed.

S24: Teacher, does this assignment have any relationship with mathematics?

Q: Of course yes, why did you ask?

S24: Because none of it seems mathematics

Q: Haven't you come across some calculations, like percentages, ratios, etc?

S24: Ye-es, but… (He was not convinced)

In general learners had shown great interest in-group discussions. Even though they all said this approach was new for them, despite what they say, they really enjoyed it. In their opinion, as it was evident from the following excerpt, tasks of this type which are based on real world situations can't be easily forgotten.

Q: As you said, one of the common barriers when you do your assignment was in relation to the availability of the required data. What other experiences do you think you get?

A-2: Despite of the above-mentioned problem, the group work was a first experience to me. I came to understand that; this is a kind of problem that needs discussion to identify goals before you start to work. Different opinions and different views had been entertained. We had to argue a lot before we come to one conclusion.

Q: Were you familiar with this approach of learning where, mathematics is related to the outside reality, in your present or previous classes? If not how did you find it now?

A-2: I don't think we all had such an experience before. Especially for me, it was really interesting. The objective was also clear and interesting.

Q: How do you evaluate the overall advantages of this approach?

A-1: I think it is good.

4.3.3 Major findings summary of section 4.3

1. Imitating the given model

Providing practice and training in the skills of mathematical modelling by working through a given model as a worked example and then provide further exercise is one of the approaches of teaching mathematical modelling. As stated in chapter one, this study had followed this approach to explore learners' strategies when studying a given model.

In such an approach, when further exercises are given, imitation of the given model is inevitable, though the degree of extent may vary. This was evident in this study. When learners were asked to develop CDI, they were frequently imitating the HDI type of calculation especially when computing the index values.

2. Expectation of readily available information

According to Cross and Moscardini (1985; 81), "mathematical modelling is a hard work, there is no magic formulae and there is no guaranteed route to success". Despite this fact, in this study, learners had shown high expectations of readily available data. Comments made by some learners such like, "I don't think we can get complete information regarding the issue of income", "… it is not easy to get source document" …etc. are clear indications of these expectations. In my opinion, some of the reasons behind such behaviors are related to the lack of experiences associated with mathematical modelling. In regular classes of mathematics, mathematical applications are treated in the form of closed exercises with well-defined equations that demand well-defined answers.

3. Consensus with reasons

Mathematical modelling problems require more than just the ability to solve a set of equations no matter how complex they may be. In many occasions of this study, reasonable assumptions that passed through careful and all rounded judgments of the whole group were being made. For instance decisions regarding the maximum and minimum values of the factor sanitation, the weights that must be given to each level of education, … etc. All these need common agreements and common decisions of the whole group. Many times, learners were being engaged in long discussions and reach certain agreements as a means of resolving tensions.

4. Learners used school-learned mathematical procedures

The experience of tackling open-ended problems and activities provides learners with the opportunity to:

-Use mathematical tools at their disposal in situations where the choices of algorithm and method of solution is not obvious, as is the case in real life,
-Apply mathematics to every day situations and began to appreciate its power and limitations, etc.

(de Lange et-al, 1993; 325)

In this study, school-learned mathematical techniques have been used in many occasions. Some of these are, computing the overall average of ratios, percentiles and others. But as it was evident from the interviews conducted, some of the students were aware that they were applying school-learned mathematics while others were not. In my opinion, the reasons why learners have used school mathematics with or without their awareness could be attributed to the following reasons:

- Subjects of the study were learners; hence, their daily school activity might have an influence.

- The school environment (i.e. the task was given in a school, and by a teacher.) might also have contributions.

5. Distortion of reality

Sometimes, learners were making assumptions that suit their mathematical operation, but distorted reality. The assumption, which states, "the literacy rate in Asmara is 100%" is one typical example.

Chapter Five

Interpretation, Discussion and Conclusion

5.1 Interpretation

As indicated in the methodology, a "conceptual model" of the "emerging activity system" will be constructed to interpret and discuss the findings of the study.

Basically, the work activity of school going learners is *to learn.* However, in this study, groups of learners were found in order to participate in studying a given model collaboratively. Of course one can say in such situation the work of learners has been expanded to include studying mathematical modelling which is not part of the "formal secondary school curriculum" within the context under study. Though studying learners' task in its wider activity context would naturally give clear and complete picture of the whole process, the activity system under study mainly focuses on the selected subjects and the objects they are after with a little reference to the wider context -the school environment.

The existing activity system of school going mathematics doing by learners is the traditional one. Its conceptual model is depicted below:

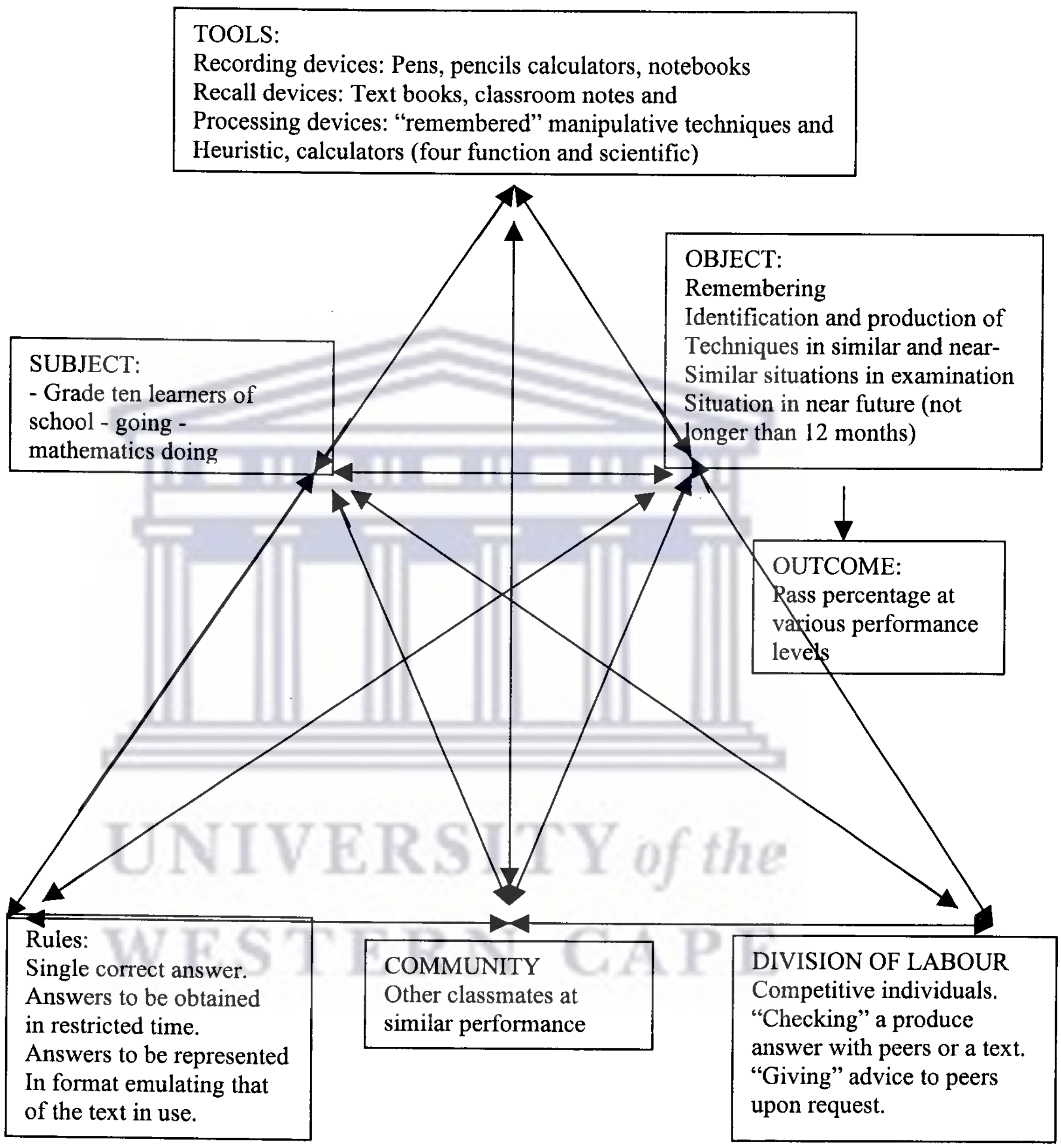

Fig 5.1

The conceptual model of the emerging activity system is depicted below:

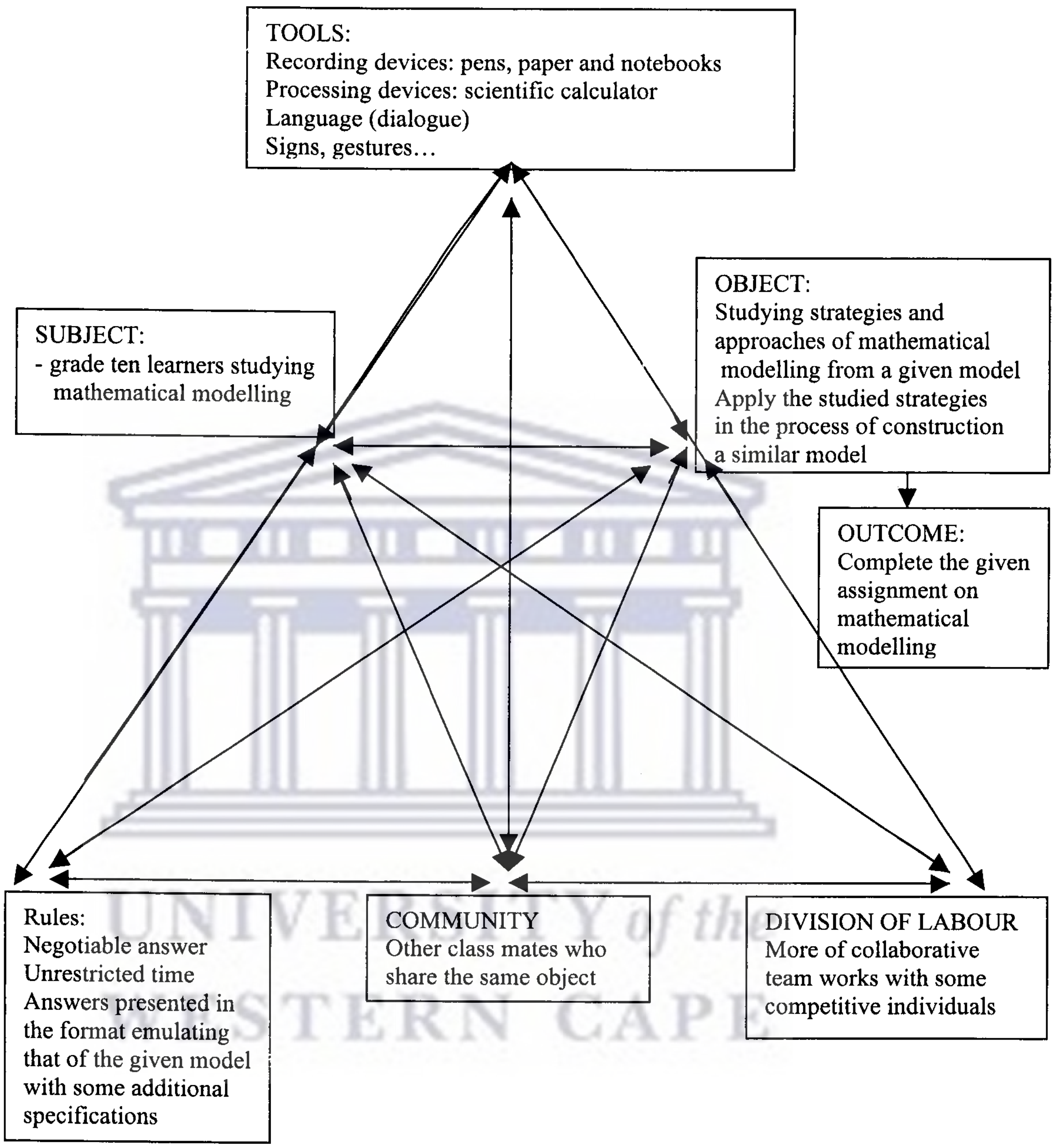

Fig. 5.2

5.2 Discussion

Similarities and differences between the above-depicted conceptual models of activity system are elaborated in the following discussion.

5.2.1 Similarities between the traditional and the emerging activity systems:

1. Subject and community: The two conceptual models share more or less the same "subjects" of study. These subjects are learners of school – going - mathematics doing. In both systems subjects represent other classmates at similar performance level, hence in both systems "community", refers to the same group of learners.

2. Tools: Both systems share similar tools, but the emerging model of activity system includes more. The language used for dialog, the signs and gestures, which represent different activities and meaning, are some of the tools used by the new activity system. Of course, language is also used as a tool in the traditional activity system, but its main function is restricted to mere transmission of facts. This one-way transmission, without the required learners' participation, makes mathematical knowledge to remain as nontransferable property of the educator. But in the emerging activity system, because of the close contact, learners had been observed communicating in a language of gestures.

5.2.2 Differences between the traditional and the emerging activity systems

1. Rules: One main difference that appears between the two systems lies in the explicit and implicit regulations that constrain actions. These are the written and the unwritten rules. For instance, the rule in the traditional system that restrict the answer of a given mathematical problem to be single and correct is not the same in the new model of activity system. Answers in this new system are subject to change depending on different assumptions taken into consideration or different assumptions taken for granted. In this new system, problems are not uniquely solvable, "…the start is the problem and the end is open." (Freudenthal, 1980; 181). As evidenced in this study, answers for the "same problem" given to different groups were "different" or "non equivalent".

In this study, more emphasis has been placed by learners on the mathematical aspect of the given problem, without having a look at the whole picture of the task. This was one indication that they were more interested in "computational security". They were becoming frustrated when they couldn't get the "correct answer". In their prior studies, they know that every given mathematical problem has one correct answer. But in the process of developing the new model, (when they are asked to develop CDI), they had a chance of constructing a problem. In the process of solving the problem they had constructed, they had an opportunity to learn that a given problem might have different answers depending on different assumptions one might consider. They understood how assumptions affect solutions. This was vivid to them when they couldn't reach the desired answer after ignoring some basic assumptions. It becomes clear to them that a solution for a given mathematical modelling problem can be negotiated depending on different assumptions, consensus and requester specifications.

Another difference observed between the two systems, regarding the rule is concerning the "time factor". The rule in the traditional activity system demands the time to be explicitly restricted. All given assignments, home works, class works and examinations have restricted given deadlines. Answers in a given assignment or examination are supposed to be obtained in a restricted time. Thus in most assignments and examinations, all necessary data or information is directly given along with the problem. This was what learners had witnessed. When they were asked about the nature of the word problem in their text, they said that every necessary data or information is given in the problem itself. According to them, the task of the student is to manipulate the given data, interchange the given numbers, multiply or subtract one from the other and then try to get the correct answer. Finally, answers are then compared against the correct ones found at the back of the text or the answers given by the teacher. Learners' adaptation to these kind of mathematical problems, where every bit of information is provided, logically, lead them to expect readily available information, which had been evidenced in this study.

The format of presenting answers was also another difference evidenced in this study. In the traditional model of activity system, answers are represented in the format emulating that of the text in use. In this new emerging system, answers were also presented in the format emulating that of the given (HDI) model, but with some additional specifications and information to justify and convince external users (in this case readers of the report).

The format of representing answers used by learners involved in this study had included the following details:

- Operational definition of terms
- A table which shows summary of data.
- Conclusion which includes the interpretation of the answer given and its' limitations. (see appendix A)

Therefore, the format used to represent responses in the new model of activity system may vary depending on the interest and requisition of the user. But in the traditional model of activity system, responses are represented in the predetermined formats adopted by the text in use.

2. Division of labour: The division of labour in the "traditional" activity system of school going - mathematics - doing learners is based on the competitive nature of individuals. Division of labour mainly refers to distribution of tasks, authority and benefits among learners. In general, the competitive nature of individuals lead to an individual oriented tasks and goals. In such situations cooperation and teamwork are not motivated. This is evidenced in the traditional classroom situation where learners are unwilling to share their views and unwilling to show the details of their work to their colleagues. They are only willing to give advice upon request and they wish to check their final answers with peers or a text.

The division of labour in the new emerging activity system was mainly based on collaborative teamwork. Even though in some instances the influence of the traditional system was clear, in most of the times, learners were willing to share and collaborate in every activity at the level of their capacity. The influence of the traditional system was evidenced in some rare instances when individual learners favor individualistic and competitive character. Competitions and rushing of learners have been observed and recorded when they were doing some mathematical computations. These observed characters explain the deeply rooted competitive behavior of learners in the traditional system.

Besides the above situation, where learners had been observed to compete with each other, collaborative teamwork had also been observed in the phases of data gathering, and processing of data. "Consensus with reasons" was one of their main tools of passing group decisions. Long dialogues had been used as techniques of solving disagreements and as a means of choosing among alternative ways of reaching the final solution.

3. Object and outcome: The object determines the horizon of possible goals and actions. These goals and actions function as the motive force deriving the activity system. The objects of an activity system vary depending on the subjects who construct these objects. One major object of learning in the traditional model of activity system is "remembering". Even though one can say "objects" of a system are not fixed and clearly defined, in the traditional activity system, " remembering" is an object of learning where most learners desire what they are after. Another object of learning in the traditional activity system is " identification and representation of techniques in similar and near-similar situations -in examination situation in near future (less than a year)". These objects of activity are oriented towards a particular goal and are transformed to produce an outcome. The outcome, which is closely related to these objects, is "pass percentages at various performance levels". Thus the object of an activity system is the "raw material" to which the activity is directed - the outcome.

The object and outcome in the new emerging activity system were quite different from that of traditional one. One "object" of learning in this new activity system was "studying the strategies and approaches of mathematical modelling from a given model". The second "object" is "applying the strategies and approaches in the process of construction a similar model. Both objects were oriented towards the completion of the given assignment on mathematical modelling as their "outcome".

5.3 Conclusion

Is mathematics really a human activity? How do curriculum designers, educators and learners view mathematics? Different scholars and educators view mathematics as a tool for some activity. Some also view mathematics as a distinct subject that doesn't have any relationship with activity. Still others view mathematics as an activity by itself. For those scholars, who view mathematics as an activity, mathematics means "not only a stock, the result of some activity, but also the activity itself" (Freudenthal, 1980; 3). These different views and beliefs held by different scholars and mathematicians have certain effects in the strategies and approaches that need to be adopted in teaching-learning mathematics.

The main objective of this study was not to investigate different views of educators or curriculum designers regarding the relationship between activity and mathematics. Its main focus was to explore strategies and approaches, grade ten learners in Eritrea use when studying a given mathematical model. I raised the above issues because I believe that views held by curriculum designers and educators do affect positively or negatively the existing system of education in general and to the teaching learning process in particular. Past researches confirm that learners imitate and apply what they had seen and learnt in class. As a result, their conceptual knowledge and skills, including the strategies and approaches they used to solve mathematical problems, greatly depends on activities done in the classroom.

The strategies and approaches used by learners to solve mathematical modelling cannot be viewed in isolation from the above situation. The result of this study partially revealed the truthfulness of the above arguments. The existing "traditional" activity system had great influences in the performances of learners. This doesn't mean that learners were not applying new approaches in their work, when confronted with new situations. They do. This was evident from findings of this study. The restrictive nature of the traditional activity system and the ever increasing demands and expectations of society from education necessitates the emergency of new activity system. Through reflection of the analysis of findings of this study, it seems possible to identify some basic facts that give strength to the above argument. The researcher's overall views and comments are also included.

- Learners show lack of understanding in visualizing the whole picture of the given problem. This was quite vivid especially at the early stage of the study, when they were studying the given model. During this time, they took very little care for reading and rushed for computational securities by plugging numbers into equations without having thought the basic notion of the question asked. It could be argued that such problem is related to the traditional step-by-step methods of teaching. This step-by-step teaching method, which is widely practiced in secondary school mathematics lessons, doesn't give the required emphasis to the whole picture of a given problem. What teachers usually do, when using this approach, is to break the given problem in to bits of steps in a procedure, which finally will be integrated to give a solution. This method might have its own advantage and I am not saying it is not appropriate in teaching mathematical modelling. Depending on the particular nature of the given problem, methods of solving a problem may vary, but generally, in this step-by-step approach, learners tend to memorize sets of procedures rather than acquire a process of solving a given problem. I think it could be this attitude of learners, which influences them to view mathematical modelling as a procedure. In this view, learners focus on the completion of each step without paying much attention to the whole process.

- Learners had a problem of data gathering both in quality and quantity. I think the reason for this problem lies partially in the unsystematic and uncoordinated methods of searching information. In traditional classrooms, learners are given detailed information with each given problem. The "expectation of readily available information", that had been observed during this study might be the result of this situation.

- Some learners preferred individual work than collectively. In the traditional teaching approach, where the role of teaches is limited to mere transmission, learners are rarely engaged in discussions or group interactions. This type of teaching approach tends to restrict learners from participation. In other words, individual work is encouraged. Some of the learners in the study were hesitant to share their ideas and views with their colleagues. They were also reluctant to show the details of their work. Such behaviors could be related to the fact that learners are accustomed to non-collaborative individual work.

The following facts were also results of observation:

1. Learners applied school learned mathematics, which often goes unnoticed, that is, learners were often not aware that they were applying it.This could be

because of:

- The mathematical contents they used were below their grade level,
- The non-mathematical context of the given problem might also have an influence.

2. Both groups chose familiar setting context that makes sense to them. This facilitated communication among the group and afforded them the opportunity of making sense and understanding the problem that they were dealing.

3. Both groups show slow progress at the early stage of the given task.

- There were more interventions (by the researcher) at the beginning stage of the task, and this was to:
- Explain instructions,
- Explain meaning of words,
- Explain unclear concepts etc.

4. Interventions of the researcher reduced with the progress of the task.

5. In both groups there was at least one student who was prepared to take the initiative by suggesting opinions towards tackling the problems at hand.

The following were the stages of activities followed when learners were asked to develop a similar model.

- Decide on variables and formulation of equation,
- Decide on methods of computation,
- Performing computations,
- Making sense of the answer obtained (interpretation).

5.4 Recommendations

- "Mathematical modelling is a form of real world problem solving" (Swetz and Hartzler 1991; 6). It is really a type of problem solving that learners do in class. Its main difference is that in mathematical modelling, "the phenomenon that is seemingly non mathematical in context must be modelled" (Swetz and Hartzler 1991; 2). The *project-work,* which is presently practiced in our secondary schools, can be used as a steppingstone to introduce mathematical modelling problems in our secondary school syllabus; or at least it seems possible and worth testing. Of course in the future, it can be incorporated in the curriculum in many other different ways. The result of this study seems to be encouraging in that it gives concrete evidence that learners can do mathematical modelling problems along with their regular classes (the same as project works).

- One of our new educational policies is to prepare young Eritreans who will function confidently in the national reconstruction and development program. Mathematical modelling is an approach, which exactly fits this ultimate goal of education. And it is my believe that the changes and developments that are being conducted recently concerning the curriculum of our secondary schools will consider this issue along with some other similar important ones.

- One deriving tool of educational development is research. The role of research in education is multidimensional. But to me researches that focus on teaching and learning process at classroom level are most important. It is the researcher's belief that future researches that will be made to insure the continued improvement of mathematics education will focus and give more emphasis to the problems that are presently encountered in our mathematics classrooms. With this notion, the researcher hopes that the experience and discussions of related literature in this study will serve as a steppingstone for future researches that will be made in the field of mathematics education.

The following are some suggestions on the basis of this study for school mathematics teachers who may intend to incorporate mathematical modelling at classroom level.

1. Select appropriate mathematical modelling problems. This should take the following facts into account:

a) Learners' level of mathematical knowledge,
b) Learners' familiarity with setting context.

2. Allow time for discussion before any work on the given problem begins. This should include:

a) Discussion on the meaning of key terms in the problem,
b) General discussion on the whole essence of the problem,
c) Give learners guiding points to follow stages of mathematical modelling (with out imposing).

3. Make sure that learners do not skip the *discussion* and *exploration* stages

4) Allow time for:

a) Presenting reports,
b) Reflections on what have been done. This should include discussions, interpretations and justification of solutions and exchange of experiences.

In the process of teaching mathematical modelling, the teacher must play a role as a *facilitator*. In this role she/he is expected to intervene in such away as to insure that learners should not stagnate at a certain point. In this approach, Slater (1994;

106), learners "will discover maths rather than being taught".

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Appendix

Appendix A

Date 30-1-01

Assignment Group 1

1

ተዳለወ ብ

1. ጎይቶም ተኽለማርያም 10^{10}
2. ኣለመሰገድ ሃይሉ 10^{12}
3. ሚልዮን ገብረእግዚኣብሔር 10^{9}
4. ዳንኤል ተስፋ 10^{11}
5. ጸጋብ ተወልደ 10^{12}

COMMUNITY DEVELOPMENT INDEX (CDI)

እዚ CDI ብናትና ንገጠራት ዝተገልጸ ክፍሊ ዝተዳለወ እዩ።

→ ስለምንታይ CDI ንደሊ?

CDI ንምፍላጥ ለውጢ ዘመልክቱ ምዕባለ ናይ ሓደ ሕብረተሰብ ኣብ ምንታይ ደረጃ ኣሎ ንምምዛን ዝዳለው እዩ።! ገለ ካብቲ ቀንዲ ኣገዳስነቱ ድማ ፦

1. ጸገማትን ሕጽረታትን ናይቲ ሕብረተሰብ ንምፍላጥ፡ ብኡኡ ኣቢልካ ድማ እቲ ጸገማት ዝኣለዎ ክም- ፈውን እቲ ሕጽረታት ዝወገደሉ መንገድታት ብሓባር ንምግባር!!
2. ጽሉዋት ጉድኣታት ናይቲ ሕብረተሰብ ንምድህሳስ፡ ዝዕቀበሉ መንገዲታት ንምንዳይ!!

→ CDI እንታይ ዓይነት ረቛሒታት የጠቓልል?

- CDI ከከም ኣድላይነቱ ዝፈላለዩ እንተኾነ፡ ንሕና ግን ነዚም (ዝኣዓሉ) ሸውዓተ ረቛሒታት ኣብ ግምት የእቲና ኣለና!! ትምህርቲ ; ጥዕና ; ቀረብ ኤለክትሪክ; ቀረብ ማይ; ጽሬት; መራኸቢታት (communication); መጓዓዝያ።

- ትምህርቲ ፦ ዝዕቀኑሉ ብህላወ ናይ ካልኣይ ደረጃ ቤት ትምህርቲ ($\frac{1}{4}$ weight); ማእከላይ ደረጃ ቤት ትምህርቲ ($\frac{1}{4}$ weight); መባእታ ቤት ትምህርቲ ($\frac{1}{4}$ weight) ን፡ መጥፍኣ ሃይምነት ($\frac{1}{4}$ weight)
- ጥዕና ፦ ዝዕቀኑሉ ብህላወ ፋርማሲን ($\frac{1}{3}$ weight) ክሊኒክን ($\frac{2}{3}$ weight).
- ቀረብ ኤለክትሪክ ፦ ዝዕቀኑሉ ብብዝሒ ናይ ጎደና መብራህቲን ($\frac{1}{3}$ weight)፡ ህላወ መብራህቲ ኣብ ነብሲ ወከፍ ገዛን ($\frac{2}{3}$ weight)
- ቀረብ ማይ ፦ ዝዕቀኑሉ ብማይ ክንደይ መዓልቲ ኣብ ሰሙን ይረክቡ።
- ጽሬት ፦ ብሓፈሻዊ ጽሬት ናይቲ ከባቢ ይዕቀን፡፡ ሓደሽቲ ጽሬት ዝምልከቱ ነገራት፦ ኣጽራይቲ ጉድጓዳት! ሽቓቕ! ገንዘባትን መንጸይን ናይ ጎሓፍ ኣለዎዶ ወይስ የብሉን?
- መራኸቢታት ፦ ብዝርጋሐ መርበብ ቴሌፎን ይዕቀን!!
- መጓዓዝያ ፦ ብብዝሒ ታክሲታት፡ ኣውቶቡሳትን ሚኒባሳትን ናብቲ ክፍሊ እንዳተመላለሱ ኒት ...

ሕብረተሰብ ኣገልግሎት ዝህብ ደፂቐን!!

→ ስለምንታይ ኩሎም ስድራቤታት ሬድዮታት ዘይብሎም?

ኩሎም ስድራቤታት ሬድዮታት ንኽህልዎም ገለ ሬድዮታት ኣዝዮም ክቡራት እዮም ; ኩሎም ከኣ ንስድራ ዝኸውን ዘይኮነ ብዙሕ (ማለት CD ንምፅዋት) ንምውሳድ የኽእሉ'ዮም!! ንብረቶም ግና ንምውሳድ ዝኽእሉ ኣታዊ (income) የብሎምን!! ግን ብሕብረት ሓገዝ ክወሃቦ ይደሊ እዮም!!

ገለ ግዜ ዘለው ሬድዮታቶም ንጥርናፍ ይኽእሉ'ዮም, ግን ፈለማ ክንጥቀመሉ'ሞ ክልና ዓቢ ምዕባለ ዓዲ ሕብረተሰብ ብንፁር ክገልፁ ስለዝኽእሉ ተፈልዮም ንውልቐም መሪሖም ኣለው!!

→ ኩሎም ሬድዮታት ብኽመይ ይሰርሑ?

* ትምህርቲ

1\. ካልኣይ ደረጃ ቤት ትምህርቲ — ዝለዓለ – 5 → 1, ዝተሓተ – 0 → 0

ጉጅለ 1 ካልኣይ ደረጃ ቤት ትምህርቲ ትውዳእ!!

$$\begin{matrix} 5 \rightarrow 1 \\ 1 \rightarrow S \end{matrix} \Longleftrightarrow S = \frac{1}{5} \Longleftrightarrow S \rightarrow 0.2$$

2\. ማእከላይ ደረጃ ቤት ትምህርቲ — ዝለዓለ – 2 → 1, ዝተሓተ – 0 → 0

ጉጅለ 1 ማእከላይ ደረጃ ቤት ትምህርቲ ኣለዎ!!

$$\begin{matrix} 2 \rightarrow 1 \\ 1 \rightarrow J \end{matrix} \Longleftrightarrow J = \frac{1}{2} \Longleftrightarrow J \rightarrow 0.5$$

3\. መባእታ ቤት ትምህርቲ — ዝለዓለ – 3 → 1, ዝተሓተ – 0 → 0

ጉጅለ 2 መባእታ ቤት ትምህርቲ ትውዳእ!!

$$\begin{matrix} 3 \rightarrow 1 \\ 2 \rightarrow E \end{matrix} \Longleftrightarrow E = \frac{2}{3} \Longleftrightarrow E \rightarrow 0.67$$

4\. መቕፀሊ ህፃናት — ዝለዓለ – 5 → 1, ዝተሓተ – 0 → 0

ጉጅለ 2 መቕፀሊ ህፃናት ኣለዎ!!

$$\begin{matrix} 5 \rightarrow 1 \\ 2 \rightarrow K \end{matrix} \Longleftrightarrow K = \frac{2}{5} \Longleftrightarrow K \rightarrow 0.4$$

$$\Rightarrow \frac{1}{4}(0.2) + \frac{1}{4}(0.5) + \frac{1}{4}(0.67) + \frac{1}{4}(0.4)$$

$$\frac{0.2 + 0.5 + 0.67 + 0.4}{4} = \frac{1.77}{4} \Rightarrow 0.4425$$

ትምህርቲ → $\underline{0.4425}$

* ጥዕና

1\. ፋርማሲ — ዝለዓለ – 8 → 1, ዝተሓተ – 0 → 0

ጉጅለ 2 ፋርማሲ ትውዳእ

$$\begin{matrix} 8 \rightarrow 1 \\ 2 \rightarrow F \end{matrix} \Longleftrightarrow F = \frac{2}{8} \Longleftrightarrow F = 0.25$$

2. [illegible] — ዝለዓለ — 5 → 1 ; ዝተሓተ — 0 → 0.

[illegible] 1 [illegible] [illegible].

$5 \to 1$
$1 \to c$ $\iff c = \frac{1}{5} \iff c \to 0.2$

$\frac{1}{3}(0.25) + \frac{2}{3}(0.2)$

$\frac{0.25 + 0.4}{3} = \frac{0.65}{3} = \underline{0.216}$

[illegible] $\to \underline{0.216}$

* ቀሊል [illegible]

1. [illegible] — ዝለዓለ — 100 → 1 ; ዝተሓተ — 20 → 0

[illegible] 70.

$100 - 20 = 80 \to 1$
$70 - 20 = 50 \to L$ $\iff L = \frac{50}{80} \iff L = \underline{0.625}$

2. [illegible] — ዝለዓለ − 120 → 1 ; ዝተሓተ − 80 → 0

[illegible] 120 → 1

$\frac{1}{3}(0.625) + \frac{2}{3}(1)$

$\frac{0.625 + 2}{3} = \frac{2.625}{3} = \underline{0.875}$

ቀሊል [illegible] $\to \underline{0.875}$

* ቀሊል [illegible] — ዝለዓለ $\frac{6}{7} \to 1$; ዝተሓተ $\frac{2}{7} \to 0$

[illegible] $\frac{5}{7}$.

$\frac{6}{7} - \frac{2}{7} = \frac{4}{7} \to 1$ $\iff w = \frac{3/7}{4/7} \iff w = \frac{3}{7} \times \frac{7}{4} = \frac{3}{4} = \underline{0.75}$
$\frac{5}{7} - \frac{2}{7} = \frac{3}{7} \to w$

$\iff$ ቀሊል [illegible] $\to \underline{0.75}$

* [illegible] — ዝለዓለ — 85 → 1 ; ዝተሓተ — 25 → 0

[illegible] — 60.

$85 - 25 = 60 \to 1$
$60 - 25 = 35 \to x$ $\iff x = \frac{35}{60} \iff x = \underline{0.5833}$

→ [illegible] $\to \underline{0.5833}$

* [illegible] — ዝለዓለ → 100 → 1 ; ዝተሓተ — 20 → 0

[illegible] 70.

$100 - 20 = 80 \to 1$
$70 - 20 = 50 \to c$ $\iff c = \frac{50}{80} \iff c = \underline{0.625}$

[illegible] $\to \underline{0.625}$

* መጓዓዝያ — ዝለዓለ – 80 → 1, ዝተሓተ – 25 → 0.

ገጠር 40

$80 - 25 = 55 \rightarrow 1$

$40 - 25 \Rightarrow 15 \rightarrow T \iff T = \frac{15}{55} \iff x = 0.2727$

መጓዓዝያ → 0.2727

	ትምህርቲ	ጥዕና	ቀረብ-ኤለክትሪክ	ቀረብ-ማይ	ቁጠባ	መራኸብቲ	መጓዓዝያ	Community Development Index (CDI)
ገጠር	0.4425	0.216	0.875	0.75	0.5833	0.625	0.2727	0.5377

→ መደምደምታ

ብዚ ዝወሃደናዮ መዐቀኒታትን ረቛሒታትን፡ ዝሓለፍናዮም መስርሕታትን ምርኩስ ብምግባር ገጠራት ኣብ ማእከላይ ደረጃ ምዕባለ ትርከብ፡፡ ወፍሪታትን ደገፍ ምልዕዓል ሓገዛታትን ክገብሩ ክርድኡ ኣለዎ ዘድልዮ፡፡ ብዚ መሰረት ገጠራት ኣብ ዝለዓለ ደረጃ ምዕባለ ክትበጽሕ ገና ነዊሕ ጉዕዞ ይጽበያ ኣሎ፡፡

→ N.B.

- እዚ CDI እዚ ንዝኾኑ ደቂቕ ጉዳያት ዕላማ (ከም መወከሲ ንመንግስታዊ ደቂቕ ማሕበራዊ ረብሓ) ኣይገልጽን፡፡ ምኽንያቱ ብሓፈሻዊ ገምጋም ይትግበር ብኣካል ዝበለ መዐቀኒ ዝተዳለወ ስለዘይኮነ፡፡ ተዳለወት

29/01/2001

Assignment Group 2.

1. የዕሬቋስ - ኝገፌሶ - 10^7
2. ሐበን - ጲሄሎ - 10^6
3. ተመሰገን - ተኝገቄ - 10^{10}
4. ዴርጋችለው ደብሩ - 10^8
5. ኦምጸ - ኦእፎጠ - 10^5

ስለምንታይ CDI ተደልዩ:

- ነቲ ምድላው ዓሌት ሓበሬታ ሰብ ንምርካብ
- CDI እንታይ የጠቓልል:
- ትሕቲ ቀርኒ : ትምህርቲ : ፓይናን ፋርዮታን የጠቓልል
- ትሕቲ ቀርኒ ኣብ ክልተ ይምቀል ህንጻ (½) : መጓዓዝያ (½)
- ትምህርቲ ብቑጽሪ ዓዩ ክልቲ ይረኣ ቤት ትምህርትታት
- ፓይና ኣብ ክልተ ይምቀል : ብቑጽሪ ዓዩ ክሊኒክ (⅓) : ብቑጽሪ ዓዩ ~~[illegible]~~ ፋርማሲ (⅔):

ስለምንታይ ኣርባዕተ ረቛሒታት ፓሀዩ

- ምኽንያቱ ዓዩ ክልቲ ሓበሬታ ኣርክብ ስለዘይተኻእለ ክምኡ ውን ኣዛም ኣርባዕተ ረቛሒታት ብ ክሪቅንሞ ስለዘኽእሉ ኢልና ስለ ዘገመትና::

- CDI እንታይ ኢዩ ፓቅሙ:
- ዓ ገዛት ንምዕቃብ ቀዳምነታት ክንስርዕ የኽእለና::
- እቲ ሓበሬታ ኣብያናይ ይረኣ ከምዘሎ ንምፍላጥ::

ስለምንታይ ኣብ ትምህርቲ ቁጽሪ ዓዩ ክልቲ ይረኣ ፕሮዮ መረጽና:

- ምኽንያቱ መበገሲ ብትምህርቲ ኣብ ከተማ ንስመራ ኣብ ኩሉ ብዙሓትን ብመዓልቲን ስለ ዘለዉ ፣ ሬ ዓዩ ክልቲ ይረኣ ምርጫን ተመሃሮ::
- ስለምንታይ ኣብ ትሕቲ ቀርኒ መጓዓዝያን : ቁጽሪ ህንጻን መረጽና: ኣብ ስሉሕ ክፍላይ ስለዘየቐመጡን ንኣዋቓሪታትን :መኪና
- መጓዓዝያ ሰብ ብኣዋቓሪት ስለዘየቕም ዓብ ስሉሕ
መረጽና::
- ቁጽሪ ዓዩ ህንጻ ዘመልክት ምኽንያት ቁጽሪ ህንጻ መልክዕ ዓዩ ክፍሊ ስለ ዘሕለ ክልቲ ከ
እቲ ህንጻ ቁጽሪ እንታይነቶ ቁጽሪ ኣገልግሎት ይህብ::
- ስለምንታይ ክሊኒክ ⅓ , ንፋርማሲ ⅔
- ፋርማሲ ክሊኒክ ስለ ዘሎ : ምኽንያቱ መድሃኒታት ሰብ ኣብ ክሊኒክ ተሓኪሙ ኣብ ፋርማሲ ብ
መድሃኒት ክገዝእ ስለዘኽእል::

ስለምንታይ ቁጠት መዐቀኒ መረጽና:

- ምኽንያቱ ቁጠት ኣደ ፓይና ስለዘየገልግል: ብዙሕ ሰብ ንኣኡ ምጥቃም ኣይክእልን እንደኾነ ቁጠት ኣሎ
- ቁጠት ክኸውን ምልክዕ መምዘኒ ዓዩ ሓበሬታ ስለ ዘይኮነ::

ዝተወሰኑ ሓበሬታት ብዝተወሰኑ መቐነታት ከመይ ገይርና ተጠቒምናሉ:

- መብዛሕትኡ ነዚ ተመሓሪ ዝለዓለን ተመርጸ ኢና ስሌጣኖ ዘሎ
- ብዚ መረጽናዮ ዘለዉ ረቛሒታት መቝጸሪ መረጺና ዘሎ ቦታ ስታንዳርድ ይምክሪ ኣሎ
ኢዩ::
- [illegible]
[illegible]

- ዓዩ መልክዕ ህንጻ ዝተሓተ 1 ዝለዓለ ክሳብ 5 ኢዩ
- ዓዩ መጓዓዝያ ብቑጽሪ ዓዩ ኣዋቓሪትን ወዲኒቦን ዝለዓለ መጠን 20 ዝተሓተ ክሳብ 4 ኢዩ::
- ትምህርቲ ክሳብ ዝለዓለ ክልቲ ይረኣ ዘለዎ ቦታ መጠን 3 ዝተሓተ ዘለዎ (ዘይብሉ) 0 ኢዩ::
- ፓይና ክሳብ ዝለዓለ ክሊኒክ ዘለዎ 3 ዝተሓተ ክሳብ 0 ኢዩ::
- ዓዩ ፋርማሲ ዝለዓለ 10 ዝተሓተ ክሳብ 0 ኢዩ::

[illegible]

(1) [illegible]

(2) [illegible]

$5 - 1 = 4 = 1$

$3 - 1 = 2 = x$

$x = \frac{2}{4} = 0.5 = \underline{\underline{50\%}}$

(5) [illegible]

$20 - 4 = 16 = 1$

$7 - 4 = 3 = x$

$x = \frac{3}{16} = 0.18 = 0.20 = \underline{\underline{20\%}}$

(2) [illegible]

$3 - 0 = 3 = 1$

$1 - 0 = 1 = x$ $\quad x = \frac{1}{3} = 0.33 = 33\%$

(3) [illegible] $\frac{2}{3}$ [illegible]

[illegible] $\frac{1}{3}$ [illegible]

(a) [illegible] $= 10$ [illegible] $= 0$

$10 - 0 = 10 = 1$

$2 - 0 = 2 = x$ $\quad x = \frac{2}{10} = 0.2 = \underline{\underline{20\%}}$

(b) [illegible] $= 3$ [illegible] $= 0$

$3 - 0 = 3 = 1$

$1 - 0 = 1 = x$ $\quad x = \frac{1}{3} = 0.33 = \underline{\underline{33\%}}$

(4) [illegible]

[illegible] $= 3$ [illegible] $= 0$

$3 - 0 = 3 = 1$

$2 - 0 = 2 = x$ $\quad x = \frac{2}{3} = 0.66 = \underline{\underline{66\%}}$

[illegible]

$$\frac{0.35 + 0.33 + 0.23 + 0.66}{4} = 0.39 = \underline{\underline{0.4}}$$

[illegible] %	[illegible] %	[illegible] %		[illegible]	[illegible] %	index ([illegible]) [illegible]	[illegible]	[illegible]	[illegible]
		[illegible] %	[illegible] %						
50 %	20 %	33%	20%	66%	33 %	0.23	0.35	0.33	0.66

Appendex B

ቃለ መጠይቕ ምስ 2 ተመሃሮ 2ይ ጉጅለ

ሕ. መጀመርያ ሽምክን ክፍልኽን ደ ምገለጽክለይ ?

መ. ሽመይ፡ ይርጋኣለም ደበሳይ ይብሃል። ክፍለይ 10 -8

ሕ. ጽቡቕ፡ ኣብዚ ተዋሂቡኩም ዘሎ ናይ «ኮሙኒቲ ዕቤት» ኣርእስቲ ኣዮኖት ረቋሒታት ኢኹም መሪጽኩም ዘለኹም ?

መ. ሓደ ጽሬትዩ 2ይ ትምህርቲ 3ይ ጥዕና 4ይ ክኣ ትሕተቅርጺ

ሕ. ነዞም ኣርባዕተ ረቋሒታት መምረጺኹም እንታዩ ? እቲ ምኽንያት

መ. ሕራይ ንኣብነት ትሕተ ቅርጺ እንተወሲድና ኣብ ክልተ መቒልናዮ። እቲ ሓደ ጽባቐ ናይ ገዛውቲ እቲ ካልኣይ ክኣ ትራንስፖርት።
- ጽባቐ ገዛውቲ ነቲ ሕብረተሰብ ብሓፈሻ ብተዘዋዋሪ ብጽቡቕ ድዩ ብሕማቕ መነባብሮ ከንጸባርቐልና ይኽእል'ዩ ኢልና ስለዝገመትና እና ወሰድናዩ።
- ትምህርቲ ኸኣ ኣብ ዕቤት ሕ/ሰብ ወሳኒ ተራ ስለዝጻወት ከምኡውን ጥዕናን ትሕተቕርጽን ብተመሳሳሊ ምኽንያት መሪጽናዮም።

ሕ. ትምህርቲ ኣብ ዝብል ረቛሒ ጥራሕ 2ይ ደረጃ ኢኹም ኣብ ግምት ኣእቲኹሞ ዘለኹም፡ ስለምንታይ ?

መ. ምኽንያቱ መባእታ ኣብ ኩሉ ሰፈር ስለእንረኽቦ 2ይ ደረጃ ግን ውሑድን ኣብ ዝተወሰነ ከባቢ ስለዝርከብን።

ሕ. ሕራይ ሽምካን ክፍልኻንዶ ምገለጽካልና

መ. ሽመይ ዬሲያስ ክፍሉ ክፍለይ ክኣ 10 - 7

ሕ. ሕራይ ዬሲያስ ነዚ ሕጂ ይርጋኣለም ክትገልጸለይ ዝጸንሕት ኣገባብ ኣመራርጻ ረቛሒታት ዕቤት ሓደ ሕብረተሰብ ብቑዕ ኣገባብ እዩ ኢልካዶ ትግምት ?

መ. እወ ብቑዕ እዩ ኢለ እየ ዝግምት።

ሕ. ካልኦት ዝሓሹ ረቛሒታት ክህልዉ ኣይምኽኣሉንዶ ዋላስ እዚኣቶም እኹላት'ዮም ?

መ. ንሕና ነዚኦም እዩ ብቑዓት ኢልና መሪጽናዮም ዘሎና። ምናልባት ካልኦት ዝሓሹ ክህልዉ ይኽእሉ ይኾኑ።

ሕ.   ማለተይሲ እዞም መሪጽኩም ዘለኹም እቶም ዝበለጹ እዩም ኢልኩም ዲኹም መሪጽኩሞም ዘለኹም ዋላስ ካልኣት ምኽንያ ኣለኩም ?

መ.   እወ ካልኣት ረቛሒታት ኣብዚ ዘየጠቓለልናዮም ክህልዉ ይክኣሉ እዮም። ነዚኦም ዝመረጽናዮም ሓበሬታ ብቐሊሉ ክንረኽበሎም ስለእንኽእል'ዩ። ካልኣት ረቛሒታት እንተወሲድና ሓበሬታ ኣብ ምርካብ ክንሽገር ንኽእል ኢና።

ሕ.   ሕራይ ነዞም 4 ረቛሒታት መሪጽኩም ክትሰርሑ ከለኹም እንታይ ጸገማት ኣጋኒፉኩም ?

መ.   ገለ ካብዞም መሪጽናዮም ዘሎና ረቛሒታት እቲ ናቶም ዝለዓለን ዝተሓተን ደረጃታት ኣብ ምፍላጥን ኣብ ምውሳንን ንሽገር ኔርና።

ሕ.   ሕራይ ይርጋኣለም ነዚ ክጠቕሶ ዝጸንሐ ሽግራት ብኸመይ ፈቲሕኩሞ ብኸመይ ተሰማሚዕኩም ሰሪሕኩሞ ?

መ.   እወ ቁሩብ ዘሸገረና ንሱ ኔሩ ድሓር ግን ነቲ ዝለዓለን ዝተሃተን ገሊኡ ኣብቲ ቦታ ኬድና ዝቑጸር ቆጺርና እቲ ካልእ'ውን ኬድና ሓፈሻዊ ግምት ወሲድና ተረዳዲእና ሰሪሕናዮ።

ሕ.   ሕራይ ዬሲያስ ነዞም ረቛሒታት ክትወስዱ ከለኹምን ኣብ ምዕቃኖምን ሓደ ሓደ ከም ውሁብ ዝወሰድኩሞ ነገራት ኣሎዶ ? እስከ ጥቐሰላይ ?

መ.   እወ ሕጂ ከምቲ ቅድም ዝጠቀስናዮ ኩሉ ከባቢ ኣስመራ ናይ መባእታ ደረጃ ትምህርቲ ከምዝርከብ ወሲድናዮ።

ሕ.   ሕራይ ዳታ (ኢንፎርመሽን) ክትእኩቡ ከለኹም ዝተጠቐምኩምሉ ኣገባባት እስኪ ግለጹለይ ?

መ.   (ዬስያስ) ሕራይ ንኣብነት ኣብ ጥዕና ቁጽሪ ናይ ክሊኒካትን ፋርማስታትን ቆጺርና። ከምኡ'ውን ኣብ ትምህርቲ ቁጽሪ ሃይስኩልስ ወሲድና እዚ እቲ ክቑጸር ዝከኣልዩ። ካልኣት ንኣብነት ከም ጽሬት ዝኣመሰሉ ረቛሒታት ክንዕቅኖም ባዕልና ደረጃታት ሰሪዕና ነጥቢ ሂብናዮ ማለት'ዩ።

ሕ.   ብድሕርዚ'ኸ እንታይ ጌርኩም ነቲ ዝተኣከበ ዳታ ?

መ.   (ይርጋኣለም) ብድሕርዚ ነቲ ዝተኣከበ ዳታ መቓቒልና ደረጃታት ኣውጺእና ኣብ ዝለዓለን ዝተሓተን ሰሪዕና ነጥብታት ሂብናዮ።

ሕ.   ከመይ እንታይ ኢኹም ሰሪሕኩም እስኪ ኣስፊሕኪ ግለጽለይ ?

መ.   (ይርጋኣለም) ሕራይ ሕጂ ንኣብነት ከም ሕንጻ እንተወሲድና፡ ኣብ ሓሙሽተ ደረጃታት ማለት ኣዝዩ ጽቡቕ ብማዕሚ ጽቡቕ ድሓን ሕማቕ

ኢልና ነቲ ዝለዓለ ኣዝዩ ጽቡቕ 5 ነጥቢ ሂብናዮ። ነቲ ዝተሓተ ማለት ሕማቕ ክኣ ሓደ ነጥቢ ሂብናዮ። ብድሕር'ዚ እዚ መሪጽናዮ ዘሎና ከባቢ ሰታንታ ኦቶ ጽቡቕ ዝብል ደረጃ ስለዝሃብናዮ 3 ነጥቢ ማለት'ዩ።

ብድሕሪ'ዚ እቲ ካልኩለሽን ሰሪሕንዎ ማለት'ዩ።

5 - 1 = 4   4 = 100% ⇒ 2x100% = 50
3 - 1 = 2   2 = ? 4

ሕ. ነዚ ክተርእየኒ ዝጸናሕካ ኣገባብ ካልኩለሽን ካብቲ ቅድሚ ሕጂ ኣብ ክፍሊ ዝተማሃርኩሞ ተጠቂምኩሙሉ ዶ ?

መ. (ዩሲያስ) እወ ንኣብነት ሚኢታዊት ናይቲ ዝለዓለን ዝተሓተን ድሓር'ውን ናይቲ መሪጽናዮ ዘሎና ከባቢ ሚኢታዊት ንምውድዳር ቅድሚ ሕጂ ዝተማሃርናዮ ቁጽሪ ተጠቂምናሉ።

ሕ. ብወገንኪ ይርጋኣለም ኣብ ክፍሊ ዝተማሃርክዮ ቁጽሪ ነዚ ሰሪሕኩሞ ዘልኹም ኢንደክስ ኣብ ምውጻእ ሓጊዙኒ ዶ ትብሊ ?

መ. እወ ሓጊዙኒ

ሕ. ብኸመይ ?

መ. ንኣብነት ጽቡቕ ናይ ሕንጻታት ኣብ ዝሰራሕናሉ ነቲ ከባቢ.ና 3 ነጥቢ ምስ ሃብናዮ ናይዚ Index (ኢንደክስ) ኣብ ምፍላጥ ነቲ ዝለዓለ 100 ሂብና ካብ ሚኢቲ ክንደይ ምዃኑ ኣብ ምፍላጥ ክሪስክሮስ ጌርና ቫሉዩ ናይ x (ዘይተፈልጠ) ረኺብና እዚ ምስ ቅድም ኢልና ንሓደ ዘይተፈልጠ ዋጋ (value) ንምፍላጥ ኣብ ክፍሊ ዝተማሃርናዮ እዩ።

ሕ. ኣኬ ብሓፈሻ ከምዚ ሕጂ ዝተዋህበኩም ዓይነት ቁጽሪ (ማትስ) ምስ ተግባር ዝተተሓሓዘ ኣብ ክፍሊ ሰሪሕኩሙሉ ወይ ከም ዕዮ ገዛ ተዋሂቡኩም ዶ ይፈልጥ ?

መ. (ዩሲያስ) ኣነኳ ከምዚ ዓንየት ቁጽሪ ምስ ናይ ደገ ተግባር ዝተተሓሓዘ ወሲደ ኣይፈልጥን

መ. (ይርጋኣለም) ልክዕዩ ዎርድ ፕሮብለምስ ንሰርሕ ኢና ከምዚ ዓይነት ግን ኣኮነን።

ሕ. ሕራይ ይርጋኣለም እዚ ሕጂ ወሲድኩሞ ዘለኹም ዓይነት ስራሕ ምስቲ ክትጠቕስዮ ዝጸናሕኪ ዎርድ ፕሮብለም ፍልልዩ እንታይ'ዩ ?

መ. ዎርድ ፕሮብለም ንሰርሖ ዝነበርና ንሓደ ኣብ ሕቶ ዝተዋህበካ ዘይተፈለጠ ቫርየብል ንምርካብ ወይ ንምፍታሕ እዩ ዕላምኡ። እዚ ግን ብዙሕ ነገር

ንኣብነት ባአልኻ ደረጃታት ኣውጺእካ Index (ኢንደክስ) ምፍላጥ የድልየካ።

ሕ. እንታየ ክብል ደልየ ዋላ ዬሲያስውን ክትምልስ ትኽእል ኢኻ ዎርድ ፕሮብለም ኣብ ክፍሊ ትሰርሑ ኢኹም። እዚ ሕጂ ዝተዋህበኩም ዘሎ ዓ ይነት ሕቶታትን ተመሳሳሊ ውን ከምዚ ዓይነት ሕቶታት ፍልልዩ ማለት እቲ ቀንዲ ፍልልዩ እንታ'ዩ ኢልኩም ትግምቱ ?

መ. (ዬስያስ) እቲ ቀንዲ ፍልልይ ኣብ ክፍሊ ንሰርሖ ዎርድ ፕሮብለምስ ንሓደ ነገር ንኽትረክብ ኢልካ ኢኻ ትሰርሖ። ነታ ዝደለኻያ ረኺብካ ትውድእ። ኣብዚ ከምዚ ናይ ሕጂ ዓይነት ሕቶታት ግን ኅብዙሓት ረቋሒታት ኣብ ግምት ብምእታው ንኹሉ ሓዋዊስካ ኢኻ እትሰርሕ።

ሕ. ነዚ ሕጂ ሰሪሕኩሞ ዘለኹም ኣወጻጽኣ ኮምፐነንትስ ናይ ዕቤት ሓደ ከባቢ ከምኡ'ውን ተጠቒምኩሙሉ ዘለኹም ኣገባብ ካልኩለሽን ኸመይ ትርእይዎ? ነቲ ውጺኢቱኸ ብኸመይ ትግምግምዎ ?

መ. (ይርጋኣለም) እቲ ውጺኢቱ እንተረኢና ኣብ ማእከላይ ደረጃ እዩ ዘሎ። ሰታንታ ኣቶ ምስ ካልኦት ዘባታት ኣወዳዲርካ እንተረኢኻዮውን ዳርጋ ኣብ ማእከላይ ደረጃ ዕቤት ከምዘላ ኢና ንዕዘብ።

ሕ. ስለዚስ ውጺኢትና ኣዕጋቢ እዩ ዲኺ ትብሊ ዘለኺ ?

መ. (ይርጋኣለም) እወ ኣዕጋቢ እዩ።

ሕ. ሕራይ ነዚ ዝተዋህበኩም ሕቶ ክትሰርሑ ከለኹም ሓደ ሓደ ጊዜ ግዜ ንዘጋጠመኩም ሽግራድት ንምፍታሕ ብናታትኩም ሜላ ዝተጠቐምኩሙሉ እዋናት ኔሩዶ ? እስኪ ግለጹለይ

መ. (ዬሲያስ) ነዚ ኣብ ምስራሕ ካብ ዘጋጠሙና ሽግራት ነቶም ዝመረጽናዮም ረቋሒታት ማክሲመም ክንደዩ ሚኒመምከ ኣብ ዝብል ንቲ ክንፈልጦ እንኽእል ብናትና ሜላ ባዕልና መሪጽናዩ ነቲ ክንፈልጦ ዘጸግመና ኸኣ ካብቲ ናይ ቅድም ተመኩሮናን ንፈልጦን ተሞርኪስና ብምግማት ኢና ሰሪሕናዩ።

ሕ. ሕራይ ይርጋኣለም ከ ?

መ. እቲ ቀንዲ ጸገም እኳ ነቶም ብኣሃዝ ንምርካቦም ዘሸግሩ ክቔጸሩ ይኹን ወይ ዳታ ክርከበሎም ዘይክኣል ንኣብነት ከም ብዓል ጽሬት ብናትና ተባላሓትነት ኢና ደረጃ ኣውጺእናሎም።

ሕ. ሕራይ ከምዚ ናይ ሕጂ ዓይነት ስራሕ ክዋሃበኩም ከሎ፡ ኣገባብ ኣሰራርሕኡ ብዝምልከት ከምዚ ንስኻትኩም ዘቕረብኩሞ ዓአይነት ጥራሕ ድዩ ዋላስ ካልእ ዓይነት ኣገባብ (ዝሓሸ) ክህሉ ይኽእልዩ ትብሉ ?

መ. (ዴስያስ) ንሕና በዚ ኣቕሪብናዬ ዘሎና ኣገባብ ኢና ሰሪሕናዬ ዘሎና። ካልኣት ግሩፕ ኣብ ካልእ ቦታ ብኻልእ መገዲ ክሰርሕዎ ይኽእሉ ይኾኑ።

ሕ. እወ ኣበሃህላይሲ ሓደ ሕጽረታት ኣብ ሓበሬታ ምእካብ የጋጥመኩም ዶ ኔሩ ? ከምኡ'ውን እቲ ዝእከብ ዳታ ኣብ ሓቂ ዝተሞርኰሰ ክኸውን ስለዘለዎ ብወገንኩም እንታይ እንተዝህሉ ወይ እንተዝርከብ ዝሓሸ ውጺኢት መምጻእና ኔርና ትብሉ ?

መ. (ዴስያስ) ብመጀመርያ ዝርዝርን ደቂቕን (Detailed) ሓበሬታታት ካብ ዝምልከቶ ኣካል ኬድካ ወይ ኮምፑተር ተጠቒምካ ምስራሕ ነቲ ውጺኢት ዝበለጸ ምገበሮ።

ሕ. ሕራይ ኣብዚ ሰሪሕኩሞ ዘለኹም ካልኩለሽን ክመልሰኩም መጀመርያ «ጽባቐ ሕንጻታት» ኣብ ዝብል ረቛሒ ኣብ ዝሰራዕኩሞ ደረጃታት ካብ 1 - 5 እዩ። ካብዚ ተበጊስኩም ንከባቢ ሰታንታ ኣቶ 0.5 ዝብል ኢንደክስ ረኺብኩም ብኸመይ ?

መ. (ይርጋኣለም) ብመጀመርያ ነቲ ዝተሓተ ካብቲ ዝለዓለ ኣጉዲልና 5 1 4 መጺኡልና ሕጂ 4 ማለት እቲ ዝለዓለ ኢንደክስ 1 ማልት'ዩ። ከባቢና ሰታንታኣቶ 3 ነጥቢ (ጽቡቕ) ስለ ዝሃብናዮ ብተመሳሳሊ 3 - 1 2 መጺኡልና። ብድሕሪ እዚ
ነጥቢ 4 ኢንደክስ 1 እንተሂብናዬ ?
ነጥቢ 2 ኸ ክንደይ ይኸውን ኢልና ሰሪሕናዮ።

$$\frac{2 \times 1}{4} = 0.5$$ መጺኡልና።

ሕ. ሕራይ ዴሲያስ ንነጥቢ ኣርባዕተ ሓደ ኢንደክስ ሂብናዬ ክትብሉ ከለኹም እንታይ ማለት ዶ ? እቲ ሓደ ዝብል ኢንደክስ ንምንታዩ ዝውክል ዘሎ?

መ. እቲ 4 ነጥቢ ከም ሙሉእ 100% እዩ ዝውክል። እዚ ማለት ከኣ እቲ ዝለዓለ ኢንደክስ 1 ማለትዩ።

ሕ. ሕራይ ነዚ ክትሰርሑ ከለኹም ምስቲ ቅድሚ ሕጂ ትሰርሕዎ ዝነበርኩም ንኣብነት ከም ዎርድ ፕሮብሌምስ ኣዛሚድኩም ሓድሽ ነገር'ዩ ዝረኸብኩሞ እንተሎ'ስከ ግለጹለይ ?

መ. (ይርጋኣለም) ሓድስ ነገር እዩ ዝብሎ ኣብ ክፍሊ መምህር ዝሃበካ መልሱ ዝተፈጠ (መምህር ዝፈልጦ) ምስራሕ ጥራሕ'ዩ። ኣብዚ ግን ባዕልኻ ደሊኻ ዲስከስ እንዳገበርካን እንዳተራዳዳእካን ኢኻ ትሰርሕ።

ሕ. ሕራይ ከም'ዚ ዓይነት ኣገባብ ኣመሃህራ ንተማሃሮ ካብ ሪል ዎርልድ ፕሮብሌም ተዋሂቡዎም ብናታቶም መገዲ ዳት ኣኪቦም ተመያይጦም ክሰርሑ ዝኽእሉሉ ዓይነት ኣገባብ ኣመሃህራ ኣብ ካሪኩለም ሰፊሩ ምስ ናይ ቁጽሪ ፔረድ እንተሰፈረ ኸመይ ትሪኦ ?

መ. (ዬሲያስ) ከምኡ እንተዘኣቱ ኔሩ እቲ ትመሃሮ ዘሎኻ እንታ'ዩ ጥቕሙ ክትፈልጠ ትኽእል። ኣብ ደገ ወጺእካ ብተግባር ሓበሬታታት ኣኪብካ ኣብ ክፍሊ ንዝተማሃርካዮ ምስ ደገ ከተዛምዶ ምኽኣል ብጣዕሚ ጽቡቕ እዩ።

ሕ. ስለዚስ ኣብ ካሪኩለም ክሰፍር ክኽእል ኣለዎ ኢኻ ትብል ዘሎኻ ማለት ድዩ ?

መ. (ዬስያስ) እወ ጽቡቕ'ዩ።

ሕ. ሕራይ ከምዚ ሪኢኹሞ ዘለኹም ኣገባብ ኣመሃህራ ብወገን ተማሃሮ ተቐባልነቱ ከመይ ምኽኑ ትብሉ እንታይ ጸገማት ከ ምሃለዎ (ብወገን ተማሃሮ) ?

መ. (ይርጋኣለም) ተቐባልነት ምሃለዎ። ቁጽሪ እንታይ ምኺኑ ትፈልጥ ሕጅስ ማትስ ንምንታይ ይምሃር ኣለኹ ትብል ሓደ ሓደ ግዜ ሕጂ ግን ከምዚ ዓይነት እንተሰሪሕካ ጥቕሙ ስለእትርዳእ ናይ ግድን ኢኻ ክትመሃሮ ዘሎካ። ኣብዚ ከይደስ ከምዚ ዓይነት ጠቕሚ ክረኽበሉየ ኢልካ ስለትሓስብ ጥቕሙ'ውን ስለዝፈለጥካዮ ሓንጐልካ'ውን ተቐቢልዎ ስለዘሎ ፈጺምካ ኣይትርስዖን ኢኻ ማለት'ዩ።

ሕ. ዬስያስከ ?

መ. ነቶም ትምህርቲ ክመሃሩ ዝደልዩኳ ከምዚ ዓይነት ኣገባብ ኣመሃህራ እንተዝህሉ ጽቡቕ ኔሩ መብዛሕትኡ ስብሲ ከምጽቡቕ ምተቐቐበሎ ኔሩ። ሓደ ሓደ ምናልባት ኣይምተቐበልዎን ይኾንይ ምኽንያቱ ደገ ኬድካ ኮሊልካ ሓበሬታታት ምእካብ ስለዘለካ ነቲ ክመሃር ኢሉ ዝመጽእ ሰብ ግን ጽቡቕ'ዩ።

ሕ. ሕራይ ይርጋኣላም እዚ ተዋሂቡኩም ዘሎ ኣሳይንመንት ምስ ተዋህበኩም ቁጽሪ ኢና ንሰርሕ ዘሎና ዶ ኢልኩም ትሓስቡ ኔርኩም ዶ ዋላስ ካልእ ሓሳብ ኔሩኩም? እንታይ ይስመዓኩም ኔሩ ?

መ. (ይርጋኣለም) ቁጽሪ (ማትስ) ኢና ንሰርሕ ዘለና ኢልና ንሓስብ ኣይነበርናን። ጥራሕ ኣብቲ ከባቢና ኣብ ክንደይ ይኽፈል ብኽመይ ? እንዳበልና ኢና ንካታዕ ኔርና እምበር ቁጽሪ ከምንሰርሕ ዘሎና ኸማን ኣይፈለጥናን ኔሩ።

ሕ. ሕራይ ከምዚ ዓይነት ኣገባብን ንዑ ዝመሳሰል (ማለት ነቲ ዝተዋህበኩም) ኣብ ክፍሊ ንተማሃሮ ምሃብ ካብ ዝህቦ ረብሓታት ምገለጽካለይ ዶ ?

መ. (ዬሲያስ) መጀመርያ ነቲ ኣብ ክፍሊ ዝመሃርዎ ምስ ናይ ደገ ከዛምድዎ ይኽእሉ። ብፍላይ እዛ ናትና ሕቶ ኸኣስ ከባቢና ኣበየናይ ደረጃ ዕቤት ከምዝርከብ ንምግምጋም ይኽእለካ።

ሕ. ሕራይ ይርጋኣለም ኣብዛ ናይ ኢዱኬሽን ረቛሒ ክመልሰኪ ኢዱኬሽን ክትመዝኑ ከለኹምሲ ቁጽሪ ናይ ላዕለዋይ ደረጃ ቤት ትምህርትታት ጥራሕ ኢኹም መሪጽኩም። ግን ኣብ ሓደ ሰፈር ልዕሊ ቁጽሪ ናይ ላዕ ለዋይ ደረጃ እንተሃለዎስ ዕቤቱ ብኡዶ ክምዘን ይከኣል ? ንምንታይ ኢኹም ከምኡ ጌርኩም ነቶም ካልኦት ደረጃታትከ ስለምንታይ ግምት ዘይሃብኩሞም።

መ. (ይርጋኣለም) ኪንደርጋርተን ከምኡ'ውን መባእታ ኣብ ኩሉ እዩ ዝርከብ ዝብል ኣሳምፕሽን ወሲድና። ብድሕሪ'ዚ መጋእታ ተማሃሪኻ ናይ ማእከላይን ላዕለዋይን ደረጃ ትምህርቲ ከምዘድሊ ተረዲእና በዚ መሪጽናዮ።

ሕ. ሕራይ ንኣብነት መሃይምነት ኣብ ገልገለ ከባቢታትስ መሃይምነት ዘየጥፍእ ክህልዉ ይኽእሉ ኣብ ብካልእ መዳይ ኣብ ካልእ ከበቢ መሃይምነት ፍጹም ከይህሉ ይኽእል። ነዚ ስለምንታይ ኣብ ግምት ዘየእተኹሞ ?

መ. (ይርጋኣለም) ናይዚ (መሃይምነት) ሓበሬታ ክንረክብ ኣይንኽእልን ኢና። ብምንታይ ከምንመዝኖ ከማን ክሽግረና እዩ። በዚ ምኽንያት ኣይመረጽናዮን።

ሕ. ሕራይ ዬሲያስ ንጥዕና ብዝምልከት ክኣ ኣብ 2 መቒልኩም ክሊኒክን ፋርማስን ንክሊኒክ 1/3 ረሾ ንፋርማሲ ኸኣ 2/3 ሂብኩሞ ስለምንታይ ኢኹም ንፋርማሲ ዝለዓለ ንክሊኒክ ዝተሓተ ረሾ ሂብኩሞ ?

መ. (ዬስያስ) ኣብ ከተማ ኣስመራ ከምዝረኣናዮን ንፈልጦን ቁጽሪ ክሊኒክ ካብ ቁጽሪ ፋርማሲ ይውሕድ'ዩ። ፋርማሲታት ስለዝበዝሓን ኣብ ኩሉ ከባቢ ዳርጋ ክርከባ ስለዝኽእላን ከም ዝሓሸ መዓቀኒ ዕቤት ጌርና መሪጽናዮ 2/3 ረሾ ኸኣ ሂብናዮ።

ሕ. ኣብ ኣንፍራስትራክቸር ክኣ ንሕንጻ ኣእቲኹም ኣለኹም ኣብዚ ጽባቐ ሕንጻ ከም ሓደ መዓቀኒ መሪጽኩም ብኸመ እዩ ጽባቐ ሕንጻ መዓቀኒ ዕ ቤት ሓደ ከባቢ ዝኸውን ?

መ. (ይርጋኣለም) ህንጻ ናይ ሓደ ከባቢ መልክዕ እንተሃልይዎ ነቲ ከባቢ ኸኣ የመልክዖ እቲ ኣብኡ ዝሰፍር ሕብረተሰብ ክኣ ከም ምዕቡል (ዝሓሸ ኣገልግሎት ስለዝረክብ)ክቁጽሪ ይከኣል።

ሕ. ሕራይ ዬሲያስ ነዚ ኣብ መወዳእታ ረኺብኩሞ ዘለኹም ናይ መወዳእታ መልሲ ኢንዳክስ 0.39 ብኸመይ ረኺብኩሞ ?

መ. (ዬስያስ) መጀመርያ ነተን ኩለን መጅረጽናዬን ዘሎና ረቛሒታት ንኣብነት ኣብ ትሕተ ቅርጺ ሕንጻ 50% ፣ መጓዓዝያ 20%፣ ኣብ ጥዕና ክሊኒክ 33% ፋርማሲ 20% ወዘት እንዳብልና ናይ ኩሉ ምስወዳእና ኣቨረጅ ናይ ኩሉ ብምውዳእ 0.39 ረኺብና።

ሕ. ሕራይ እዚ ኣብ መወዳእታ መጺእልኩም ዘሎ 0.39 እንታይ ትርጉሙ ብኸመይ ? ከ ትግምግምዎ ?

መ. (ዩሲያስ) እዚ 0.39 ≈0.4 ዝህበና ትርጉም መሪጽናዩ ዘሎና ከባቢ ስታንታኦቶ ድረጃ ምዕባለኡ ምስ ኩለን ናይ ኣስመራ ዞባታት ኣወዳዲርካ ካብ ሓደ 0.4 እዩ ወይ 40% እዩ። እዚ ማለት ክኣ ከባቢ ስታንታኦቶ ደቡባዊ ምብራቕ ኣስመራ ዳርጋ ኣብ ከባቢ ማእከላይ ደረጃ ምዕባለ ይርከብ ማለት'ዩ።

ሕ. ሕራይ እቲ ዝለዓለ 1 እቲ ዝተሓተ ኸኣ 0 እንተወሲድኩሞ 0.4 ዳርጋ ኣብ ከባቢ ፍርቂ ኣሎ ማለት'ዩ። ሕጂ እዚ ውጺኢት እዚ ምስቲ ርያሊቲ ማለት ምስቲ ንስኻትኩም ምስቲ ከባቢ ዘለኹሞ ኣፍልጦ ኣዕጋቢ መልሲ እዩ ኢልኩም ዶ ትግምቱ ?

መ. (ይርጋኣለም) እወ ኣዕጋቢ እዩ ኢልና ገሚትናዩ ኣለና። በቲ ዘሎ ሪያሊት ከማን ጽቡቕ ገምጊምናዩ ኣሎና ንብል። ንኣብነት እዚ ርሕቕ ዝበለ ማእከላይ ከተማ 0.8 እንተመጺኡስ እዚ ከባቢና ምስቲ ዘሎ ሓድሓደ ሕጽረታት ናይ ትምህርቲ ድዩ ናይ ካልእ ሪኢኻ ጽቡቕ ገምጊምናዩ ኣሎና እብል።

ሕ. ሕራይ ዩሲያስ ነዚ ክትሰርሑ ከለኹም ካብ ዘጋጠመኩም ጸገማት ተበጊስካ ኣብ 40 ድዩ 50 ተማሃሮ ዘለዎ ክፍሊ ከምዚ ዓይነት ፕሮጀክት ምሃብ እንታይ ጸገማት የጋጥም ኢልካ ትግምት ?

መ. ከምቲ ኣቐዲሙ ዝተጠቕሰ ኣብ ሓበሬታት ምእካብ ክጽገሙ ይኽእሉ ይኾኑ ካልእ ሽግር ዘሎ ኣይመስለንን።

ሕ. ብወገን ግዜ ኸ ?

መ. (ዩሲያስ) እወ ብዝሕ ዝበለ ግዜ ይሓትት'ዩ። ነቲ ዘድሊ ሓበሬታ ምስ ኣከቡ ከፍ ኢሎም ከጻፍፍዎ ምስቲ ኣብ ክፍሊ ዝተማህርዎ ቁጽሪ ተጠቂሞም ናብ ዝርድኣካ ሓበሬታ ንኽልውጥዎ ናይ ግድን ግዜ ይሓትት'ዩ።

ሕ. ሕራይ ይርጋኣለም ነዚ ዝተዋህበኩም ስራሕ ክትሰርሑ ከለኹም ብግሩፕ ነቲ ስራሕ ተኸፋፊልኩም ድሓር ትመያየጡ ኔርኩም መጀመሪያ እዚ ዓ ይነት ኣሰራርሓ ሓድሽ ድዩ ንዓኹም ዋላስ ቅድሚ ሕጂ ተጠቂምኩሙሉ ትፈልጡ ኢኹም

መ. ንዓና ሓድሽ'ዩ ቅድሚ ሕጂ ከምዚ ዓይነት ዲስካሽን ጌርና ኣይንፈልጥን። እዚ ንዓና ብጣዕሚ ጽቡቕ'ዩ ኔሩ።

ሕ. ሕራይ ዩሲያስ ኣብ ግሩፕ ዲስካሽን ተሳትፎ ኣባላት ከመይ ኔሩ ?

መ. እወ ኣብቲ ዲስካሽን ዳርጋ መብዛሕትና ሓሳብ ንህብ ኔርና። ግን ክአ ዝበዝሐ ሓሳብ ዘመንጩዉ ኔሮም። ውሑድ ዝህቡ ኸአ ኔሮም ግን ኩላትና ኣብቲ ስራሕ ተሳቲፍና ኢና።

ሕ. እንታይ እንታይ ሓገዝቲ ማተርያልስ ትጥቀሙ ኔርኩም ?

መ. (ይርጋኣለም) ኣብ Index (ኢንደክስ) ምውጻእ ካልኩሌተር ተጠቂምና እምበር ኣብ ካልእ ብኢድና (Manual) ኢና ሰሪሕናዮ።

ሕ. ቅድሚ ነዚ ዝተዋህበኩም ሕቶ መጀመርያ ሓንቲ ዝሰራሕኩማ ውህብቲ ሞዴል ኔራ (H.D.I) እዚኣ ካብ ሂዩማን ደበሎፕመንት ሪፖርት ዝተዋጸት እያ። መጀመርያ ንዓአ ከመይ ሰሪሕኩማ ከመይ ከ ንዝመጽእ ስራሕኩም ጠቒማትኩም ?

መ. (ዮሲያስ) መጀመሪያ ነታ ሪፖርት ብንጽልን ብግሩፕን ኣንቢብና ተረዲእናያ። እቲ ኣገባብ ኣወጻጽኣ ኢንደክስ ከምኡውን ኣገባብ ኣጸሓሕፋ ሪፖርት ካብቲ ናታ ስታይል ተጠቂምና ኢና።

ሕ. ሕራይ ይርጋእኣለም ከ ?

መ. መጀመርያ ኣንቢብና ክንርድኦ ፈቲና ነቲ ኣወጻጽኣ ኢንደክስ ብምምይያጥ ተረዲእናዮ። ካብኡ ተሞርኲስና ነቲ ዝተዋህበና ልክዕ ከምኡ ክንሰርሕ ኪኢልና።

ሕ. ኣብዛ ዝተጠቅሰት ሪፖርት ሰለስተ ዓይነት ረቛሒታት ማለት ፍልጠት ዕድመ ወዲሰብ ከምኡ'ውን ናብራ እየን ተጠቂሰን ዘለዋ። ኣብዚ ናትኩም ግን ካልእ ኢኹም ተጠቒምኩም ዘለኹም ብኸመይ ኢኹም ልክዕ ከምኡ ሰሪሕና ዝበልኩም ?

መ. (ዮሲያስ) ኣብታ ሪፖርት ናይ ሃገራት ምዕባለ ኢንደክስ እዩም ኣውጺኦም። ንኣብነት ኣብ ኢዱከሽን ከም መሃይምነትን ናይ ትምህርት ዓ መታትን ተጠቒሞም። ንሕና ግን ናይ ሓንቲ ኮሚኒቲ ምዕባለ ንዕቅን ስለዘሎና ምስቲ ከባቢና ዝኸይድ ፍልይ ዝበለ ረቛሒታት ኢና ተጠቒምና። ኣገባብ ኣሰራርሕኡ ግን ተመሳሳላይ እዩ።

ሕ. ሕራይ ብዘይካ እዘን ኣርባዕተ መሪጽኩመን ዘለኹም ኮምፖነንትስ ማለት ጥዕና፣ ጽሬት፣ ትምህርትን እንፍራስትራክቸርን ንሓንቲ ኮሙኒቲ ምዕባለ እቶት (Income) ወሳኒ እዩ ኔሩ ንስኻትኩም ግን ኣይተጠቐምኩሙሉን ስለምንታይ ?

መ. (ይርጋኣለም) ኢንኳም ክነእቱ እንተኾናስ ካልእ ብዙሕ ረቛሒታት ኣብ ግምት ክነእቱ ኣለና ማለትዩ። ብዙሕ ሕልኽልኽ ስለዝፍጠርን ከሸግረና ምኽኑ ተረዲእና ገዲፍናዮ ማለት'ዩ።

ሕ. ስለዚ እዞም መሪጽናዮም ዘሎና ረቛሒታትስ ተሸጊርና ኢና እምበር ሙሉእ ስእሊ ዝህቡ ኣይኮኑን ዲኹም ትብሉ ዘለኹም ?

መ. (ዬሲያስ) እቲ መጺኡልና ዘሎ በዘን መሪጽናየን ዘሎና ረቛሒታት ጽቡቕ ገምጋም ጌርና ኢና ንብል። ከም ኢንካም ዝኣመሰሉ ዓበይቲ ረቛሒታት ግን ብቐሊሉ ሓበሬታ ረኺብና ናይ ሓደ ኮሚኒቲ ዝኣክል ብዙሕን ፍሉይን መጽናዕትታት ስለዘድልየካ በዚ ነዚኣን መሪጽና።

ሕ. ስለዚ እተን ሓበሬታታት ክትረኽቡለን ትኽእሉ ረቛሒታት ጥራህ ኢኹም መሪጽኩም እምበር እቲ ጸገም ክፈጥረልኩም ዝኽእል ረቛሒታትስ ኣየእቶኹሞን ማለት'ዩ ?

መ. (ዬሲያስ) እወ ንኣብነት ከም ኢንካም፡ ዝኣክል ረቛሒ ብግምት ዝስራሕ ኣይኮነን። ኣብ ሓቂ ዝተሞርኮሰ ሓበሬታ ንምርካብ'ውን ኣጸጋሚ እዩ። ሕጂ ምስቲ ዘሎ ግዜ ሪኢና በተን መሪጽናየን ዘሎና ሰሪሕናዮ ማለት'ዩ።

ሕ. ሕራይ እታ መሪጽኩማ ዘለኹም ከባቢ ስታንታኦቶ ብምንታይ ኢኹም መሪጽኩማ ? ብዛዕባኣ ኽ ኣፍልጠ ኔርኩም ድዩ ?

መ. (ይርጋኣለም) ስታንታኦቶ ዝወመረጽናላ ምኽንያት ኣብዚ ከባቢና ብምህላዋን መብዛሕትናውን ጽቡቕ ሓበሬታ ክንረኽበላ ንኽእል ኢልና ስለዝገመትናን ኢና መሪጽናያ።

ሕራይ የቐንየለይ።

APPENDIX C. Guided Exploration of Existing Model.

The Human Development Index (HDI)

☞ The following is an excerpt from the 1994 Human Development Report (HDR)

Why do we need a human development index

Because national progress tends otherwise to be measured by Gross National Product (GNP) alone, many people have looked for a better, more comprehensive socio-economic measure. The human development index is a contribution to this search.

What does the HDI include?

The HDI is a composite of three basic components of human development: longevity, knowledge and standard of living. Longevity is measured by life expectancy. Knowledge is measured by a combination of adult literacy (two-thirds weight) and mean years of schooling (one-third weight). Standard of living is measured by purchasing power, based on real GDP per capita adjusted for the local cost of living (purchasing power parity, or PPP).

Why only three components?

The ideal would be to reflect all aspects of human experience. The lack of data imposes some limits on this, and more indicators could perhaps be added as the information becomes available. But more indicators would not necessarily be better. Some might overlap with existing indicators: infant mortality, for example, is already reflected in life expectancy. And adding more variables could confuse the picture and detract from the main trends

How to combine indicators measured in different units?

The measuring rod for GNP is money. The breakthrough for the HDI, however, was to find a common measuring rod for the socio-economic distance travelled. The HDI sets a minimum and a maximum for each dimension and then shows where each country stands in relation to these scales—expressed as a value between 0 and 1. So, since the minimum adult literacy rate is 0% and the maximum is 100%, the literacy component of knowledge for a country where the literacy rate is 75% would be 0.75. Similarly, the minimum for life expectancy is 25 years and the maximum is 85 years, so the longevity component for a country where life expectancy is 55 years would be 0.5. For income the minimum is $100 (PPP) and the maximum is $40,000 (PPP). Income above the average world income is adjusted using a progressively higher discount rate. The score for the three dimensions are then averaged in an overall index.

Is it not misleading to talk of a single HDI for a country with great inequality?

National averages can conceal much. The best solution would be to create separate HDIs for the most significant groups: by gender, for example, or by income group, geographical region, race or ethnic group. Separate HDIs would reveal a more detailed profile of human deprivation in each country, and disaggregated HDIs are already being attempted for countries with sufficient data.

How can the HDI be used?

The HDI offers an alternative to GNP for measuring the relative socio-economic progress of nations. It enables people and their governments to evaluate progress over time—and to determine priorities for policy intervention. It also permits instructive comparisons of experiences in different countries.

☞ What were the main assumptions made in the development of the HDI?

The table below gives the human development index for a few countries in the categories high, medium and low human development.

	Life expectancy at birth (years) 1995	Adult literacy rate (%) 1995	Combined first-, second- and third-level gross enrolment ratio (%) 1995	Real GDP per capita (PPP$) 1995	Adjusted real GDP per capita (PPP$) 1995	Life expectancy index	Education index	GDP index	Human development index (HDI) value 1995
High human development									
1 Canada	79.1	99	100	21916	6230.98	0.9008	0.9933	0.987	0.
3 Norway	77.6	99	92	22427	6231.96	0.8758	0.9667	0.987	0.9
56 Seychelles	72	88	61	7697	6072.63	0.7833	0.79	0.962	0.8
Medium human development									
85 Cuba	75.7	95.7	66	3100	3100	0.8448	0.8592	0.483	0.7
89 South Africa	64.1	81.8	81	4334	4334	0.6518	0.8169	0.682	0.7
97 Botswana	51.7	69.8	71	5611	5610.67	0.4457	0.7015	0.887	0.6
Low human development									
139 India	61.6	52	55	1422	1421.99	0.6098	0.529	0.213	0.4
166 Mozambique	46.3	40.1	25	959	958.72	0.3542	0.35	0.138	0.2
168 Eritrea	50.2	25	29	983	982.82	0.4207	0.2621	0.142	0.2

- The report states that "Knowledge is measured by a combination of adult literacy (two-thirds weight) and mean years of schooling (one-third weight)." Show with a few examples from the table above that the "education index" was calculated in this way.

  If you were part of the team developing the HDI, would you have agreed with the other team members that this is a good way to calculate the education index? Why? Why not?

- How do you think the adult literacy rate is determined?

- It is stated that "...the minimum for life expectancy is 25 years and the maximum is 85 years, so the longevity component for a country where life expectancy is 55 years would be 0.5." How was 0.5 obtained? Does your method work for the "life expectancy index" for the different countries in the table above?

  In doing calculations of this nature we say that we **normalise** the measure.

  Is the education index also normalised?

- For the determination of the GDP it is stated that "For income the minimum is $100 (PPP) and the maximum is $40,000 (PPP). Income above the average world income is adjusted using a progressively higher discount rate." The average world income for 1995 was pegged at $5990.

From the table Canada's real GDP is adjusted from $21916 to $6230.98 according to this calculation. For consistency the maximum $40000 for the GDP must also be adjusted. This adjusted maximum according to the same calculation is $6311.

Does the formula that you have used for the life expectancy and education indexes work for the calculation of the GDP index?

- In the paragraph headed *"How to combine indicators measured in different units?"*, it is stated that "The score for the three dimensions are then averaged in an overall index." Verify this statement.

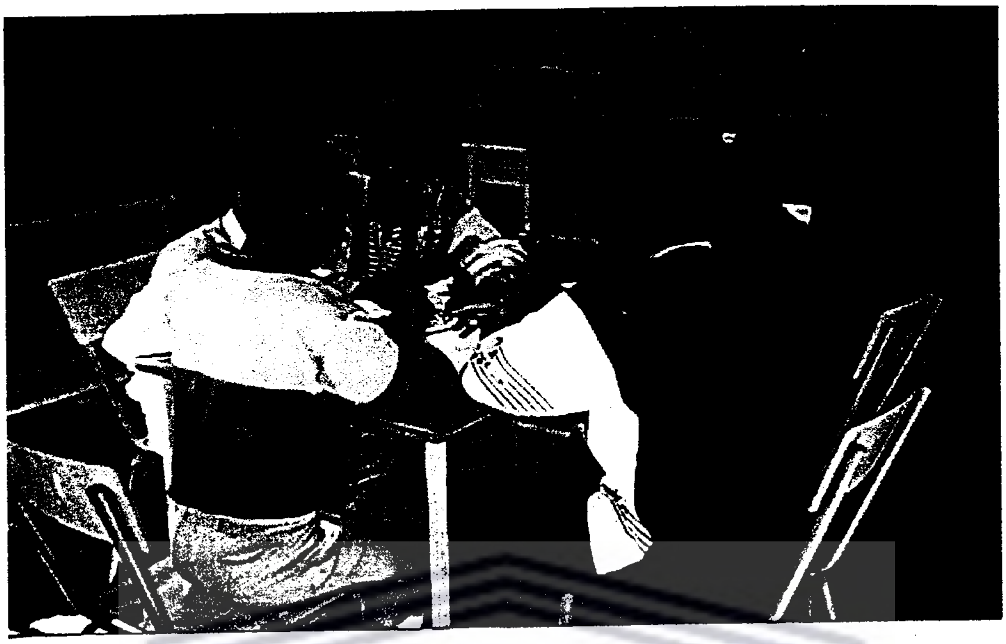
- In "*Why only three components?"* It is stated that "The ideal would be to reflect all aspects of human experience." Say that you want to include the aspect "Satisfaction with the government of the day" in a revised HDI.

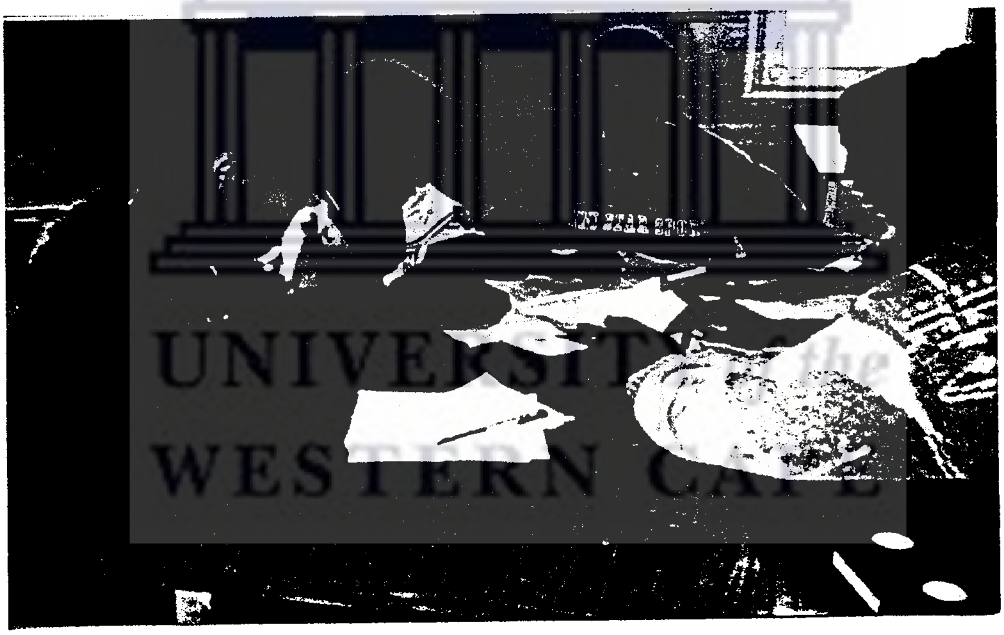
  How would you go about to measure and normalise this aspect?

ARE SCHOOLS EFFECTIVE? you ask them to construct a "new" model

The letter below appeared in the Cape Times of 23 August 2000. From the article it is evident that this survey does not give an indication on how effective schools are. However, there still seems to be a need for some kind of measure on how effective schools are. You are given the task to develop such a School Effectiveness Index (SEI). Based on your experiences with the price/performance index for printers and the HDI develop such a SEI that schools can use.

Apply your index to two schools that you perceive as being different on a variety of aspects and comment on your index. If used, your index is likely to be challenged by parties with interests in maintaining privileges certain schools enjoyed under apartheid. Write an article for the local newspaper defending your index.





Members of Group 1 Discussing how to develop & Combine different Community development Components.