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CHAPTER ONE

INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION AND RATIONALE FOR THE STUDY

1.1.1 Introduction: contextualisation

This chapter presents an overview of the study, the problem statement, research design and methodology, as well as an indication of the division of chapters. The context of the study is a sample of universities in Oromia in Ethiopia.

Ethiopia covers a total area of 1.25 million square kilometres with an estimated total population of 75.6 million (2007), growing at an annual rate of 2.7% (Federal Democratic Republic of Ethiopia, 2007:112). Nearly 84% of the current population lives in rural areas and depends for its livelihood predominantly on a traditional agricultural economy that is susceptible to persistent drought and low levels of productivity. At present Ethiopia is made up of nine federal states and two chartered cities and follows a decentralised form of administration (Federal Democratic Republic of Ethiopia, 2007:102-114). In the education sector, district educational administrators are responsible for managing and supervising primary schools. Secondary schools are managed and supervised by zone education departments. While regional education bureaus guide and supervise education from primary to college level, it is the responsibility of the ministry of education to manage and supervise the overall education system (Ministry of Education [MoE], 2002:25).

The current education system provides 10 years of general education, consisting of eight years of primary education (divided into two cycles: grades one to four of basic education and grades five to eight of general primary education) and two years of general secondary education (grades nine and 10). The education system also offers preparatory education (grades 11 and 12) that prepares students for university and a system of vocational and technical education parallel to preparatory education. Students who passed the Ethiopian Higher Education Entrance Certificate may enrol at a university (MoE, 2001:31).

Until the final decade of the 20th century, due attention was not given to University education in Ethiopia so that its curriculum was not always relevant to the country's problems and the training needs of individuals (MoE, 2002:18). However, actions have been implemented to change this situation. The Ethiopian Government has been working to re-align its university system so that it can contribute more directly to its national strategy for economic growth and poverty reduction (Saint, 2004:34). As of 2009, there are 21 universities in the country. From these, six universities are in the Regional State of Oromia. The University Capacity Building Program (UCBP) has planned to build 10 more new universities nationwide (University Capacity Building Programme, 2009:25).

1.1.2 Rationale for the study

Today, in developing countries like Ethiopia, education is considered as a means of development and eradicating poverty. The needs of society should be reflected in the educational objectives of a particular country. In line with this, the Ethiopian Education and Training Policy formulated the following general objectives (MoE, 2002:35-37):

- to develop the physical and mental potential and the problem-solving capacity of individuals by expanding education in particular and by providing basic education for all;
- to educate citizens who can take care of and utilise resources wisely, who are trained in various skills by raising the private and social benefits of education;

- to educate citizens who respect human rights, stand for the well-being of people, as well as for equality, justice and peace, endowed with a democratic culture and discipline;
- to educate citizens to differentiate harmful practices from useful ones, to seek and stand for truth, appreciate aesthetics and show positive attitudes towards the development and dissemination of science and technology in society and
- to cultivate the cognitive, creative, productive and appreciative potential of citizens by appropriately relating education to environmental and societal needs.

The realisation of the above listed educational objectives of the country requires effective teaching and learning, which in turn necessitates the use of effective pedagogical and psychological approaches to meet the demands of the new generation. These helpful approaches should be used to stimulate the creative abilities of today's generation. The traditional approach (the knowledge transmission approach) may not be suitable for the current generation who lives in a rapidly changing world. This is because the traditional teaching approach requires of students to be passive receivers of facts provided by the lecturer through lectures. It also considers the instructor as the only resource of knowledge and information.

To facilitate effective and useful learning, a methodology that concentrates on *active* learning, an approach that gives opportunities for active involvement and participation of students is needed. Silberman (1998:1) emphasises the need for active learning by the following statements:

> *What I hear I forget.*
> *What I hear and see, I remember a little.*
> *What I hear, see, discuss and do, I understand.*
> *What I teach to another, I master.*

Active learning is about learning through doing, performing and taking action. The action can be either mental or physical and it usually contrasts with a conventional lecture method. It involves students' active participation in course material through carefully constructed activities. Active involvement of students in teaching-learning processes in the classroom and outside the classroom enables them to develop critical thinking skills. Nardos (2000:24) explains that active learning is likely to be enjoyed, offers opportunity for progress, and thereby fosters positive students' attitudes towards the subjects. One should think of active learning first and foremost in terms of students being intellectually active. By intellectually active is meant that instructors do not simply expect students to memorise and regurgitate facts. Lecturers should expect students to use information critically and analytically. Besides this, students in an active learning approach have relative freedom and control over the organisation of learning activities. Usually these activities involve problem solving, inquiry and investigational work (Nardos, 2000:87). In other words, active learning happens when students are given the opportunity to engage in an interactive relationship with the subject matter of a course when they are encouraged to generate knowledge rather than simply to receive knowledge.

In an active learning environment lecturers facilitate rather than dictate the students' learning and students construct their own knowledge through interaction with themselves and others. In line with this, Fink (2002:5) offers a model of active learning, which suggests that all learning activities involve some kind of experience or some kind of dialogue. The two main kinds of dialogue are "dialogue with the self" and "dialogue with others." The two main kinds of experience are "observing" and "doing." "Dialogue with the self" involves cognitive concerns and refers to what happens when a learner thinks reflectively about a topic. "Dialogue with others" occurs when a lecturer creates a focused group discussion on a topic. Sometimes lecturers can also find creative ways to involve students in dialogue situations with people other than students. "Observing" occurs whenever a learner watches or listens to someone else doing something that is related to what is being learnt. "Doing" refers to any learning activity where the learner actually does something (Biggs, 2003:56-59; Chase & Goldenhuys, 2001:1071; Daley, 2003:23-30).

In learning institutions throughout the world, there is a movement away from learning that focuses on rote memorisation to active learning which emphasises students' active involvement in the teaching-learning process, understanding, making connections in the world around us, collecting and using information in active manner (Lea, Stephenson & Troy, 2003:322-324; Leu**,** 2006:41-48).

As already indicated, one of the goals of the Ethiopian Education Policy is "to develop the physical and mental potential and problem-solving skills of individuals by expanding education for all" (MoE, 2002:42). These potential and skills are partly to be developed through educating students in mathematics. According to Feden and Vogel (2003:785-817) mathematics is an aspect of human activity and culture that can produce pleasure, enjoyment and fascination. They stress that all persons should have the opportunity to have such positive experiences. Mathematics lecturers could make this happen by establishing an active learning culture in their classrooms. Results of empirical research on and discussions about mathematics teaching during the last two decades support the view that an active and social approach to the teaching and learning of mathematics might be a way to prevent undesirable and negative attitudes towards mathematics (Seeger, Voigt & Waschescio in Eggen & Kauchak, 2001:23-24). Among other factors, such a pedagogical approach puts forward the necessity of social construction of mathematical meaning and the role of the lecturer as facilitator in this construction process. It includes a view of the learner as an active problem-solver working individually and in small groups to make connections between multiple forms of representations of mathematical concepts, i.e. spoken symbols, written symbols, concrete models, graphics and real-world situations (Biggs, 2003:46-51; Schnotz & Lowe, 2003:117-119).

Evidently an alternative to the traditional top-down and passive teaching and learning approach requires changes in the pedagogical practices of the mathematics classroom. According to Grouws and Cebulla (2000:74), mathematics instruction should focus on meaningful development of important mathematical ideas and highlight their significance. This includes how the idea, concept or skill is connected in multiple ways to other mathematical ideas and forms of representations in a logically consistent and sensible manner. Further, mathematics instruction should give the students an opportunity to discover new knowledge and to practice what they have learned as well as to connect mathematics to other subjects and to the world outside school. The teaching methods that are implemented in mathematics instruction should incorporate and also make explicit intuitive ways of finding solutions, combined with opportunities for verbal interaction in small groups or in whole-class discussions. Hence, the suggestions put forward by Grouws and Cebulla (2000:75) reflect a view of the student as an active participant in the pedagogical processes in the classroom. Within the active learning approach, the students actively construct their understanding of mathematical concepts in an iterative fashion. Thus, the structure and content of the teaching process enhances procedural (being sure of which steps to take) and conceptual (to know the meaning, to know why the steps are taken) knowledge simultaneously. Hence, a complex cognitive network of relationships between different pieces of mathematical information forms in the mind of the student. The cognitive network includes knowledge of both procedures and concepts, knowledge that is connected in ways that give the students both a good intuitive feel for mathematics and a good problem-solving and answer-generating capacity (Daley, 2003:23-30; Leu**,** 2006:49-58; Roj-Lindberg, 2001:9).

In general, lecturers of mathematics set up ambitious goals for their work and would like all their students to love mathematics and also to reach a high level of learning and understanding. However, the traditional teaching approach might be among the factors that work against these goals. Richard Skemp (in Linnanmaki, 2001:19), a well-known mathematician and psychologist, describes the type of learning that often is an effect of the traditional approach as habit learning or rote-memorising. Skemp has also described the type of understanding that is related to habit learning as instrumental understanding. The student knows separate chunks of mathematical knowledge by heart and applies those without deep understanding of the inherent mathematical structure and how the different knowledge chunks are connected. This type of knowledge without deep understanding of the used concepts could be called procedural (Eggen & Kauchak, 2001:46-47; Grouws & Cebulla, 2000:34).

In contrast to the above, the goal of the teaching process in mathematics should be to establish a learning culture that promotes intelligent learning and a deep understanding of mathematical concepts. Knowledge of the learned mathematical concepts could in such a case be called conceptual (Rittle-Johnson & Siegler in Tanner & Jones, 2000:28). This type of deep understanding of the conceptual structure is viewed by Schnotz and Lowe (2003:120) as relational understanding. Tanner and colleagues studied classroom practices in mathematics in 20 schools and found that particularly successful schools emphasised relational rather than instrumental understanding. (Tanner & Jones, 2000: 21)

As Feden and Vogel (2003:20) put it, active learning instruction is characterised by problem solving, students' active participation and inquiry oriented teaching and learning strategies. Yoder and Hochevar (2005:91) add that active learning instruction focuses on supporting the student towards the development of cognitive, affective, and psychomotor behaviours as a learner, decision maker and community participant with success measured in terms of student outcome. From this point of view it can be said that active learning contributes to bringing about sustainable change in the economic, social, cultural, and political standards of a nation because the proper implementation of an active learning instructional method helps the students to become problem solvers, a generation who takes responsibility and participates in social activities at present and in the future (Feden & Vogel, 2003:18). Many results of empirical research and discussions about mathematics teaching during the last two decades support the view that an active learning approach to the teaching and learning of mathematics might be a way to prevent or overcome the undesirable and negative effects of traditional lecturer-centred approaches (Tanner & Jones, 2000:28). Among other factors, an active approach puts forward the necessity of the social construction of mathematical meaning and the role of the lecturer as facilitator in this construction process. It includes a view of students as active problem-solvers working individually and in small groups to make connections between multiple forms of representations of mathematical concepts, i.e. spoken symbols, written symbols, concrete models, graphics and real-world situations (Roj-Lindberg, 2001:34).

In Ethiopia, in order to produce problem solving citizens by the application of active learning, the main focus is on mathematics and science education. In particular the Ethiopian Government has decided on a current ratio of the study of natural science (including mathematics) to social science of 70:30 at university level. Hence, active learning is expected to be implemented in mathematics classrooms at all education levels of the country. This is particularly important at university where students learn independently, because any problem and misunderstanding at this stage may affect individuals in their work throughout life. This implies that the status of the implementation of active learning should be continuously assessed. In Ethiopian mathematics education, the curricula were designed to provide students with the mathematical knowledge and skills in order to develop problem-solving and decision-making skills for everyday use (MoE, 2002:39). The mathematics curriculum at university also seeks to inculcate noble values and love for the nation. However, the researcher has observed that in the mathematic classes at Ethiopian universities many students, including those who are potentially successful, become uninterested in mathematics and fail to learn it well or to enrol in subsequent courses. They don't experience mathematics as a dynamic, exciting and a creative discipline. This may be related to how they are taught. The lecturers have been required only to explain to students set sequences of procedures prescribed by textbooks. Thus lecturers accustomed to teaching the traditional curriculum may lack knowledge about mathematics learning and teaching methods that is essential to implementing fruitful changes in the classroom learning culture (Daley, 2003:23-30; Tanner & Jones, 2000:43).

In view of the above, it is clear that there are many challenges in promoting lecturers' use of active learning/student-centred approaches (Alexander, 2002:36-38; UNESCO, 2005:48). It is in consideration of the above that the researcher became interested in exploring the nature of the teaching–learning process in line with the active learning approaches and investigating the problems related to the implementation of active learning/student-centred approaches in mathematics education in the Oromia Regional State Universities, Ethiopia. In the Oromia Regional State little research has been carried out in exploring the issue of active learning approaches in the universities.

1.2 PROBLEM STATEMENT AND RESEARCH QUESTIONS

The paradigm shift from a lecturer-centred to active learning/student-centred approaches has been widely advocated throughout the world. Numerous research studies have shown that active learning-based teaching methods are more effective than traditional methods, such as the lecture method, in improving student academic performance (Cook & Hazelwood, 2002:297; Saville, Zinn, & Elliott, 2005:50; Starke, 2007:15).

In the Ethiopian context the previous curriculum design and instructional processes suffered from the old, traditional approach (MoE, 2002:56-58). Hence continual curriculum revisions have been made and different programmes were designed by the new education and training policy of the country to offer quality training and to make the active learning approaches practical at different levels of the country. For instance, the Teacher Education System Overhaul (TESO) programme was introduced in 2001 and emphasises the implementation of participatory, active learning in the pre-service and in-service programmes of teacher education among other major programmes (MoE, 2002:23). Thus the Ministry of Education (2002:28) underlined the importance of implementing active learning/student-centred approaches in teaching at various levels to promote the development of problem-solving capacities and competencies of the students.

Even though the effectiveness of an active learning approaches is supported by different researchers and this approach wins the debate over the lecturer-centred approaches (Cook & Hazelwood, 2002: 297), and even though the traditional approaches became theoretically obsolete with rapid advancement in technological resources, educators have noted the existence of a separation between theory and practice in reality. Thus various research findings consistently have shown that the traditional lecture, demonstration and question and answer methods, that is, the lecturer-centred approaches (which do not encourage students to actively participate in the teaching-learning process), dominate in schools and universities (Sternberg, 2003:325-329). Some research studies were conducted on the implementation of active learning approaches in Ethiopia. Sirak (2000:51) indicates that about 58% of class activities in teachers' training institutions were inclined to be lecturer-centred while 42% were identified as student-centred. The study conducted by Oli (2006:84) revealed that the status of the active learning/student-centred approaches in teachers' education colleges was also relatively low (less than 50%).

In order to make the teaching of mathematics more relevant to the immediate needs of the students, society, and the nation at large, it is imperative to improve the quality of Ethiopian university lecturers through direct involvement of their students in active learning approaches as a means of rectifying the differences in their educational backgrounds. However, as mentioned, in the Oromia Regional State in particular little research has been carried out in exploring the issue of active learning approaches in higher education, especially in mathematics education. The traditional “exposition by the lecturer" style is common as indicated by observation and informal interviews. Hence, the researcher believes that this study will be helpful to fill the existing gap in current research.

To this end, the following five basic research questions were set:

- To what extent are active learning approaches implemented in mathematics education in the universities in the Oromia, Ethiopia?
- What are the major factors/challenges in implementing active learning approaches in these universities?
- What are the attitudes of university lecturers towards active learning /student-centred approaches?

- What training has been provided for the implementation of active learning approaches in the teaching mathematics?
- What support, conditions and material are provided for the implementation of active learning approaches?

1.3 AIMS OF THE RESEARCH

The Ethiopian education and training policy of 1994 emphasises the implementation of active learning approaches in teaching (MoE, 2002:31)**.** As indicated, this is an approach that promotes higher order thinking and problem-solving capacities in order to produce problem-solving citizens. It is also a way of improving the quality of education (MoE, 2001:40). Hence, the aims of the study is to explore the nature of the teaching–learning process in line with the active learning/student-centred approaches and identify the major challenges/factors that hinder the implementation of this approaches in mathematics education in universities in Oromia, Ethiopia.

The specific objectives of the current research are to:

- Examine to what extent active learning approaches are implemented in mathematics education in the universities in the Oromia, Ethiopia;
- Identify the major factors/challenges in implementing active learning approaches in these universities.
- Determine the attitudes of university lecturers towards active learning/student-centred approaches.
- Discover what training has been provided for the implementation of active learning approaches in the teaching mathematics.
- Determine what support is provided for the implementation of active learning approaches.

- Make recommendations for the enhancement of active learning in mathematics education in universities in Ethiopia.

1.4 SIGNIFICANCE OF THE STUDY

The Ethiopian Education and Training Policy has widely been advocating active learning/student-centred approaches (Melese, 1999:15; MoE, 2002:40). The results of this study will provide information on the problems that are currently experienced in the teaching of mathematics at the University of Ethiopia. These results may be pivotal for implementing the education and training policy in general and in instructional processes in particular. The results may also provide recommendations for solutions to problems experienced. Since the authorities at the various levels of educational administration are responsible for creating conducive working environments in educational institutions and for guiding practitioners, they may also benefit from the findings of the present study. In view of the above, this study will help university lecturers, students, academic department heads, deans, the Ministry of Education, the Regional Education Bureau, Woreda Education Office and other concerned bodies to design measures for addressing the possible problems related to the implementation of an active learning/student-centred approach in university mathematics education.

Furthermore the researcher believes that this study has the following significance:

Policy wise:

- The study may help policy and other educational decision-making authorities at different levels to design viable policies that can promote the proper implementation of active learning/student-centred approaches.

The teaching-learning process:

- It can indicate to educational authorities and module writers factors that have to be considered in designing curricula and modules for the implementation of active learning/student-centred approaches;

- It can help academic department heads and deans to provide the necessary follow-up and support in the implementation of active learning/student-centred approaches;

- The study may help lecturers to improve their methods of teaching;

- It can help students to understand issues related to active learning approaches which impact on their performance.

Theoretically:

- The study can contribute to modify and strengthen theories that focus on the importance, perceptions and beliefs regarding active learning approaches.

Further research:

- The study serves as a stepping-stone for further and more extensive research in the area of active learning/student-centred approaches by identifying areas that need further research.

1.5 DEFINITION OF CONCEPTS

1.5.1 Learning approaches

A learning approach is a method, or a way of dealing with learning material to facilitate understanding (Felder & Brent, 2001:69-74). The way that students approach learning or conceptualise their own learning goals has been the topic of extensive research over the past two decades, and has contributed substantially to our understanding of teaching and learning in university settings. Most researchers distinguish between “deep” and “surface” approaches, also known as a “meaning orientation” as contrasted with a “reproducing orientation”. Learning approaches are thought to be more malleable than learning styles. There is evidence that the design of learning experiences often encourages a move to more surface learning, largely because of the nature of most assessment tasks (examinations and tests).

1.5.2 Active learning/student-centred approaches

Active learning is an activity that engages students in doing something besides listening to a lecture. Students may be involved in communicating with one another, or writing, reading, and reflecting individually. In this approach students may also be actively involved by means of discovering, processing, and applying information. Active learning "derives from two basic assumptions: (a) that learning is by nature an active endeavour and (b) that different people learn in different ways" (Benek-Rivera & Mathews, 2004:104-106). In active learning, students are involved in varieties of active learning approaches such as cooperative/collaborative learning, inquiry learning, problem-based learning, discovery learning and projects within and out of the classroom (Benek-Rivera & Mathews, 2004:104; Starke**,** 2007:8).

Research has demonstrated that students learn more if they are actively engaged with the material they are studying. Active learning/learner-centred approaches place students at the centre of the teaching-learning process and it can be identified by at least some of these characteristics (Biggs, 2003:36-59; Cook & Hazelwood, 2002:297; Feden & Vogel, 2003:25; Fink**,** 2002:6):

- Students are involved in more than just listening and taking notes, they participate in a variety of class activities, and often interact with one another (in discussing, reading, presenting and sharing their writing);

- Students are involved in higher-order thinking skills (including analysis, synthesis, and evaluation);

- Students reflect on their learning and their learning processes;

- Greater emphasis is placed on students' exploration of their own attitudes and values; and

- Less emphasis is placed on transmitting information but more on developing students' skills.

According to McCormack and Jones (1998:14), active learning is anything that students do in a classroom other than merely passively listening to a lecturer's lecture. This includes everything from listening practices that help students to absorb what they hear, to short writing exercises in which students react to the material, to complex group exercises in which students apply course material to "real life" situations and/or to new problems. Regarding students' learning Starke (2007:4) says that:

> *… Learning is not a spectator sport. Students do not learn much just by sitting in class and listening to teachers, memorizing pre-packaged assignments, and*

spitting out answers. They must talk about what they are learning, write about it, and relate it to past experiences, apply it to their daily lives. They must make what they learn part of themselves.

1.5.3 Lecturer-centred method

Lecturers are defined as the university instructors/professors who are responsible for teaching. Lecturers control what happens in class such as the flow of questions and answers from one group or individual to another.

The traditional, lecturer-centred approach is a methodology that gives the priority role and responsibility to the lecturer (Cook & Hazelwood, 2002:297). The lecturer is placed at the centre of instruction and is thought to hold most of the knowledge necessary for students to be successful. This implies that the lecturer assumes responsibility for students' learning.

The lecture-centred approaches use sequenced and structured materials. It refers to teaching activities where goals are clear to students, time allocated for instruction is sufficient and continuous, coverage of content is extensive, the performance of students is monitored and feedback to students is immediate. In this method, the lecturer plays a primary role in structuring and explaining the content. The student in the lecturer–centred approach receives knowledge from the lecturer, internalises it and later during assessment regurgitates it. The meaning making and adaptation to previously acquired knowledge are left to the learner and are not emphasised in the teaching process.

The student and the lecturer's roles are that of receptor and disseminator respectively. In this methodology, the lecturer usually follows a logical sequence of presentation which may include reviewing the previous lesson, presenting the daily lesson, providing guided practice, getting feedback and finally evaluating the students' performances.

The lecturer-centred method of instruction considers the *product* (learning output) more important than the *process* of arriving at it. Moreover, a lecturer–centred instructional methodology focuses on content and learning objectives. Students work as individuals and often in competition with other students and they are highly dependent on the lecturer's activities. The lecture is the dominant method of curriculum delivery.

1.6 RESEARCH DESIGN AND METHODOLOGY

A literature study is essential for the researcher to have a global and exhaustive picture of the topic under investigation. The literature review is presented in Chapters two and three. As mentioned earlier, the major objective of the present study is to investigate the extent to which an active learning approach is implemented and to assess the major factors that hinder the implementation of active learning in mathematics education in universities in Oromia Regional State, Ethiopia (see section 1.2 and 1.3).

A mixed-method approach is used in this study as recommended by Thomas (2003), as follows: In the quantitative phase, a descriptive survey method is used as it is the most appropriate method for collecting information and opinions from quite a large number of respondents. It is also relevant to gather detailed descriptions of the existing conditions, current practices or interests of a group of people (Gay & Airasian, 2000:11). Questionnaires are used to collect data as explained in chapter 4.

In the qualitative phase, observation checklists and interviews are employed for gathering the information required for the present study. All the information gathered through the interviews and observation checklists are used as supplementary information to complement the data gathered through questionnaires. Gay and Airasian (2000:201) point out that such triangulation gives broad coverage of education characteristics and allows for the crosschecking of information. More detail is provided in chapter 4.

Regarding sampling, from the six universities (Jimma, Haramayia, Adama, Wallega, Mada-Wlabu and Ambo) found in the Oromia Regional State of Ethiopia, two of the newly established universities (younger than 5 years) and two of the older universities (15 years and older) are involved in the study. Lecturers, deans and department heads from the field of mathematics are purposively selected for participation. This will be explained further in Chapter four.

The information gathered through the three instruments regarding active teaching/learning approaches in mathematics education in Oramia, Ethiopia, is analysed using appropriate quantitative and qualitative techniques. This aspect is explained further in Chapter four.

1.7 THE DIVISION OF CHAPTERS

CHAPTER ONE

The first chapter contains the introduction and background to the investigation, the problem statement and aims, definition of concepts as well as an overview of the research design and methodology.

CHAPTER TWO

This chapter presents the theoretical framework of the study. This includes learning theories with special reference to active learning. This chapter also includes teaching methods that influence active learning of mathematics such as cooperative learning/collaborative learning, problem-based learning, role-playing, project methods, discovery methods and discussion.

CHAPTER THREE

Chapter three presents a review of the literature that relates to the work other researchers have done on the effect of different teaching and learning methods on the learning of students, with special reference to mathematics education. The focus will also be on the university sector.

CHAPTER FOUR

In this chapter the research design and methods used to conduct the investigation are explained. This chapter also includes sampling, data collection methods, methods of data analysis, validity and reliability and research ethics.

CHAPTER FIVE

This chapter presents the research results and a discussion of the results.

CHAPTER SIX

This chapter provides the conclusions, recommendations and limitations of the present study.

1.8 SUMMARY

Chapter one presented an overview of the study. The purpose of the research is to investigate the extent to which active learning/student-centred approaches are implemented in mathematics education and factors that hinder its implementation in four sample universities. Both instruction and learning have strong psychological roots and this research is therefore relevant for a study in Psychology of Education.

The chapter delimited the problem statement, aims of the research and possible significance of the study. This was followed by a definition of concepts and a brief overview of the research design and data collection methods.

In the next chapter, Chapter two, a review of the theoretical framework of the study is given. The focus is on learning theories and their related teaching methods.

CHAPTER TWO

THEORETICAL FRAMEWORK: LEARNING THEORIES AND TEACHING METHODS WITH SPECIAL REFERENCE TO ACTIVE LEARNING

2.1 INTRODUCTION

In the first chapter, an overview of the study, the statement of the problem and research questions, research design and methodology, as well as an indication of the division of chapters were presented. The intention of this chapter is to present a review of the literature on the theoretical framework of learning theories: behaviourism, cognitive theories, social learning, constructivism and experiential learning theories with special reference to active learning. This chapter also includes teaching methods that influence active learning in mathematics education such as cooperative learning, problem-based learning, inquiry-based learning, discovery learning and discussion methods.

2.2 THEORIES OF LEARNING

Anderson and Elloumi (2004:4) mention that theories are reasoned explanations rather than absolute facts that deal with a particular phenomenon. Learning theories attempt to explain how students think and what factors determine their behaviour and learning. Learning theories are the basic raw materials, which are applied in the teaching-learning process. It is, therefore, essential for the lecturer to understand learning theories and learning and teaching approaches to design effective teaching activities.

According to Schunk (2000:30), *one* learning theory only is not enough to explain all the learning types and the problems related to learning. Theorists of most learning theories such as constructivist, experiential theory of learning, behaviourist and also cognitive theories have made important suggestions for improving and arraying teaching. However, there is a very important suggestion that theorists in many different groups agree on and that is that students must be active in learning. The active learning approach attempts to shift students from the passive mode of receiving knowledge to the active role of generating, synthesising, understanding, and applying knowledge (Chance, 2005:17).

In accordance with the above, Anderson (2005:306) reported that theorists came to a standpoint that one theory will not be able to completely comprehend the learning process and value the outcome of the learning process in mathematics. In the mathematical context, the notion of cognitive change is more important than behavioural change. Given the increasing importance of this notion in constructing a functioning active learning/student-centred environment, it was suggested that the cognitive theory of learning compensates and complements for the shortcomings of the behavioural approach. Regarding the correlation between experience, learning and learning theories, Tan, Parsons, Hinson and Sardo-Brown (2003:23) assert that learning theories clarify how learning can be facilitated through experience. Tan *et al.* indicate that learning theories adopt a systemic account of the numerous standpoints of theorists on how students learn from experience.

Learning theory has a long history. In this century, the study of learning is mainly a concern of psychology and gains ground in the context of learning and teaching of mathematics at a university level. There is a shift from a lecturer-centred approach to an active learning/student-centred approach to learning and teaching. These changes encourage lecturers to reflect not only on the key principles of learning and teaching but also on their role in the process.

In an active learning classroom environment, the role of a lecturer is often that of a facilitator, supporting students as they learn and develop skills in, for example, assessing evidence, negotiation, making informed decisions, solving problems, working independently and working with others. Students' participation and involvement in their learning is essential (McConnell, 2005:36).

A number of learning theories will be explained next. Their implications for mathematics teaching are pointed out.

2.2.1 Behavioural theory of learning

2.2.1.1 Theory

Behaviourism is a perspective on learning that focuses on changes in individuals' observable behaviours, that is, changes in what students say or do. Behaviourism, which is most often associated with the work of Skinner (in Burton, Moore & Magliaro, 2004:166) was the most prominent learning theory for much of the 20th century. Behaviourism is comprised of several individual theories that have a common theme. This common theme is found in the ways the theorists define what learning is, and how it is accomplished. The common assumptions of these theorists are threefold, as explained by Merwin (2003:243). The first common assumption is the emphasis on observable behaviour rather than internal thought processes that create learning. Second, ultimately it is the environment that creates learning and it determines what is learned, not the individual student/learner. Lastly, it is the student's ability to understand the overall process, and the ability to repeat or reinforce that process that is a common thread (Mazur, 2005:31-38; Merwin, 2003:242-244).

Behaviourism holds that learning is the result of an event (stimulus), the reaction to that event (response), and the consequences of that response (Burton *et al.,* 2004:129). Through this process, participants modify their behaviour to obtain a favourable outcome. Behaviourism regards learning as the shaping of a student's behaviour to get the outcome that the lecturer wants to have and providing reinforcement for behaviour that needs to be affirmed or punishment for behaviour that the person should not repeat (Anderson & Elloumi, 2004:7). It focuses on objectively observable behaviour and discounts mental activities. Behaviourists focus on eliminating maladaptive, conditioned reflexes and developing more adaptive ones, often working with people suffering from irrational fears or phobias (Chou, 2004:11). Behaviourists view learning as the acquisition of new behaviour and rely primarily on two basic images or models of behavioural learning, called respondent (or "classical") conditioning and operant conditioning, as a universal learning process.

Behavioural theory explains learning in terms of observable phenomena and ignores thoughts and feelings of students/students. According to the behaviourists, learning occurs as a 'response' to certain definite and identifiable stimuli in one's environment. Since it is not possible to observe what is happening inside a student/learner's brain, they advocate that measuring and theorising about learning must be limited to merely the stimulus and the response. Behavioural theory emphasises changes in behaviour due to the influence and control of the external environment, rather than the internal thought processes of the subject (Merwin, 2003:242-244; Van Liet, 2005:416-426). Teaching of a student centres on the concept that all learning is the result of the environment acting upon behaviour. The environment of an individual reinforces behaviour either positively or negatively.

A more centrist approach to learning is neo-behaviourism. Neo-behaviourism suggests that not only does the environment reinforce behaviour, but there is an interaction between the individual and the environment (Mazur, 2005:21-28; Gupta, 2005: 48-51).

It can be concluded that behaviourism emphasises a process-product and lecturer-centredness approach of the teaching and learning process that have been prevalent in traditional classroom teaching (Holt & Willard-Holt, 2000:114). A behaviourist teaching style in mathematics education tends to rely on practices that emphasise rote learning and memorisation of formulas, one way to solve problems, and adherence to procedures and drill. Repetition is seen as one of the greatest means to skill acquisition. Teaching is therefore a matter of stating objectives and providing the means to reach those objectives and situated learning is given little value in instruction (Kolar & McBride, 2003:67-68). This over emphasis on procedures and formulas resembles lecturer-centred formalist ideas. To sum up the behaviourist perspective are on two major theories or models of learning, called respondent conditioning and operant conditioning. Respondent conditioning describes how previously neutral associations can acquire the power to elicit significant responses in students. Operant conditioning describes how the consequences and cues for behaviour can cause the behaviour to become more frequent. In either case, from a lecturer's point of view, the learned behaviour or responses can be either desirable or unwanted.

2.2.1.2 Mode of assessment

The teaching and learning process in a traditional behaviourist approach focuses on covering extensive subject areas, which causes the students to have little time to engage in thinking beyond the facts and problem solving, and consequently minimising independent and autonomous learning (Holt & Willard-Holt, 2000:244). Lecturers concentrate on measuring overt behaviour, particularly whether students are able to reach the terminal course objectives. Students' attitudes and commitment to program objectives receive little attention. Hence, assessment methods in behaviourist approaches comprise of close-ended questions such as true-false, matching and multiple-choice questions (Winter, Lemons, Bookman & Hoese, 2001:328-329).

2.2.2 Cognitive theory of learning

2.2.2.1 Theory

The cognitive theory of learning is a prominent school of thought that appeared as a complement to the behaviourist theory of learning. The current cognitive view of learning has its antecedents in Gestalt theory (which emphasised learning through insight) and the work of Piaget (in Sternberg, 1999:20-22). Gestalt theory, which is otherwise known as purposive behaviourism, is the most important cognitive theory relevant to training. The gestalt psychologists explain that learning is neither a matter of adding new traces nor subtracting old ones but of changing one gestalt into another. They view learning as a purposive, exploratory, imaginative and creative process of developing new insights or modifying old ones (Mayer, 2005:45-46; Pressley & Hilden, 2006: 514).

Ainsworth and Th Loizou (2003:671) report that cognitive theorists view learning as involving the acquisition or reorganisation of the cognitive structures through which humans process and store information. Moreover, they report that cognitive theorists use observable and measurable outcomes in behaviour as a means of conjecturing what goes on in a person's mind. Thus, unlike behaviourism, the cognitive theory of learning recognises that the human mind is not simply a passive recipient of knowledge. Rather, the student/learner interprets knowledge and gives meaning to it. It endeavours to make learning meaningful to each student in a particular context (Papert, 2000:720-729). Opposed to behaviourist theories of learning, advocates of cognitive theory were more inclined to appreciate and discriminate factors that prompt the student to process information. Thus, cognitivists are concerned with how information is received, organised, stored, and retrieved by the mind (Hening, 2004: 143-168). According to Lewandowsky, Little and Kalish (2007:98), unlike behaviourism, cognitive learning theory emphasises mental events rather than overt, observable behaviours. Therefore, in cognitive theory the focus is on the formation of concepts (or cognitive structure) and the acquisition, processing, organisation, and storing of information.

Cognitive theory (e.g. that of Piaget) is often associated with schema theory, information processing theory, and the "mind as computer" metaphor of cognition. It focuses on a student’s schema as an organised knowledge structure and on the promotion of mental processing; how students think through problems (Aleven & Koedinger, 2002:177-180). The centre of attention is on how students interact with and process the world. For cognitivists, the learning environment is only part of the learning process. It is the most immediate, but it does not and cannot account for individual students' interaction with the content and the connections that they build between existing concepts and new concepts. These interactions are iterative and accumulative resulting in increasingly complex understandings (Healey& Roberts, 2004:34-39; Kozma, 2003:218).

Cognitive psychologists, such as Jean Piaget and Vygotsky, have long espoused the constructivist theory of learning. Piaget said (in Wilson, Cooney & Stinson, 2005) students learn better when they can articulate knowledge through inquiry and experimentation, instead of passively acquiring facts. Piaget’s theory on the development of thinking is grounded in the notion that students construct their own knowledge. To understand our environment and the world, people organise new experiences and adapt new ideas into schemas (cognitive structures). Assimilation occurs when these new experiences and ideas are incorporated into our existing knowledge. On the other hand, accommodation occurs when a person adjusts her/his knowledge to a new idea. That is, when it encounters an unfamiliar experience or idea, the schema tries to fit it into on the existing knowledge. If no similar structure exists, a new schema is created to accommodate the unfamiliar experiences. The construction of new knowledge occurs when new ideas disturb the current organisation of knowledge (Savin-Baden & Wilkie, 2004:29-31; Slavin, Hurley & Chamberlain, 2003: 187-188).

To sum up, the goal of the teaching and learning process in both behaviourism and cognitive theory is the communication and transfer of knowledge to students in the most efficient and effective manner possible (Anderson, 2005:292). Motivation is a crucial aspect of the learning process (Hill, 2002:56). It is closely related to arousal, attention, anxiety, and feedback. Hofer and Yu (2003:30-33) point out that behavioural theories tend to focus on extrinsic motivation (rewards) while cognitive theories deal with intrinsic motivation (*i.e.,* goals). The characteristics of cognitive learning theory that assume importance in the context of teaching and learning mathematics are: (a) individual behaviour is goal directed so teaching should take into account the students' goals; (b) learning is a meaningful process so teaching must evolve a process where the student/learner can understand what he/she learns; and (c) each student learns through his/her own cognitive map (Anderson, 2005:285). Hence, lecturers should take this into account and organise mathematics teaching and learning on the basis of the cognitive maps of the students.

2.2.2.2 Mode of assessment

According to the cognitive information processing view, the human learner is conceived to be a processor of information, in much the same way a computer is. When learning occurs, information is the input from the environment which is processed and stored in the memory, and the output is in the form of a learned capability. This group of educators looks at universities as composed of groups of individuals with varying needs and skills and views humans as "rule-forming beings." Lecturers need to assess the student's abilities to discover whether he or she is ready to learn. In line with Ausubel, "the most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly" (Yoder & Hochevar, 2005:94). With this approach, instructional focus begins to move away from the lecturer and toward the students. Cognitivists favour procedural rather than declarative learning and promote the idea that learning is achieved through an active process of creating hypotheses through activities.

2.2.3 Social learning theory

2.2.3.1 Theory

Social learning theory falls a category of learning theories which are grounded in the belief that human behaviour is determined by a three-way relationship between cognitive factors, environmental influences and behaviour (Bandura, 2002:270). Furthermore, social learning theory points out that the individual learns from the behaviour of others through observation, imitation and modelling. This theory was introduced by Albert Bandura in 1971 and it bridges behavioural and cognitive learning theories by taking into account how imitable behaviours are affected by cognitive constructs, such as attention, retention, and motivation (Bansberg, 2003:142-144). Bandura's social learning theory was widely accepted because of its complete but economical interpretation of social learning (Bolt & Brassard, 2004:65; Kukla, 2000:10-15).

Learning takes place both as a result of experienced responses and vicariously through observing the effects on the social environment of another student's behaviour. In explaining his theory of modelling, Keil (2006: 609-635) considers four distinct components or sub-processes: attention, retention, motor reproduction and motivational processes. These processes explain the acquisition and maintenance of observational learning or modelling (Child & Heavens, 2003:310-312; Hening, 2004:153-168).

Social learning theory is a valuable and effective tool for lecturers who want to assist their students in gaining new skills. Its implications for the teaching and learning of mathematics are as follows: Social learning theory can help lecturers determine why certain learning activities work, and why other activities aren't very effective. Social learning theory also plays an important role in learning and teaching in the following ways: Firstly, the lecturer, by becoming a role model for his/her students, can improve their behaviour. In fact, students are more likely to imitate their superiors rather than their peers because of their status, experience and reward power. Second, modelling has a considerable role to play in implementing a self-managed approach through self-observation and self monitoring (Bandura, 2002:279-281). Third, for improving the effectiveness of teaching, a vicarious or modelling principle has been proposed to be used in four stages, namely, (1) presentation of models displaying the desired behaviours; (2) imitation or rehearsal by the observer of the modelling behaviours; (3) social reinforcement or favourable recognition for adoption of the modelled behaviours by the observer; and (4) transfer of teaching to encourage the use of learned behaviours back on the job (Hofstetter, 2005:28; Slavin, 2005:66-70). In the application of social learning theory to mathematics teaching, the student is encouraged to:

- observe and imitate the behaviours of others,
- see positive behaviours modelled and practiced,
- increase their own capabilities and confidence to implement new skills such as mathematics problem solving skills,
- gain positive attitudes about implementing new skills to mathematical problem solving, and
- experience support from their environment (e.g. the mathematics lecturer) in order to use their new skills.

Observers perform the desired behaviour only if they have some motivation or reason to do so. Various factors determine motivation. The presence of reinforcement or punishment, either to the model or directly to the observer, is an important factor. An important component of motivation in Bandura's theory is self-efficacy, defined as "individuals' confidence in their ability to control their thoughts, feelings and actions, and therefore influence an outcome" (Bandura, 2002:147). Perceptions of self-efficacy are associated with the students' actual performances including academic performance and achievement through observation, practical activities and project work (Bandura, 2002:145-146; Kukla, 2000:18-21).

2.2.3.2 Mode of assessment

Bandura's social learning theory states that both deviant and normative human behaviour is learned through a combination of observed behaviour, communication with others, encounters with disciplinary action and cognitive modelling (Bandura, 2002:145; Snowman & Biehler, 2000). Essentially, people gather information about the potential outcomes of any given behaviour from a variety of sources, including both other people and media, and use that information to make assumptions about the outcome before engaging in that behaviour themselves. Without this capacity for learning by example, Bandura argues that human development would have been severely retarded, tedious and hazardous. Without social learning, humans would have no method for learning beyond simple trial and error (Bandura, 2002:146). Social learning theory views the individual as an active participant in his or her behaviour, interpreting events and selecting courses of action based on past experience.

2.2.4 Constructivist theory of learning

2.2.4.1 Theory

The field of education has undergone a significant shift in thinking about the nature of human learning and the conditions that best promote the varied dimensions of human learning. As in psychology, there has been a paradigm shift in views of learning; from behaviourism to cognitivist learning theory and now to constructivism (Bolt & Brassard, 2004:161-162).

Constructivism is a learning theory that attempts to explain how students learn by constructing understanding for themselves. This section will explore the constructivist learning theory by defining constructivism, providing varying views of constructivism, and illustrating how constructivism relates to independent learning (of mathematics in particular) and university education. Constructivism gives lecturers another perspective to rethink how students learn and to focus on processes and provide ways of documenting change and transformation. It also reminds lecturers to look for different ways to engage individual students, develop rich environments for exploration, prepare coherent problem sets and challenges that focus the model-building effort, elicit and communicate student perceptions and interpretations (Angeli**,** 2002: 9-15; Eggen & Kauchak, 2001:56-58).

Constructivism is viewed as a meaning–making theory that offers an explanation of the nature of knowledge and how human beings learn. Knowledge, as viewed here, is acquired through an involvement with content rather than imitation or repetition. According to this explanation of learning, "individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact" (Boudourides, 2003:6). Moreover, a constructivist view of learning holds that the student, in trying to make sense of new events or objects, begins from relevant existing ideas or models, and tests the extent to which the new phenomena can be explained using these existing ideas or models. If predictions based on a related existing idea or model fits the new observations, then the range of applications of the idea or model is extended; if the evidence does not fit the prediction, however, this may mean that the idea or model has to be modified or rejected in the light of the new evidence. To acquire meaningful learning, the students therefore require a deliberate effort to relate new knowledge to relevant concepts they already possess. Based on the learning perspectives as described above, one of the instructional approaches, concept mapping, could offer a means for course design, which promotes the development of a structured course within a good pedagogical framework (Christensen, 2003:386). By means of concept maps, students would foster meaningful learning.

Constructivism is recognised as a unique learning theory in itself. Behaviourism and cognitivist learning theory both support the practice of analysing a task and breaking it down into manageable chunks, establishing objectives, and measuring performance based on those objectives. Constructivism, on the other hand, promotes a more open-ended learning experience where the methods and results of learning are not easily measured and may not be the same for each learner. There are very distinct differences in the way the different theories view the learning process. In the constructivist classroom, students are required to be "active learners," meaning that they engage more in self-directed, experiential learning; reflect on their individual learning processes, and have more learner autonomy (Christensen, 2003:235-243). Students are encouraged to ask questions, use their prior knowledge and experiences to develop theories, as well as work in groups. Constructivist teaching requires that instructors be partners with students in their learning that they actively solicit students' points of view, as well as provide for them learning experiences that are relevant to the world outside the classroom (Santrock, 2001:116).

The core of the constructivist view is construction of knowledge using old knowledge and materials at hand. A mathematics lecturer that uses a constructivist approach relates representations and explanations of new information which will meaningfully connect with prior knowledge. The theorists in this perspective argue that cognition is enhanced when construction of knowledge is encouraged within the classroom discourse (Huang, 2002:30). That is, construction does not occur in vacuum. The student interacts with the environment, objects or persons (Hendry, Frommer & Walker, 1999:63-64). The nature of the object causes a reaction in the schema, which according to Piaget's theory, causes either an equilibrium or disequilibrium state. If it matches, then there is assimilation or if not, the schema is rearranged for new information to be accommodated (Bransford, Brown, & Cocking**,** 2000:327). The constructivist believes in the value of discourse during interactions. The lecturer encourages the students to engage in a dialogue, both with the lecturer and with one another. Students, for example those in the mathematics classroom, communicate about their interpretation of the representation. They elaborate and justify their interpretations. This enables students to reorganise their existing knowledge and accommodate newly constructed information (Felder & Brent, 2001:72-73; McConnell, 2005:34-36).

Learning activities in constructivist settings are characterised by active engagement, inquiry, problem solving and engagement with others. Accordingly, a lecturer's role in such settings is not merely that of a dispenser of knowledge. The lecturer here is a guide, facilitator and co-explorer who encourages students to question, challenge and formulate their own ideas, opinions and conclusions. However, a lecturer who follows the constructivist views on learning will not look for 'correct answers' and will de-emphasise single interpretations. Constructivist also sees students as constantly checking new information against old rules and then revising rules when they no longer work. This view has profound implications for mathematics teaching, as it suggests a far more active role for students in their own learning than is typical in many classrooms. Because of the emphasis on students as active learners, constructivist strategies are often called an active learning/student-centred approach (Healey& Roberts, 2004:44-52; Taylor, 2000:109; Swan, 2005:52).

Furthermore, constructivist learning theorists believe that all learning involves mental construction, no matter how one is taught. All learning, constructivists argue, occurs in students' minds as students create and adjust internal mental structures to accommodate their ever growing and ever changing stores of knowledge. Thus, all learning is an active process and all knowledge is unique to the individual, whether acquired from lecture and text or discovered through experience. All learning is therefore intimately tied to experience and the contexts of experience, no matter how or where that learning takes place (Jacobs & Hall, 2002: 52-56; McCombs, 2003:589)

Constructivism posits that students in the mathematics classroom construct their own knowledge from their experiences. Constructivism requires students to be "active learners," meaning that they engage more in self-directed, experiential learning, reflect on their individual learning processes, and have more student autonomy. Constructivist classroom practices include asking questions, the lecturer as partner with the student, working in groups, an emphasis on intrinsic motivation and assessment interwoven with instruction (McCombs, 2003:599). Constructivists also recognise that challenging and helping students to correct their misconceptions are essential to effective learning (Schunk, 2000:326). Conditions that foster such knowledge construction include the development of "a cognitive apprenticeship" between lecturer and student, the use of realistic learning tasks and exposure to multiple perspectives (Richardson, 2003:1632).

Constructivists believe that all humans have the ability to construct knowledge in their own minds through a process of discovery and problem solving. The extent to which this process can take place naturally without structure and teaching is the defining factors amongst those who advocate this learning theory. Piaget (in Slavin, 2005:119) observed human development as a progressive stage of cognitive development. Fundamentally, constructivism is a cognitive learning theory because of its focus on the mental processes that construct meaning. According to constructivism, learning is not passive reception of information but a student's active continuous process of constructing and reconstructing his or her conceptions of phenomena or mathematical problems.

Culture influences learning. Because students interpret new information on the basis of their existing knowledge, constructivist pedagogy is grounded on students' previous conceptions and beliefs about the topics to be studied. It emphasises understanding instead of memorising and reproducing information, and it relies on social interaction and collaboration in meaning making. Although common languages and cultures enable us to understand things in basically the same way, people, because of their individual experiences, may attribute different meanings to similar things. It follows that it is useful to organise learning on the basis of interactive and cooperative forms of studying in which individual interpretations and understandings meet each other.

Teaching is not transmitting knowledge but helping students to actively construct knowledge by assigning them tasks that enhance this process. This does not mean that mathematics lectures should be entirely removed from the learning process in constructivist learning environments. Rather it means that lectures should be accompanied by assignments in which students must reflect on and use the information given them in the lectures. An important aspect of lecturer guidance relates to the constructivist notion of generative learning. Since constructivists believe that the student must transform or appropriate whatever is learned, one can say that all learning is discovered. To appropriate new understanding from one's social environment and to become an efficient maker of meaning requires the adoption of specific intellectual skills, ones that should be modelled from more competent adults (e.g. mathematics lecturers) and peers. Thus generative learning strategies (learning-to-learn) in the mathematics classroom may be explicitly taught to students or may be discovered by students as they are trying to find strategies for solving problems. For example, students have been guided to generate their own questions and summaries and analogies during the reading of relevant texts (Winter *et al.,* 2001:328).

Constructivism suggests that students learn concepts or construct meaning about ideas through their interaction with others, with their world, and through interpretations of that world by actively constructing meaning. Students relate new knowledge to their previous knowledge and experience. A constructivist model of teaching has five characteristic features: (a) active engagement, (b) use and application of knowledge, (c) multiple representations, (d) use of learning communities, and (e) authentic tasks (Siemens, 2006:16-18). The mathematics lecturer's task, according to this approach, is to tutor students and teach them how to learn mathematics. He/she is not a mere "purveyor of knowledge" or "provider of facts", but is, rather, a mentor, facilitator, helper, and mediator for learning. The lecturer must create a learning environment that will allow the student to construct his/her own knowledge by experiencing and interacting with the environment (Hill, 2002:78). Hill (2002:110) delineates as essential for constructivist classrooms:

> *… when the classroom environment in which students spend so much of their day is organised so that student-to-student interaction is encouraged, cooperation is valued, assignments and materials are interdisciplinary, and students' freedom to chase their own ideas is abundant students are more likely*

to take risks and approach assignments with a willingness to accept challenges to their current understandings. Such teacher role models and environmental conditions honor students as emerging thinkers.

In conclusion, the following may be stated with respect to the differences between the behaviourist and constructivist learning theories in so far as learning is concerned. Behaviourism, as Kim (2005:8-10) considers, follows a 'banking' model in which the lecturer fills students with deposits of information considered by the lecturer as true knowledge and the students are required to retain this till such time as needed. Hence, a lecturer who uses a behaviourist approach follows a memory-oriented transmission strategy. The difficulty with such a method is that the knowledge acquired is not well integrated with prior-knowledge and is often accessed and articulated only for formal academic occasions such as examinations. Constructivist approaches, in contrast, are regarded as producing greater internalisation and deeper understanding than lecturer-centred methods. Constructivists have many similarities to cognitivist learning theorists. They both describe theories of learning that emphasise the construction of knowledge; however, they differ in a number of areas (related to realism and the role of social interactions). According to constructivists social interactions are vehicles for learning and development. Growth comes through these interactions, while behaviourists emphasise lecturer-centred methods and stimulus-response interaction (Biggs, 1999:21; Hinde & Kovac, 2001:95-98; Jacobs & Hall, 2002: 56-58; Prince & Felder, 2006:146).

The study on constructivist theory of learning brings into discussion the many advantages of this learning theory for the teaching of mathematics in encouraging optimal student participation in the teaching and learning process. The constructivist theory of learning is supported by numerous publications in the literature that highlights the role of the student as an active participant and the lecturer as a facilitator in moderating the knowledge in a teaching and learning process (McConnell, 2005:37-38). In applying constructivist theories of learning a mathematics lecturer should take the following actions:

- understand student learning styles and become aware of one's own learning style
- help students identify their mathematics learning style(s)
- implement multiple instructional strategies to address multiple learning styles (Felder & Brent, 2001:68-70; Kim, 2005:15-18)

In this part of chapter two, constructivism was identified as the term for a set of epistemological theories which are grounded in a belief that meaning is constructed in the minds of individuals through cognitive processing of interactions in world. Significant aspects of constructivist theories were shown to include the notion that learning is active, social and situated in particular physical, social and cognitive contexts, that it involves the ongoing development of complex and interrelated mental structures, and that the construction of knowledge is, to a greater or lesser degree, distributed across individuals, tools and artifacts. Constructivism was moreover seen to have various implications for instruction, the most significant of which is to shift the focus of pedagogical design away from instruction and toward the design of learning environments that are active learning/learner-centred, knowledge-centred and community centred.

2.2.4.2 Mode of assessment

Moving from the knowledge-transmitting paradigm of learning towards constructivist instruction requires fundamental changes in assessment procedures (Biggs**,** 1999:183**;** Slavin, 2005:129**)**. In constructivist learning environments assessment is not a separate examination at the end of the course; rather, assessment methods are integrated into the learning process itself. Traditional examinations often lead students to adopt a surface approach to learning and studying, and to attempt to memorise the material instead of trying to understand it (Boudourides, 2003:158). Furthermore, traditional examinations are not able to capture the actual changes in students' knowledge. In contrast, assessment methods that emphasise the learning process itself and encourage students to engage in meta-cognitive and reflective activities are in harmony with a constructivist view of learning. Authentic assessment or performance assessment represents this type of alternative assessment methodology**.**

Most learning theories recognize the importance of assessment and feedback. Indeed, according to constructivists, learning results from our reflections on feedback from environmental interactions. What is perhaps different about constructivist approaches to assessment are their emphases on the importance of the individual's processing of environmental feedback and so on the design of assessment-centred environments (Bransford *et al.,* 2000:25-27) that provide ongoing meaningful feedback to students, e.g. in mathematics. Constructivism suggests that self-assessment is integral to learning, and so implies that opportunities for self-assessment should occur continuously and be embedded within learning activities. Constructivist theory also implies that it is especially important to encourage students to continuously construct and reconstruct their knowledge, to evolve and change their understanding, in response to feedback. Thus, constructivist approaches contend that good assessment practices are those that value revision and the *processes* of knowledge construction. Because constructivism views knowledge as complex mental structures, constructivist approaches further contend that good assessment practices emphasise learning *with understanding* and the *application* of knowledge, and not the memorisation of isolated facts and procedures. Assessment in mathematics focuses on problem solving, research and exploration of possible answers or solutions and developing projects as well as presentations. There is emphasis on group collaboration rather than individual work. Learning and assessment methods comprise of open-ended questions and scenarios, creating portfolios and descriptive narratives (Roblyer, 2006:53-54).

2.2.5 Experiential learning theory

2.2.5.1 Theory

The importance of *experience* in learning is acknowledged by more and more psychologists. Kolb and Boyatis (2001:38) provide major insights into experiential learning which they describe as "the process whereby knowledge is created through the transformation of experience". They proposed that experiential learning follows a cyclical process – from experience to reflection to conceptualisation to application, with this cycle being continuously repeated. Adams, Kayes and Kolb (2005:342-343) build on this with a description of experiential learning that clearly places it within the constructivist paradigm:

> *Experiential learning is based on the notion that ideas are not fixed or unchangeable elements of thought but are formed and re-formed through 'experience'. It is also a continuous process, often represented as cyclical, and being based on experience, implies that we all bring to learning situations our own ideas and beliefs at different levels of elaboration (342).*

Moreover, experiential learning theory provides a holistic model of the learning process and a multi-linear model of student development, both of which are consistent with what students know about how they learn, grow, and develop. The theory is called "experiential learning" to emphasise the central role that experience plays in the learning process, an emphasis that distinguishes experiential theory of learning from other learning theories. The term "experiential" is used therefore to differentiate experiential theory of learning both from cognitive learning theories (which tend to emphasise cognition over affect), and behavioural learning theories (that deny any role of subjective experience in the learning process) (Beard, 2007:28; Healey & Jenkins, 2000: 190-192).

Close examination of the experiential learning theory suggests that learning requires abilities that are polar opposites, and that the student must continually choose which set of learning abilities he or she will use in a specific learning situation, e.g. the mathematics classroom. In learning through experience, some of us understand new information through experiencing the concrete, tangible, felt qualities of the world, relying on students' senses and immersing them in concrete reality. Others tend to perceive, grasp, or take hold of new information through symbolic representation or abstract conceptualisation– thinking about, analysing, or systematically planning, rather than using sensation as a guide. Similarly, in transforming or processing experience some of us tend to carefully watch others who are involved in the experience and reflect on what happens, while others choose to jump right in and start doing things. The watchers favour reflective observation, while the doers favour active experimentation (Beard & Wilson, 2006:62; Beard & Wilson, 2005:11-14).

Kolb and Boyatis (2001:32-34) briefly conceptualise the process of research as a spiral of action and examination consisting of four general moments: plan, action, observation, and reflection. The description of all the learning cycle phases is:

- **First phase: Concrete experience /trying or involving in** "**doing**". The individual, the team, or the organisation merely executes the task. During that time, they do not reflect on it but have the intention to contemplate on it.

- **Second phase**: **Reflexive observing**. The reflection includes returning to the beginning point of the task and reviewing what has been done and tried. Listening skills, paying attention, distinguishing the differences, and applying ideas help to reach insights and to share them with the others. Adjustments, values, and beliefs impact on the definition of particular insights.

- **Third phase**: **Abstract conceptualising**. The conceptualising includes interpretation of the marked results and understanding the connections between them. Theory can be useful as a base of shaping and explaining the results. In that phase the adjustments, values, and beliefs also have an influence on the interpretation of the results. During the critical reflection phase, questions are asked from the perspective of the previous experience, while during the phase of conceptualising an attempt to find answers is done. Generalisation and conclusions are made from hypotheses that were developed from experience. About the abstract conceptualising, Kolb and Boyatis (2001:32- 34) say, “In that phase learning involves more logic and ideas than feelings of understanding the problems or the situations. It is typical to follow systematic planning and development of theories and ideas for solving problems.”

- **Fourth phase: Active experimenting (planning)**. The planning (active experimenting) gives an opportunity to master the new understanding and to predict what is likely to happen, or what other actions must be taken. About the active experimenting, Kolb and Boyatis (2001:245-247) state: “Learning during that phase has an active form – experimenting, influence or change of the situation. Experiential Learning theory affirms the significance of experience. Students differ from one another in their learning styles. Accepting this is an important premise that enables the students to realise the possible alternative approaches and to become more flexible in different learning situations. Mathematics lecturers also need to realise their own learning style as a basis for the development of effective teaching and study strategies. Studying can suffer if there is an underlined discrepancy between the style of the students and the style of the lecturer (Beard & Wilson, 2006:46; Kolb & Kolb, 1999:53).

As observed by Beard (2007:14) the term ‘experiential learning’ is being used with two connotations. On the one hand, it is used to describe the learning where a student acquires and applies knowledge, skills and feelings in an immediate and relevant setting. It thus involves a ‘direct encounter with the phenomena being studied rather than merely thinking about the encounter, or only considering the possibility of doing something about it”. The second connotation of experiential learning is “education that occurs as a direct participation in the events of life" (Beard, 2007:29). Unlike in the first connotation, learning here is not sponsored by some formal educational institution but is undertaken by people themselves. It is learning that is achieved through reflection upon everyday experience and is the way that most of us do our learning.

According to Kolb and Boyatis (2001:227), "Learning is a process, in which knowledge is created through transformation of experience." Their theory provides concrete understanding of how a class or a whole course of study can be taught in order to achieve better learning by the students. Kolb and Boyatis (2001:234-236) developed the model of experiential learning on the basis of the work of Lewin. Lewin's research discovered that learning is best facilitated when there is a conflict between a student's immediate concrete experience and a detached analysis of it by the individual. His four phase cycle of action, reflection, generalisation, and testing is characteristic of experiential learning. Kolb and Boyatis (2001:237-238) agree that effective learning entails the possession of four different abilities. These are concrete experience abilities, reflective observation abilities, abstract conceptualisation abilities and active experimentation abilities. These four abilities manifest in four basic learning styles on two different continuums of learning viz. concrete experience to abstract conceptualisation and active experimentation to reflective observation. To date the vast majority of experiential learning theory-related research has examined conditions of extreme learning specialisation. A new direction for experiential learning theory is the empirical testing of its theoretical propositions with regard to integrated learning. Integrated learning is conceptualised as an idealised learning cycle or spiral where the learner "touches all the bases" – experiencing, reflecting, thinking, and acting – in a recursive process that is responsive to the learning situation and what is being learned (Beard & Wilson, 2002:34-38; Beard & Wilson, 2005:4-7; Beard & Wilson, 2006:36; Truscott, Rustogi & Young, 2000:60-65).

To sum up, the implications of experiential learning for the mathematics lecturer: As far as its central idea is concerned, the theory is not totally new, but it suggests a renewed look at the way teaching and learning get organised in our classrooms. It suggests that the students must occupy the centre stages of classroom activity and not the lecturers. The theory also encourages the use of approaches which engage students in interdisciplinary exploration, collaborative activity and field based opportunities for experiential learning, while reflection and self-examination are used more and more by the lecturers. Furthermore, experiential learning theory provides a holistic model of the learning process and a multi-linear model of human development, both of which are consistent with what lecturers know about how students learn, grow, and develop. The theory is called “experiential learning” to emphasise the central role that experience plays in the learning process, an emphasis that distinguishes this theory from other learning theories. For example, in contrast to experiential learning theory, cognitive learning theories tend to emphasise cognition over affect, and behavioural learning theories deny any role for subjective experience in the learning process.

2.2.5.2 Mode of assessment

The experiential learning theory affirms the significance of experience. It also emphasises the role that true experiences and reflections on these experiences play in the learning process. Assessment focuses on problem solving, research and exploration of possible answers or solutions and developing projects as well as presentations. There is an emphasis on group or cooperative learning rather than individual work. Learning and assessment methods comprise of open-ended questions and scenarios, creating portfolios and descriptive narratives (Healey & Jenkins, 2000:193-194). Experiential learning theory has a vast range of applications, including helping students realise themselves, helping lecturers become reflexive teachers, identifying learning styles of students, and development of key teaching skills. The logic of the cycle is to do little bits at a time to increase improvements that, especially if done by many people, may lead to significant improvements later. For instance, if the lecturer daily reflects on his/her work and defines one little thing to change in order to improve his/her work, then at the end of the year, there will be many improvements. When this procedure is put into practice as a habit or rule by mathematics lecturers, there will be positive results.

2.2.6 Summary

All in all, this part of chapter two describes the main theories of learning and their usefulness for active learning in mathematics education in particular.

- Behaviourists view learners/students as relatively passive recipients of information, who are expected to repeat what they have learned when asked. If they provide a correct answer, they receive a positive reinforcement based on their observable behaviour (Beard & Wilson, 2002:24-26; Snowman & Biehler, 2000:51-53). The pre-eminent example of behaviourism is demonstration instruction.

- Cognitivist theory, for example as formulated by Ausubel, Bloom, Gagné and Reigeluth (in Kozma, 2003:223-224) concentrated exactly on cognitive activities. A cognitivist lecturer not only presents and explains information, but also leads the students in their learning and monitors their progress. The students themselves play a passive role in receiving the information. However, in comparison to the behaviourist theories, cognitivist learning theory emphasises the processing of the information that takes place within each individual student (Kozma, 2003:220).

- Constructivism views the learning process as the active construction of knowledge. The students/learners are active participants in this process: they construct their knowledge on the basis of their experiences and interactions with others and the environment. The lecturer’s role is to facilitate and support the students’ effort whenever needed, primarily when the students need further information (Mahoney, 2003:9). A constructivist lecturer offers the students a variety of learning activities from which they can select the activities that meet their personal needs.

Table 2.1 A comparison of different aspects of behaviourist, cognitive and constructivist learning theories

Type of learning	Knowledge	Learning	Focus of learning	Key learning concept	Centre
Behaviourist	Passive, largely automatic responses to external factors in the environment	A relative permanent change in behaviour	Association, operant behaviour, conditioning	Reinforcement and programmed learning	Lecturer
Cognitive	Abstract symbolic representations in the mind of individuals	A change in a learner's understanding	Increased meaning and improved memorisation	Elaboration	Students
Constructivist	A constructed entity made by each individual through the learning process	Discovery and construction of meaning	Problem solving and construction of meaning	Intrinsic motivation	Students

In conclusion, all learning is circumscribed by at least a minimal amount of three important and interrelated dimensions: (1) cognitive information processing, **(**2**)** affective or emotional reaction, and **(**3**)** behavioural readiness, i.e., the acquisition and performance of behaviours. Basically one-dimensional, cognitive learning focuses on learning in which the individual receives, processes, and integrates information into a personal data base. It involves all aspects of searching for, receiving, and processing of data. Experiential learning, on the other hand, is an ongoing process involving the affective and behavioural dimensions of learning: "Experiential learning exists when (a) personally responsible participant(s) affectively and behaviorally process(es) knowledge, skills and/or attitudes in a learning situation characterized by high levels of active involvement" (Adams *et al*., 2005:72-74). Cognitive teaching methodologies emphasise the traditional modes of information acquisition and transmittal. Experiential teaching methodologies emphasise the active involvement of the learner through structured individual or group-related experiences contrived: (1) to develop the individual's perceptual capacities, (2) to reinforce and develop cognitions, and most importantly, (3) to develop the capacity to behave (perform) consistently with one's insights. Experiential methodology shifts the class emphasis from a lecturer-centred environment to the role of a lecturer as a facilitator, creator and manager of student learning experiences. In the cognitive mode, the professor is concerned primarily with decisions related to what technical knowledge the course will impart. In the experiential mode, the lecturer designs a set of learning experiences to achieve a set of outcomes involving and integrating knowledge acquisition and affective and behavioural outcomes.

2.3 TEACHING METHODS THAT INFLUENCE ACTIVE LEARNING

The purpose of this part of chapter two is to examine teaching methods that influence learning in mathematics education. Effective learning is the act of developing and refining knowledge not only mentally, but also physically, cognitively and emotionally. It is an active process of internalising knowledge through inquiry and experience (Santrock**,** 2001:58). The challenge in education today is to effectively teach students of diverse ability and differing rates of learning. Lecturers are expected to teach in a way that enables students to learn mathematics concepts while acquiring process skills, positive attitudes and values and problem solving skills. A variety of teaching methods have been advocated for use in mathematics classrooms, ranging from a lecturer-centred approach to more student-centred ones.

Effective university mathematics teaching is an opportunity for students to experience a focused and organised as well as a social environment for the learning process to take place effectively. Effective mathematics teaching is all practices that empower students to have a greater awareness and understanding of themselves, the world around them and their effect on the world and on others. Effective mathematics teaching at university requires the use of appropriate methods and techniques to meet the demands of the current generation of students and the ever changing educational environments. The challenge is to find new ways to stimulate and motivate the creative abilities of today's generation who have higher expectations from learning than mere memorisation. Furthermore, the traditional "chalk and talk" lecture-centred approach has its own merits, but with the student as the passive recipient of knowledge may not be suitable for today's generation (Balch, 2005:29-34; Emmer & Gerwels, 2002:84-87; Hoffman, 2001:5-10).

Several studies in the field of mathematics have shown that learning and teaching processes, especially at the university level remains overwhelmingly lecturer-centred with greater emphasis being placed on lecturing and on the textbook than on helping students to think critically across subject areas and on applying their knowledge to real-world situations (Beard & Wilson, 2005:9-10). There is a need to adopt some of the recent reform-based active learning approaches, along with some lecturer-centred practices that have been overlooked and underutilised in university mathematics teaching (National Council of Teachers' of Mathematics [NCTM], 2000:31). Such practices include individual exploration, peer interaction and small group work, each of which emphasises the use of multiple approaches to problem solving, active student inquiry, and the importance of linking mathematics to students' daily life experiences (Beard & Wilson, 2005:11-12). A key component in reform is the movement from lecturer-centred to active learning practices in mathematics. It is important to examine the effects and relationships among different types of instructional practices and the resulting achievements of students and their attitudes towards mathematics. Studies on active learning practices and academic achievement have suggested that the quality of lecturers' instructional messages affects students' task involvement and subsequent learning in mathematics (Steckol, 2007:14-15). NCTM (2000:38) has advocated the development of inquiry based mathematics teaching. According to Robertson (2005:186-188), students who experience active learning are encouraged to explore, develop conjectures, prove and solve problems. The assumption is that students learn best by resolving problematic situations that challenge them through conceptual understanding.

In the study by Smith (1999:108-110), he/she investigated the use of enhanced instruction as a means of building student capacity for mathematics thinking and reasoning. The conclusion was that students must first be provided with opportunities, encouragement and assistance before they can engage in thinking, reasoning and sense making in the mathematics classroom. Consistent engagement in such thinking practices should lead students to a deeper understanding of mathematics as well as an increased ability to demonstrate complex problem solving, reasoning and communication skills on assessment of learning outcomes. The tasks used in the mathematics classroom highly influence the kind of thinking processes students employ, which in turn influence learning outcomes. Perhaps this is the reason why the mode of questioning in mathematics classrooms becomes relevant. It is therefore imperative for lecturers to appreciate and inculcate in students positive attitudes towards mathematics by using improved and appropriate instructional strategies. It is believed that the lack of appropriate teaching methods has one way or the other hindered learning achievement among students.

The teaching methods presented in this part of the study are cooperative learning, inquiry learning, problem-based learning and discovery learning methods. The content knowledge and skills that the students are supposed to acquire are presented in the context of those teaching methods. Lecturers who set out to implement an active learning approach should therefore first familiarise themselves with best practices such as providing adequate and extensive support and guidance when students are first introduced to the method, followed by gradual withdrawal of the support as the students gain more experience and confidence in its use. Lecturers should also anticipate some student resistance to active learning and should be aware of effective strategies for defusing it, many of which are outlined by different authors (Felder & Brent, 2001:69-75; Petrosino, Martin & Svihla, 2007:32-39). If these precautions are taken, both the students and the lecturer should experience positive outcomes as envisaged by the research. There is no single set of active learning methods that will work with all students in all situations. Hence, below are explanations of each method.

2.3.1 Cooperative learning method

2.3.1.1 Explanation of the method

Modern constructivist thought provides the theoretical basis for cooperative learning, problem-based learning and other discovery-oriented learning-teaching processes, all of which support mathematical learning. As students are exposed to their peers' thinking processes, they take cognisance of others' ideas and ways of thinking (Slavin *et al.,* 2003:187). Therefore, constructivists make extensive use of cooperative learning tasks, as well as peer tutoring, believing that students will learn more readily through dialogue with each other about significant problems. To acquire new information, ideas or skills, students have to work actively with each other in purposeful ways. In cooperative learning situations, students are not simply taking in new information or ideas regarding mathematics. They are creating something new with the information and ideas. These acts of intellectual processing or of constructing meaning or creating something new are crucial to learning.

Cooperative learning is one aspect of active learning in which students interact with one another while they learn and apply course material in the mathematics classroom. Cooperative learning is at the heart of problem-based learning. It is related to collaborative learning, which emphasises the "natural learning" that occurs as a result of the interaction in the community in which students work together in unstructured groups and create their own learning situation (Lea *et al.,* 2003:321-334). Cooperative learning is also a mathematical teaching technique that brings students together to learn in small, heterogeneous groups. In these groups, students work interdependently without constant and direct supervision from the lecturer. Assignments are structured so that everyone contributes. Challenges as well as rewards are shared. Brainstorming, lively discussion and collaboration are the hallmarks of the cooperative-learning classroom. Moreover, cooperative learning is one of the main active learning approaches, along with collaborative learning. It is well documented that students retain more knowledge when actively engaged in the learning process and cooperative learning is often cited as an extremely effective learning and teaching method (Felder & Brent, 2001:24-25). Cooperative learning is more than students working together in teams. According to Vaughan (2002:362-364) the five essential elements of cooperative learning are:

- clear positive interdependence between students,
- face to face interaction,
- individual accountability,
- emphasis on interpersonal and small group skill, and
- processes in place for group review to improve effectiveness.

In view of the above, cooperative learning of mathematics is a structured process in which team members work towards accomplishing a common goal, stressing positive interdependence, individual accountability and group accountability. Positive interdependence is a state in which all members must cooperate to accomplish the goal. Under the accountability rules, each member is individually and collectively responsible for the group's work product (Lowyck & Poeysae, 2001:512). Cooperative learning differs from collaborative learning in that the former "requires carefully structured individual accountability" (Lowyck & Poeysae, 2001:509-510). Baines, Blatchford and Chowne (2007:665-668) note the following benefits of students who are "cooperatively taught": "longer information retention, better performance in examinations, higher grades, stronger critical thinking and problem-solving skills, more positive attitudes toward the subject and greater motivation to learn it, better interpersonal and communication skills, higher self-esteem, and if groups are truly heterogeneous, improved race and gender relations."

Cooperative learning can refer to any learning-teaching method in which students work together in small groups toward a common goal, for example to acquire mathematical problem-solving skills (Baines *et al.,* 2007:675). In contrast, some authors distinguish between collaborative and cooperative learning as having distinct historical developments and different philosophical roots*.* Cooperative learning is a form of collaborative learning in which students work together on structured assignments or projects under conditions that assure positive interdependence, individual accountability, periodic face-to-face interaction, appropriate development and use of interpersonal skills and regular self-assessment of group functioning (Baines *et al.,* 2007:678). The core element of cooperative learning is the emphasis on student interactions rather than on learning as a solitary activity. As pedagogy, collaborative learning involves the entire spectrum of learning activities in which groups of students work together in or out of class. It can be as simple and informal as pairs working together in a think-pair-share procedure, where students consider a question individually, discuss their ideas with another student to form a consensus answer and then share their results with the entire class, to the more formally structured process known as cooperative learning (Slavin *et al*., 2003: 177-198).

Think-pair-share is a collaborative learning strategy that was developed for university classrooms. When using this approach a lecturer poses a question during a lecture, asks students to think about the topic individually for a minute, and then has them discuss their conclusions in pairs. Usage of think-pair-share results in increased participation and improved retention of information as well as higher levels of learner confidence (Healey & Roberts, 2004:24). The benefits of collaborative learning activities may derive from their tendency to foster active learning. Information presented in lectures must be moved into long-term memory by having the students develop into communities who discuss, debate and summarise academic content. Most people know from experience that a powerful way to learn material at a deep level is to teach it to others (Cohen, Brody & Sapon-Shevin, 2004:10; Hoffman, 2001:5-10).

Students working together are engaged in the learning process instead of passively listening to the lecturer presenting the reading information. Pairs of students working together to solve mathematical problems represent the most effective form of interaction, followed by threesomes and larger groups (Baines *et al.,* 2007:672). When students work in pairs one person listens while the other partner discusses the question under investigation. Both are developing valuable problem-solving skills by formulating their ideas, discussing them, receiving immediate feedback and responding to questions and comments by their partner (Baines *et al*., 2007: 678). The interaction is continuous and both students are engaged during the session. In comparison, during instruction students may or may not be involved by listening to the lecturer or by taking notes (Weimer, 2002:26).

Teaching as learning, refers to the mutually beneficial practice of students teaching one another concepts and skills. This practice falls within the larger domain of collaborative learning where students work together in small groups in order to achieve learning goals (Webb, Farivar & Mastergeorge, 2002:14-16). Moreover, Webb *et al.* (2002:14-16) defined five attributes of collaborative learning:

- a common task or learning opportunity suitable for group work
- small-group learning
- cooperative behaviour
- interdependence
- individual accountability and responsibility

When a cooperative learning method is applied, students perform at higher intellectual levels than when working individually. Cooperative learning may promote the active exchange of ideas, critical thinking skills and retention. Cooperative learning reduces classroom anxiety created by new and unfamiliar situations faced by students (Slavin *et al.,* 2003:189) and can therefore be of particular importance for mathematics teaching.

In a traditional classroom when a lecturer calls upon a student, he/she becomes the focus of attention of the entire class. Any mistake or incorrect answer becomes subject to scrutiny by the whole class. In contrast, in a collaborative learning situation, when students work in a group, the focus of attention is diffused among the group. In addition, the group produces a product which its members can review prior to presenting it to the whole class, thus diminishing prospects that mistakes will occur at all (Baines *et al.,* 2007:681). When a mistake is made, it becomes a teaching tool instead of a public criticism of an individual student.

Lea *et al.* (2003: 329) reported that regardless of the subject matter, students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional format. Students who work in collaborative learning groups also appear more satisfied with their class. Placing students in groups and giving them tasks in which they depend on each other to complete the work is an effective way to capitalise on the social needs of students. Students in collaborative learning groups tend to become more engaged in the learning process, because they are doing it with their peers. In line with this Savery **(**1999:33-42) states that cooperative learning activities help to drive active learning. Thus, the ability to teach through small group, cooperative activities will promote active learning in significant ways. Furthermore, giving different assignments to different groups enables students not only to learn together but also teach each other. What students discuss with others and what students teach others enable them to acquire greater understanding and master learning.

Cooperation among students is an integral component of the student-centred approach. Working as a team, according to Felder and Brent (2001:73–75:) can create a positive interdependence and individual accountability among students as each member attempts to contribute to the team product and thus is in charge of helping his/her teammates to learn. Cooperation can also foster students' growth, develop social and learning skills and help them construct their own knowledge through engaging in the exchange of ideas. By recognising the individual differences in approaches to learning, lecturers should set multiple mathematics tasks and allow students the choice to select and sequence their own activities independently. Lecturers should reinforce the idea that the source of knowledge is not confined within the walls of a classroom, but may also be discovered outside. Some examples of sources of knowledge include parents, elders, libraries, museums, historical sites, authentic materials and the Internet. Lecturers should also draw from different disciplines to integrate learning experiences and more importantly, use team teaching to achieve integrated learning outcomes. For example, when lecturers with different expertise like algebra and geometry work together, they can interchange the concepts in different courses to teach about mathematics in general. Lecturers need to draw attention to the relation between the students' prior knowledge and experiences of the new learning. This is based on the notion that the learning experiences that relate to students' personal knowledge and experiences are the most easily learnt and often the most difficult to forget (Felder & Brent, 2001:70–72).

To conclude, cooperative learning provides many advantages to lecturers and students. Many of these advantages arise from the intrinsic motivational strengths of cooperative learning and the extent to which cooperative learning fosters student interest, behavioural and attitudinal change, and opportunities for success. Cooperative learning is an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and lecturers together. Usually, students are working in groups of two or more, mutually searching for understanding, solutions, or meanings in mathematics or creating a product. Cooperative learning activities vary widely, but most centre on students' exploration or application of the course material, not simply the lecturers' presentation or explication of it. Cooperative learning represents a significant shift away from the typical lecture-centred milieu in university classrooms. In collaborative classrooms, the lecturing/listening/note-taking process may not disappear entirely, but it lives alongside other processes that are based on students' discussion and active work with the mathematics course material. Lecturers who use cooperative learning approaches tend to think of themselves less as expert transmitters of knowledge to students, and more as expert designers of intellectual experiences for students – as coaches or mid-wives of a more emergent learning process (Hinde & Kovac, 2001:93-99; Perrenet, Bouhuijs & Smits, 2000: 345–358).

2.3.1.2 The implication of cooperative learning for the teaching of mathematics at university

Many potentially successful students become disinterested in mathematics, and fail to learn it well or to enrol in subsequent courses (Cohen ***et al.,*** 2004:23-25). Furthermore, women are particularly affected in this way, so traditional teaching practices may partially account for the small numbers of successful female mathematics students in university. Recent empirical studies conducted on mathematics students at university have shown the positive effects of cooperative learning activities for increased academic achievement. In considering the effects of cooperative learning on academic achievements, researchers have repeatedly examined cooperative versus individual learning experiences by comparing academic achievement of students. Results indicate that cooperative learning experiences promote higher achievement and greater retention than do individual learning experiences for all students (Cohen ***et al.,*** 2004:148-149). Cooperative learning, in addition to impacting on academic achievements, also positively influences the attitudes of (and towards) students. The effects of cooperative learning on attitudes are evidenced by increases in self-esteem, social acceptance and lecturer ratings of students (Koppehnaver & Shrader, 2003:17). Cooperation is working together to accomplish shared goals. Within cooperative activities individuals seek outcomes that are beneficial to themselves and beneficial to all other group members in mathematics education. Carefully structured cooperative learning during a mathematics course involves students working in teams to accomplish a common goal, under conditions that involve both positive interdependence and individual and group accountability.

To be a successful cooperative group, members must have confidence in each other, members must promote each other's learning and success face-to-face, hold others accountable to do their share of the work, appropriately use interpersonal and small group skills needed for cooperative efforts to be successful, and determine as a group how effectively members are working together in mathematics. A learning activity becomes cooperative only when everyone realises that no group member can be successful unless all group members are successful. The “we’re all in this together” part of group work fosters positive interdependence. The cooperative learning method appears to promise positive effects for the learning of mathematics by students at university, as reflected in increased academic achievement and improved social attitudes and behaviour. Although cooperative activities may require more lecturer preparation of group material and monitoring of group activities, the rewards and benefits for both the lecturers and students are significant. Mathematics lecturers should encourage positive interdependence by assigning each mathematics student some meaningful role or allow students to assign these themselves. The lecturer can also encourage positive interdependence by dividing materials, resources, or information among group members. The problem-based learning method is discussed next.

2.3.2 Problem-based learning method

2.3.2.1 Explanation of the method

Problem-based learning is one of the most important active learning/student-centred approaches that promote students’ problem solving abilities. The problem-based learning ability enables the students to find appropriate solutions to problems that confront them (Hmelo-Silver, 2004:258). It is a technique whereby the lecturer and students attempt in a conscious, planned and purposeful effort to arrive at some explanation or solution to solve some educationally significant difficulty (Achike & Nain, 2005:308-310). It is a process of producing or closing a perceived problem gap. This technique involves providing students with content-related problems to find some answers or find reasons why the problem exists.

Problem-based learning, widely used in mathematics, frequently is built around collaborative learning methods. Dewey endorsed discussion-based teaching and believed strongly in the importance of giving students direct experiential encounters with real-world problems. Guided design, case studies and simulations are all forms of problem-based learning, which immerse students in complex problems that they must analyse and work through (McConnell, 2005:35). These approaches develop problem-solving abilities, understanding of complex relationships and decision making in the face of uncertainty. While problem solving has long been a focus of professional education, it is increasingly regarded as an important aspect of teaching (Savin-Baden & Wilkie, 2004:27-34). Given that problem-centred learning is a very engaging, motivating and involving form of experiential learning; students are often very close to the immediate details of the problem and the proposed solution. The purpose of the post-experience debriefing process (Duch, Groh & Allen, 2001:9-11) is to consolidate the learning and ensure that the experience has been reflected upon.

According to Miller (2004:578-579), when using problem solving techniques, the following steps have to be implemented:

- defining and delimiting the problem,
- gathering evidence that may help to solve the problem,
- formulating hypothetical solutions to the problem and
- testing the hypotheses, solving the problem and restarting the process if the problem has not been solved.

This shows that problem-based learning is an instructional active learning/student-centred approach that empowers students to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem. Critical to the success of the approach is the selection of ill-structured problems (often interdisciplinary) and a lecturer who guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience.

In problem-centred instruction, students often work in small groups to solve the problem with the lecturer's guidance and present their work to the whole class for discussion. In the class discussion, the lecturer often calls on students with less mature strategies first, challenging those with more mature strategies to think of alternative ways to solve the problem. By this method the instructor encourages the use of multiple solution strategies and emphasises the importance of the students using a strategy that is most appropriate for them. This provides students with a chance to learn from their successes and failures. The method allows groups to work through a situation from beginning to end to solve the problem. Studies suggest that problem-based learning develops more positive student attitudes, fosters a deeper approach to learning and helps students retain knowledge longer than traditional instruction (Peterson, 2004:630-647). Further, just as cooperative learning provides a natural environment to promote interpersonal skills; problem-based learning provides a natural environment for developing problem-solving and life-long learning skills. Indeed, some evidence shows that problem-based learning develops enhanced problem-solving skills in mathematics students and that these skills can be improved further by coupling problem-based learning with explicit instruction in problem solving.

To sum up, the descriptions of the characteristics of problem-based learning clearly identify (a) the role of the lecturer/tutor as a facilitator of learning, (b) the responsibilities of the students to be self-directed and self-regulated in their learning, and (c) the essential elements in the design of ill-structured instructional problems as the driving force for inquiry. The challenge for many lecturers when they adopt a problem-centred instruction method is to act as knowledge provider as well as manager and facilitator of learning (Baker, 2000:258-260; Ertmer & Simons, 2006:45-48). If teaching with problem-centred instruction were as simple as presenting the students with a "problem" and students could be relied upon to work consistently at a high level of cognitive self-monitoring and self-regulation, then lecturers would not be challenged by this method.

The reality is that students who are new to problem-based learning require significant instructional scaffolding to support the development of problem-solving skills, self-directed learning skills and teamwork/collaboration skills to a level of self-sufficiency where the scaffolds can be removed. Universities that have adopted problem-based learning methods in their instruction have developed extensive tutor-training programmes in recognition of the critical importance of this role in facilitating the problem-based learning experience. Duch *et al.* (2001:9-12) explain the importance of the tutor as the meta-cognitive coach for the students. Given that change to teaching patterns in public education moves at a glacial pace, it will take time for institutions to commit to a full problem-based learning approach. However, there are several closely related student-centred instructional strategies, such as project-based learning, case-based learning, and inquiry-based learning that are used in a variety of content domains that can begin to move students along the path to becoming more self-directed in their learning (Mierson & Parikh, 2000:23; Normala & Maimunah, 2004).

2.3.2.2 The implication of problem-based learning for the teaching of mathematics at university

Becoming an efficient, independent problem solver should be a goal of every mathematics student at university. But for many students, mathematics is viewed as a "string of procedures to be memorized, where right answers count more than right thinking" (Mierson & Parikh, 2000:12-18; Yusof & Tall, 1999:70-72).

> *"... good problem-solving behavior usually is not fostered by having students imitate how teachers solve problems. Because teachers typically demonstrate only correct moves, students often come to view problem solving as that of delving into a mysterious bag of tricks to which only a select few are privy." (*Wilson *et al.*, 2005:93).

To build problem-solving skills, lecturers need to engage students actively in the learning process, create opportunities for exploration, and help them recognise that there may not be a rule to memorise or algorithm to follow for a given problem. Student problem solvers need access to rich, well-connected knowledge of mathematical concepts. If they become successful at solving problems, this builds their confidence. Students may then have the ability to imagine and conjecture possible solution paths, to monitor their progress and dynamically revise or abandon solution paths, and to verify that a solution is reasonable and makes sense. In contrast, currently many university mathematics students rarely plan a solution in advance, demonstrate an inability to consistently monitor their progress, and have varying degrees of success in recognizing that a solution attempt is not progressing toward the desired goal (Salman, 2005:25-26). When their initial strategy is not productive, these students have difficulty switching to an alternative strategy. Lecturers and students need to take these characteristics into consideration and employ and engage in classroom activities that focus on boosting students' confidence and building a reservoir of problem-solving strategies. When students are given opportunities to use multiple approaches to solve problems, they come to recognise that mathematics is more than computation or getting the single right answer – it is a balance of process and product, a combination of good thinking and meaningful answers.

2.3.3 Inquiry-based learning method

2.3.3.1 Explanation of the method

Inquiry-based learning is an active learning/student-centred method focused on questioning, critical thinking and problem solving. Inquiry-based learning activities begin with a question followed by investigating solutions, creating new knowledge as information is gathered and understood, discussing discoveries and experiences, and reflecting on new-found knowledge. Inquiry-based learning is frequently used in mathematics education (Bissell & Lemons, 2006: 66-72) and encourages a hands-on approach where students practice the mathematical method on authentic problems (questions).

Inquiry learning begins when students are presented with questions to be answered, problems to be solved, or a set of observations to be explained (Dochy, Segers, Van den Bossche & Gijbels, 2003:556). If the method is implemented effectively, the students should learn to "formulate good questions, identify and collect appropriate evidence, present results systematically, analyze and interpret results, formulate conclusions, and evaluate the worth and importance of those conclusions" (Karagiorgi & Symeou, 2005:34). The same statements could also be made about problem-based learning, project-based learning, discovery learning, certain forms of case-based instruction and student research. Thus, inquiry learning may be considered an umbrella category that encompasses several other inductive teaching methods. Lee (2004:32) makes this point, observing that inquiry is also consistent with interactive lectures, discussion, simulation, service learning and independent study, and in fact "probably the only strategy that is not consistent with inquiry-guided learning is the exclusive use of traditional lecturing" (Karagiorgi & Symeou, 2005:24). In this study, the researcher will use the term *inquiry learning* to refer to instruction that uses questions and problems to provide contexts for learning and does not fall into another more restrictive inductive learning category.

The inquiry-based teaching method is a method where active processes of seeking understanding occur. It produces new ideas, which contribute to human civilisation. Every person has the potential to create new ideas and the process of inquiry is both an individual and interpersonal adventure. Students are naturally curious and eagerly seek to understand the world around them. This is the essence of inquiry. The lecturers' task is to create situations in which each student can discover the power of ideas and generate concepts about the world. This method is designed to teach students how to investigate a question or a problem through the systematic gathering of facts. The lecturer has to guide the students to help them to work towards a solution to a problem. Generally, Bissell and Lemons (2006:69) have identified the following roles for lecturers in an inquiry method: develop lessons that develop students' abilities to recognise problems, suggest tentative answers, identify and gather relevant facts and critically assess tentative solutions. There are skills of inquiry, and development of these skills is an explicit process when inquiry methods are used. If a student plays a primary role in inviting an inquiry lesson, a lecturer must facilitate the process. The lecturer designs a problem or questions for investigation and ensures that the students have access to data that allow examination of problem.

Regarding the role of students in the inquiry method, students begin their analysis by responding to open-ended questions. These are the questions that ask the students to simply describe or compare and contrast, and have variety of acceptable answers. It is also the student that connects what is new to his or her past experiences and knowledge. To increase student participation time to think is needed (Karagiorgi & Symeou, 2005:225-26).

The main aim of inquiry teaching is to stimulate or promote independent resourceful thinking. Involving students in the inquiry method is one of the most effective ways to help them to develop their higher order critical thinking skills for students' inquiry involves learning through explanation and investigation (Clark & Starr in Feden & Vogel, 2003:37-39). In inquiry, experiences can take place in the classroom, in interaction with the literature or outside during a field trip. While inquiring, the student uses sight, smell, touch and the kinaesthetic sense to gain general and specific information that will help to form concepts and categories for making sense of experiences.

2.3.3.2 The implication of inquiry-based learning for the teaching of mathematics at university

An educator states: "*Tell me and I forget, show me and I remember, involve me and I understand*." The last part of this statement is the essence of inquiry-based learning in mathematics education at university (McKeachie, 1999:159). Inquiry in mathematics learning implies possessing skills and attitudes that permit students to seek solutions to questions and issues while they construct new knowledge. Inquiry-based learning is a research-based method that actively involves mathematics students at university in the exploration of the content, issues and questions surrounding a course area or concept in mathematics education. The activities and assignments in an inquiry-based learning mathematics classroom can be designed in such a manner that students work individually or together to solve problems involving both in-class work and fieldwork. While the method is meant to be highly student-focused, the extent of teacher-directed *vs.* student-directed learning can vary depending on the level of the students in their course and their understanding of the inquiry process. Other than increasing student motivation, one of the main reasons to use inquiry-based learning for mathematics teaching is because it provides an effective means to actively involve students in the mathematics learning process. Inquiry-based learning gives lecturers the opportunity to help students learn the content and course concepts by having them explore a question and develop possible answers. This gives mathematics students more opportunity to reflect on their own learning, gain a deeper understanding of the course concepts in an integrated fashion and become critical thinkers.

2.3.4 Discovery learning method

2.3.4.1 Explanation of the method

Discovery learning refers to the process of obtaining knowledge through one's own efforts. Discovery learning is an inquiry-based approach in which students are given a question to answer, a problem to solve, or a set of observations to explain, and then work in a largely self directed manner to complete their assigned tasks and draw appropriate inferences from the outcomes, "discovering" the desired factual and conceptual knowledge in the process (Balım, 2009:2-3). Discovery learning seems to be a promising approach for a number of reasons. Discovery learning is an approach to learning that can be facilitated by particular teaching methods and guided learning strategies. The term 'discovery learning' will refer to the learning taking place within the individual, the teaching and instructional strategies designed by the instructor and the environment created when such strategies are used. In the classroom, discovery learning often occurs through structured or directed activities that require students to manipulate, investigate and explore materials that may lead them to discover important principles or relationships (Balım, 2009:14; Schunk, 2000:64). Therefore, students are not presented with concepts and ideas in their final form, but rather are required to formulate them for themselves. Though structured discovery learning has long been a part of mathematics education, the latest trend in discovery-based teaching, constructivism, has resulted in renewed and multidisciplinary interest in discovery-based learning.

Discovery learning is the opposite of being told or being passive; rather in this method students seek out and discover knowledge (Balım, 2009:10-14). It encourages students to ask questions and formulate their own tentative answers and to deduce general principles from particular examples or experience. It is commonly equated with inductive learning and arrives at generalisations from specific tasks. The discovery learning method requires that the student participate in making many of the decisions about: what, how and when something is to be learned. Instead of being told the content by the lecturer, it is expected from the student to explore examples to discover the principles or concepts which are to be learned. Learning is more meaningful, more thorough and therefore more usable when students seek out and discover knowledge rather than just being receivers of it. Students discover facts for themselves and they learn how to learn (Benedict & Anderson, 2004:198-199). When the student is actively involved in discovery learning, the connections made are based on his or her own prior knowledge rather than someone else's. Because the connections are the student's, they are already more meaningful than an artificially imposed connection (Bicknell-Holmes & Hoffman, 2000:318-320).

In discovery learning, the problem situation results in a solution unique to the student. It also forces students to confront their own current ideas about a topic, many of which may be misconceptions, and reconcile them with what students now observe to be the case. In mathematics education one of the most difficult problems is the predicament of misconceptions that students bring into the classroom. Unless these are confronted directly by each student, it is easy for the student to not see the contradictions. In addition, many lecturers forget to address common student misconceptions because their own understanding of the subject is so great that they forget how a novice might think about it (Hijzen, Boekaerts & Vedder, 2007: 673-687). Most discovery tasks are based on real problems or real situations. Their ''concrete'' nature makes them easier to visualise and relate to. Abstractions require a great deal more background before students can mentally manipulate them (Bicknell-Holmes & Hoffman, 2000:321).

Because discovery learning is intended to take place in a ''real life'' context, students learn the context along with the information. This situation is called situated learning because what is learned is not just the information, but the situation. Later, when that context or a similar one appears, students have a greater chance of remembering what to do because students have already been through it once and the authentic retrieval cues present in the situation flag it as appropriate for this information use (Doerr & Lesh, 2003: 26-30).

Discovery learning encompasses an instructional model and strategies that focus on active, hands-on learning opportunities for students (Dewey & Meyer, 2000:269). Bicknell-Holmes and Hoffman (2000:313-320) describe the three main attributes of discovery learning as (1) exploring and problem solving to create, integrate, and generalise knowledge, (2) student driven, interest-based activities in which the student determines the sequence and frequency, and (3) activities to encourage integration of new knowledge into the learner's existing knowledge base. The first attribute of discovery learning is a very important one. Students rather than the lecturer drive the learning. Expression of this attribute of discovery learning essentially changes the roles of students and lecturers and is a radical change difficult for many lecturers to accept (Papert, 2000:724). The second attribute of discovery learning is that it allows students to learn at their own pace (Bicknell-Holmes & Hoffman, 2000:321). Through discovery learning, some degree of flexibility in sequencing and frequency with learning activities can be achieved. This attribute contributes greatly to student motivation and ownership of their learning. The third major attribute of discovery learning relates to existing knowledge as a basis to build new knowledge (Bicknell-Holmes & Hoffman, 2000:321). Scenarios with which the students are familiar allow the students to build on their existing knowledge by extending what they already know to invent new ideas.

How do these three attributes combine to make discovery learning different from traditional forms of learning? The most fundamental differences are (1) learning is active rather than passive, (2) learning is process-oriented rather than content-oriented, (3) failure is important, (4) feedback is necessary, and (5) understanding is deeper (Papert, 2000:326; Kim, 2005:17-19). The emphasis is placed on a mastery and application of overarching skills (Dochy *et al.,* 2003: 533-548). Discovery learning is a powerful instructional approach that guides and motivates students to explore information and concepts in order to construct new ideas, identify new relationships, and create new models of thinking and behaviour. Discovery learning educational sessions are highly experiential and interactive. Lecturers use stories, games, simulations, visual maps and other techniques to get attention, build interest and lead students on a journey of discovery toward new thinking, actions and behaviours.

The discovery learning approach incorporates three key ideas:

- **Problem solving:** The learning design must guide and motivate students to participate in problem solving as they combine information and generalise knowledge.

- **Student management:** Learning must be student-driven so that participants, working alone or in small teams, can learn in their own ways and at their own pace.

- **Integrating and connecting:** Learning must encourage the integration of new knowledge into the student's existing knowledge base and clearly connect to the real world (Bicknell-Holmes & Hoffman, 2000: 318). The learning environment promotes strong involvement – participants may be manipulating pieces on a game board, working with other students to make a decision, or putting together seemingly disconnected pieces of information from a variety of sources to solve a problem. Because it engages students' brainpower, discovery learning accelerates the learning process and results in higher levels of retention than more traditional learning approaches do. With learning time in short supply, and learning in great demand, discovery learning can help organisations offer training that works quickly- and well (Petrosino *et al.,* 2007:25).

2.3.4.2 The implication of the discovery method for teaching of mathematics at university

When using the discovery method for the teaching of mathematics at university, instructors need to encourage students to ask questions and formulate their own tentative answers, and to deduce general principles from practical examples or experience (Balım, 2009:6-8). The tools and information needed to solve a problem or learn a concept are provided and the students "make sense" of them. In discovery learning, there is experimentation with some extrinsic intervention to help mathematics students get to a reasonable conclusion. The mathematics students call on their past experience and prior knowledge to discover new information or skills. It is a personal, internal, constructivist-style learning environment. The discovery method for the teaching of mathematics at university takes place most notably in problem-solving situations where students draw on their own experiences and prior knowledge to discover general truths. Some of the benefits of the discovery method for teaching of mathematics at university are (Balım, 2009:16-18):

- It increases critical thinking.
- The acquired knowledge is long lasting.
- It trains the students to solve problems.
- The students are better motivated.

Furthermore, the active involvement of the student outperforms more traditional ways of learning in that it results in the student’s attainment of a better structured base of knowledge

2.3.5 Discussion method

2.3.5.1 Explanation of the method

Discussion is a kind of teaching method that often involves solving problems that students have identified and chosen. It is tied with the discovery method, which requires students to find their own concepts, principles and solutions, not to adopt them from a lecturer. In this method, problems may also be presented by the lecturer for students to discuss in small groups and report the results. In comparison with the lecture method, discussion yields better retention, higher order thinking, better attitudes and motivation (Ainsworth, 2006:96-97). Group discussions can help students increase their subject matter knowledge, learn skills in leadership and in sharing with others.

2.3.5.2 The implication of the discussion method for the teaching of mathematics at university

The discussion method develops higher level thinking skills (McConnell, 2005:36). Mathematics students at university are engaged in the learning process instead of passively listening to the lecturer. Pairs and or larger groups of students working together represent the most effective form of interaction (Mayer, 2005:37-38). When mathematics students work in pairs and or larger groups, one person is listening while the other partner is discussing the question under investigation. Both are developing valuable problem-solving skills by formulating their ideas, discussing them, receiving immediate feedback and responding to questions and comments (Miller, 2004:578-580).Whole class discussion is enhanced by having mathematics students discuss ideas thoroughly before the entire class discusses an idea or concept. In addition, the mathematics lecturer may temporarily join a group's discussion to question ideas or statements made by group members or to clarify concepts or questions raised by the students. The discussion method in mathematics education at university fosters improved performance (Mierson & Parikh, 2000:24-26). Critical thinking skills increase and retention of information and interest in mathematics improve (Martinez, 2001:116). This creates a positive cycle of good performance, builds self esteem which leads to more interest in mathematics and to better performance (Leung, 2001:42-43). Students share their success with their groups, thus enhancing both the individual's and the group's self esteem. Clarification and explanation of one's ideas is a very important part of the group discussion process and requires higher order thinking skills (Kolar & McBride, 2003:67-68). Students must develop a clear idea of the concept they are presenting and orally communicate it to their partners (Jacobs & Hall, 2002:54-55). The focus of discussion method is to actively involve mathematics students in the learning process (Holton, 2001:23).

2.3.6 Teaching methods for teaching mathematics at university

While the quality of research data supporting the different active learning methods for the teaching of mathematics at university varies, the collective evidence favouring the active learning (student-centred) approach over a lecturer-centred approach is conclusive (An, Kulm & Wu, 2004:162-164; Boyer, 2002:49-50). Active learning is supported by widely accepted educational theories such as cognitivist, constructivist, experiential theories and by empirical studies of teaching and learning (Chance, 2005:18-22). Active learning methods promote students' adoption of a deep (meaning-oriented) approach to learning, as opposed to a memorisation-intensive (surface) approach. Active learning also promotes intellectual development, challenging the dualistic type of thinking that characterises many entering university students (which hold that all knowledge is certain, professors/lecturers have it, and the task of students is to absorb and repeat it) and helping the students acquire the critical thinking and self-directed learning skills that characterise expert mathematicians.

Mathematics students at university may be more interested in learning mathematics and be active learners if introduced to a variety of teaching methods. How much information a learner retains varies from method to method. A single method is not effective for the teaching of mathematics at university. However, cooperative learning and problem-based learning methods are grounded in the belief that learning is most effective when mathematics students are actively involved in sharing ideas and working cooperatively to complete mathematical tasks through problem-based learning at university (Doerr & Lesh, 2003:21-24; Tan, 2004:169-184; Tan, 2005:29-46). Cooperative learning has been used as both learning and teaching method and as a learning tool at university level of mathematics teaching in various courses. Cooperative learning may raise mathematics students' self-esteem because they are learning something on their own through cooperation, rather than being handed pre-packaged knowledge. It helps mathematics students become self-sufficient, self-directed and lifelong learners. With group work, everyone has the chance to participate, and everyone has a role to play. As university students join forces to achieve a common goal, they come to recognise commonalities that cut across differences related to ethnicity, socio-economic background and gender. Likewise, cooperative learning provides an excellent vehicle for mathematics students of differing ability levels to work together in a positive way. Challenged students can interact successfully with average and advanced students and in so doing can learn that they too have something to offer. Siciliano (2001:15-18) proposed five essential elements of cooperative learning: (a) Positive interdependence: The success of one student is dependent on the success of the other students; (b) Promotive interaction: Individuals can achieve promotive interaction by helping each other, exchanging resources, challenging each other's conclusions, providing feedback, encouraging and striving for mutual benefits; (c) Individual accountability: lecturers should assess the amount of effort that each member is contributing. These can be done by giving an individual test to each student and randomly calling students to present their group's work; (d) Interpersonal and small-group skills: Lecturer must provide opportunities for group members to know each other, accept and support each other, communicate effectively and resolve differences constructively and (e) Group processing: Lecturers must also provide opportunities for the class to assess group best on procedural knowledge later (Prince & Felder, 2006:22-25).

Mathematics students with good conceptual understanding are able to perform successfully on near transfer tasks and develop procedures and skills they have not been taught. In the traditional lecturer-centred education, the dominance of the lecturer takes centre stage. The students rely on their lecturers to decide what, when, and how to learn. This approach to instruction works relatively well. However, it is clear that students are not learning at a high, conceptual level of thinking (Kane, 2004:282-285). The goal of using cooperative learning in the classroom is to make the student stronger through interaction and communication around the process of mathematics education. Students improve their thinking and problem-solving skills in mathematics. To the professional mathematician, the ability to actively identify, formulate, and solve problems is essential to a successful career.

Mathematics teaching at university asks for constructivist-based instruction using problem-based teaching method in which the students' own productions and constructions play a central role (NCTM, 2000:31). Mathematics students must actively participate in the learning process to become active learners at university. Instead of the lecturer passing on mathematics knowledge in small and basically meaningless parts, mathematics students have to play an important role in the construction of their own knowledge base (Remillard & Kaye, 2002:12-14). The challenge of teaching mathematics at university from such a constructivist perspective is to create experiences that engage students and encourage them to discover new knowledge in mathematics education settings (Zan & Martino, 2007:158-160). By working together and discussing possible solutions to a problem with one another, students develop problem-solving strategies, which they must explain and justify to one another. Such learning can be promoted by problem-based learning methods. Research suggests that problem-based instruction based on constructivist principles leads to better results than more direct, traditional mathematics education (Remillard & Kaye, 2002:24). Researchers have observed that learning in problem-based instruction is motivating, exciting, and challenging (Achike & Nain, 2005:308; Remillard & Kaye, 2002:28-30). Students who learn to apply active learning approaches are also expected to acquire more useful and transferable knowledge (Remillard & Kaye, 2002:27). Problem-based learning is likely to positively influence student attitudes and study habits. Studies also suggest that students will retain information longer and perhaps develop enhanced critical thinking and problem-solving skills, especially if problem-based learning is coupled with explicit instruction in these skills. When mathematics students at university are actively involved in saying and doing, they will retain about 90 percent of the material (Ainsworth & Th Loizou, 2003:679-681). Most mathematics students learn best by actually doing. Lecturers should provide opportunities for the students to practice and explore what they have learned. Actual project work, cooperative learning, discussion/planning and presenting a demonstration and problem-based learning are examples of an active learning ‘saying and doing’ strategy.

To sum up, while the quality of research data supporting the different active learning methods is variable, the collective evidence favouring the active learning approach over lecture/traditional deductive pedagogy is conclusive. Active learning is supported by widely accepted educational theories such as cognitive theories, social learning, constructivism and experiential learning theories. Active learning promotes students’ adoption of a deep, meaning-oriented approach to learning and promotes intellectual development.

2.4 ADVANTAGES AND DISADVANTAGES OF ACTIVE LEARNING

2.4.1 Advantages of active learning

2.4.1.1 The value of active learning to the students

The most important value of active learning is that it increases students' retention and comprehension of the course material. Tasks to be executed should be made explicit. Active learning utilises the students' data and knowledge base. Students have an opportunity to provide personal insights and interpretation. The process allows students to experiment with ideas, to develop concepts, and to integrate concepts into systems. Research shows that active learning seeks to engage a greater range of students in effective mathematics learning. Furthermore, it positively affects the attitude of students toward self and peers in the mathematics learning process. Active learning develops social experiences between students and between teacher and students. It can build community within the classroom.

2.4.1.2 The value of active learning to the lecturers

Active learning concentrates on the mathematics teaching function. It helps the lecturer select objectives at the correct level of difficulty to meet the students' needs. The lecturer encourages the students to be responsible for their own mathematics learning. Active mathematics learning brings the students into the organisation, thinking and problem-solving process of the discipline. Active learning also gives the lecturer time to perform the helping instructor functions of coach, listener and advocate.

The instructor’s role in an active learning/student-centred approach is much more crucial than that of the lecturer in the lecturer-centred approach. For students to gain the best value of active learning, the lecturer needs to change from the role of authority and presumed expert who possesses all knowledge to become a facilitator who provides a setting in which the students can play an active and inquiring part in their own learning. Create a learning environment that stimulates and challenges students, fosters critical thinking and the process of knowledge construction (Chance, 2005:26-41).

The following are other key advantages of the active learning approaches, which are summarised by different authors (Duffy & Kirkley, 2004:21-42; Kane, 2004:275-286; Kim, 2005:10-18):-

Active teaching and learning approaches may, amongst other things, allow for or encourage:

- *High level of participation:* Students usually find such activities energising and are likely to engage more with the subject matter as a result.

- *Use of prior experience or knowledge*: All students have previous experiences and knowledge of some kind and active strategies offer them the opportunity to make informal connections with things they have already learned.

- *Adoption of new perspectives and positions:* The opportunity to discuss topics with others and to listen to or address other points of view (as in small group work or role play, for example) may often lead to the revision of existing perspectives and to enhanced learning opportunities.

- *Contestation of values and assumptions from different disciplines:* Many of these strategies are appropriate in inter-disciplinary contexts where students may need to address a problem from a range of viewpoints. In collaborating with each other, they are more likely to have the opportunity to learn to debate and challenge basic assumptions and values.

- *Openness with respect to learning outcomes:* Active teaching and learning approaches will often yield unanticipated outcomes; there will be some learning that takes place that has not been (and could not have been) planned for and this can be rewarding for both students and lecturers.

- *Peer support and peer learning:* Collaborative activities (such as group work or simulations) provide students with opportunities to learn from and support each other in ways that are not facilitated by more formal, teacher-centred approaches.

- *Critical reflection on action and experience:* By sharing knowledge and experiences, by being encouraged to take a different perspective on a particular topic (e.g. in a debate) students may learn to reflect critically on the things they do and say.

- *Greater ownership of and responsibility for learning:* Active teaching and learning approaches may encourage students to become more self-directed and self-motivated. By taking on a more enquiring and autonomous role, they are more likely to develop a sense of ‘ownership’ in relation to their learning and to be able to build on this independently in later life.

- *Development of generic communicative skills:* Active learning affords many opportunities for students to develop interpersonal and communicative skills; as well as being important in any search for employment, these skills are essential to personal effectiveness in a range of contexts.

2.4.2 Disadvantages of active learning

The key drawbacks in using active teaching and learning methods may include:

- *Shortage of time:* Active learning approach may take more time than, for example, a straight lecture from the front of the room. Lecturers often feel the only way they can 'get through' their subject in the available time is to deliver it, in a formal didactic style, with as little 'distraction' from students as they can manage! (The problem here is that it does tend to be the lecturers who get through it rather than the students and the saving of time can represent a false economy.)

- *Professional bodies' constraints:* Some professional bodies (e.g. at validation) may place constraints on the curriculum both in terms of content and delivery to the extent that these constraints may work against the adoption of active teaching and learning approaches; they represent significant drawbacks. Many professional bodies, however, do actively encourage student-centred approaches to learning.

- Lecturers' *view of their role:* Some instructors may genuinely believe it is inappropriate (or even irresponsible) for them to relinquish the centre-stage in the way that would be required of them if, for example, they set up a simulation or student-led debate. This can be a barrier to the adoption of active teaching and learning approaches.

- *Student groups may be dysfunctional:* Not all students are expert collaborators; students may bring personal issues to the learning contexts that effectively disrupt the learning experience for others.

- *Emotional risk may be too great:* Some students may be unwilling to place themselves at risk emotionally in the way that a role play, for example, may require them to. (Careful handling can overcome many of these sort of problems and adequate time for a proper de-briefing of participants is also important.)

- *Experience may be emphasised at the expense of abstract thought:* Some lecturers and students in higher education may feel that 'learning' in their subject is not connected to 'doing' in any obvious way, that it is 'thinking' (not 'doing') that leads to learning and that thinking is best carried out independently. They may see active teaching and learning approaches as promoting a 'diluted' form of learning.

- *Student access to teacher's expertise may be decreased:* Some feel that the adoption of more student-centred approaches in higher education will effectively limit the access that students have to lecturers' knowledge and expertise in the subject. This view may represent a constraint on the adoption of such approaches.

- *Lecturers may feel they lack the expertise or confidence:* Some colleagues may be genuinely interested in moving towards more student-centred approaches in their work, but may feel unable to do so because of a lack of confidence or knowledge of what such approaches might entail. Staff developers have an increasingly important role to play in such situations.

2.5 SUMMARY

Chapter two explained a number of learning theories including behaviourist, social learning theory, cognitive learning theory, constructivism learning theory and experiential learning theory, some of which are related to an active learning approach. This chapter also explored different teaching methods that are related to the active learning approach.

The next chapter, chapter three, will present empirical evidence on the effects of the above mentioned learning and teaching methods, with special reference to mathematics education. The chapter will also explain factors affecting the implementation of active learning in mathematics education. The focus will be on university level.

CHAPTER THREE:

EMPIRICAL EVIDENCE OF INFLUENCES OF/ON ACTIVE LEARNING OF MATHEMATICS AT UNIVERSITY

3.1 INTRODUCTION

In the previous chapter (Chapter two), some learning theories and their associated teaching methods were explained. This chapter presents empirical evidence of the results of active learning of mathematics at universities. Furthermore, this chapter explores factors such as the attitudes of lecturers and students, the training of lecturers, support from academic department heads and deans, class size, and instructional material that affect the implementation of an active learning approach of mathematics at university.

3.2 THE EFFECTS OF USING ACTIVE LEARNING METHODS IN MATHEMATICS LEARNING

The goal of this section is to understand the effects of active learning methods in mathematics learning at university. There has been much work done on the effect of active learning and teaching methods on student cognitive learning. The relationship between active learning/student-centred teaching methods on student learning has consistently shown a positive effect (of such approaches) on students' cognitive and affective outcomes. Particular attention is given to the effects of active learning on students' cognition, motivations, their attention to and emotional response to learning, and the value they attach to learning. Investigations of the effect of the teaching approach, particularly an active learning/student-centred teaching approach on students' cognitive and affective learning has consistently shown positive effects. In general, active learning methods are more effective than lecturer-centred/traditional learning and teaching methods for achieving a variety of learning outcomes (Timmermans & Van Lieshout, 2003:11-16). The cognitive and affective effects of active learning are discussed in the next two sections.

3.2.1 Cognitive effects of active learning on the student

The goal of an active teaching and learning process in mathematics education at university level should be to establish a learning culture that promotes intelligent learning and deep understanding of mathematical concepts. The knowledge of the learned mathematical concepts could in such a case be called conceptual knowledge (Setati & Adler, 2000:263-265). In short, the before mentioned researchers (Setati & Adler, 2000:263-265) found that conceptual knowledge and relational understanding is generated and intelligent learning occurs when the student is given a chance to actively create rich structures of cognitive connections within and between mathematical concepts. Hence, the teaching procedures and interpersonal relations in the mathematics classroom should provide a framework that enhances such a creative and active learning culture. The research calls this type of framework an active learning approach.

Active learning is an approach that is extremely effective in maintaining students' information processing, developing skills, attitude and interest. The responsibility for learning is focused on the students. Most importantly, to be actively involved, students must engage in such higher-order mathematical thinking tasks as analysis, synthesis and evaluation. Students are involved in acquiring information and interpreting or transforming it. To do all this, time must be provided within the curriculum. Norman and Schmidt (2000:727–728) argue that optimal student participation in the teaching and learning process is imperative to ensure that the students are able to effectively practice self-regulated learning methods. Research underlying the active learning/student-centred approach confirms that learning is nonlinear, recursive, continuous, complex, relational and natural in humans (Burbach, Matkin & Fritz, 2004: 482-493). An active learning approach which is based on constructivist theory helps students absorb knowledge and make connections in their mind, understanding not just what they learn, but how they learn (Benek-Rivera & Mathews, 2004:104).

Active teaching and learning methods offer opportunities for interaction between lecturers and students, amongst the students themselves, as well as between students and the materials (Schaeffer, Epting, Zinn & Buskist, 2003:135-136). Students are expected to become active learners who can demonstrate what they know and do by applying their knowledge and skills to real problem-solving situations. According to O'Sullivan and Copper (2003:449) if students are not actively involved in their mathematics learning, they will less likely to construct personal meanings or retain the lesson. Rather they simply memorise answers to the questions that will appear on tests. Research has shown that active learning is an exceptionally effective teaching and learning approach (Chou, 2004:18-21). Doerr and Lesh (2003:19-21) assert that in mathematics education students cover more material, retain the information longer, and enjoy the class more through active learning methods compared to lecturer-centred learning and teaching methods (such as lectures). McNair (2000:560-565) notes that the application of active learning methods (cooperative, inquiry, discussion, discovery and problem-based learning methods) in mathematics education help students to make connections to and apply mathematical knowledge in the real world. Boyer (2002:49-51) also argues that the use of an active learning approach in the classroom enables students to apply mathematical concepts and to foster meaningful learning.

A study conducted on mathematics education shows that an inquiry-based learning and teaching process is superior to lecturer-centred/traditional instruction for cognitive learning, which includes conceptual and subject learning, reasoning ability and creativity, as well as for non-cognitive learning including manipulative skills and attitudes

(Aleven & Koedinger, 2002:171-176). Stead (2005:122-128) also asserts that an inquiry-based method is likely to be more effective than lecturer-centred teaching methods in helping students gain understanding of concrete observable phenomena. He recommends the planning of activities around questions that students can answer directly via investigation and activities oriented towards concrete concepts. He also places an emphasis on use of materials for which students have the prerequisite skills and on activities that involve situations familiar to students. In addition, lecturers need to pose a sufficient level of challenge to help students develop better thinking skills.

As regards cognitive effects, cooperative learning has proven itself to be superior to other methods (Harton, Richardson, Barreras, Rockloff & Latané, 2002:13-14). Evidence to this claim is in fact abundant and there is little disputing that the active learning/student-centred approach which encourages active, collaborative and constructivist learning improves students' learning in more ways than one. For example, a very important outcome of active learning/student-centred approach, which is often less noticeable, is its effect on students' approach to learning. Working together with fellow students, solving problems together and talking through material together has other benefits as well (Johnson & Johnson, 1999:68-70): student participation, lecturer encouragement, and active learning/student-student interaction positively relate to improved critical thinking. These different activities confirm other research and theories stressing the importance of active learning, motivation and feedback in thinking skills as well as other skills. This confirms that discussions are superior to lectures in improving thinking and problem solving in mathematics education (Johnson & Johnson, 1999:78-80). Students who collaboratively work with peers in active learning situations are able to identify solutions to problems, develop negotiation and mediation skills, distribute cognitive responsibilities amongst members and externalise thinking through explaining ideas to peers (Tan, 2005:38).

The students' ability to perform logical operations as described by Piaget in active learning in mathematics education is manifested in their ability to solve word problems involving those logical operations. Evidence of attainment of thought processes at

Piaget’s levels of intellectual development can be gathered through investigation of their problem-solving skills. An indicator of the acquisition of the problem-solving skill is the ability to articulate one’s problem-solving solutions and reason these out adequately. For instance, one significant finding came from a study by Duch *et al*., (2001:3-11). They investigated the levels of cognitive achievement of university freshmen using the test of logical operations. Interviews were conducted to investigate the adequacy of their reasoning patterns. This study showed the relation between the levels of cognitive skills achievement of university freshmen and their formal reasoning patterns. A significant relationship was drawn between reasoning abilities and cognitive skill achievement in mathematics. This study showed that 61% of the university freshmen were at the concrete level. This study also revealed that as an individual goes through the four successive cognitive levels of performance, expertise on reasoning develops progressively. This study further provided evidence that there are certain logical operations that are not fully developed even at the university level. An investigation in this study showed that more than 50% of the university students have inadequate understanding of the concept of ratio and proportion as they exhibited ambiguous reasoning patterns during the interview (Duch *et al.,* 2001:3-11). Active learning by using problem-solving skills can facilitate problem solving at more abstract levels.

Furthermore, Siciliano (2001:12) argues that, when students participate or share in an active learning method in the mathematics lecture room, this serves to appropriate the purpose that actuates it; students become familiar with its methods and mathematical contents, acquire needed cognition and skills, and are saturated with its emotional spirit. Contemporary approaches to active learning/student-centred methods build on these early foundations but place greater emphasis on the *context* of theory-practice integration, learning communities, and implementation of a wide range of active learning in mathematics education (Gupta, 2005:48-50). In the present context of societal change and significant educational reform, active learning provides a flexible and multifaceted approach to meet the diverse needs and circumstances of students in university. Therefore, the lecturer's role in choosing worthwhile problems and mathematical tasks is crucial in implementing active learning approach. By analysing and adapting a problem, anticipating the mathematical ideas that can be brought out by working on the problem, and anticipating students' questions, a lecturer can decide if particular problems will help to further the mathematical goals for the class in active learning. There are many problems that are interesting and fun but that may not lead to the development of the mathematical ideas that are important for a class at a particular time. Choosing problems wisely and using and adapting problems from instructional materials, is the difficult part of using active learning methods in teaching mathematics (Blumberg, 2007:11-125; NCTM, 2000:53).

Furthermore, lecturers with an active learning/student-centred approach assist the students in learning content focusing on thinking skills. By asking questions and providing access (to what?), they interpret, organise and transfer knowledge which is important to solve authentic problems in the content areas being studied, and in daily life as well. Thus, an important role of the lecturer is choosing learning problems and situations that make students actively involved and stimulate interest in understanding how mathematics is applied in real-world situations (Holton, 2001:41). The development of a supportive classroom environment can also serve to enhance student motivation for learning mathematics (Boyer, 2002:48-50; Hines, 2002:275-278).

Students may transfer the skills that they acquire through active learning to other learning tasks. When students engage in active learning when set problem-based learning tasks, several steps are followed. These steps are: meet the problem, define the problem, gather facts about the problem, hypothesise solutions to the problem, research the problem, rephrase the problem, generate alternatives and advocate solutions to the problem (Angeli**,** 2002:9-15). Many of these steps align with standards in several disciplines apart for mathematics (NCTM, 2000:42). Moreover, a lecturer in a university may use a problem-based learning task to encourage students to investigate standard deviation while a lecturer in another university may use the same problem-based learning task to encourage students to investigate correlation (Normala & Maimunah, 2004:16).

The findings of a study conducted by Wilson *et al.* (2005: 83-91) asserts that students who frequently solve problems related to mathematics topics and discuss practical problems using active learning methods (cooperative, inquiry, discussion, discovery and problem-based learning methods) tend to score higher mathematics test scores than other students. It is shown that the results of students whose lecturers frequently requested them to do mathematics problems during typical lessons achieved better than students whose lecturers discussed and completed the given activities themselves**.** Thus, the frequent use of an active learning approach is significantly related to high mathematics test scores.

Further, central to the goals of active learning like cooperative learning methods in mathematics education is the enhancement of achievement, problem-solving skills, attitudes and inculcation of values. Several research findings asserted the positive effect of cooperative learning on academic achievement and problem-solving skills. For instance, the study conducted by McConnell (2005:35-38) shows that the experimental group that applied the active learning method (cooperative learning) significantly achieved better results in mathematics and problem-solving skills than the control group that was instructed in the lecturer-centred, traditional lecture manner. McConnell also finds that students instructed in the active learning method had a favourable response towards group work. Other researchers also report findings that assert the achievement benefits of cooperative learning (Siciliano, 2001:15-18).

Several research findings assert that as an inquiry-based learning method, active learning has a positive effect on students' achievement. For example, Hill, Rowan and Ball (2005:398-402) find that an inquiry learning method improved the academic achievement and critical thinking skills of students. An analysis of the results of 81 experimental studies on thousands of students shows that the inquiry learning method produces significant positive gains for academic achievement, student perceptions, process skills and analytic abilities (Steinberg, Empson & Carpenter, 2004:252-261).

However, the results of the different studies differ. For example, Healey and Roberts (2004:31–34) note that: (a) the effects on academic achievement (i.e., reading, writing, mathematics) of a lecturer-centred educational approach was generally found to be more effective than the active learning/student-centred approach; (b) research that compared active learning and lecturer-centred approaches found an interaction with mathematics class such that lecturer-centred approach was particularly beneficial for lower achievement students. The data on the effect of the two approaches were either equivocal or non-existent for middle-class students. Interestingly, some data suggest that the active learning approach may have a negative effect on the achievement level of low-achieving students who are unable to engage in the desired behaviours required by this approach; (c) the advantages of individualised learning (i.e., different pace for different students, choice of what and how to learn about a topic, and learning style differences) have not found empirical support. This finding was particularly true for lower achieving students; (d) learning by groups and by lecturer-led instruction leads to higher achievement; (e) the methods (derived from the work of Thorndike and Skinner) which have the greatest positive effect on achievement use cues, engagement, corrective feedback, and reinforcement and are more likely to occur in a lecturer directed context; (f) while there is a paucity of data on the comparative effects of lecturer-centred and student-centred approaches at the different levels.

3.2.2 Affective effects of active learning on the student

The affective effects of active learning on the student include psychological notions as such as feelings, emotions, moods, interest, motivation and values. Active learning also impacts on behavioural changes, students' self concept, self-esteem and social interactions in the learning environment.

Various studies on these emotional effects have been done highlighting different aspects:

- Shen, Leon, Callaghan and Shen (2007:274) state that:

> *It has become evident that effective teaching is not a question of putting information across a group of students. Rather, it is more of a question of initiating behavioral change in every student… Indeed, it has become clear that students learn in dynamic social learning environments in which the various interactions continuously influence each other, thereby changing the leaning situation itself as well as their own appraisal of the situation. Theories of learning that focus exclusively on information processing cannot grasp this complexity*.

- Researchers such as Schaeffer *et al.* (2003:133-136) and Shen *et al. (*2007:267-278) support an active learning approach. This method considers the contextual information of the students and the learning setting, and generates appropriate responses to the student, based on their emotional state, cognitive abilities and learning goals. This method can also be used to customise the interaction between the student and the active learning process, to predict students' responses to behaviour, and their interactions with the active learning process.

- Zan and Martino (2007:165-168) point out that emotions could provide feedback to lecturers in the classroom and to fellow students in team work. An active learning approach enables lecturers to recognise the emotional states of their students and respond in ways that positively affect students' learning. Lecturers can provide a solution for problems via real-time feedback to students' emotional states. This is valuable because emotion plays an important role in interaction, involvement and development. Hence, the lecturer should be aware of the students' emotional states while organising group discussion so as to enhance the information flow within the group by smoothing the emotion flow.

- Webb *et al.* (2002:15-18) agree that active learning has emotional effects on learners. The use of an active learning method, such as cooperative learning, increases students' motivation for working on mathematical proofs and thus resulted in improved achievement. According to Webb *et al.* (2002:13-20), students who have been taught by this active learning method developed interactional (communications) skills, such as how to ask for help and help each other. Such skills had resulted in positive outcomes like an increase in intrinsic motivation, love for the university and improved self-esteem (Savin-Baden & Wilkie, 2004:18-21).

- Effective implementation of active learning approaches also has other positive effects in mathematics education. In this regard, the study conducted by Bush (2005:122-134) on active learning involving 966 students and using Jigsaw structures, found that active learning in cooperative learning experiences inculcated values such as independency, love and cleanliness. Gutstein (2003:63-72) from the results of his investigation conducted using Jigsaw as a model and including 180 sample students from eight universities concluded that the values of self-dependence, rational thinking, love and hard working are prominently inculcated by an active, cooperative learning method. It was also found that this method enhances students' mathematical skills and achievement, and promotes enquiry learning.

3.2.3 The effects of active learning on the lecturer

Learning by doing is not an innovation in mathematics education; however, there is great emphasis on active learning techniques today. It is recognised as an important teaching and learning method and the findings of several researches have shown the effectiveness of this approach. Lecturers' attitudes towards teaching-learning approach influence their teaching behaviours and the selection of methods. Lecturers with positive attitudes to active learning implement active learning/student-centred methods to provide opportunities to their students to participate in the teaching-learning process. This approach involves all aspects of the lecturers' personalities – their opinions, attitudes, cognitions, feelings, and insights – to be involved in the mathematics teaching and learning process. It is the only paradigm explicitly aimed at the personal, social, and cognitive growth of the facilitator of learning (the lecturer) and provides satisfaction from the interaction with their students.

In an active learning approach, the role of the lecturer is to facilitate (rather than lead), or to coach students' personal learning via a guided discovery approach (Dewey & Meyer, 2000:268, Tan, 2005:39). Emphasis therefore is on interpersonal values. This makes the lecturer aware of his/her own values.

3.2.4 Summary

To sum up, the findings of different studies indicate that:

- Students become more actively engaged in solving mathematical problems when an active learning method like cooperative learning is employed in mathematics education. Thus, reluctant students, those who previously did not do their work, begin to participate in the problem-solving process.

- In active learning students move from a competitive to a cooperative stance. That is, they begin to share their problem-solving skills while solving the problems and discussing their answers to mathematical problems rather than competing for the correct answer. They also learn different ways of solving problems in general and specific mathematical terms.

- The classroom lecturer becomes more aware of students' abilities when they work in small groups. Some students who do not normally participate in whole group activities are actively involved in small group work (Fink**,** 2002:16; Gupta, 2005:26-39; Zehr, 2004:55-56).

- Active learning methods such as collaborative learning and cooperative learning enhance the accountability of students for their learning. Problem-based learning enhances students' retention and ability to apply material (Prince, 2004:223-231: Zehr, 2004:55-56).

- As an active learning method**,** problem-based learning has a robust positive effect on students' skill development and understanding the interconnections among concepts (Gijbels, Dochy, Van den Bossche & Segers, 2005:46-58), and on deep conceptual understanding, ability to apply appropriate meta-cognitive and reasoning strategies (Novick & Bassok, 2005:335-342),. Problem-based learning has also been shown to promote self-directed learning and the adoption of a deep (meaning-oriented) method to learning, as opposed to a superficial (memorisation-based) approach (Blumberg, 2007:11-125; Kroesbergen, Van Luit & Maas, 2004:233-251).

- Classrooms designed for an active learning approach include more hands-on activities and provide opportunities for students to discuss their solutions with each other; teaching incorporates problems based on realistic situations (Benek-Rivera & Mathews, 2004:104). There is a positive correlation between the amount of time students spend on discussion of learning activities and high mathematics test scores (Alexander 2002:36-37; Dixon in Kroesbergen *et al.,* 2004: 233-251).

3.3 FACTORS AFFECTING THE IMPLEMENTATION OF ACTIVE LEARNING IN MATHEMATICS EDUCATION

The purpose of this section is to reflect on the problems that affect the implementation of an active learning/student-centred approach learning as a step forward to overcoming them. Factors which must be considered in implementing active learning include: (a) attitudes of the lecturers and students towards the implementation of active learning in mathematics education; (b) the training of lecturers; (c) support from department heads and deans (d) the classroom condition; (e) class size; and (f) instructional material.

3.3.1 Attitudes of lecturers and students towards the implementation of active learning

Observation and informal interviews in Ethiopia have indicated that in most classes of mathematics education in universities, lecturer-centred/traditional teaching methods seem to be favoured in teaching and learning. Research conducted on attitudes and views on teaching approaches has shown how lecturers' and students' beliefs and attitudes influence their teaching and learning behaviours respectively (Gruber & Boreen, 2003:17-18). It is, therefore, necessary to explore the effects of attitudes and beliefs of lecturers and students on the implementation of active learning in mathematics education. Thus, researchers have pointed out that understanding and changing the attitudes and belief structures of lecturers and students is essential to improve their professional preparation and teaching-learning processes (Peterson, 2004:639; Zan & Martino, 2007:157-168).

3.3.1.1 Attitudes of the students

Attitudes are psychological constructs composed of emotional, cognitive and behavioural components. Attitudes have social, value, utilitarian, and defensive functions for the students who hold them (Newbill, 2005:41).

Effective implementation of active learning approaches enables students to acquire deep understanding of mathematical concepts and problem-solving skills which are essential to identify and tackle real problems employing appropriate mathematical methods. This approach has positive effects on students' academic achievement. Besides from promoting academic achievement, students should be inculcated with attitudes and values that are appropriate to their lives as students and for career development. If active learning is properly implemented in mathematics education, students become successful in their learning. On the other hand, ineffective use of this approach brings academic failure. This in turn affects students' attitudes towards active learning methods and the subject. Thus, student's attitude towards mathematics education could be enhanced by using effective active learning and teaching methods (Olowojaiye, 2000:129).

Other researchers who studied active learning approaches in mathematics education have also shown that the implementation of active leaning methods develops positive attitudes in students towards the approach. For instance, the study conducted by Zan and Martino (2007:159-164) indicates that students in the experimental group held positive attitudes towards active learning in mathematics education. Vaughan's (2002:359-364) study affirms this. Niess (2005:509-523) also finds that students in the experimental group held positive attitudes toward mathematics education. Mathematics students' interests and attitudes towards active learning affect their learning (NCTM 2000:37). Students with positive attitudes to the teaching and learning methods and those who show interest in the subject will score high grades and succeed.

3.3.1.2 Attitudes of the lecturers

The view of university lecturers towards teaching and learning have an impact on their beliefs and attitudes towards learning approaches in general and the implementation of active learning in fields like mathematics education in particular. Petrosino *et al.* (2007:44) confirmed this.

A lecturer-centred approach is directive and characterised by lecturers' belief that lecturers, should control decisions and processes related to education rather than students, and the basic elements of this dimension are firm discipline, attention to order, and procedure, and lecturer-centred curricula (Petrosino *et al.,* 2007:44). Educators assert that lecturers, deans and academic department heads' attitudes towards a teaching and learning approach is a determinant variable for effective implementation of an active learning/student-centred approach in mathematics education. Those educators who strongly support positivist epistemology assume that knowledge exists separated from the student fixed in the world and it is made up of discrete and irrefutable pieces of information or facts. The assumption is that the lecturer is the source of knowledge and knows best whereas students are "empty vessels" to be filled by the lecturer (Petrosino *et al.,* 2007:24-26). Thus, those lecturers who are in favour of positivist epistemology could have negative attitude towards active/student-centred learning.

Since the attitudes and beliefs of lecturers vary; copying the mathematics teaching and learning methods employed at one university to another may not be successful. Thus, it is necessary to inculcate positive attitude in lecturers towards teaching and learning methods which the lecturers need to adopt. They should also accept their own and the students' appropriate roles and put them into practice in the instructional processes to facilitate students learning. Active learning approaches put the students at the centre of the teaching and learning process to construct knowledge by themselves through interaction with the material, their teacher and partners. Thus, in this approach students are active participants. Hence the lecturer should be willing to employ active learning methods such as cooperative learning method that give students opportunities to interact and he or she should encourage students to actively participate in the teaching-learning process that focus on higher order thinking as much as possible (Lea *et al.,* 2003:321-334).

An active learning/student-centred approach is characterised by attitudes and beliefs of lecturers' regarding the importance of "empathic, supportive relationships which free students to discuss their feelings and experiences". They believe that students should be "actively involved in learning through opportunities to predict, infer, generalise, and evaluate" (Duffy & Kirkley, 2004:44). As indicated, a lecturer-centred approach contrasts to this, is directive and is characterised by lecturers' beliefs and attitudes that it is the lecturer, rather than the students, that should control decisions and processes related to mathematics education. The basic elements of this approach are "firm discipline, attention to order and procedure and lecturer-centred curricula" (Duffy & Kirkley, 2004:45).

3.3.2 The training of lecturers

Zan and Martino (2007:160-162) state that good and effective teaching and mathematics learning in the classroom demands a well-prepared and academically and pedagogically competent lecturer and the selection of teaching methods, activities and appropriate materials to achieve the designed educational objectives for different levels. The way students were trained has an effect on their future work. If they learned mainly through the active learning/student-centred methods, they prefer to use these methods in their own future teaching. Becker and Watts (2001:276) point out that "lecturers should be taught by the same methods which they will be expected to use in their future career". Thus, for the effective implementation of an active learning/student-centred approach in universities' mathematics education, lecturers should take academic and professional courses founded on active learning methods in their pre-service/in-service training.

However, scholars (in Child & Heavens, 2003:318-320) have found that the trainers themselves failed to relate theory with practice. Thus, there is a gap between theory and practice, between what lecturers are told to do and what they actually do in teaching universities mathematics education. The reason for this is that the trainers themselves don't have adequate training in the implementation of active learning methods to teach their students to employ the approach. Generally, the active learning/student–centred approach in mathematics education will be effectively implemented in the universities where lecturers are acquainted with this methodology. Hence university lecturers must get the required training on how to implement instructional methodologies in general and the active learning approach in mathematics education in particular.

3.3.3 Support from department heads and deans

The deans and academic department heads are responsible for both academic and administrative affairs in the university. They can be considered prominent figures in the university system as they are assigned to lead the activities in the teaching and learning environment. Thus, the implementation of educational programmes is dependent upon the effectiveness of the deans and academic department heads. They are expected to have dedication, commitment, the necessary training and positive attitudes towards their profession, and the implementation of active learning in universities mathematics education in particular.

According to Weimer (2002:174), for the effective implementation of active learning/student-centred approaches the deans and academic department heads of the university need to recognise active learning approaches as building blocks for lifelong learning. They should do everything possible to facilitate active learning. This involves allocating funds for additional equipment and other instructional materials like books to satisfy students' needs while working in groups. In addition to this, they should provide the necessary training and continuous professional support and encouragement to lecturers who are implementing the approach. To realise all of this, provision should be made for extensive training in educational policies and programmes in active learning for the deans, academic department heads and the managers of the university through both pre- and in-service training programmes. To sum up, deans and academic department heads should get appropriate and continuous training that enables them to give the necessary support to lecturers for the effective implementation of active learning approaches.

3.3.4 The classroom conditions

Alexander (2002:36-38) and the National Council of Teachers of Mathematics [NCTM] (2000:16-17) claim that students' understanding of mathematics education will be improved through effective implementation of active learning approaches in classrooms. According to the NCTM (2000:16-17) lecturers are facilitators of students' learning and they should create conducive learning environments. That is an environment in which there is free lecturer- student, and student-student interactions and adequate material resources including the required curricula. Thus, appropriate classroom conditions must be facilitated.

Lecturers can establish and nurture an environment conducive to an active learning approach in mathematics education through the decisions they make, the conversations they orchestrate, and the physical setting they create. Lecturers' actions towards the implementation of active learning approaches are what encourage students to think, question, solve problems, and discuss their ideas, methods, and solutions. The lecturer is responsible for creating an intellectual environment where serious mathematical thinking is the norm. More than just a physical setting with desks, bulletin boards, and posters, the classroom environment communicates subtle messages about what is valued in the active learning and doing of mathematics. Students' discussion and cooperation are encouraged, and students are expected to justify their thinking. If students are to learn to make conjectures, experiment with various active learning methods to solving problems, construct mathematical arguments and respond to others' arguments, then creating an environment that fosters these kinds of activities is essential (Mupinga, Nora & Yaw, 2006: 185-189; NCTM, 2000:18).

The classroom condition is one of the most important factors that should be considered in the teaching-learning process in general and active learning in mathematics education in universities in particular. Burns and Myhill (2004:42) point out that the physical environment in classrooms can make or break active learning approaches. Thus, to engage students in learning activities the classroom should be well equipped with furniture. There should be a movable desk for every student to use different lay outs in the classroom. In another study, Silberman in Zweck (2006:2-6) suggested 10 different types of classroom layouts, which facilitate active learning approaches. These layouts include a U-shape, team style, conference table, circle, group on group, work station breakout grouping, traditional classroom, auditorium arrangements etc.

Generally, in an active learning approach in mathematics education in universities the act of the student is learning by doing. Thus, it may be necessary for the students to move around the classroom (McCombs, 2003: 583-607). Accordingly, the arrangement of desks and tables should allow movement and communication and should be changed whenever necessary so that it is appropriate for the learning experiences that lecturers have planned.

3.3.5 Class size

Class size refers to the number of students regularly scheduled to meet in the administrative and instructional unit, usually under the direct guidance of a single lecturer. It has its own impact on the teaching-learning process in general and on the implementation of active learning in particular. Hence the idea of class size is becoming a concern and an essential point of discussion among scholars in implementing active learning. These scholars assume that as the class size increases, students face any or all of the following problems: lack of clarity of purpose; knowledge about progress; advice on improvement; lack of opportunity to discussion; inability to support independent study and inability to motivate students. According to McKeatchie and Svinicki (2005:7-9), in a large class individualisation of instruction is limited. Thus, the instructional method most frequently used is the lecture-centred approach, without group participation; oral communication within the classroom from student to lecturers is minimised; written work is assigned less frequently and when assigned, receives less lecturer attention and students are also less known to lecturers as individuals.

In contrast to the above, Jarvis (in Slavin, 2005:85-87) suggests that class size is not a significant factor in students' achievement. He found that individual lecturers varied in their effectiveness in different class sizes. Some were more effective in large classes than in small ones, while others were less effective in large classes than in small ones. Other researchers have taken middle position. As stated by McKeachie (1999:158-166) whether a large or a small group is appropriate depends on the following factors: learning objective that are to be realised; nature of the subject to be taught; pupil attention and learning resources.

In Ethiopia the average class size that is envisaged by the Ministry of Education is 50 for universities. However, as the existing statistics of the Ministry of Education indicates, the average class size in the universities of the country in the year 2008 was 75 (MoE, 2002:29).

3.3.6 Curricular and instructional material

The organisation of the curriculum material (course catalogue and course outline) has an impact on lecturers' and students' practices and roles played by them in the teaching-learning process. The course outline is only one of the many media through which lecturers and students communicate with each other and it is prepared by experts to achieve the desired educational objectives. Hence, the course catalogue and course outline should be available to interested parties.

As mentioned by Feden and Vogel (2003:47), active learning and teaching materials should contain plenty of exercises and samples of work. They should also be flexible for students to allow the chance to work at their own speed and by their own methods.

The university curriculum materials (course catalogue and course outline) are designed towards achieving the ideals of a national citizenry whose members are wholesome and balanced in all dimensions of human development, and who can contribute to the well-being of fellow members and to the nation. One of the premises of these curriculum materials is that the teaching and learning process should allow for the developmental growth of students in both affective and cognitive dimensions through active leaning. This is clearly visible in the curriculum materials prescriptions at the university level where lecturers are to adopt an active learning/student-centred approach in the classroom (Taylor, 2000:112). A well-prepared lecturer's curriculum materials provides him/her with a variety of learning and teaching methods that promote active learning/student-centred learning corresponding to each topic (Alexander, 2002:36-38; Mierson & Freiert, 2004:10-12).

However, at the university level, lecturers have been given much freedom to choose the way they teach and to what extent lecturers adopt an active learning/student-centred approach has been a concern to curriculum material developers. The emphasis on examination results and the paper-chase culture has in fact resulted in lecturers resorting to the teaching methods that are more lecturer-centred. Lecturers who produce better student examination results are generally perceived as more effective than others. Various studies on curriculum implementation have painted a dismal scenario. Although lecturers are delivering the content, there is concern as far as the process is concerned (Taylor, 2000:113-115). The failure to adopt an active learning approach seems to be attributed to lecturers' fear that such instruction is inferior to a lecturer-centred approach as far as promoting students' academic achievement.

Instructional materials, which are categorised into visual aids, audio aids and audio-visual aids, are any materials used as media of communication by the lecturers or students to advance learning (Shores in Felder & Brent, 2001:23). They are instruments with which a lecturer teaches and from which students learn. Hence, teaching without instructional materials boils down to teaching without technology (Ainsworth, 2006:188). International experiences have shown that modest teaching tools such as course catalogues, libraries, laboratory equipment and classroom instructional material are significant determinants of student achievement (Ainsworth & Th Loizou, 2003:674). Instructional material enable students to use more than one sense and to facilitate active learning, relate theory to practice, encourage creative thinking and effective student skill development, and make learning more functional (Ainsworth, 2006:185). In general, the problem of instructional materials may involve a shortage of lecturer-guidance, pedagogical centres, libraries, laboratory equipment, reference books, and audiovisuals, among others. The presence or absence of these materials may facilitate or hinder the implementation of an active learning approach.

3.4 SUMMARY

Chapter three explained empirical evidence of the effects of active learning teaching methods, with special reference to mathematics education at university. The chapter also included factors affecting the implementation of active learning approaches, including attitudes of lecturers and students towards the implementation of active learning, the training of lecturers, support from academic department heads and deans, the classroom condition, class size, and curricula and instructional material.

The next chapter, chapter four, will present the research design used to conduct the investigation to answer the research questions stated in Chapter one. This includes the research methods, sampling, methods of data analysis and ethical considerations.

CHAPTER FOUR

RESEARCH DESIGN AND METHODS

4.1 INTRODUCTION

Chapter two presented the theoretical framework of the study. It included learning theories with special reference to active learning approaches. Chapter three explained the influences on and of active learning in mathematics education at university. This chapter describes the research design and the data collection procedures that were followed in this investigation. It specifically focuses on data collection, data processing, measures to ensure validity and reliability, and ethical measures.

4.2 RESEARCH PROBLEM

The problem under focus in this study pertains to the nature of the teaching-learning process in line with active learning/student-centred approaches. It investigates the major factors that hinder the implementation of such approaches in mathematics education in a sample of universities in Oromia, Ethiopia. To this end, a number of specific research questions were posed (see section 1.2). Care was taken to ensure that research questions were clearly formulated, intellectually worthwhile, researchable, and used as means to move from broad research to specific research (Mason, 2002:19). This research addresses the following specific questions (see section 1.2):

- To what extent are active learning approaches implemented in mathematics education in the universities in the Oromia, Ethiopia?

- What are the major factors/challenges in implementing active learning approaches in these universities?

- What are the attitudes of university lecturers towards active learning/student-centred approaches?

- What training has been provided for the implementation of active learning approaches in the teaching mathematics?

- What support, conditions and materials are provided for the implementation of active learning approaches?

In line with the above, recommendations for improvement may be made.

4.3 RESEARCH DESIGN AND METHODOLOGY

The research design is the plan and procedures for the study, providing the overall framework for collecting the data. It outlines the detailed steps of the study and provides guidelines for systematic sampling techniques, the sample size, instruments and data gathering decisions from broad assumptions to detailed methods of data analysis (Creswell, 2009:116-118). Further, the research design encompasses all the structural aspects of a study (Gay & Airasian, 2000:109-117).

In this study a mixed methods approach is followed. Mixed methods research intentionally engages a multiple set of approaches; all approaches are valuable and have something to contribute to understanding, but only partially. The use of several approaches and methods leads to a better understanding of the issue under investigation (Cohen, Marion & Morrison, 2003:31-34). Hence, a mixed-method approach using a survey design for obtaining descriptive statistics supported by a qualitative investigation are employed. The two approaches are seen as complementary. Thus, as full a picture as possible of this issue may be obtained (Creswell, 2009:203-223) and the limitations of one approach can be offset by the advantages of another (Creswell, 2009:204-226; Healy & Perry, 2000:119-122). According to Cohen, Marion and Morrison (2003:24-28), “use of both forms of data allows researchers to simultaneously make generalizations about a population from the results of a sample and to gain a deeper understanding of the phenomena of interest”.

The specific type of research design that is used for the quantitative phase of this study is a *descriptive survey*. In descriptive survey research, the researcher selects a sample of subjects and administers a questionnaire to collect data (Creswell 2009:36). The descriptive survey is used to describe the attitudes, beliefs, and opinions of the respondents towards the nature of active learning approach in universities.

The research design in the qualitative phase is a *phenomenology*. This is to get insight into the phenomenon from the participants’ views. It is also contextual. According to Creswell (2009:16), a context represents a specific set of properties that pertain to phenomena and a contextual study tends to be descriptive and exploratory. The context of this study is mathematics teaching at universities in Oramia, Ethiopia. In this phase, observation and interviews are used.

4.4 RESEARCH METHODS

4.4.1 Data collection methods/instruments

As has been mentioned in chapter one (section 1.1), the objective of this research is to explore the extent of implementation and major factors that hinder the implementation of active learning/student-centred approaches in Ethiopian universities' mathematics education. In a mixed methods approach, the study adopts data triangulation. Gay and Airasian (2000:201) point out that triangulation gives broad coverage of education characteristics and allows for crosschecking of information. The aim of triangulation is to ensure the validity and reliability of the findings. Hence, questionnaires, observation and interviews are employed for data gathering in the present study as follows:

4.4.1.1 The questionnaire

A questionnaire containing mainly closed ended items was administered to mathematics lecturers (see Appendix A). The respondents responded on different items concerning their use of active teaching/learning approaches and the major problems/challenges that hinder the implementation of this approach in universities' mathematics education in the Oromia Regional State, Ethiopia, among others. The questionnaire implemented a four point Likert Scale with the following meanings: 1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree.

The items in the questionnaire were divided into the following five main sections:

- Section 1: Biographic characteristics of the respondents (items 1 to 7).
- Section 2: The extent to which the university lecturers implement active learning approaches.

Category 1: Regarding providing students' opportunities to actively participate in the teaching-learning process (items 8 to 23).
Category 2: The extent of implementing active learning/student-centred practices while assessing (items 24 to 36).

Category 3: Factors affecting/hindering the implementation of active learning/student-centred approaches in the sample universities in the Oromia Regional State, Ethiopia (items 37 to 51).

- Section 3: Lecturers' attitudes towards active learning (items 52 to 80).
- Section 4: The pre-service and in-service training of lecturers (items 81 to 95).
- Section 5: Provision of support provided for the implementation of active learning approaches (items 96 to 110).

Regarding the above:

- Items in Category 2 of the questionnaire (opportunities for active learning), were generated from chapter 2. It covers 2.3.1 the cooperative learning method; 2.3.2 the problem-based learning method; 2.3.3. inquiry-based learning; 2.3.4 the discovery learning method; and 2.3.5 the discussion method.

- Items in Category 2 of Section 2 (assessment) were generated from 2.2.1.2, 2.2.2.2, 2.2.3.2, 2.2.4.2 and 2.2.5.2.

- Items in Category 3 of section 2 (factors hindering active learning) were generated from Chapter 3sections 3.3.3, 3.3.4, 3.3.5 and 3.3.6 including a few general questions on attitudes toward training and support, although these are again covered in the following three sections.

- Items in Section 3 (attitudes toward active learning) were generated from 3.3.1, namely 3.3.1.2 and 3.3.1.3.

- Items in Section 4 (training for active learning) were generated from 3.3.2.

- Items in Section 5 (support provided for active learning) were generated from 3.3.3.

A final section consisted of three open-ended items for lecturers regarding the active learning/teaching of mathematics. These were:

- What works well regarding active teaching and learning?
- What does not work well regarding active teaching and learning?
- What do you recommend for the improvement of active teaching/learning of mathematics?

4.4.1.2 Observation

In this study the observation method of data collection is used practically to assess the extent of implementation of active learning approaches in mathematics classrooms. The classroom observations focused on the following areas: (a) what lecturers and students do at the start, during and at the end of a lesson; (b) the extent to which appropriate active learning methods are applied/implemented by lecturers or not; and (c) whether students individually or in a group are free to express their opinions and to interact with each other and their lecturers. The researcher sat in the participants' class during their regular mathematics time and used an observation sheet to record what he saw, heard, and experienced during a teaching session (Gay & Airasian 2000:213). In total 16 observations (two lecturers from each four sample universities) were twice observed. (See Appendix B for field notes on observations.)

4.4.1.3 Interviews

Semi-structured interviews were conducted with four mathematics department heads and eight observed lecturers. In this research, interviews were used for collecting rich information regarding the nature of the teaching–learning process in line with the active learning approaches and the major problems/challenges that lecturers experience that hinder the implementation of this approach in mathematics education at universities. A flexible approach was used regarding the interview guide. The interview guide focused on two issues: (a) the results of the questionnaire and (b) the lessons that were observed by the researcher. In both cases the aim was to further clarify and thus to complement the quantitative and the observation data. (The interview guide appears as Appendix C.)

4.4.1.4 Time frame

As indicated above, data were collected through the use of questionnaires, observation, and interviews. Following the selection and initial contact with staff, two weeks were spent in separate weekly intervals at each of the four sample universities. A further six weeks were spent completing follow-up visits, classroom observation, dispatching and collecting of questionnaires and conducting interviews. During this time 16 observations were made and 12 lecturers were interviewed. Eight of these were lecturers whose lessons were observed and four were mathematics department heads.

4.4.2 Sample

A population is a complete group of entities sharing some common set of characteristics and a sample is the group of specific population elements relevant to the study (Gay & Airasian, 2000:121). The process of making a selection to include in the study is sampling (Gay & Airasian, 2000:119-114). In the selection of the sample, purposive and systematic sampling was used. Among the six universities that are found in Oromia, Ethiopia, a total of four was sampled: two from the newly established universities (younger than five years) and two from the old universities (older than 10 years**)** were involved in the study. The selection of the particular university was based on the researcher's judgment of the potential for providing worthwhile and comprehensive data. This approach was adopted on the basis of reputational-case selection. The use of a reputational-case selection, according to Merrianam (in Gay & Airasian 2000:120-140), presumes the sample will provide valuable information for the researcher that will help answer the research questions. All the mathematics lecturers (84 in total, 79 males and five females) of the four sample universities were involved in the quantitative section of the study.

As mentioned in 4.4.1.4, 16 observations were made: two lecturers from each of the four sample universities were observed twice. In addition, eight lecturers were interviewed: eight of these were lecturers whose lessons had been observed. Four department heads were also interviewed. These were also purposefully selected for being information rich and willing to participate.

To assist in the data-gathering process and to develop a sense of familiarity at each of the universities, visits were conducted on separate occasions prior to the commencement of individual weekly-data collection blocks. The researcher had been introduced to each staff member by the mathematics department heads at formal staff gatherings. At all four universities the researcher was made to feel very welcome.

4.4.3 Pilot study

A 'pilot study' is an abbreviated version of a research project. In this study the researcher pilot tested the questionnaire on a small scale before using it on a larger scale with the sampled lecturers (Dane in Gay & Airasian, 2000:191-193). Thus it provided a trial run for the questionnaire that involved testing the wording of the questions, identifying ambiguous questions, determining how long it takes to complete the questionnaire, and if all important content has been included. A pilot study enhances the content validity of the questionnaire. Therefore, the questionnaire was tested with a total of 10 experienced lecturers (two who teach teaching methods and curriculum studies and eight mathematics lecturers) from a university which is not part of the sample of the study.

A number of problems with the wording of questions came to light. Changes were made accordingly. The lecturers claimed some words (e.g. 'diploma' regarding educational qualification, and 'good'*)* be omitted. Words that included 'homework' needed to be replaced by 'worksheet'; 'too much' work needed to be 'enough' work; 'how frequently' should rather be 'I ask frequently'; and *'*big classes' needed to be replaced by 'large class size'. In addition, the item 'I believe students learn mathematics by doing things' needed to be modified to: 'I believe students learn mathematics through repeated practice approaches'*.* The total time to complete the questionnaire was 40 to 45 minutes.

4.4.4 Data analysis

The quantitative data obtained from mathematics lecturers through the questionnaires was analysed by using frequencies, percentages and mean values. No hypotheses were tested as this is not the aim of the study.

Qualitative data obtained through observation of classes and interviews with the lecturers were analysed qualitatively (using words). To this end, the following method to analyse qualitative data was used. This method follows a bottom-up strategy by starting with the lowest level categories closest to the data in the following way (Johnson & Christensen 2000:426-431):

- Segmenting

This involves dividing the data into meaningful analytical units. You do this by reading the transcribed data line by line and asking yourself: Do I see a segment of text that is important for the research? Is it different from the text coming before and after it? Where does the segment start and end? Such segments (words, sentences or several sentences) are bracketed to indicate where they start and end. You can bracket the segments by means of [ ] or by underlining.

- Coding

According to Miles and Huberman (in Johnson & Christenson 2000:427), "codes are tags or labels for assigning units of meaning to the descriptive or inferential information complied during a study. Codes are attached to 'chunks' of varying size – words, phrases, sentences, or whole paragraphs ..."

The identified segments of data are coded by means of category names and symbols. Facesheet codes that apply to a complete transcript are also given to enable us to search for interviewee or group differences.

- Compiling a master list

All the category names that are developed are put on a master list followed by the symbolic codes. The codes on the master list are then reapplied to new segments of text each time an appropriate segment is encountered. Thus the master list is expanded as the need arises.

- Checking for intercoder reliability

In order to address intercoder reliability checks were carried out for consistency about the appropriate codes with another coder. In this research, the promoter checked the coding.

- Enumeration

The frequency with which observations were made can be noted to identify important ideas and prominent themes or patterns in the research group as a whole or between the diverse subgroups. However, these patterns are not normally presented in *numbers* but in *words* (such as *many* or *most*).

- Showing relationships among categories

To identify relationships among the categories Spradley's (Johnson & Christenson, 2000:437) summary of nine possible relationships was used.

These are:

Title	Form of relationship
1. Strict inclusion	X is a kind of Y
2. Spatial	X is a place in Y; X is a part of Y
3. Cause-effect	X is a result of Y; X is a cause of Y
4. Rationale	X is a reason for doing Y
5. Location for action	X is a place for doing Y
6. Function	X is used for Y
7. Means-end	X is a way to do Y
8. Sequence	X is a step (stage) in Y
9. Attribution	X is an attribute (characteristic) of Y

4.4.5 Measures to ensure validity and reliability

By establishing both the content and face validity of the quantitative data collection instrument (the questionnaire) the researcher can improve the validity of his research results (Healy & Perry, 2000:122-124). This was done as follows:

Content validity: Content validity is the degree to which elements of an assessment instrument are relevant to and representative of the targeted construct for a particular assessment purpose. Content validity is a self evident measurement because it relies on the assurance that the researcher can demonstrate the adequate coverage of the known field. Both the literature and the items in the questionnaire should cover the 'full breadth' of the theory on the research problem. Content validity is closely related to face validity (Cohen, Marion & Morrison, 2003:129-132).

Face Validity: The term face validity is a technical description of the judgment that the items are meaningful and relevant to the construct that is measured. Face validity simply indicates whether, on the face of it, the instrument appears to be assessing the desired qualities. The criterion here represents a subjective judgment based on a review of the measure itself by one or more experts. In this research, the promoter will judge the items to determine if they test what they are supposed to test.

According to Healy and Perry (2000:122-124), reliability is the extent to which results are consistent over time. In other words, reliability is used to judge whether the same results are obtained if this study is to be replicated that whether the results of a study can be reproduced under a similar methodology. A correlation coefficient closer to one indicates that a scale is more internally reliable. Many researchers agree that a reliability coefficient of 0.7 or above is acceptable (Cohen, Marion & Morrison, 2003:104-132; Gay & Airasian, 2000:173-175). For this study, reliability was done statistically by means of the Cronbach alpha correlation coefficient. In this study calculated reliability coefficients are indicated hereunder:

The calculated reliabilities of the different section were as follows:

- Provision of opportunities for students to actively participate in the teaching-learning process (lecturers' use of active learning methods) is 0.76.
- Extent of implementing active learning/student-centred practices while assessing is 0.82
- Factors hindering the implementation of active learning/student- centred approaches in the sample universities is 0.78

- The attitudes of lecturers towards active learning is 0. 80
- The pre-service and in-service training of lecturers is 0.79
- Provision of support provided for the implementation of active learning approach is 0.81

Thus, the average reliability coefficient for the questionnaire is 0.79 which is very good for this kind of questionnaire.

Through the process of triangulation of data sources, that is, data gathered from a range of different participants, events and activities within each site and by use of different methods of data collection, a broad range of data was gathered. The use of multiple data collection methods and multiple perspectives served as a verification check. For the purpose of checking data accuracy, information feedback and checking of data were sought from participants as an ongoing part of the research. In this way, participants' were given an opportunity for involvement in the verification process, thereby, enhancing the truth value of the project.

4.5 ETHICAL MEASURES

Ethics is concerned with what is wrong or right in conducting research (Gay & Airasian, 2000:94-95).

4.5.1 Informed consent

This implies that adequate information on the aims of the research, the procedures that were followed, possible advantages and disadvantages for the respondents, the credibility of the researcher and how the results were used was given to the respondents so that they could decide to participate in the research or not. All participants were voluntarily involved in the research project.

4.5.2 Deception of subjects and/or respondents

No form of deception was inflicted on respondents. In other words, withholding information or offering incorrect information to ensure participation of subjects is seen as unethical.

4.5.3 Violation of privacy

Privacy can be defined as that which normally is not intended for others to observe or analyse. In this research, the privacy of respondents was protected at all costs. Concealed media such as video cameras or one-way mirrors were not used.

4.5.4 Actions and competence of researcher

The researcher ensured that he was competent to undertake the research project. This implies thorough preparation before embarking on the project and requesting the participation of others. During the research *no value judgements* were made under any circumstances.

4.5.5 Cooperation of collaborators

In this research the Ministry of Education provided financial support. This is acknowledged but it did not influence the findings of the study.

4.5.6 Confidentiality and anonymity

Information about subjects needs to be seen as confidential unless otherwise agreed on, through informed consent. Only the researcher has access to names and data. In this investigation, confidentiality was ensured by collecting data anonymously. The need to maintain confidentiality in order to protect participants' rights was a matter of continual concern for the study. There were a few occasions when the respondents expressed concern or apprehension about the process being used and some respondents were concerned with issues of confidentiality. The researcher ensured participants that the names of participants would not be revealed.

4.5.7 Permission to conduct research at an institution

For research to be conducted at an institution such as a university, approval for conducting the research should be obtained before any data are collected. Such permission was obtained from the institutions and from the respondents/participants themselves. Letters of permission were used (see Appendix D). This facilitated the support and cooperation of participants.

4.6 SUMMARY

This chapter explained the mixed methods research design and data collection techniques that were used to gather information with regard to this study. This study aims at gathering reliable and valid information through questionnaires, observation and interviews. The study aims to answer the five specific research questions that focus on the issue of active teaching/learning approaches in mathematics teaching in a selected area in Ethiopia.

The presentation and discussion of the research results are the focus of the next chapter.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 INTRODUCTION

In chapter 4 the research design and methodology were explained. As this is a quantitative approach, a descriptive survey design was used. This chapter discusses the presentation and interpretation of data. In doing so, the data collected through questionnaires are presented with the help of tables. These results are complemented by data obtained by means of qualitative methods, namely classroom observation and interviews. The chapter presents the findings on the extent to which the university mathematics lecturers implement active learning approaches. This includes the extent to which lecturers help students to actively participate in the teaching-learning process; implement active learning/student-centred approaches while assessing, and factors/challenges which hinder the implementation of active learning/student-centred approaches in sample universities. The chapter also highlights the attitudes of lecturers towards active learning approaches, the pre-service and in-service training they received and the support provided for the implementation of active learning approaches.

5.2 ANALYSIS OF BIOGRAPHICAL DATA

Before discussing the data related to the basic questions, a summary of the characteristics of the subjects is presented here. Seven biographical variables were selected on the basis of their potential to influence respondents' use of active learning approaches. The biographical variables included: the particular university, and the lecturers' gender, age, years of teaching experience, educational qualification, teaching workload per week and average number of students in a class. Table 5.1 shows the biographical data of the respondents.

Table 5.1: Biographical data of respondents

Variable	Frequency	Percentage
Gender:		
Male	79	94
Female	5	6
Age:		
29 yrs and younger	38	45.2
30-39 yrs	33	39.3
40-49 yrs	11	13.1
50 yrs and older	2	2.4
Experience in teaching:		
Less than one year	1	1.2
1-5 yrs	40	47.6
6-10 yrs	27	32.1
11-15 yrs	5	6
More than 15 years	11	13.1
Level of Education:		
Bachelors degree	11	13.1
Honours degree	-	-
Masters degree	69	82.1
Doctorate	4	4.8
Teaching workload per week :		
Less than six credit hours	3	3.6
6-10 credit hours	23	27.4
11-15 credit hours	49	58.3
More than 15 credit hours	9	10.7

Average number of students in a class:		
Less than 40	-	-
41-50	3	3.6
51-60	11	13.1
More than 60	70	83.3

According to Table 5.1, 39.3% and 45.2% of the respondents were between 30 and 39, or 29 years and younger respectively. Only 15.5% of the respondents were 40 years and older. Of the respondents, 94% were male and 6% were female. This study therefore shows that the participation of females as mathematics lecturers at universities is low. Almost 48% of the respondents have between one to five years of experience as educators and are therefore relatively inexperienced. About 32% of the lecturers served as a lecturer for six to 10 years, while only 19.1% of the respondents worked as lecturers for 11 and more years. Most of the lecturers (82%) had attained a Master's degree. Only 4.8% and 13% of the respondents have a Doctorate and Bachelors degree in education respectively. This implies that hard work is required of the universities to develop and capacitate their staff members.

Workload influences teaching style. In this regard Table 5.1 indicates that only 27.4% of the respondents had a workload of six to 10 credit hours; 58.3% of the lecturers have workload that ranges from 12 to 15 credit hours; and more than 10% of the lecturers have a workload in excess of 15 credit hours. The implementation of active learning approaches requires a certain amount of time to think about and explore each topic. Such approaches may take more time than a lecture. Heavy workloads and excessive material to cover motivates lecturers to fall back on lecturer-centred approaches that they are familiar with rather than use active learning approaches.

The above is complemented by the qualitative data. Classroom observation also indicated that the classroom *seating arrangement* does not allow lecturers to employ active learning approaches. Front to back seating arrangements encourage one-way communication only since such seating arrangements discourage students from talking among themselves and focus attention on the lecturer. During interviews respondents complained that the large class sizes does not allow them to change this type of seating arrangements and it also has a great impact on the implementation of active learning approaches. According to Table 5.1, most lecturers (83.3%) replied that a typical classroom generally has more than 60 students. This was confirmed by classroom observations: the researcher observed 52 to 118 students in a given class. Only a very small number of students ever spoke to respond to questions. Lecturers could thus not continuously follow up on lectures. It was therefore difficult to implement active learning approaches.

5.3 ACTIVE LEARNING/STUDENT-CENTRED APPROACHES AND INFLUENCING FACTORS IN MATHEMATICS EDUCATION

The purpose of this part of the study was to assess the nature of the teaching-learning process in line with the active learning/student-centred approaches and the major factors that hinder the implementation of these approaches in mathematics education in universities in Oromia, Ethiopia. Using questionnaires supported by classroom observation and interviews, the following was determined:

- the extent to which lecturers provide students with opportunities to actively participate in the teaching-learning process or lecturers' use of active learning methods (presented in Table 5.2);
- the extent to which lecturers implemented active learning/student-centred approaches while assessing (illustrated in Table 5.3);
- the factors that hindered the implementation of active learning/student-centred approaches in the sample universities (indicated by Table 5.4);
- the attitudes of lecturers towards active learning (shown in Table 5.5);
- the pre-service and in-service training of the relevant lecturers (illustrated by Table 5.6); and

- the provision of support provided for the implementation of active learning approaches (Table 5.7).

The data taken from the questionnaires, classroom observation and interview results were analysed in line with the above and the research questions as formulated in Chapter 1, section 1.2. These are now addressed.

5.3.1 Research question one

To what extent are active learning approaches implemented in mathematics education in the universities in the Oromia, Ethiopia?

5.3.1.1 The use of active approaches while teaching

The data on this issue were collected by means of 30 items and the results are presented in Tables 5.2 and 5.3, followed by classroom observation and interviews. Table 5.2 illustrates the extent to which the lecturers provided students with opportunities for active participation in their mathematics classes.

Table 5.2: The extent to which lecturers provides students with opportunities to actively participate in the teaching-learning process or lecturers' use of active learning methods

No.	Students opportunities to actively participate in the teaching- learning process	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
		f	%	f	%	F	%	F	%	
1	I rarely arrange the students into groups for mathematics team work.	8	9.5	12	14.3	45	53.6	19	22.6	2.9
2	I think that lectures are the best way to teach students to solve mathematics problems.	10	11.9	20	23.8	40	47.6	14	17.1	2.7
3	I encourage students to ask questions.	3	3.6	2	2.4	15	17.9	64	76.2	3.6
4	I think that inquiry-learning is effective to actively involve students in the mathematics learning process.	2	2.4	3	3.6	52	61.9	27	32.1	3.2
5	I often confront the students with problems to solve.	4	4.8	11	13.1	43	51.2	26	31	3.1
6	I encourage students to deduce general principles from practical experiences.	3	3.6	5	6	46	54.8	30	35.7	3.3
7	I consciously create conditions to stimulate students' need to know.	-	-	5	6	51	60.7	28	33.3	3.3
8	I discuss worksheet results with students.	1	1.2	7	8.3	31	36.9	45	53.6	3.4
9	I think a well prepared lecture can stimulate students to solve mathematics problems.	1	1.2	3	3.6	39	46.4	41	48.8	3.4
10	I think cooperative work in groups is good for efficient learning.	-	-	2	2.4	25	29.8	57	67.9	3.7
11	I consciously facilitate problem solving in the mathematics class.	-	-	2	2.4	39	46.4	43	51.2	3.5
12	I discourage students to discuss their feelings.	54	64.3	24	28.6	5	6	1	1.2	1.4
13	I discourage students to explore their current beliefs.	63	75	13	15.5	5	6	3	3.6	1.4
14	I support students to discover the desired conceptual knowledge in the learning process for themselves.	-	-	3	3.6	22	26.2	59	70.2	3.7

No.	Students opportunities to actively participate in the teaching- learning process	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
		f	%	f	%	F	%	F	%	
15	I believe that cooperative learning is needed to help students understand new concepts.	1	1.2	5	6	26	31	52	61.9	3.5
16	I think that discussions between students on new course materials are vital for deep understanding.	-	-	8	9.5	29	34.5	47	56	3.5

Regarding teaching method, an item (number 2) stated: “I think that lectures are the best way to teach students to solve mathematics problems.” Table 5.2 shows that 64.7% (47.6%+17.1%) of the lecturers agreed with this statement. Accordingly, they responded positively on the item that stated that a well prepared lecture stimulates students to solve mathematics problems (item 9). However, on encouraging students to ask questions, most (76.2%) lecturers also strongly agreed. This means that the lecturers realise that lecturing alone is not enough to prepare students to understand their environment.

On the question (four) if inquiry-learning is effective to actively involve students in the mathematics learning process, 61.9% and 32% agreed or strongly agrees (mean value of 3.2). This is in line with item five that asked if students were confronted with problems to solve: about 82% (51.2% and 31%) showed their agreement (mean value of 3.1); item 11 that asked if lecturers facilitate problem solving (a mean of 3.5) and if students were encouraged to deduce general principles from practical experiences: supported by about 90% (54.8% and 36%, mean value of 3.3).

On consciously creating conditions to stimulate students’ need to know, 60.7% of the respondents agreed and 37% and 54% of the lecturers indicated that they discussed worksheet results with students. In item 14 of Table 5.2, the majority of the respondents (70.2% and 25%, mean 3.7) indicated that they supported students to discover the desired conceptual knowledge in the learning process for themselves. Most of the lecturers thus seem to realise the importance of active, discovery learning. However, nearly 90% of the lecturers indicated their belief in the lecture method (item nine).

Most lecturers (67.9%) strongly agreed on the *idea* that cooperative work in groups is good for efficient learning (see item 10 of Table 5.2). The results on items 15 and 16 show this. However, observation confirmed that in most of the cases the role of the students was to listen carefully to the lecturer, to learn by doing lots of exercises and by working alone in silence. The role of the students was to memorise the facts and rules lectured on and to implement them. In addition, the students seemed to prefer to work individually in class. When the issue was raised with the lecturers, they indicated that group work was a problem because some students did not do their share of the work – they were inactive 'passengers' in the group activities. These students preferred lecturer-centred approaches in which they were passive. Moreover, some students did not want to share their ideas and in other cases group work led to conflict.

Regarding *discouraging* students to explore their feelings and beliefs (items 12 and 13), about 93% (64 and 29%) and 91% (75 and 16%) disagreed. This seems to indicate that most lecturers believe that lecturing alone is not enough for learning well. However, observation contrasted to these responses. This was confirmed by the interviews that showed preference for lectures only.

Lecturers make numerous instructional decisions that can either discourage or promote an active learning environment for mathematics. Eight lecturers were observed as they were teaching mathematics at four different universities. In some instances, two lessons were observed on different days. It was noted that most of the observed lecturers in the sample universities did *not* make use some of basic activities; lecturers did not:

- use a wide variety of teaching methods to engage students in learning (e.g. linking previous knowledge and experience; using appropriate pacing; questioning strategies; encouraging higher level thinking skills; implementing flexible grouping; differentiating instruction; and accommodating print, non-print, and electronic resources);
- request students to demonstrate the solution process on the chalkboard. When students work out problems on the chalkboard, the lecturer develops a sense of potential misunderstandings in the solution process. Working problems out at the chalkboard gives the lecturer another tool for student assessment;
- use cooperative groups for problem solving activity. Students were not allowed to present and explain their solutions to problems on the board to the other students;
- encourage students to investigate problems further by asking them questions that begin with "what, when, where and how".

- do ongoing formative assessment throughout the learning period. This might be accomplished through "jigsawing" solutions to pre-determined mathematics problems and/or requiring small student groups to solve problems at the board.

In addition to the questionnaires and classroom observations, nine semi-structured interviews were held with the lecturer participants. When the lecturers were interviewed on *how* they used active learning/student-centred approaches in mathematics teaching, some were positive. Two examples include:

> *I have practiced active learning for the last six years. I am really interested and believe in the views of active learning. It is exactly the way in which one can learn. I have also taken the training that improves my method of teaching. Before five years, I really thought that using active learning was wastage of time. But now I can practically see that students learn more when they are engaged in activities that make them participant* [Lecturer A, June 8/2010].

> *I have always preferred to encourage students to learn through activity rather than through passive listening and note taking. Active learning has been deeply embedded in my teaching for many years. Letting go of the classic lecturer 'font of all knowledge' position is actually very liberating! Once you have created the climate for a more active learning/ student-centred contribution, then it tends to grow by itself and you learn along with the students* [Lecturer E, June 14/2010].

Some lecturers were undecided, for example:

> *My conclusion about active learning/student-centred approaches is that both lecturer-centred and active learning/student-centred approaches have positives and negatives. My students do feel like they 'got' more out of the critical thinking (active learning) approaches because they had to take control of their learning.*

Overall, I think I teach better with the balance of lecture and discussion that I found towards the end of the semester [Lecturer B, June 8/2010].

Some lecturers and some students were negative about active learning approaches, for example:

I am concerned that problem solving and cooperative learning method is becoming overused and that without a broad range of source data for reference the 'problem' is more guesswork. In such cases, it may be that students are active, enjoy the activity and remember the desired outcomes without truly challenging their own existing concepts. I do not believe in 'active listening' but I feel that using simple pauses to allow students to review what has been discussed could make lecturers much more active [Lecturer C, June 11/2010].

When I tried active learning in one of my classes, many of the students hated it. Some refused to cooperate and made their hostility to the approaches and for this reason most of the time I am using explanation and description of the steps for each problem [Lecturer D, June 11/2010].

5.3.1.2 The use of an active approach while assessing

Table 5.3 presents the data obtained from the respondents on the extent of implementing active learning/student-centred approaches while assessing.

Table 5.3: The extent to which lecturers implement active learning/student-centred approaches while assessing

No.	Active learning/student-centred practices while assessing	Strongly disagree (1)		Disagree(2)		Agree (3)		Strongly agree (4)		Mean
		F	%	f	%	f	%	f	%	
1	I have too much work to evaluate students continuously.	7	8.3	8	9.5	43	51.2	26	31	3.1
2	I frequently ask close-ended questions for which there is only one correct answer.	8	9.5	34	40.5	38	45.2	4	4.8	2.5
3	Students become too noisy if I ask many questions.	22	26.2	48	57.1	11	13.1	3	3.6	1.9
4	I praise students' work as often as possible.	2	2.4	10	12	46	54.8	26	30.9	3.1
5	I frequently ask open-ended questions.	11	13.1	41	48.8	22	26.2	10	12	2.4
6	Students need to be able to respond very quickly to questions.	9	10.7	36	42.9	30	35.7	9	10.7	2.4
7	I often assess students' understanding during group work.	7	8.3	34	40.5	36	42.9	7	8.3	2.5
8	I often assess students' understanding through questioning.	1	1.2	5	6	45	53.6	33	39.3	3.3
9	I provide exercises on some of the lessons.	-	-	2	2.4	38	45.2	44	52.4	3.5
11	It is impossible to follow students' participation in learning.	45	53.6	19	22.6	11	13.1	9	10.7	1.8
12	I help students to take responsibility for their own learning.	-	-	1	1.2	49	58.3	34	40.3	3.4
13	Providing ongoing meaningful feedback to students is too time-consuming.	12	14.3	19	22.6	40	47.6	13	15.5	2.6
14	I often assess students when they solve problems in a group.	4	4.8	23	27.4	39	46.4	13	15.5	2.6

Implementing active learning approaches starts with involving the students in making decisions about their progress. The students should be made fully aware of the institutional requirements for submitting grades, but also instructed on the importance and relevance of the self-directed learning experience. However, since examinations have a very high priority in the Ethiopian education system, active learning assessments are viewed with suspicion by some students.

What is outstanding in Table 5.3 is the following: In response to the item testing respondents' views if they have too much work to evaluate students continuously, 82.2% (51.2% and 31%) of the respondents supported this. This was confirmed by observation. As was informed during interviews, the evaluation of students was "once up on time". Although lecturers were divided on the issue of frequently asking close-ended questions for which there is only one correct answer, observation revealed that lecturers tended to ask such close-ended questions.

In response to the question if students were too noisy if they were asked many questions, 57% and 26.2% of the respondents disagreed/strongly disagreed. However, it was observed that the students tended to make a lot of noise when lecturers asked questions and facilitated group discussions. This problem occurred almost in all sample universities. Even the lecturer who taught next to the class complained about the high noise level.

In addition to the above, most lecturers (54.8 plus 30.9%, mean of 3.1) indicated that they praised students' work as often as possible; (53.6 plus 39.3% mean of 3.3) that they often assessed students' understanding through questioning; (45.2 plus 52.4, mean of 3.5) that they provided exercises on some of the lessons; (58.3 plus 40.3, mean of 3.4) that they helped students take responsibility for their own learning and most (53.6 plus 22.6) that it was quite possible to follow students' participation in learning.

When interviewed, the lecturers were asked: *How do you assess mathematics learners and why?* Lecturers' responses indicated the following:

Lecturers were not sure how to assess in an active learning approach. For example, one lecturer stated:

> *If I set a student an assessment, an essay, then they will go out and they will be active and try and respond to that and they will be active in response to things that I tell them so I think that… well what I'm still not clear about in my own mind is what makes active learning different from what we currently do rather than an add on as I've said* [Lecturer H, June 18/2010]*.*

Lecturers had problems with the amount of work that assessment caused. One example is:

> *One of the things that I decided to do, and I've done the last five years, is to give the students an opportunity to present on their reflections and in effect present their portfolios and then discuss them because that gives me a chance to assess what they've done, which is part of it, but secondly to give them feedback that then they can use in these documents that they then submit a week later. That's fine except I was talking about hundred plus students…*[Lecturer G, June 18/2010].

Some lectures were using an appropriate way of assessment for active learning. For example:

> *The homework and assignments changed the way students read. Rather than reading to memorise facts or lists, I gave my students challenging and practical*

questions... This allowed them to critically think about the reference/source read, rather than just memorising information for final exams. For me, this fostered a sense of evaluating their problem solving rather than accepting its solution…When memorising information exclusively for an exam, they tend to remember isolated facts rather than larger concepts from the source [Lecturer A, June 8/2010].

Some lecturers commented on students' lack of understanding of what was expected of them. For example:

Some of my students just don't seem to get what I'm asking them to do – they keep trying to find "the right answer" to open-ended problems, they still don't have a clue about what a critical question is, and the problems they make up are consistently trivial. Hence, most of the time I am asking closed types of questions such as true-false, matching and multiple-choice [Lecturer C, June 11/2010].

Some lecturers also commented on the fact that some students were passive while other students did all the work. One example is:

Many of the cooperative teams in my class are not working well. Their assignments are superficial and incomplete and some team members keep complaining to me about others not participating. Because of this and large size, I use short answer, true-false, matching and multiple-choice [Lecturer E, June 14/2010].

5.3.2 Research question two

What are the major factors/challenges in implementing active learning approaches in these universities?

In order to address this question, 15 items were presented to mathematics lecturers. Table 5.4 presents the data obtained.

Table 5.4: Factors that hindered the implementation of active learning/student-centred approaches in the sample universities

No	Factors hindering the implementation of active learning/student-centred approaches	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
		f	%	f	%	f	%	f	%	
1	I feel that lecturers in general have negative attitudes towards group work.	5	6	36	42.9	39	46.4	4	4.8	2.5
2	There is a lack of time to actively involve students in my classroom teaching.	7	8.3	11	13.1	42	50	24	28.6	3.0
3	To involve students in active learning will add too much to my work load.	8	9.5	29	34.5	41	48.8	6	7.1	2.5
4	It is difficult to cover the prescribed work if students ask many questions.	9	10.7	31	36.9	39	46.4	5	6	2.5
5	Active student learning will create problems in my classroom management.	33	39.3	38	45.2	11	13.1	2	2.4	1.8
6	It is impractical to implement active learning in large classes.	10	11.9	11	13.1	40	47.6	23	27.4	2.9
7	The amount of content that needs to be covered prevents the use of active learning in the classroom.	6	7.1	25	29.8	43	51.2	10	11.9	2.7
8	The rigidity of the time table prevents the implementation of an active learning technique.	8	9.5	17	20.2	46	54.8	13	15.5	2.8
9	I think students have negative attitudes towards active learning.	7	8.3	50	59.5	27	32.1	-	-	2.2
10	I think that lack of administrative support (e.g. financial, facilitating) inhibits the implementation of active learning in class.	4	4.8	15	17.9	31	36.9	34	40.5	2.8
11	Lack of classroom space inhibits group work.	4	4.8	11	13.1	38	45.2	31	36.9	3.1
12	Lack of resources affects the implementation of problem-based learning.	3	3.6	11	13.1	48	57.1	22	26.2	3.0

No	Factors hindering the implementation of active learning/student-centred approaches	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
		f	%	f	%	f	%	f	%	
13	Active learning demands too much effort from lecturers.	4	4.8	27	32.1	38	45.2	15	29.8	2.8
14	I think educational administration is unsupportive towards active learning.	8	9.5	28	33.3	39	46.4	9	10.7	2.6
15	I think that lack of instructional materials inhibits the implementation of active learning.	6	7.1	17	20.2	45	53.6	16	19	2.8

Table 5.4 shows factors hindering the implementation of active learning/student-centred approaches. Fifteen factors were assumed to hinder the implementation of active learning are presented.

In order of importance (as indicated by the percentages and means), the following were mentioned as the most important factors hindering the implementation of active learning approaches.

- Lack of classroom space that inhibits group work (45.2 plus 36.9%, mean 3.1);
- Large classes (47.6 plus 27.4%, mean 2.9);
- Lack of time to actively involve students in teaching (50 plus 28.6%, mean 3);
- Rigidity of the time table that prevents implementation of active learning techniques (54.8 plus 15.5%, mean 2.8);
- The amount of content to be covered (51.2 plus 11.9, mean 2.7).
- Lack of resources to implement problem-based learning (57.1 plus 26.2%, mean 3);
- Lack of instructional materials (53.6 plus 19%, mean 2.8);
- Lack of administrative support (36.9 plus 40.5%, mean 2.8).
- Too much effort expected from lecturers (45.2 plus 29.8%, mean 2.8);

Although questionnaire responses indicated that lecturers believed that there was not enough space for group work, classroom observation showed that most of the classes had enough space for group discussions. It was observed that in the sample universities no lecturers arranged their students into groups for different activities.

During the interviews, participants were asked: *What problems do you experience regarding the implementation of active learning approaches?*

Lecturers' responses focused on attitudes of lecturers, lack of support, classroom conditions and shortage of time. Examples include:

> *I think many active learning approaches require group interaction. For groups, adaptive classroom environments with movable chairs and tables work better than fixed seats and tables. In my university, one of the problems that affect the use of active learning approaches is the classroom furnishing and layout, because it was arranged in fixed seats and tables* [Lecturer F, June 20/2010].

> *My students have expectations of the role of the lecturer and their role as students. Active learning challenges these expectations. Actively participating in the class … may be viewed as a failure of the lecturer to carry out his/her responsibilities. There may be … a sense that the expertise of the lecturer is lost to the students … and shortage of time. Such factors make its practicability less even though it is useful* [Lecturer G, June 18/2010].

> *I experienced that it [active learning gives me] less opportunity to deliver content… consequently, I need to decide whether there will be material on exams not covered directly in class. If so, I should be mindful to reserve class time for the more challenging concepts* [Lecturer E, June 14/2010].

> *Theoretically active learning is very useful, but practically impossible for a number of reasons like large class size, work load of lecturers, lack of teaching material, lack of interest and some complaints of both the lecturers and students…* [Lecturer B, June 8/2010].

5.3.3 Research question three

What are the attitudes of university lecturers towards active learning /student-centred approaches?

To examine this question, 29 items were presented to the lecturers, followed by classroom observation and interviews. The results appear in Table 5.5.

Table 5.5: Lecturers attitudes towards active learning

No.	Attitudes towards active learning	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree(4)		Mean
		f	%	f	%	f	%	f	%	
1	I encourage students to reflect during the process of knowledge construction.	2	2.4	2	2.4	51	60.7	29	34.5	3.3
2	I try to create a classroom environment that supports inactive learning.	6	7.1	50	59.5	24	28.6	4	4.8	2.3
3	I use lectures to help students to develop critical thinking skills.	4	4.8	24	28.6	48	57.1	8	9.5	2.7
4	I prefer classes in which students are quiet.	12	14.3	30	35.7	32	38.1	20	23.8	3.0
5	I believe lecture method is the most valuable teaching approach.	7	8.3	45	53.6	25	30	7	8.3	2.4
6	I believe group work discourages students' mathematical insight.	36	42.9	39	46.4	8	9.5	1	1.2	1.7
7	I believe students learn mathematics through repeated practice.	2	2.4	5	6	48	57.1	29	34.5	3.2
8	I motivate students to actively participate in the teaching-learning process.	-	-	1	1.2	32	38.1	51	60.7	3.6
9	I believe problem solving enhances students' mathematics learning.	-	-	-	-	27	32.1	57	67.9	3.7

No.	Attitudes towards active learning	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree(4)		Mean
		f	%	f	%	f	%	f	%	
10	I generally link new knowledge to students' prior experiences.	1	1.2	28	33.3	54	64.3	1	1.2	2.7
11	I believe students dislike active participation in class.	9	10.7	47	56	27	32.1	1	1.2	2.2
12	In active learning my responsibility is to facilitate students' learning.	2	2.4	3	3.6	52	61.9	27	32.1	3.2
13	I feel that good lectures enhance students' sense of commitment.	1	1.2	11	13.1	53	63.1	19	22.6	3.1
14	Active problem solving offers students' opportunities for quick progress.	1	1.2	-	-	54	64.3	29	34.5	3.3
15	Through lectures I stimulate students' responsibility for their own learning.	2	2.4	23	27.4	54	64.3	5	6	2.7
16	Guided feedback is impractical in large classes.	7	8.3	43	51.2	25	29.8	9	10.7	2.4
17	I lack time to provide students with constructive feedback on their work.	6	7.1	19	22.6	48	57.1	11	13.1	2.8
18	I believe students learn more effectively if they work individually than in groups.	12	14.3	55	65.5	9	10.7	8	9.5	2.2
19	I engage students mostly as fine listeners during learning.	8	9.5	21	25	48	57.1	7	8.3	2.6
20	There is no time for reflection in my classes.	6	7.1	29	34.5	47	56	4	4.8	3.0
21	I react on feedback from students about how they learn effectively.	-	-	37	44	42	50	5	5.9	2.6
22	I actively engage students in my mathematics classes.	1	1.2	26	31	49	58.3	8	9.5	2.8
23	I encourage students to make decisions about the what, how, and when of learning.	2	2.4	24	28.6	48	58.3	10	11.9	2.8

No.	Attitudes towards active learning	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree(4)		Mean
		f	%	f	%	f	%	f	%	
24	Students participate in activities in my mathematics class.	-	-	22	26.2	51	60.7	11	13.1	2.9
25	Students should be lectured on how to formulate conclusions.	1	1.2	26	31	42	50	15	17.9	2.8
26	It is impossible to learn actively in large classes.	2	2.4	34	40.5	44	52.4	4	4.8	2.6
27	I think well prepared lectures are most important for student achievement.	3	3.6	16	19	47	56	18	21.4	3.0
28	I believe that teaching at university level is generally lecturer-centred.	3	3.6	19	22.6	54	64.3	8	9.5	2.8
29	Learning is an active process of creating hypotheses through activities.	-	-	6	7.1	48	57.1	30	35.7	3.3

Table 5.5 indicates in order of importance (as indicated by the percentages and means) the following attitudes of lecturers as most influential, as indicated by their responses. Lecturers indicated their view that:

- problem solving enhanced students' learning of mathematics (mean 3.7);
- they motivate students to actively participate in the teaching and learning process (mean 3.6);
- they encourage students to reflect during the process of constructing knowledge (mean 3.3);
- active problem solving offers students' opportunities for quick progress (mean 3.3);
- learning is an active process of creating hypotheses through activities (mean 3.3);
- students learn mathematics through repeated practice (mean 3.2);
- their responsibility in active learning was to facilitate students' learning (mean 3.2);
- good lectures enhance students' sense of commitment (mean 3.1);
- they prefer classes in which students were quiet (mean 3.0);
- there was no time for reflection in their classes (mean 3.0); and
- well prepared lectures were most important for student achievement (mean 3.0).

In contrast to the above, it was noted during classroom observations that the predominant mode of instruction was lecturer-centred. The class was taught as a whole, and all students were expected to cover the same amount of material, in the same way, and at more or less the same pace. The approach may be characterised as business-like and fairly highly structured. Discipline was maintained.

During the interviews, the lecturers were asked: *Lecturers sometimes have positive views on active learning approaches for mathematics teaching and yet do not implement this approach in their own teaching. Why do you think this is the case?*

Lecturers' response indicated the following as important factors that influenced their attitudes toward active learning:

Lack of training and thus continuing with the same style in which they were taught, for example:

> *The use of innovative teaching techniques presumes specialised knowledge on the part of lecturers that only constant training and substantial experience can provide. But enough training was not provided in my university* [Lecturer H, June 18/2010].

> *Actually I kind of followed on from the way in which I was taught as a student because I have studied in university through telling and taking. Specifically, the typical approaches during my time as a student was that we would have a very didactic one hour lecture and then a worksheet which was more active where the students would work in small group and I found that quite useful…* [Lecturer E, June 14/2010].

Related to lack of training, was lecturers' own self-doubt:

> *University lecturers with low self-efficacy can experience self-doubt … hence they are unsuccessful in implementing these approaches* [Lecturer G, June 18/2010].

They had perceptions of difficulties with the approach, for example related to “large class size, shortage of time, lack of training and overload” [Lecturer F, June 20/2010; Lecturer D, June 14/2010].

Some lecturers believed that an active approach was not always appropriate. One example is:

> *Active learning … needs to be appropriate to the task involved and the lecturer needs to consider the importance of the task set.* [Lecturer D, June 11/2010].

Their responses also indicated an understanding of what the approach needs from a lecturer. Among others, they mentioned:

- thorough preparation by the lecturer for problem-based learning, project based learning, discovery learning and inquiry-based learning;
- reflection;
- learning by doing; and
- mentoring.

A warning was also voiced by another lecturer:

> *I can imagine that a heavy handed approach to active learning may well be alienating and off-putting for some students* [Lecturer H, June 18/2010].

5.3.4 Research question four

What training has been provided for the implementation of active learning approaches in teaching mathematics?

The question seeks to determine the nature of the training provided to lecturers in implementing active learning/student-centred approaches and the lecturers' satisfaction with the pre-service and in-service training received. In the questionnaire, 14 items focused on this issue. The results appear in Table 5.6.

Table 5.6: The pre-service and in-service training of the relevant lecturers

No.	Pre-service and in-service training of lecturers	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
		f	%	f	%	f	%	f	%	
1	I had adequate pre-service training on the implementation of active learning techniques.	9	10.7	45	53.8	25	29.8	5	5.9	2.3
2	I have received training on the implementation of active learning techniques.	4	4.8	43	51.2	26	31	6	7.1	2.6
3	I have adequate in-service training on the implementation of active learning techniques.	6	7.1	42	50	36	42.9	-	-	2.5
4	I have received training on how to prepare teaching material through active learning.	5	6	32	38.1	37	44.0	10	11.9	2.6
5	I know how to structure courses so that students can be active participants.	-	-	20	23.8	39	46.4	25	29.8	3.2
6	I lack training on the implementation of active learning techniques in mathematics teaching.	8	9.5	47	55.9	23	27.4	6	7.1	2.3
7	Special training motivated me to implement active learning approaches.	7	8.3	29	34.5	39	46.4	9	10.7	2.6
8	Special funds have allowed me to be trained in active learning.	39	46.4	37	44.0	5	6.0	3	3.6	2.1
9	Training in active learning is helpful.	1	1.2	2	2.4	43	51.2	38	45.2	3.4
10	I have participated in off-campus training on active learning techniques.	7	8.3	28	33.3	44	52.3	5	6	2.4
11	I was trained in general teaching methodology rather than in active learning techniques.	-	-	14	16.7	60	71.4	7	8.3	2.8
12	I lack training on how to implement group work.	10	11.9	46	54.8	26	31.0	2	2.4	2.2

No.	Pre-service and in-service training of lecturers	Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
		f	%	f	%	f	%	f	%	
13	I am qualified for the implementation of active learning techniques.	9	10.7	45	53.6	30	35.7	-	-	2.3
14	The university has organised workshops or seminars to mathematics teaching staff on active learning techniques.	11	13.1	22	26.2	45	53.8	6	7.1	2.5

Table 5.6 indicates the following as most important regarding the pre-service and in-service training of teachers. The teachers indicated that they believed:

- Training in active learning is helpful (mean 3.4); and special training motivated them to implement active learning approaches (mean 2.6);

- They have received training in active learning techniques (mean 2.6); and on how to prepare teaching material through active learning (mean 2.6); and they know how to structure courses so that students can be active participants (mean 3.2).

- In contrast to the above, participants indicated that they were trained in general teaching methodology rather than in active learning techniques (mean 2.8).

The above indicates that teachers have been trained in active learning methods. However, they do not implement the active learning approaches.

During the interviews, the lecturers were asked: *Describe the training you received and its value for you on active learning or student-centred approaches in mathematics teaching.* Lecturers reported the following:

Some lecturers learnt about active learning by means of formal study. Examples include:

> *I took a general teaching methodology course at undergraduate level, which basically covered the basic skills of teaching methods. As an obligation, I have been trained in Higher Diploma Program (HDP). However, I do not think that I gained enough knowledge and skills of using active learning approaches effectively* [Lecturer B, June 8/2010].

> *I have been taken Higher Diploma Program (HDP); I have also taken training on teaching methodologies and attended workshops and seminars. I have adequate training on the implementation of active learning techniques* [Lecturer C, June 11/2010].

Other lecturers trained themselves:

> *I have tried to improve my skills on active learning approaches by closely observing and examining literature and my colleagues' practical uses of active learning approaches. Furthermore, if I needed some help, for instance, on how to use some active learning approaches such as problem solving method, inquiry learning, discovery learning, group discussion cooperative learning, I asked for help from my colleagues. By doing so I improved my teaching skills and knowledge of the use of active learning approaches* [Lecturer D, June11/2010].

5.3.5 Research question five

What support, conditions and material are provided for the implementation of active learning approaches?

Fifteen items focused in this issue. Table 5.7 presents the data.

Table 5.7: The provision of support provided for the implementation of active learning approaches

No.		Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
		f	%	f	%	f	%	f	%	
1	The dean of my faculty/school is committed to the implementation of active learning.	6	7.1	43	51.2	29	34.5	6	7.1	2.4
2	My department head is committed to stimulate the development of well prepared lectures.	4	4.8	26	31.0	47	60.0	7	8.3	2.7
3	My university allocates funds for instructional materials to facilitate group work.	23	27.4	45	53.6	11	13.1	5	6	2.0
4	I get relevant feedback from my department head on how to implement active learning in class.	10	11.9	54	64.3	20	23.8	-	-	2.1
5	My university provides continuous professional support to lecturers who implement active learning in class.	19	22.6	45	53.6	14	16.7	6	7.1	2.1
6	My department head supports training to develop good lectures.	11	13.1	34	40.5	30	35.7	9	10.7	2.4
7	The university provides funding for resources to promote activity in the class.	7	8.3	50	59.5	32	38.1	-	-	2.4
8	The university provides resources to lecturers for group work.	9	10.7	59	70.2	15	17.9	1	1.2	2.1
9	The university encourages mathematics departments to promote activity in their classes.	8	9.5	52	61.9	24	28.6	-	-	2.2
10	My university discourages activity in class.	53	63.1	24	28.6	5	6	2	2.4	1.4
11	My university administrators prepared short term training on the implementation of active learning techniques.	4	4.8	28	33.3	48	57.1	4	4.8	2.6
12	My university administrators prepared long term training on the implementation of active learning techniques.	21	25	51	60.7	12	14.3	-	-	1.9

No.		Strongly disagree (1)		Disagree (2)		Agree (3)		Strongly agree (4)		Mean
13	My department has a discussion group among mathematics lecturers on the implementation of active learning techniques.	28	33.3	45	53.6	7	8.3	4	4.8	1.8
14	The university has offered rewards to lecturers who are efficient at lectures.	35	41.7	43	51.2	4	4.8	2	2.4	1.7
15	My university discourages activity in large/big classes.	30	35.7	39	46.4	10	11.9	5	6	1.9

Table 5.7 indicates that the lecturers do not believe they are well supported for active learning. In order of importance, they indicated:

- Their department heads are committed to stimulate the development of well prepared lectures (mean 2.7) and supports training to develop good lectures (mean 2.4);
- However, some deans of faculties are committed to the implementation of active learning (mean 2.4).
- Lecturers only received short term training on the implementation of active learning techniques from their university administrators (mean 2.6);

I know that faculty deans and department heads expected to provide support to lecturers in university in the form of training. However, the training is not provided continuously. They also do not allocate funds for this [Lecturer A, June 8/2010].

I am very frustrated to have attended various workshops and training about active learning... Further, the dean of my faculty is not committed to its implementation [Lecturer G, June 18/2010].

I can say my university does not allocate funds for instructional materials to facilitate active learning approaches [Lecturer B, June 8/2010].

I have served eight years in this university, but I haven't been involved any discussion group among mathematics lecturers on the implementation of active learning techniques [Lecturer E, June 14/2010].

Most interviewees commented on improper use of active learning approaches in their teaching practice. Some said that any transformation from a lecturer-centred classroom to an active learning/student-centred classroom, since it involves fundamental change, will meet with resistance. In contrast a number of respondents noted that it was an approach they already used, had used for a considerable time, or was an implicit part of teaching their mathematics courses.

5.4 DISCUSSION OF RESULTS

The purpose of this study is to examine the nature of the teaching-learning process in line with the active learning/student-centred approaches and to identify the major challenges/factors that hinder the implementation of these approaches in mathematics education in universities at Oromia regional state, Ethiopia. In this section the results of the study are discussed regarding lecturers' use of active learning/ teaching methods in class and while assessing students, major factors affecting the implementation of active learning approaches, attitudes of lecturers towards the issue, lecturers' training in the implementation of active learning approaches and the adequacy of the support they receive.

5.4.1 Lecturers' use of active learning in the teaching-learning process and while assessing students

Active learning/student-centred approaches focus on students to play a more active and dominant role in their learning. Thus, it gives students the opportunity to learn through their own efforts and to take full responsibility for their own learning with the lecturers as facilitators.

The results of this study indicate that the extent to which university lecturers implemented active learning/student-centred approaches at various stages of the instructional process is low. It is not only lecturers' attitudes that affect the implementation of active learning approaches. The attitudes and expectations of students also affect how learning is viewed and how teaching is organised. In the interviews, some lecturers complained that students had negative attitudes towards active learning approaches. It is known that learning is active when students take initiative and responsibility for their own learning and this is dependent on students' positive attitudes. This is not the case in the samples universities, where observation indicated that the majority of the lecturers mainly used lectures to teach students to solve mathematics problems and they rarely arranged the students into groups for mathematics team work. This may be caused by large class sizes. Table 5.2 also shows that the majority of the sample lecturers thought that a well prepared lecture could stimulate students to solve mathematics problems. However, students build and share their own knowledge with others when they interact with each other and with their lecturers (Zweck, 2006:112-114).

Furthermore, active learning/student-centred approaches such as the inquiry method, problem-based learning and discovery methods which foster the critical thinking and problem-solving capacity of students were not widely employed. In this regard Balım (2009:16-18) emphasises that students should do more than just listen. They need to read, write, discuss or engage in problem solving activities. In active learning classrooms, students are engaged in activities like dialogue, debate, writing, discussion and problem solving as well as higher order thinking such as analysis, synthesis and evaluation**.** Learning includes students' mutual construction of knowledge and their interaction with each other and with their lecturers.

In the teaching learning process, lessons can be divided into: starting phase (summarising work covered in previous lessons); new content introduction phase, central phase (explanation of the content); activities phase (students work on the content); closing (final feedback) phase. The classroom observations showed that all the phases, with the exception of activities phase, are lecturer-centred approaches. It was also observed that low level order questions were frequently asked by the lecturers. This is also supported by the result obtained from questionnaire item “I frequently ask close-ended questions for which there is only one correct answer”. Half of the lecturers showed their agreement to this item (see Table 5.3).

Further, students in the observed classes were responsible only to listen to lectures, take notes and respond to questions upon request. This is associated with the students’ prior experience of active learning, as pointed out by most of lecturers. Students have no experience to play the active roles expected of them because many come from authoritarian cultural backgrounds and therefore talk only when motivated by someone. Lecturers don’t take this into consideration when they encourage student participation in instructional processes. This is confirmed by the low mean values obtained for the lecturers’ agreement that they implemented active learning approaches – their means are generally less than the prior validation mean, 3.12, as reported by McComb (2002:102-103).

Discussion methods help to facilitate active learning/student-centred approaches, as indicated by the work of Baines, Blatchford and Chowne (2007:674-676). Discussion can help to develop improved cognitions. Most of the lecturers stated that discussion was important. However, a number of the lecturers said that interaction occurred more easily in a relatively small class.

Regarding assessment, lecturers did not always know *how* to assess in active learning approaches, in particular in big classes. Table 5.3 shows that the lecturers believed they had too much work to evaluate students continuously. In addition, the students also posed problems. They lacked understanding of assessment and, during group work some were passive while other students did all the work. This shows the need for training.

In most of the sample universities it was observed that students were requested to memorise, rephrase, and infer meaning in the teaching-learning process. The use of problem solving, higher order thinking and open type questions was narrowed and limited. Students' activities were recalling information rather than developing understanding by discussing and exploring content. Observation showed that most of the university lecturers did not implement active learning/student-centred approaches as expected at different instructional stages (pre-assessment, introduction, explanation, and post-assessment). Almost none of the observed lecturers praised and encouraged the students, discussed their work individually or followed the students' participation to provide feedback. Table 5.3 indicates that many lecturers believed that providing ongoing meaningful feedback to students was too time-consuming. This relates to negative attitudes towards active learning assessment practices.

5.4.2 The major factors influencing the implementation of active learning approaches

According to Table 5.4, many educators believed that lack of classroom space and large classes prevented group work. In addition, the following prevented active learning: lack of time to actively involve students in teaching; rigidity of the time table that prevents implementation of active learning techniques; the amount of content to be covered; lack of resources to implement problem-based learning; lack of instructional materials; lack of administrative support; and that is took too much effort from lecturers. This was confirmed during interviews.

The above mentioned indicates how lecturers' attitudes strongly affect their efforts in achieving the objectives of active learning approaches. For example, according to Table 5.4, about half of the respondents indicated that lecturers in general had negative attitudes towards group work. On the other hand, the application of active learning should not be the sole responsibility of the individual lecturer. Changes in teaching and learning approaches are likely to mean that the universities' resources will become more important to the quality of teaching and learning in general and implementation of active learning approaches in particular. For example, many respondents (see Table 5.4) had lack of time to actively involve students in their classroom teaching. Although lecturers may find active learning approaches to be more enjoyable and lead to improved student learning, they still have questions about the amount of time and content that needs to be covered using the approaches (Burns and Myhill, 2004:41-45).

Research conducted on attitudes and views on teaching approaches has shown lecturers' and students' attitudes influence their teaching and learning behaviours (Gruber & Boreen, 2003:17-18). In this study, some lecturers indicated that students had negative attitudes towards active learning. According to the interviewees the students preferred to sit passively and listen to lecturers rather than being actively involved in activities – they view lecturers as spoon-feeders. These findings are consistent with the findings of other authors. For example, some students wish others would do the work for them. These kinds of students prefer traditional /lecture-centred methods which emphasis imitation, practice, feedback on success and habit formation (Steckol, 2007:24-25). According to Petrosino *et al*. (2007:117-118), there were students who found it difficult to contribute their ideas to the teaching-learning process.

According to Weimer (2002:174), for the effective implementation of active learning/student-centred approaches the deans and academic department heads of the university also need to recognise active learning approaches as building blocks for lifelong learning and provide the support required from them. However in this study lack of administrative support and lack of resources inhibited the implementation of active learning in class.

As mentioned, content coverage was a high priority for lecturers, especially for lecturers teaching prerequisite modules as preparation for other courses. Although some lecturers indicated that they covered some or most content with active learning approaches, other adopters of active learning approaches indicated that they covered less content than when they lectured exclusively, but that students were learning more. Silberman in Zweck (2006:2-6) showed that students in courses in which lecturers paused at intervals and talked six minutes less performed significantly better on the same examination than students in courses where lecturer lectured the entire time.

Time was an issue. Based on their experience, a large number of lecturers thought that active learning would take up more time than the traditional way of teaching. Lecturers believed that due to time constraints, active learning could not be applied in a short period of time. They also believed that the students were passive and that it took a long time to motivate them.

The curricular materials and classroom environment were also factors that played a role. For active learning, the materials should include carefully sequenced sets of guiding activities designed to be performed actively by the students. However, as shown by responses from the majority of interviewees and as observed, the activities during instruction were not presented in a way to encourage independent, purposive and a reflective way of learning. They were not written to be used in active learning classrooms. As mentioned by Feden and Vogel (2003:47), active learning and teaching materials should contain plenty of exercises and samples of work. They should also be flexible and allow students the time to work at their own pace and using their own methods. But in the present study, teaching materials were filled with large amounts of information to be memorised by the students. Thus, many lecturers felt responsible to cover the curriculum in the time provided by a rigid time table.

Class size was also a factor. McKeatchie and Svinicki (2005:7-9) stated that in a large class, individualisation of instruction is limited. Thus, the most frequently used instructional method is the lecture-centred approach, without group participation. In such classrooms even oral student-lecturer communication is minimised, written work receives less lecturer attention, and students are also less well known as individuals by their lecturers.

Interviewees also indicated that a factor that influences the implementation of the approach is interpersonal relationships or interactions among individuals. Active learning/student-centred approaches are characterised by "empathic, supportive relationships which free students to discuss their feelings and experiences" so that students are "actively involved in learning through the given opportunities to predict, infer, generalise, and evaluate" (Duffy & Kirkley, 2004:44).

Further, as mentioned in the literature review, the role of the students in active learning/student-centred approaches is learning by doing. So as to engage students in learning activities, the classroom should be well equipped with furniture and there should be movable desks for every student to use in different layouts in the classroom. As described by Arias and Walker (2004:311-329), the activity may require the students to move around the classroom. Therefore the classroom setup should be conducive to learning; it should stimulate learning through different methods such as problem solving and cooperative learning. From this point of view, the arrangement of desks and tables should allow movement and communication and should be changed whenever necessary. Furthermore, ample teaching resources should be available to implement active learning approaches as required**.** Lecturers can spend more of their time in assisting students in their quest to learn if appropriate resources are available and support from deans and department heads are provided to them. In this regard, the majority of lecturer respondents replied that they were constrained by lack of adequate resources from using active learning approaches (see Table 5.4).

The data obtained from classroom observation show that the classroom seating (the front to back arrangement) does not allow lecturers to employ active learning approaches. The desks and tables in most of the classrooms were heavy and could not easily be moved.

5.4.3 Attitudes of lecturers towards active learning/student-centred approaches

Ethiopian education policies and implementation strategies encourage active learning/student-centred approaches that include discussion methods, discovery learning, cooperative learning, inquiry learning, problem-based learning and the development of critical thinking. Different educators argued that lecturer's attitudes affect the effectiveness of the implementation of active learning/student-centred approaches (Zan & Martino, 2007:157-168; Lea *et al.,* 2003: 321-334). In this study, educators broadly agreed on the idea that lecturer-centred approaches which assign passive roles to students were undesirable. Lecturers' positive attitudes toward active learning were illustrated by their beliefs (in Table 5.5) that:

- problem solving enhanced students' learning of mathematics;
- they motivated students to actively participate in the teaching and learning process;
- they encouraged students to reflect during the process of constructing knowledge;
- active problem solving offered students opportunities for quick progress;
- learning was an active process of creating hypotheses through activities; and

- their responsibility in active learning was to facilitate students' learning.

In contrast, they also had the following beliefs:

- Good lectures enhanced students' sense of commitment and were most important for student achievement;
- Classes in which students were quiet were preferable to noisy classes;
- Students learnt mathematics through repeated practice; and
- There was no time for reflection in their classes.

Thus, students were expected to be silent unless they are commanded to respond. This is associated with lecturers' and students' lack of prior experience of active learning approaches. Active learning approaches demand lecturers not only to be experts in their fields, but also in their understanding of how students learn. Without such understanding, it is not easy to motivate lecturers to participate in active learning/student- centred approaches (Derebssa, 2006:136).

5.4.4 Lecturers training in the implementation of active learning approaches

For education to be successful, lecturers' training is of special significance. Since lecturers' training has a great effect on instructional activities, university lecturers require training on how to implement instructional approaches in general and active learning/student-centred approaches in particular (Stead, 2005:124-126). In line with this, many lecturers complained that they had no training in the implementation of active learning techniques. Although some of them had training, the adequacy of the training in the implementation of active learning/student-centred approaches was questionable. According to Zan and Martino (2007:160-162) good and effective teaching and mathematics learning in the classroom demand well-prepared, academically and pedagogically competent lecturers to select and implement appropriate teaching methods, activities and materials to achieve the desired educational objectives for different levels.

Table 5.6 indicates this study's finding on lecturers' opinions regarding the most important factors in the pre-service and in-service training of teachers. These are:

- Training in active learning was helpful; and special training motivated them to implement active learning approaches;
- Some had received training in active learning techniques and on how to prepare teaching material for active learning and they knew how to structure courses so that students could be active participants.
- In contrast to the above, participants indicated that they were trained in general teaching methodology rather than in active learning techniques.

Although some were trained via formal courses, others trained themselves. Considering the above, it was clear that the training and the follow-up support from educational administration (deans, department heads and other educational officials) was not adequate. Moreover, many lecturers' responses indicated that their university administrators provided only *short* term training on the implementation of active learning techniques (see Table 5.6).

5.4.5 Support for the implementation of active learning approaches

As indicated in the literature part of this study, Weimer (2002:162-174) stated that education systems should provide support (training, commitment, feedback and continuous professional support) on active learning/student-centred approaches in addition to resources to help them succeed in the teaching-learning process. For the proper implementation of active learning/student-centred approaches, department heads and deans should supervise the effectiveness of the teaching approaches employed by lecturers, give feedback to lecturers, provide continuous training that enables them to support student learning and budget for this. The lecturers should also be supported to evaluate the success of their educational programmes. All of these activities require lecturers' training in active learning/student-centred approaches and the commitment of deans and department heads.

Table 5.7 indicates that the lecturers did not believe they were well supported for active learning. They indicated:

- Their department heads were committed to stimulate the development of well prepared lectures and support training to develop good lectures;
- However, some deans of faculties are committed to the implementation of active learning.
- Lecturers only received short term training in the implementation of active learning techniques from their university administrators;

Most of the interviewees indicated a lack of support from managers and lack of funding for this issue.

Even though the university administrators encouraged mathematics departments to promote activity in their classes, they did not provide resources to lecturers for group work. Training is important in implementing active learning approaches, but the administrators were not in a position to prepare short term and long term training in the implementation of active learning techniques. The majority of departments, including mathematics departments, had no group discussion among the department members on the implementation of active learning techniques. In addition, the university did not reward lecturers who were effective in implementing active learning approaches.

In summary: in the sample universities instruction/teaching-learning was lecture-based instruction. However, research shows that learning is enhanced in contexts where students have supportive relationships, have a sense of ownership and control over the learning process, and can learn with and from each other in safe and trusting learning environments (McCombs, 2003).

5.5 SUMMARY

This chapter indicated the results of data collected. Results were presented, deductions made and explained in relation to the basic questions. In the next chapter, conclusions from the results presented in this chapter, recommendations and limitations of the study are presented.

CHAPTER SIX

CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

6.1 INTRODUCTION

The previous chapter, chapter 5, presented the results of this study and a discussion of the results. In this chapter, conclusions in line with the major results and recommendations of the study are presented. Finally, the limitations of the research project are highlighted.

The main purpose of this study has been to explore the nature of the teaching-learning process in line with active learning/student-centred approaches and to identify the major challenges/factors hindering the implementation of these approaches in mathematics education in universities in Oromia, Ethiopia. In order to meet these aims, the following five basic questions were posed:

- To what extent are active learning approaches implemented in mathematics education in the universities in Oromia, Ethiopia?
- What are the major factors/challenges affecting the implementation of active learning approaches in these universities?
- What are the attitudes of university lecturers towards active learning/student-centred approaches?
- What training has been provided to lecturers for the implementation of active learning approaches in mathematics teaching?

- What support, conditions and materials are provided to mathematics lecturers for the implementation of active learning approaches?

To find answers to these basic questions, the study was conducted in four universities in Oromia, Ethiopia. The data were collected from 84 mathematics lecturers. Using a mixed-methods design, the data were mainly gathered through questionnaires, observations and interviews. The quantitative data obtained were analysed using percentages and mean values. The qualitative data were analysed by means of appropriate methods as explained in section 4.4.4. The conclusions now follow.

6.2 CONCLUSIONS

Many educators describe the constructivist approach to learning as a process whereby students work individually or in small groups to explore, investigate and solve authentic problems and become actively engaged in seeking knowledge and information. This is in contrast to being passive recipients as in the traditional lecturer-centric learning which has its foundation embedded in the behavioural learning theory. In traditional learning approaches the lecturer mainly controls the instructional process, the content is delivered to the entire class and the lecturer tends to emphasise factual knowledge. Moreover, in these approaches the focus of the learning is on memorising *content*. Thus, in these teaching approaches learners are passive and play little part in their learning (Mayer in Richardson, 2003:1623–1640; Schunk, 2000:23-28; Swan, 2005:43-57). However, in active learning/student-centred learning approaches, students participate actively in their learning and become autonomous learners who actively construct new meaning within the context of their current knowledge, experiences and social environments. They mainly construct knowledge through solving realistic, relevant problems, often in collaboration with others.

As has been seen in chapter two of the literature review, research results of studies conducted on active learning approaches by many educators show that these approaches enhance the quality of teaching and learning in mathematics education. In summary, active learning:

- leads to improvement in the quality of education and its success,
- requires that students move from a competitive to a cooperative stance,
- requires active participation of students in a class as an indicator of successful teaching,
- such as collaborative learning and cooperative learning methods enhance accountability of students for their learning,
- requires students' participation and encourages students to generate their own ideas and provide opportunity to extend their horizons of thinking. This type of teaching and learning arrangement generates news ideas and knowledge, even for the lecturers (Balch, 2005:29-34; Petrosino *et al.,* 2007:110-126; Robertson,2005:186-188; Santrock, 2001:50-58, Shen *et al*., 2007:267-278; Steckol, 2007:24-25; Vaughan, 2002:362-364; Zweck, 2006:112-114).

Accordingly, the Ethiopian government policies encourage the implementation of active learning/student-centred approaches in general. Group discussion, cooperative learning, discovery learning, and inquiry-learning methods in particular are supported to develop students' critical thinking and problem-solving skills. However, as indicated in section 1.1, many lecturers may keep to teaching mathematics at university in traditional ways. This issue was the incentive for this study. After thoroughly studying the results, what now follows are the specific conclusions that have been reached. Each of the five research questions is discussed in sequence.

6.2.1 Research question one

To what extent are active learning approaches implemented in mathematics education in the universities in Oromia, Ethiopia?

Despite the concern for quality, current conditions in most universities throughout Ethiopia is both troublesome and disturbing. The government faces challenges as it strives to expand university education and to ensure that the students receive quality education. For improving and ensuring the quality of education, the government has emphasised active learning approaches. Active learning approaches develop critical thinking, problem solving and spatial reasoning skills of students.

6.2.1.1 The use of active learning approaches while teaching

Based on the results of the current study (see section 5.3.1.1 and Table 5.2), concerning the implementation of active-learning/student-centred approaches while teaching, the following conclusions are drawn:

- According to Table 5.2 (in section 5.3.1.1), respondents attested to the fact that they applied the following methods in their mathematics teaching. They
    - encourage students to ask questions;
    - use inquiry-learning to actively involve students in the mathematics learning process;

- encourage students to deduce general principles from practical experiences;
- facilitate problem solving in the mathematics class and
- support students to discover the desired conceptual knowledge.

However, when observed, the following was noted:

- The basic active learning/student-centred activities which were *not* implemented by most of the observed lecturers in the sample universities include:
  - using a variety of teaching methods to engage students in learning;
  - requesting students to demonstrate the solution of mathematical problems on the chalkboard;
  - using cooperative groups for problem solving activities; and
  - facilitating students' curiosity.

- These results were confirmed by the interviewees' responses to the questions concerning their practices about the activities mentioned above.

- From the above it follows that the extent to which active learning/student-centred practices are implemented and the opportunities provided to students for active participation in the instructional process in the sample universities is low and inadequate. The poor implementation of active learning approaches while teaching, negatively influences the quality of the teaching-learning process in the sample universities of the Oromia regional state.

- The inadequate use of the different active learning methods would negatively affect the development of self-learning, higher order thinking and problem solving capacities among students of the sample universities in Oromia, Ethiopia.

The discrepancy between what respondents indicated in their questionnaires, and what was observed, may be because lecturers knew that active teaching/learning was the best method but they did not implement this teaching/learning method because of various constraints. These reasons are illuminated by the results of research questions two to five.

6.2.1.2 The use of active learning approaches while assessing

In active learning approaches the progress of the learners is continuously assessed and immediate feedbacks are provided to the students. Table 5.3 (in section 5.3.1.2) illustrates that:

- the majority of lecturers in the sample universities did not assess their students continuously**;**
- the majority of lecturers didn't employ a variety of assessment techniques;
- the assessment techniques frequently used by many of the lecturers were close-ended questions; only a few lecturers used open-ended questions frequently;
- the majority of lecturers provided exercises on some of the lessons only;
- many lecturers believed that providing ongoing meaningful feedback to students was too time-consuming
- many lecturers did not know *how* to assess in active learning approaches, in particular in big classes;

- students posed problems in the sense that they lacked understanding of assessment and, during group work, some were passive while other students did all the work.

The inadequate use of the above mentioned assessment techniques would hinder the development of students' understanding of mathematics in the sample universities in Oromia, Ethiopia.

6.2.2 Research question two

What are the major factors/challenges in implementing active learning approaches in these universities?

As explained in the literature review (section 3.3) the implementation of active learning/student–centred approaches is dependent on a number of factors such as the nature of the curriculum, the availability of instructional materials, lecturers' evaluation practices and training, support provided to lecturers and the policy followed by the country.

The results from this study (see Table 5.4 in section 5.3.2) revealed that the major factors/challenges in implementing active learning approaches include:

- Classroom conditions: lack of classroom space that inhibits group work and large classes of more than 70 students per class;
- Lack of time to actively involve students in teaching;

- Lack of resources to implement problem-based learning;
- Rigidity of the time table that prevents implementation of active learning techniques;
- Lecturers' attitudes – too much effort expected from them;
- Lack of instructional materials;
- Lack of administrative support;
- The amount of content to be covered; and
- A high-stakes examination system that tends to steer lecturers towards lecturing which demands memorisation of the subject matter content.

The above listed factors inhibited the implementation of active learning approaches in the sample universities. This impeded the opportunities for students to construct their own knowledge. This in turn negatively influenced the quality of the mathematics teaching and learning processes in the sample universities in Oromia, Ethiopia.

6.2.3 Research questions three

What are the attitudes of university lecturers towards active learning/student-centred approaches?

Active learning approaches are based on principles of democracy, equality and acknowledgment of the individuality of the student. In active learning/student-centred approaches student engagement encompasses much more than the traditional student behaviours of listening, reading, writing and thinking. Active student engagement in the learning process is increasingly perceived as one of the key indicators of the quality of education. However, lecturers from traditional societies that value subservience to age, gender, or hierarchical authority and lecturers who themselves were taught by traditional approaches find it difficult to fully adopt such active learning methods. These methods are based on democratic principles that put students and their lecturers on a more equal footing. This is because, in active learning, students ask question, argue and discuss rather than passively listening to lectures.

Regarding lecturers' attitudes, the present study's results (as indicated by Table 5.5 in section 5.3.3), disclosed that the majority of respondents believed that:

- problem-solving enhanced students' learning of mathematics;
- they motivated students to actively participate in the teaching and learning process;
- they encouraged students to reflect during the process of constructing knowledge;
- active problem-solving offered students' opportunities for quick progress;
- learning was an active process of creating hypotheses through activities.

However, at the same time their responses (illustrated by Table 5.5 in section 5.3.3) indicated a strong sense of belief in traditional practices such as that:

- students learn mathematics through repeated practice;
- good lectures enhanced students' sense of commitment;
- students kept quiet;
- no time was allotted for reflection in their classes; and
- well-prepared lectures were most important for student achievement.

Moreover, it was observed that lecturer-centred approaches were the predominantly approach of instruction used in all of the observed classrooms. From these results it can be concluded that although many lecturers had positive attitudes towards active learning practices, the implementation of such approaches were relatively scarce. This issue negatively affected mathematics learning of students in the sample universities in Oromia, Ethiopia.

6.2.4 Research question four

What training has been provided for the implementation of active learning approaches in the teaching of mathematics?

Due to its advantages to students the Ethiopian education policy emphasised active learning approaches. However, as delineated in the literature review (section 3.3.2), the effectiveness of the implementation of this approach can be influenced by several factors which include lecturers' training.

From the results of this study (illustrated by Table 5.6, section 5.3.4) it was found that:

- some lecturers thought they knew how to structure courses so that students could be active participants;
- many were trained in general teaching methodology rather than in active learning techniques;
- some believed that their training in active learning approaches was not adequate and
- special training would motivate them to implement active learning approaches.

The inadequacy of training regarding active learning approaches among mathematics lecturers, and deans and department heads negatively affected the efficiency of the lecturers to implement the approach in sample Universities in Oromia, Ethiopia.

6.2.5 Research question five

What support, conditions and material are provided for the implementation of active learning approaches?

The conclusions drawn by the researcher from the results in Table 5.7 (section 5.3.5) are:

Although the dean of their faculty/school was committed to the implementation of active learning, at the same time:

- their department heads were committed to stimulate the development of well prepared lectures and supported training to develop good lectures;
- the lecturers only received short term training on the implementation of active learning techniques from their university administrators.

Thus, the mathematics lecturers indicated that the support provided from deans and department heads was not adequate enough for the proper implementation of active learning approaches. The majority of the deans and department heads indicated that their budgets were insufficient. Such financial shortages hindered the universities from providing facilities in classrooms for the effective implementation of active learning approaches in mathematics education in universities in Oromia, Ethiopia.

6.3 RECOMMENDATIONS

6.3.1 Recommendations for the enhancement of active learning approaches in mathematics teaching at Oromia universities

This study concluded that the extent of implementing active learning approaches in sample universities was low. Hence, the following are recommended:

- Government initiatives and/or international organisation funded projects should help organise professional development activities to enhance lecturers' knowledge, skills and commitment to implement active learning and assessment approaches. Such efforts should be intended not only to develop lecturers' capacity to employ active learning approaches now, but also to enable the system to deliver such professional development programmes in the future. Professional development activities should include training workshops on the various issues that this research identified as well as various forms of supervisory guidance and support.

- At institutions deans and department heads must provide lecturers with the appropriate training as well as the time to be trained and the facilities needed for training. The university has made a good start in demanding lecturers to be innovative but must also continue empowering lecturers with the knowledge and skills required for proper implementation of interactive teaching and learning. Training should develop lecturers who are confident and innovative users of active learning approaches that include cooperative learning, inquiry-based learning, discovery learning, problem-based learning and discussion methods.

- It is necessary that deans and other administrators periodically solicit student feedback in a course about how it is progressing in creating an environment conducive for active learning approaches. Regular, reliable, timely assessment should be conducted by mathematics lecturers in universities in Oromia, Ethiopia. The purpose is to give learners feedback and to improve learning and teaching practices.

- Adequate resources and relatively small class sizes are required. The ministry of education in collaboration with university deans and department heads should find mechanisms to minimise the class size and replace the traditional arrangement of furniture in the classroom so as to make classroom conditions conducive for the effective implementation of active learning approaches. The current class size of 70 and more should be reduced to the national standard which is 50 students or less.

- Lecturer on-going support for the implementation of active learning approaches should be addressed as a priority. The university should provide the lecturers with adequate active learning guides and other instructional materials by working closely with other stakeholders.

- The reality in sample universities was that active learning had not been adopted in significant ways. Perhaps a more appropriate emphasis of lecturers' training efforts should be around student-friendly classrooms progressing towards adoption of active learning approaches in an incremental way. Policies and comprehensive lecturer development plans should be required to move toward active learning and to lay a pathway for change in the future.

- Deans and department heads can help, stimulate and support lecturers' efforts to change their teaching by highlighting the instructional importance of active learning in the newsletters and publications they distribute.

- Preparing students for the world of work and lifelong learning involves teaching skills to analyse problems, synthesise information and tackle a wide range of tasks. Teaching materials therefore should be re-written in a way that they involve activities to process the new material, linking it to what the student already knows. Tasks should be authentic, set in a meaningful context and related to the real world. They should not just involve repeating facts as this causes 'surface' learning. As student's learning will involve errors, tasks should offer opportunities for self-assessment, correction, peer discussion, lecturer feedback and other 'reality checks'.

6.3.2 Recommendations for further research

Base on the conclusions of this study, the researcher recommends the following for further investigation:

- External factors hindering the implementation of active learning approaches which are not covered by this study should be identified through further research. Practical ways to overcome the obstacles should also be investigated.

- In-depth case studies of individual lecturers in Ethiopia who have been successful in implementing active teaching/learning in their respected fields, may throw further light on the issue of how hindering factors may be overcome.

- The influence of active learning approaches for high, average and low achievers may be investigated.

Further research is recommended to verify the findings of the current study in order to strengthen this contribution towards the development of sound research data, based on active learning approaches.

6.4 LIMITATIONS OF THE STUDY

As with all research, there are limitations that must be acknowledged when considering results. As mentioned earlier, the limitation of this study was the small area of study (four universities in Oromia, Ethiopia), small size of sample (84 lecturers) and sources of information (only from mathematics departments). Additional research over a wider demographic area including a greater sample may enhance insight and enable greater generalisation regarding universities in Ethiopia. Moreover, the research was also limited by the fact that the sample universities were all public/government owned and did not include privately owned universities.

6.5 SUMMARY

Meaningful learning requires active teaching and learning approaches. Thus, with a specific focus on Mathematics teaching at university in Oramia, the study aimed to:

- examine the extent to which active learning/student-centred approaches were implemented;
- assess the attitudes of university lecturers towards active learning;

- investigate whether appropriate training and support have been provided for the implementation of an active learning approaches;
- assess the major challenges that hinder the implementation of active learning approaches; and
- recommend ways that could advance the use of active learning approaches in Mathematics teaching at university.

A mixed-methods design was used. Among the six universities in the Oromia Regional State of Ethiopia, two of the newly established universities (younger than 5 years) and two of the old universities (15 years and older) were involved in the study. Eighty209four lecturers participated in the study and completed questionnaires. This was complemented by a qualitative approach that used observation checklists and interviews for data gathering: 16 lessons were observed while the lecturers taught their mathematics classes (two lecturers from each of the four sample universities were twice observed). In addition, semi-structured interviews were conducted with four mathematics department heads and eight of the observed lecturers. The study adhered to ethical principles and to several techniques to enhance the validity/trustworthiness of the findings.

The study found that although the employment of active teaching and learning is emphasised in Ethiopian policies, traditional lecture methods, in which lecturers talk and students listen, dominate most classrooms. Relatively little use is made of active learning methods such as cooperative learning, inquiry-based learning, discovery learning, problem-based learning and discussion methods. The common obstacles found included: lack of time and resources to implement problem-based learning; rigidity of the time table; negative lecturer attitudes; lack of instructional materials and administrative support; and the huge amount of content to be covered. It is believed that training and support may improve lecturers' attitudes and teaching methods. To this end, various recommendations were made. Recommendations for further study were also highlighted and the limitations of this research pointed out.

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APPENDIX A: QUESTIONNAIRE to LECTURERS

Purpose: This questionnaire is designed to gather data on the nature of the teaching–learning process in mathematics and the problems that hinder learning. The data to be collected through the questionnaire is used for academic purposes only. Information that you provide will be treated as confidential.

General directions:

- Please follow the instructions carefully.
- Respond to all questions.
- Please respond within three days. Deliver the completed questionnaire to your departmental secretary.
- *You do not have to write your name or identify yourself in any way.*

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Thank you in advance for your cooperation!

Instruction: Please show your answer by circling the appropriate number on the right of each of the items.

SECTION A: BIOGRAPHIC DATA			**FOR OFFICE USE ONLY**
1. Name of the University ______________________			**V2**
2. Your gender:	Male	1	
	Female	2	**V3**
3. Age:	29 years and younger	1	**V4**
	30-39 years	2	
	40-49 years	3	
	50 years and older	4	

4. Experience in teaching:

Less than one year	1		V5
1-5 years	2		
6-10 years	3		
11-15 years	4		
More than 15 years	5		

5. Level of Education/ Educational qualification/s:

Bachelor degree	1	V6
Honours degree	2	
Masters degree	3	
Doctors degree	4	

6. Teaching workload per week:

Less than six credit hours	1	V7
6-10 credit hours	2	
11-15 credit hours	3	
More than 15 credit hours	4	

7. Average number of students in your class:

Less than 40	1	V8
41-50	2	
51-60	3	
More than 60	4	

SECTION B: MATHEHATICS LECTURERS: TEACHING METHODS

Instruction: To each of the following items, focus on the teaching of mathematics and the problems lecturers experience in this regard. The meaning of the numbers is shown in the table below.

Keys: ***1= Strongly disagree, 2= Disagree, 3=Agree, 4= Strongly agree***

No	ITEMS		Offi-cial use
	Category 1: the students	**Scale**	
8	I rarely arrange the students into groups for mathematics team work.	1 2 3 4	V9
9	I think that lectures are the best way to teach students to solve mathematics problems.	1 2 3 4	V10
10	I encourage students to ask questions.	1 2 3 4	V11
11	I think that inquiry-learning is effective to actively involve students in the mathematics learning process.	1 2 3 4	V12
12	I often confront the students with problems to solve.	1 2 3 4	V13
13	I encourage students to deduce general principles from practical experiences.	1 2 3 4	V14
14	I consciously create conditions to stimulate students' need to know.	1 2 3 4	V15
15	I discuss worksheet results with students.	1 2 3 4	V16
16	I think a well-prepared lecture stimulate can students to solve mathematics problems.	1 2 3 4	V17
17	I think cooperative work in groups is good for efficient learning.	1 2 3 4	V18

18	I consciously facilitate problem solving in the mathematics class.	1 2 3 4	V19
19	I discourage the students to discuss their feelings.	1 2 3 4	V20
20	I discourage the students to explore their current beliefs.	1 2 3 4	V21
21	I support the students to discover the desired conceptual knowledge in the learning process for themselves.	1 2 3 4	V22
22	I believe that cooperative learning is needed to help the students understand new concepts.	1 2 3 4	V23
23	I think that discussions between the students on new course materials are vital for deep understanding.	1 2 3 4	V24
Category 2: Assessment		**Scale**	
24	I have too much work to evaluate students continuously.	1 2 3 4	V25
25	I frequently ask close-ended questions for which there is only one correct answer.	1 2 3 4	V26
26	Students become too noisy if I ask many questions.	1 2 3 4	V27
27	I praise students' work as often as possible.	1 2 3 4	V28
28	I frequently ask open-ended questions.	1 2 3 4	V29
29	Students need to be able to respond to questions very quickly.	1 2 3 4	V30
30	I often assess students' understanding during group work.	1 2 3 4	V31
31	I often assess students' understanding through questioning.	1 2 3 4	V32
32	I provide exercises on some of the lessons.	1 2 3 4	V33
33	It is impossible to follow students' participation in learning.	1 2 3 4	V34
34	I help students to take responsibility for their own learning.	1 2 3 4	V35
35	Providing ongoing meaningful feedback to students is too time-consuming.	1 2 3 4	V36
36	I often assess students when they solve problems in a group.	1 2 3 4	V37

	Category 3: Influencing factors	Scale	
37	I feel that lecturers in general have negative attitudes towards group work.	1 2 3 4	V38
38	There is a lack of time to actively involve students in my classroom teaching.	1 2 3 4	V39
39	To involve students in active learning will add too much to my work load.	1 2 3 4	V40
40	It is difficult to cover the prescribed work if students ask many questions.	1 2 3 4	V41
41	Active student learning will create problems in my classroom management.	1 2 3 4	V42
42	It is impractical to implement active learning in large classes.	1 2 3 4	V43
43	The amount of content that needs to be covered prevents the use of active learning in the classroom.	1 2 3 4	V44
44	The rigidity of the time table prevents the implementation of an active learning technique.	1 2 3 4	V45
45	I think students have negative attitudes towards active learning.	1 2 3 4	V46
46	I think that lack of administrative support (e.g. financial, facilitation) inhibits the implementation of active learning in class.	1 2 3 4	V47
47	Lack of classroom space inhibits group work.	1 2 3 4	V48
48	Lack of resources affects the implementation of problem learning.	1 2 3 4	V49
49	Active learning demands too much effort from lecturers.	1 2 3 4	V50
50	I think educational administration is unsupportive towards active learning.	1 2 3 4	V51
51	I think that lack of instructional materials (e.g. lecturer guides) inhibits the implementation of active learning.	1 2 3 4	V52

SECTION C: ATTITUDES

You are focusing on the teaching of mathematics and the problems that lecturers experience in this regard. The meaning of the numbers is shown in the table below.

Keys: *1= Strongly disagree, 2= Disagree, 3=Agree, 4= Strongly agree*

No	ITEMS	Scale	For official use
52	I encourage students to reflect during the process of constructing knowledge.	1 2 3 4	V53
53	I try to create a classroom environment that supports inactive learning.	1 2 3 4	V54
54	I use lectures to help students to develop critical thinking skills.	1 2 3 4	V55
55	I prefer classes in which students are quiet.	1 2 3 4	V56
56	I believe lectures are the most valuable teaching method.	1 2 3 4	V57
57	I believe group work discourages students' mathematical insight.	1 2 3 4	V58
58	I believe students learn mathematics through repeated practice.	1 2 3 4	V59
59	I motivate students to actively participate in the teaching-learning process.	1 2 3 4	V60
60	I believe problem solving enhances students' learning of mathematics.	1 2 3 4	V61
61	I generally link new knowledge to students' prior experiences.	1 2 3 4	V62
62	I believe students dislike active participation in class.	1 2 3 4	V63
63	In active learning my responsibility is to facilitate students' learning.	1 2 3 4	V64
64	I feel that good lectures enhance students' sense of commitment.	1 2 3 4	V65
65	Active problem solving offers students' opportunities for quick progress.	1 2 3 4	V66
66	Through lectures I stimulate students' responsibility for their own learning.	1 2 3 4	V67

67	Guided feedback is impractical in large classes.	1 2 3 4	V68
68	I lack the time to provide students with constructive feedback on their work.	1 2 3 4	V69
69	I believe students learn more effectively if they work individually than in groups.	1 2 3 4	V70
70	I engage students mostly as fine listeners during learning.	1 2 3 4	V71
71	There is no time for reflection in my classes.	1 2 3 4	V72
72	I react on feedback from students about how they learn effectively.	1 2 3 4	V73
73	I actively engage students in my mathematics classes.	1 2 3 4	V74
74	I encourage students to make decisions about the what, how, and when of learning.	1 2 3 4	V75
75	Students participate in activities in my mathematics class.	1 2 3 4	V76
76	Students should be lectured on how to formulate conclusions.	1 2 3 4	V77
77	It is impossible to learn actively in large classes.	1 2 3 4	V78
78	I think well prepared lectures are most important for student achievement.	1 2 3 4	V79
79	I believe that teaching at university level is generally lecturer-centred.	1 2 3 4	V80
80	Learning is an active process of creating hypotheses through activities.	1 2 3 4	V81

SECTION D: THE PRE-SERVICE AND IN-SERVICE TRAINING OF LECTURERS

You are focusing on the teaching of mathematics and the training lecturers received. The meaning of the numbers is shown in the table below.

Keys: ***1= Strongly disagree, 2= Disagree, 3 =Agree, 4= Strongly agree***

No	ITEMS	Scale	Offi-cial use
81	I had adequate pre-service training on the implementation of active learning techniques.	1 2 3 4	V82
82	I have received training on the implementation of active learning techniques.	1 2 3 4	V83
83	I have adequate in-service training on the implementation of active learning techniques.	1 2 3 4	V84
84	I have received training on how to prepare teaching material through active learning.	1 2 3 4	V85
85	I know how to structure courses so that students can be active participants.	1 2 3 4	V86
86	I lack training on the implementation of active learning techniques.	1 2 3 4	V87
87	Special training motivated me to implement active learning approaches.	1 2 3 4	V88
88	Special funds have allowed me to be trained in active learning.	1 2 3 4	V89
89	I lack training on how to implement active learning in mathematics teaching.	1 2 3 4	V90
90	Training in active learning is helpful.	1 2 3 4	V91
91	I have participated in off-campus training on active learning techniques.	1 2 3 4	V92
92	I was trained in general teaching methodology rather than in active learning techniques.	1 2 3 4	V93
93	I lack training on how to implement group work	1 2 3 4	V94
94	I am qualified for the implementation of active learning techniques.	1 2 3 4	V95
95	The university has organised workshops or seminars to mathematics teaching staff on active learning techniques.	1 2 3 4	V96

SECTION E: PROVISION OF SUPPORT FOR TEACHING OF MATHEMATICS

Keys: 1= Strongly disagree, 2= Disagree, 3 =Agree, 4= Strongly agree			
No	**ITEMS**	**Scale**	**For official use**
96	The dean of my faculty/school is committed to the implementation of active learning.	1 2 3 4	V97
97	My department head is committed to stimulate the development of well prepared lectures.	1 2 3 4	V98
98	My university allocates funds for instructional materials to facilitate group work.	1 2 3 4	V99
99	I get relevant feedback from my department head on how to implement active learning in class.	1 2 3 4	V100
100	My university provides continuous professional support to lecturers who implement active learning in class.	1 2 3 4	V101
101	My department head supports training to develop good lectures.	1 2 3 4	V102
102	The university provides funding for resources to promote activity in the class.	1 2 3 4	V103
103	The university provides resources to lecturers for group work.	1 2 3 4	V104
104	The university encourages mathematics departments to promote activity in their classes.	1 2 3 4	V105
105	My university discourages activity in class.	1 2 3 4	V106
106	My university administrators prepared short term training on the implementation of active learning techniques.	1 2 3 4	V107
107	My university administrators prepared long term training on the implementation of active learning techniques.	1 2 3 4	V108
108	My department has a discussion group among mathematics lecturers on the implementation of active learning techniques.	1 2 3 4	V109
109	The university has offered rewards to lecturers who are efficient at lectures.	1 2 3 4	V110
110	My university discourages activity in large/big classes.	1 2 3 4	V111

Thank you very much for completing this questionnaire.

APPENDIX B: FIELD NOTES ON OBSERVATIONS

University I: Lecturer A (Male, age=40 & years of experience in mathematics teaching at university=5)

First observation

The researcher visited Lecturer A in class with third year mathematics students (M=58, F=14, T=72) at University I. Lecturer A was responsible for teaching the topic of the day which was: "Field theory and related concepts". The class consisted of unequal number of male and female students from a wide variety of cultures. There were many different religious beliefs, family backgrounds, social classes, and personalities in the class.

Lecturer A cleaned the chalkboard and wrote the topic of the day's lesson. He then gave a short revision of the previous lesson. He gave students an appropriate overview of what they needed to get started with. The lesson/activities he presented showed his students step by step, how to solve problems and indicated that he expected them to do the problems exactly the way he did. After he presented a lecture on field theory, he asked the students what they knew and understood about the lesson or activities on the topic of the day, namely "Field Theory". No student responded. He then summarised what they had learned.

Second observation

On the second observation, Lecturer A followed the same teaching style as above – the only difference being the date of observation, time, topic and the group of the students. The only different activity the researcher observed was two students who were requested to complete problems on the board while the rest of the class watched.

University I: Lecturer B (Male, age=40 & years of experience in mathematics teaching at university=5)

First observation

Again at University I, the researcher observed Lecturer B in class with third year mathematics students (M=54, F=13, T=67). Lecturer B was responsible for teaching mathematics on the topic of the day, namely “Matrices- diagnosibility”. The class consisted of an unequal number of male and female students from a wide variety of cultures. There were many different religious beliefs, family backgrounds, nationalities, races, social classes, and personalities represented in the class. Lecturer B entered the class and ordered one student to clean the chalkboard. Immediately, Lecturer B wrote the date and the topic “Linear operation” and proceeded with an explanation and short notes on the chalkboard. Students silently copied notes from the chalkboard and from what the lecturer said. Lecturer B then asked the students to form groups. One student in the group worked out the problem while the others closely observed. The lecturer did not go from group to group to facilitate learning by asking questions and to check the progress of the students. Finally, the lecturer summarised the lesson of the day.

Second observation

For the second time, on another day, the researcher observed Lecturer B. Lecturer B greeted the students and informed them of the day’s learning objective: “to review matrices- diagnolization.” Lecturer B instructed the class to take out their mathematics worksheets and page to a clean sheet of paper. The lecturer then instructed the students to copy problems written on the chalkboard; the problems involved *diagonzablities of* matrices, and proof related theorems, among others. The students were instructed to start with the first problem on their own after they had copied all of the other problems as examples. Lecturer B walked around the room to monitor the students’ progress. Finally, the lecturer solved the problems step by step on the chalkboard while the students copied the answers.

University II: Lecturer C (Female, age=39& years of experience in mathematics teaching at university=5)

First observation

At University II, the researcher observed Lecturer C as she was in class with mathematics first year students (M=89, F=19, T=118). Lecturer C was responsible for teaching the mathematics topic of the day, namely the “Domain of the function”. The class consisted of unequal number of male and female students from a wide variety of cultures. There were many different religious beliefs, family backgrounds, nationalities, social classes, and personalities in the class. Lecturer C greeted the students and revised the previous lesson. She informed them of the day’s learning objectives and indicated that the main focus of the class would be “to solve a math problem with special reference to the domain of the function.” Lecturer C instructed the class to take their mathematics notebooks and page to a clean sheet of paper. Lecturer C demonstrated a distinctive, positive rapport with her students throughout the lesson. Lecturer C also exhibited a professional yet enthusiastic demeanor in the lecture hall. She treated her students with respect and continuously exuded a sense of caring and support. The students were well behaved throughout the course of the lesson. Lecturer C made every attempt to praise and engage all her students throughout the lesson, providing an environment that encouraged inquiry and knowledge acquisition. However, the students listened passively and copied notes from the chalkboard. Lecturer C instructed the students to copy short notes, problems and solutions written on the chalkboard. The problems involved domains of the function and graphs of the function as variables. The students were told to start with the first problem on their own after they had copied all of the problems and solutions. Students were given exercises to do. Some students were approached individually.

Second observation

Lecturer C was observed a second time as she presented the topic “Limit and continuity”. She articulated clearly and persuasively the purpose of the lesson. She also elicited prior knowledge, skill level where appropriate for all the students. However, students were passively attained lecture. She demonstrated all procedures and steps, while the students copied note and solution of the problems.

University II: Lecturer D (Male, age=36 years of experience in mathematics teaching at university=4)

At University II, the researcher observed Lecturer D as she taught mathematics to first year students (M=89, F=26, T=115). Lecturer D was responsible for teaching mathematics on the topic of “Matrices and related concepts”. Lecturer D talked continuously while the students listened and took notes. Questions were asked that required one correct answer. Students also worked alone on worksheets. During this time, the lecturer did not walk the room and interact with the students. There was no enthusiasm and excitement around the activities or the problems and questions that were generated from the activity. Moreover, Lecturer D did not try to stimulate the students’ curiosity and encourage them to investigate further by asking stimulating questions.

University III: Lecturer E (Male, age=41& years of experience in mathematics teaching at university=12)

At University III, the researcher observed Lecturer E as he interacted with second year mathematics students. Lecturer E was responsible for teaching the topic “Application of mathematics”. The class consisted mostly of male students from a wide variety of cultures. There were many different religious beliefs, family backgrounds, nationalities, social classes, and personalities in the class. Lecturer E designed his lessons with clear objectives, focusing on concepts, skills, and strategies using state and district standards. He also stated learning objectives and gave clear directions. The students in Lecturer E’s class were sitting in rows and were all quietly working on their class works on worksheets. At the end of class, Lecturer E collected all students’ worksheets to be garded and handed back at another time. Lecturer E indicated his belief that all students should get the same instruction at the same time. To accomplish this, he only used whole group instruction.

University III: Lecturer F (Male, age=42 & years of experience in mathematics teaching at university=10)

First observation

At the same university (University III), the researcher observed Lecturer F as he was teaching third year mathematics students (M=50, F=2, T=52) in the same department. Lecturer F was responsible for addressing the topic: “Solve homogenous and non-homogenous algebra equation”. In Lecturer F’s class, the students were passive recipients of information from the lecture. Students were not involved in hands-on activities. Moreover, the lesson lacked a clear sense of purpose and/or a clear link to conceptual development. He did not present the lesson purposefully and students were not well engaged in meaningful work. It seemed that the lesson did not enhance students' understanding or develop their capacity to "do mathematics".

Second observation

In the second observation, Lecturer F had evaluated students’ work and explained their reasoning to problem solutions. However, most of the students were passive recipients of information. It seemed as if the material was presented in a way that made the work inaccessible to many of them.

University IV: Lecturer G (Male, age=40 & years of experience in mathematics teaching at university=10)

First observation

At University IV, the researcher observed Lecturer G of the mathematics department as he interacted with third year students (M=46, F=9, T=55). Lecturer G was responsible for teaching the topic of “derivatives and its application”. The class consisted of an unequal number of male and female students from a wide variety of cultures, religious beliefs, family backgrounds and personalities. Lecturer G demonstrated to his students how they could use derivatives and derivatives rules to find solutions to problems. Lecturer G’s explanations and directions were clear and concise. Questions were used to stimulate discussion and student engagement. Lecturer G’s use of mnemonics to assist the students in recalling important concepts and procedures was creative. Lecturer G used positive praise throughout the lesson to encourage student questioning and cognitive interaction. Most of the students recorded what they were hearing while others were just listening without taking notes.

Second observation

At University IV, the researcher observed Lecturer G a second time. He moved freely about the room making eye contact with all students. He asked questions of numerous students – some volunteered, others were asked to respond by the lecturer. Lecturer G continually asked if students needed help with the problems, and whether they understood how the answer was arrived at before moving on to the next topic. Lecturer G always checked to see if students had the information in their notes before moving on. Lecturer G prepared notes for the students to copy. She strove to give meaningful instructions. However, adaptation to individual student's needs and interests was limited. The lesson did not seem to enhance students' understanding and to develop their capacity to "do mathematics".

University IV: Lecturer H (Female, age=39 & years of experience in mathematics teaching at university=11)

At University IV, the researcher observed Lecturer H as she taught first year mathematics students (M=96, F=7, T=103). The topic of the day was “derivatives and its application”. Lecturer H demonstrated a thorough knowledge of the partial derivatives in normal lines and provided a well paced and sequenced instructional period. Lecturer H provided a review of previous concepts and skills covered to assist in ensuring student success. Student expectations were clearly delineated. The lecturer used demonstration/explanation methods for the lesson. The lesson was well planned, paced, sequenced and delivered. The learning objective was clearly stated at the beginning of the lesson. However, the students were not adequately prepared to undertake this specific activity. Lecturer H did not provide students adequate time to reflect on the activity utilizing a variety of process skills. Lecturer H was unable to work with individual groups and students without losing sight of the entire class; she did not provide individual attention when appropriate. There were some disciplinary problems, and non-participation of some group members. Furthermore, the activities did not allow the students to construct their own understanding of the concept and provide them with opportunities to discover concepts on their own.

APPENDIX C: INTERVIEW GUIDE to LECTURERS

1. What are your personal views on active learning or student-centred approaches in mathematics teaching?
2. Describe the training you received and its value for you on active learning or student-centred approaches in mathematics teaching.
3. Explain how you use active learning/student-centred approaches in your mathematics teaching.
4. How do you assess mathematics learners and why?
5. What problems do you experience regarding the implementation of active learning approaches?
6. What support do you receive from administrators or other academics to implement active learning approaches at university?
7. Lecturers sometimes have positive views on active learning approaches for mathematics teaching and yet do not implement this approach in their own teaching. Why do you think this is the case?
8. What would you recommend that will enable lecturers to implement active learning approaches in their mathematics teaching?
9. Is there anything you would like to add?

APPENDIX D: LETTER TO PERMISSION TO CONDUCT RESEARCH

ADAMA UNIVERSITY

✉ 1888 Fon: +251-221-119256 Fax: +251-221-100038
email:workish3@yahoo.com

Adama University, P.o. Box 1888, Adama – Ethiopia

To: - Whom it concern

Adama, Ethiopia

Date ________________

Ref. ________________

School of Pedagogic and Vocational Teachers Education

Department of Pedagogic, Adult Education and Educational Planning

Worku Dejene

Department Head

Subject: Request for Benefaction

Birhanu Moges is a PhD student of Psychology of Education. He is by now working on a research project (Dissertation); hence looking for information from your university. This is therefore to request your good office to help him in providing necessary information. We thank you in advance.

With Best Regards!

Seal