CHAPTER TWO

CONCEPTUAL AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

In this chapter, the broad perspective of the theoretical and conceptual framework for the INSET of educators with reference to mathematics will be presented. The first part of the chapter reviews the theoretical constructs of INSET. The second part of the chapter underscores the theoretical considerations related to mathematics.

2.2 THE RELEVANCE OF THEORY

Referring to Garrison (1989:111), Bagwandeen (1999:88) declares that:

> ***'Theory is important to any field of study to establish its identity, recognition, conceptualisation and development.'***

In this regard, Moore and Kearsley (1996:197) asseverates:

> ***'Theory is very, very valuable. A theory is a representation of everything that we know about something. Theory gives us a common framework, a common perspective, and a common vocabulary that help us ask questions in a sensible way and make sense of problems.'***

(As quoted by Bagwandeen, 1999:88)

This contention is supported by Rubin (1978:313) who states that:

> ***'... the great value of theory is that it tells us how to achieve the goals we seek.'***

(Bagwandeen and Louw, 1993:69)

It is perhaps for this reason that Dewey said 'nothing is as practical as good theory,' (Moodley, 1992:193). As will be indicated in this chapter, the researcher selected key theories concerning INSET and mathematics, which in her considered opinion, could form the theoretical basis for the provision of INSET and for the upgrading and improvement of mathematics education at the senior primary level.

2.3 THEORIES RELEVANT TO INSET

2.3.1 INTRODUCTION

Watkins (1973:12–18) contends that support for INSET comes from social, political, scientific and technological changes and growth in knowledge. Their effect on the school curriculum and teaching methods also have a vital impact and need for INSET. Educators need to adapt to these changes and INSET is a vehicle through which these changes can be met.

INSET caters for the professional growth of educators because the initial training gained by educators cannot equip them to cope with complex, demanding and changing needs of education. Viewed against this background, Pather (1995:19) maintains that, INSET should relate to all forms of activities, both formal and non-formal on a continuing basis. This will help educators to improve their professional competence and the quality of education.

With regard to the theories relevant to INSET, the researcher referred primarily to four sources, namely, Bagwandeen (1991:42–111; 132–136; 1999:52–67), Hofmeyr (1991:295–349) and Pather (1995:19–34;78–82). The aforementioned sources confirmed the need and value of INSET for educators across the spectrum.

2.3.2 DEFINITION OF INSET AND CONCEPTS RELEVANT TO INSET

2.3.2.1 DEFINITION OF INSET

With regard to the definition of INSET, Bagwandeen (1999:54) states that Bolam and Porter (1976:3) noted that, 'no agreed definition exists for INSET.' Pather (1995:30) states further that 'there are as many definitions as there are INSET programmes.' Hofmeyr (1991:57) concludes that 'INSET suffers from a lack of agreed definitions and nomenclature resulting in INSET meaning different things to different people.' In light of this, Pather (1984:19), in his research undertaken on the professional development of educators, states that:

> ***'In-service education and training (INSET), in-service training, in-service education, professional development and teacher development are often used interchangeably for all the activities that contribute to the continuing education programme of professional personnel in the field of education.'***

In the absence of consensus with respect to the definition of INSET, the researcher chose to discuss a few important definitions. Bagwandeen and Louw (1993:19; see also, Bagwandeen, 1991:42; 1999:54–55) maintain that, the definition of INSET depends to a large extent on the emphasis that is placed on it in terms of its plan or design. INSET would include such aspects as updating educator skills and knowledge without a change in role; preparation of new roles and positions; upgrading and improvement of professional and academic qualifications; external or internal school provision; focus on pedagogical issues and needs; and programmes available throughout the careers of educators. Cane (1969:X) in the 1960s stated that INSET refers to:

> ***'…all those courses in which a serving teacher may participate for the purpose of extending his professional knowledge, interest or skill. Preparation for a degree, diploma or other qualification subsequent to initial training is included within this definition.'***

Bagwandeen and Louw (1993:20) declare that this definition was proposed as the outcome of a major survey undertaken by the

National Foundation for Educational Research (NFER) in England and Wales. They conclude that this definition was seen as one which was tighter and central in its approach towards intended experiences. It presupposes that activities should be planned deliberately in order to effect specific changes that will ultimately result in improving the educator's performance in school.

Thompson (1984:4–5) defines INSET rather broadly as:

> ***'… the whole range of activities by which serving teachers and other categories of educationists within the formal school systems may extend and develop their personal education, professional competence and general understanding of the role which they and the schools are expected to play in their changing societies. INSET further includes the means whereby a teacher's personal needs and aspirations may be met as well as those of the system in which he or she serves.'***

(Ashley and Mehl, 1987:82)

With regard to Thompson's definition, Pather (1995:30) states that, while the definition includes both the individual's and the system's needs in its approach, Thompson also restricts his definition to the formal school system. He states further that Hartshorne (1985:9) recommends that Thompson's definition, if amended by omitting the phrase 'within formal school systems,' could allow for 'some flexibility' and 'provide a starting point for further discussion.'

According to Bagwandeen (1999:55) a detailed analysis of the literature of INSET undertaken from an international perspective enabled him to concede that the definition suggested by Henderson (1977:163; 1978:11; 1979:17) was generally applicable to most of the objectives of INSET:

> *'... in-service education and training, may, in the most general sense, be taken to include everything that happens to the [teachers] from the day [they take] up [their] first appointment to the day [they retire] which contributes, directly or indirectly, to the way in which [they execute their] professional duties.'*

Bagwandeen also maintains that this definition has been predicated on the commonly accepted view that INSET embraces the many professional experiences of educators. In their aggregate such experiences promote the ultimate upgrading and improvement of the qualifications of educators. Bagwandeen (1991:49; 1999:56; see also, Bagwandeen and Louw, 1993:20; Pather, 1995:31) conclude that a single definition would not satisfy every need and facet. The determination of such a definition is a complex and formidable task. With regard to this, Pather (1995:31) argues further that it is the absence of consensus and conformity on the definition of INSET that can lead to paradigm shifts. Depending on their own assumptions the variety of INSET providers can transmit different signals to the same group of clients as to what INSET is.

Besides the lack of a uniform definition of INSET, there are various concepts relevant to INSET. We need to consider the various concepts related to INSET.

2.3.2.2 <u>CONCEPTS RELATED TO INSET</u>

Pather (1995:19) maintains that a wide range of terms is used to refer to INSET. For the purpose of this study, the researcher chose to give a brief overview of the following terms that are used interchangeably with INSET by many researchers.

2.3.2.2.1 <u>CONTINUING EDUCATION</u>

Continuing education for educators in particular, can be summarized as, the provision of opportunities for qualified educators to update their professional knowledge, skills and attitudes to enable them to remain competent educators. With respect to this, Bagwandeen and Louw (1993:24; see also, Bagwandeen, 1999:57) maintain that, continuing education is seen as a purposeful interlacing of induction, renewal and redirection accentuating career – long teacher education.

2.3.2.2.2 STAFF DEVELOPMENT

Bell (1991:89) asserts that staff development refers to the activity of ensuring the personal development of the staff of the school. Furthermore, Hewton and Jolly (1991:3) claim that staff development refers to:

- any activity involving individuals or groups of staff which is undertaken to enhance knowledge, skills or behaviour or to change attitudes for the benefit of learners, schools and their staff, and
- the creation of settings which encourage and enable changes.

The researcher is of the firm belief that educators must grow and mature in their field. Growth is related to an increase in the amount and quality of knowledge possessed by individuals. Maturation means that the individual has been able to interrelate the knowledge of various types in order to reinforce the goal achievement, which each individual is entitled to identify (Sebolai, 1995:45). A static state would refer to a state of decay rather than growth. In this respect, Wideen and Andrews (1987:108) asseverate:

> ***'A teacher who is not growing personally and professionally is unlikely to make significant developments in the classroom program.'***

2.3.2.2.3 RECURRENT EDUCATION

This concept makes reference to the incompleteness of Pre-service Education and Training (PRESET), as part of the initial training of educators. Referring to Cropley and Dave (1978:41), Bagwandeen and Louw (1993:21) describe recurrent education as:

> ***'That aspect of INSET which alternates periods of teaching service with periods of further training or other forms of training. These would include components that would be seen as formal, non-formal and informal.'***

2.3.2.2.4 **PROFESSIONAL GROWTH / DEVELOPMENT**

This concept underpins the argument that educators should be exposed to learn rather than to live through the familiarity of daily events. In this regard, Bagwandeen (1999:58) refers to Rudduck (1987:129) who maintains that:

> ***'Professional growth / development of teachers signifies inter-alia, the capacity of a teacher to remain curious about the classroom; to identify significant concerns in the process of teaching and learning; to value and seek dialogue with experienced colleagues as support in the analysis of data; and, to adjust patterns of classroom action in the light of new understanding.'***

2.3.2.2.5 **ON-THE-JOB TRAINING**

According to Bagwandeen (1999:59) this concept is the handmaiden of INSET, not only for the beginner educator but also in the execution of innovative concepts for the older educator. Moreover on-the-job training empowers educators to learn to observe their own classroom activities as well as those of others, to reflect on such practices, recognise problem areas, discuss and effect solutions, evaluate the results and modify responses in the light of such evaluations. These are key elements of INSET.

Having considered the various terminologies associated with INSET, we now need to consider the objectives of INSET. This will be discussed as general and specific objectives.

2.4 OBJECTIVES OF INSET

2.4.1 INTRODUCTION

For the effective provision of INSET, it is important that general and specific types of objectives be established and communicated to all involved in INSET programmes.

2.4.2 GENERAL OBJECTIVES

Conceptual clarity can be obtained by setting the following general objectives.

- The improvement of the competencies (job performance) of individual educators (including those in managerial positions) and whole school staff.
- Extending the experience of individual educators for career development or promotion purposes.
- Developing the professional knowledge and understanding of each educator and extending the personal or general education of an educator.

(Pather, 1995:34)

2.4.3 SPECIFIC OBJECTIVES

INSET can be directed towards the attainment of certain specific objectives. These can be listed as follows:

- Extension of knowledge.
- Familiarization with curriculum development and new methods.
- Acquaintance with the psychological development of children and the youth.
- Acquaintance with the sociological basis of education.
- Acquaintance with the principles of organisation and administration.

- Positive retraining of educators returning to school after a period of absence.
- Conversion and re-tooling of educators especially for scarce subjects.
- Mastering of new aids and technology of education.
- Familiarity with changes in local and national policy.
- Comprehending the new relationship between educator and learner.
- Understanding the cultural revolution.
- Development of measuring and testing techniques.
- Acquaintance with and participation in educational research.
- Legal requirements.
- Combating 'burn out' among educators.

(Bagwandeen, 1991:89–111; 1999:60–62; see also, Bagwandeen and Louw, 1993:43–45)

These objectives of INSET may differ with regard to approach, strategy and implementation. However, the common thread is that all are concerned with the upgrading and improvement of the professional competence of the educators. Furthermore, it is also important to note that to satisfy these objectives, coordinated efforts of all providers of INSET are essential. The researcher is also confident that a sound theoretical knowledge of INSET models can also contribute to the achieving of these objectives by educators. It is for this reason that INSET models that bear relevance to this study will now be discussed.

2.5 MODELS OF INSET

2.5.1 INTRODUCTION

With respect to INSET models, Joyce (1980:32), a leading American authority on teacher education, had forecast that, in the near future, it is unlikely that a model which is both comprehensive and specific enough to be useful, could be designed for any education system. Two decades have lapsed since this statement has been made and although there have been much research, development, evaluation and improvement of INSET methods, leading to more refined models, there has not been the construction of new models. This could be attributed to the several problems that make the construction of new models in INSET so complex. A discussion of the several problems is beyond this study. However, reference can be made to Pather (1995:66–69) and Bagwandeen (1999:63–64). While several models and typologies of INSET exist, the Traditional INSET Model and the Life-Long Learning/Continuing Education INSET Model will be discussed. These models are deemed most pertinent to this study.

2.5.2 THE TRADITIONAL INSET MODEL

This model presently used by the South African Education Departments refers to curriculum related courses in which Education Department officials explain changes. These could apply to syllabus revision, teaching methods and organisational development in school. Groups of educators meet on a regional basis in a lecture or workshop situation in schools or teachers' centres. According to Pather (1995:74–75) the following criticisms have been levelled at the use of this model:

- Department officials offer solutions to problems without taking into consideration that the problems may not be the same in all schools.
- Even when a common problem is addressed by an INSET course, the conditions, facilities, resources, qualification and experience of participating educators may vary from school to school.
- Course members have minimum communication with programme leaders after they return to their schools. This does not allow for much development and can minimize change, both, in the individual and the school.
- Minimal effects of the model can also be attributed to limited or no follow-up support.

Pather (1995:77) claims further that, despite the above criticisms, and similar to all other models of INSET, the Traditional INSET Model has the following advantages:

- Educators from different backgrounds in meeting outside their school can acquaint themselves with problems in education.
- Educators can identify and redefine their future needs.
- Educators can also in an atmosphere of professional co-operation evaluate their own work and the status of the subject they teach, such as in the case of this study, mathematics.
- Such meetings also tend to reduce educator isolation.

Pather (1995:78) also maintains that in order for this model to have greater impact by facilitating change, both in the educator and the school, the following have to be assured:

- Proper needs assessment.
- Homogenous grouping of participants.
- Follow-up and on-site support.
- Adequate time must be allocated for the experimentation of new ideas so as to ensure that follow-up could be undertaken.
- On-site success will depend on resource back up and guidance to Heads of Department.

2.5.3 THE LIFE-LONG LEARNING/CONTINUING EDUCATION INSET MODEL

Pather (1995:79) affirms that life-long learning or continuing education through INSET may be defined as the means through which educators can evaluate themselves to being true professionals so that they can adjust to changes. Pather believes that in order for life-long learning or continuing education to be successful the following should apply:

- The concept should be introduced as early as possible, in that, educators in training should be exposed to the principles and importance of continuing education or life-long learning.

- The educator has to adapt an attitude of critical questioning, a keenness to keep abreast of development in education and to participate voluntarily in professional activities.

The important aspects of the processes of life-long learning is that while educators obtain formal qualifications, they should also respond to informal INSET programmes such as reading professional journals, attending seminars and conferences and becoming active members of subject societies (Pather, 1995:80). Based on this discussion, the researcher concedes that the Life-Long Learning/Continuing Education INSET Model views INSET as effective when it is part of training that continues over an extended period.

Having discussed two INSET models the researcher is of the firm belief that if these models are to be successful, educators should adopt a positive attitude to change. The researcher being a mathematics educator is constantly involved in pedagogical conversations with fellow mathematics educators and is therefore of the view that educators are resistant to change. One reason advanced for this view is the limited or lack of knowledge of the theory of change. The researcher therefore finds it pertinent to this study to devote a section to the theory of change.

2.6 <u>THEORIES OF CHANGE</u>

Hofmeyr (1988:17) alludes to the fact that a major theme in practically all the literature on INSET is change (Bagwandeen, 1991:136).

In education particularly, Barbara D. Day (1981:vii) points out:

> ***'... the school or staff which does not change and grow is destined to atrophy, to become obsolete, and to be a burden rather than a bulwark to us and to the communities we serve.'***

(Bagwandeen and Louw, 1993:72; see also, Bagwandeen, 1991:138)

Bagwandeen and Louw (1993:72–73; see also, Bagwandeen, 1991:138) state further that educational institutions are caught up in the ebb and flow of change in society. The school as an important educational institution will carry the double burden of maintaining traditional values while preparing society's young members to deal with a changing world.

INSET is seen as the mechanism for change. In theory the purpose of educational change is to help schools accomplish their goals more effectively by replacing some programmes or practices with new ones. Change suggests the acquisition of new teaching skills or the introduction of new resources which imply a modification of the logic of teaching (Bagwandeen, 1991:73; see also, Bagwandeen and Louw, 1993:73).

2.7 SUMMATION

In concluding this section it is important to note that in our rapidly changing world, traditional structures, truths and knowledge are questioned and changed at a very fast pace. In this context of rapid and major changes, educators are faced with the problem of developing contemporary models of teaching and learning and appropriate learning theory upon which to construct approaches to formal and non-formal life-long learning.

Viewed against this background of change, the researcher in investigating the problem in this study, needs to focus on the theoretical constructs of mathematics. This theoretical construct will provide educators with a common framework that will enable them to cope with the changing needs of mathematics education.

2.8 THEORETICAL AND CONCEPTUAL FRAMEWORK FOR MATHEMATICS AT THE SENIOR PRIMARY LEVEL

2.8.1 INTRODUCTION

Among the many questions that face present day mathematics educators, perhaps the four most fundamental ones are:

What is mathematics?
Why teach mathematics?
How do children learn mathematics?
How to teach mathematics?

The researcher while drawing on assumptions concerning these questions attempts to provide a theoretical framework for mathematics in this part of the chapter. In considering the first question, what is mathematics?, the researcher, in her considered opinion, believes that an overview of mathematics education as a discipline highlighting the nature of the subject should provide some form of insight into the question, if not a solution to the problem.

2.8.2 MATHEMATICS EDUCATION AS A DISCIPLINE

Dean (1982:173) maintains that the two main proponents of the disciplines thesis are Philip Phenix and Paul Hirst.

2.8.2.1 PHENIX'S ACQUISITION OF UNDERSTANDING

Phenix, an American philosopher, argued in 1964 that education is a process whereby people acquire understandings of 'meanings' and that these may be designated into six clearly defined groups. He outlined them as symbolics, empirics, aesthetics, synnoetics, ethics and synoptics (Graves, 1977:68). Phenix explains each of these concepts as follows:

- aesthetics : concerned with the meanings to be found in contemplation of the arts and music;

- empirics : a term used to describe the physical, biological and social sciences, since these all rely on scientific method and accept certain rules for the verification of the meanings which they propound;
- ethics : denotes moral meanings, emphasising the development of ideas;
- symbolics : comprises the understanding of symbols used in ordinary language, in mathematics, in gestures and rituals;
- synnoetics : a term neologised by Phenix from Greek roots; it denotes knowledge of objects and persons arrived at through personal experience, derived intuitively rather than being based on a rational nature; and,
- synoptics : comprise those fields of knowledge, which combine or integrate other meanings, for example, philosophy, religion and history.

2.8.2.2 HIRST'S FORM OF KNOWLEDGE

Hirst, a British philosopher, in 1965 stated that, the objectives of education are all basically connected with the development of a rational mind. He argued that, the knowledge of which the mind is constituted consists of a range of 'forms of thought' each of which represents a way of interpreting one's experience of the world. A learner should have the opportunity to develop his/her mind across the whole range of its rational constituents. Hirst recognised seven distinct disciplines or 'forms of knowledge' as follows:

- mathematics and logic
- physical science
- history and human sciences
- literature and fine arts
- morals
- religion
- philosophy

(Henning, 1984:7)

Phenix and Hirst's grounds for determining a discipline include a distinctive structure that connects certain representative concepts or ideas, and distinctive methods of enquiry and testing. Based on these grounds they have tried to justify their conclusions that include mathematics being a separate discipline. Phenix and Hirst's arguments follow that a school curriculum based on units in each discipline will be the most effective way of learning about the different forms of knowledge, whereas cross-disciplinary studies are more likely to offer shallow and undisciplined thinking (Dean, 1982:173).

2.8.2.3 DAVID P. AUSUBEL'S STRATEGIES FOR MEANINGFUL VERBAL LEARNING

Bell (1978:134) maintains that Ausubel regards each academic discipline as having a distinct organisational and methodological structure and each individual as having a distinct cognitive structure. Ausubel conceptualises the information-processing structure of the discipline and the information-processing structure of the mind as analogous. Both a discipline such as mathematics and a human mind contain a hierarchical structure of ideas in which the most inclusive ideas are at the top of the structure and subsume progressively less inclusive and more highly differentiated sub-ideas.

Ausubel argues further that since each discipline has its unique structure, disciplines should not be taught using an interdisciplinary approach; rather each subject should be taught separately. He regards the structure as the most important part of a discipline and combining the teaching of two disciplines will cause the unique structure of each one to be obscured from the learner. It is for this reason that he does not regard unified mathematics – science programmes as an appropriate way to teach these two subjects (Bell, 1978:134).

With regard to this, Moodley (1992:2) argues that, mathematics education emerged as a scientific discipline in the post Sputnik era of the 1960s. Though mathematics education encapsulated its own objectives, problems, language and research methodology, it bears a complex relationship to other disciplines.

In this context, Moodley (1992:2) goes on further to cite Wittman (1984) who contends that, mathematics education investigates, in an interdisciplinary manner the complexity of mathematical learning and teaching and relates mathematical and educational studies to one another providing the necessary bridge to teaching practice. Mathematics education is a discipline of its own which is related to mathematics, psychology and practice of mathematics teaching.

Moreover, in accordance with these relationships, the views about mathematics education as enunciated by Moodley (1992:2), are coloured by the opinions held about the nature of mathematics and the educational process. The researcher therefore provides a brief overview of the nature of mathematics, which will form a useful framework for this study.

2.8.2.4 <u>NATURE OF MATHEMATICS</u>

In this regard, Moodley (1992:2–3) refers to Skovsmose (1985) who has identified the following three broad trends:

- Structuralism – the essence of mathematics can be determined by crystallising fundamental concepts through logical analysis of existing mathematical theories and conveyed to the learner by means of suitable concretisations in accordance with the epistemological potentials of pedagogy of 'teach the disciplines' which means that the learner's knowledge has to be built up in accordance with structures and contents identified independently of the learners.

- Pragmatism – the essence of mathematics is to be found in its applications, and thus, in a sense, outside mathematics. The educational process must therefore demonstrate the ways in which mathematics can be useful. This trend has been largely interpreted as a reaction against structuralism.

- Process-orientation – the essence of mathematics is neither connected to particular concepts nor to the applicability of mathematics as such, but to the process of thought that have led to the mathematical insight. In this view the main concern of mathematics education is to provide learners with opportunities to construct their own mathematical ideas.

An overview of the nature of mathematics leads to the next point of educators' conceptions about the nature of mathematics. Educators' personal beliefs will be analysed in the empirical investigation. However, the approach of educators to the teaching and learning of mathematics will undoubtedly be guided by the views they hold about the nature of mathematics.

2.8.2.5 <u>CONCEPTIONS ABOUT MATHEMATICS</u>

Hobden (1999:23) outlines the following three conceptions of mathematics:

- A dynamic view, in which mathematics is regarded as an incomplete and ever expanding human creation – the result of an ongoing search for patterns and relationships that can be formalized into new knowledge to be interrogated and contested by fellow mathematicians.

- A Platonists view, in which mathematics is regarded as a complete and static body of knowledge with logic and structure.

- An instrumentalist view, in which mathematics is regarded as a collection of facts, rules, algorithms and skills to be mastered for utilitarian purpose.

In this regard Hobden (1999:23) states that, although these conceptions seem to be mutually exclusive conceptions, it is likely that an individual educator's conceptions of mathematics would include aspects of more than one of the discussed conceptions. Further to this Hobden (1999:23) in referring to Skemp (1978:11) identifies two conceptions of the nature of mathematical understanding which are linked to the already mentioned conceptions of the subject mathematics. The first is the instrumental understanding that is based on knowledge of rules and algorithms to be applied in particular circumstances. This is easiest understood as 'knowing how to do the problem.' The second type of understanding is relational understanding which implies an understanding of how to do the problem coupled with an understanding of why the procedure works and how it relates to the other areas of mathematics.

Skemp (1978:11) suggests that the classroom practice of educators who hold each of these conceptions of mathematical understanding will differ to the extent that there are two effectively different subjects being taught under the name mathematics. Teaching for instrumental understanding involves the educator's demonstration of techniques followed by practice until the rules and procedures are mastered. On the other hand, teaching for relational understanding requires more learner centred sense making activities and investigations. The rules and procedures become evident through such activities (Hobden, 1999:23–24).

Orton and Cassell (1994:11) are of the opinion that mathematics means many things to many educators such as an organised body of knowledge, an abstract system of ideas, a useful tool, a key to understanding the world, a way of thinking, a deductive system, an intellectual challenge, a language, the purest logic possible, an aesthetic experience and a creation of the human mind. However, they also believe that whatever views educators hold about the nature of mathematics and how it should be reflected in what they teach in school will have some effect on their own particular aims and objectives of teaching mathematics.

It can be conceded that the approach of educators to the teaching and learning of mathematics is guided by the view they hold about the nature of mathematics. Pivotal to this will be the knowledge that they have about the aims and objectives of mathematics.

2.9 AIMS AND OBJECTIVES OF MATHEMATICS EDUCATION

In most countries, mathematics has formed an integral part of the curriculum for many decades. Yet many learners find it extremely difficult to comprehend. It may be that mathematics is distasteful due to the methods of teaching it, or, on the other hand, perhaps mathematics is inherently difficult to understand. This leads to the bold question of why is mathematics taught to primary school learners in most countries today?

In attempting to provide insight into this question it is paramount that the researcher provides a brief discussion on the aims and objectives of mathematics at the senior primary level. The brief discussion could be attributed to the fact that the terms aims and objectives in the senior primary phase have been replaced by the terms critical outcomes, learning area outcomes and specific outcomes. These new terms are due to a new policy for the establishment of curricula for schools that was announced by Professor Sibusiso Bhengu as Minister of Education on 24 March 1997. This new curriculum is called Curriculum 2005 and will be discussed at length in the sections that follow.

From a theoretical perspective it is important to bear in mind that aims and objectives play a pivotal role in the successful teaching of mathematics. It provides a framework for the requirements of the subject.

2.9.1 THE AIMS OF MATHEMATICS EDUCATION

In this regard, Wallace (1974:27) maintains that aims are broad in context and are useful in suggesting general policy for a particular educational institution, for a group of institutions or for a type of educational programme. Furthermore, Moodley (1992:98) claims that while aims, when heeded, may give shape and direction to education they are of little use in making the more specific decisions about selection, organisation and evaluation of learning experiences in the classroom. He specifies that aims merely reflect the value judgements of a particular philosophical viewpoint. Referring to Taba (1962) Moodley (1992:98) deems aims to be:

> *'... only a step towards translating the needs and values of a society and of individuals into an educational programme.'*

Moreover, Moodley(1992:98) believes that the translation of aims into action in the classroom can provide clarity about what the curriculum is meant to achieve and make those concerned with education clearly accountable. He vindicates this contention by referring to Wood (1968) who regards aims as 'general declarations of intent' that give shape and direction to a teaching programme. While aims in any course are essential in so far as they give direction in a general way, they are insufficient for classroom use.

Considering that this study pertains to mathematics teaching in the senior primary phase, the researcher finds it apt to outline the specific aim of mathematics education. Specific aims as was provided in the KZN Department of Education and Culture Provincialised Interim Core Syllabus and Guide for Mathematics Senior Primary Phase (1996:1-2) will be outlined.

2.9.1.1 <u>SPECIFIC AIMS OF MATHEMATICS EDUCATION</u>

The aforementioned syllabus is aimed at fostering and developing the following specific aims of mathematics education at the senior primary phase (Grades 4 - 6):

- to enable learners to gain mathematical knowledge and proficiency;
- to enable learners to apply mathematics to other subjects and in daily life;
- to develop insight into spatial relationships and measurement;
- to enable learners to discover mathematical concepts and patterns by experimentation, discovery and conjecture;
- to develop the ability to reason logically, to generalise, specialise, organise, draw analogies and to prove mathematical concepts;
- to enable learners to recognise a real-world situation as amenable to mathematical representation, formulate an appropriate mathematical model, select the mathematical solution and interpret the result back in the real-world situation;

- to develop number sense and computational capabilities and to judge the reasonableness of results by estimation;
- to develop the ability to understand, interpret, read, speak and write mathematical language;
- to develop an inquisitive attitude towards mathematics;
- to develop an appreciation of the place of mathematics and its widespread applications in society;
- to provide basic mathematical preparation for future study and careers; and,
- to create an awareness of and an appreciation for the contribution of all peoples of the world to the development of mathematics.

In order to make aims more feasible it is necessary to describe and specify the expected outcomes or intended behaviour in any particular field of study. When aims have been refined in this way to an even more specific level in terms of intended behaviours or statements of what the learners should be able to do at the end of a course of study, they are called objectives (Moodley, 1992:99). These are discussed below:

2.9.2 THE OBJECTIVES OF MATHEMATICS EDUCATION

Moodley (1992:101) expresses the view that the taxonomy of educational objectives by Bloom represents the first of three interacting areas of behaviour roughly corresponding to thinking (cognitive), feeling (affective) and acting (psychomotor). In teaching mathematics emphasis is often laid on the cognitive domain, because it is difficult to measure objectives in the affective domain and assessment instruments in this field are not as well developed as those for the testing of the attainment of cognitive objectives. Apart from the development of psychomotor skills it is difficult to visualize many objectives in the psychomotor domain.

Bloom classified objectives within the cognitive domain into six categories, namely, knowledge, comprehension, application, analysis, synthesis and evaluation. These are conceived as a hierarchy of objectives in which the achievement of one class of objectives is likely to make use of the preceding categories. The greatest benefit to mathematics educators is that Bloom's taxonomy of objectives has a direct bearing on mathematics teaching, in that, the mathematics educators are able to structure and systematize their teaching of mathematics along more scientific lines in terms of their educational objectives. Mathematics tests are also designed to cover the range of Bloom's objectives, though clearly a test designed for the senior primary phase will tend to be relatively more directed to items in the 'knowledge', 'comprehension' and 'application' categories than in the others. Aligned to the importance of aims and objectives in mathematics education is the rationale for including a subject like mathematics as compulsory in the curriculum for all primary school learners.

2.10 THE CASE FOR MATHEMATICS EDUCATION IN THE SENIOR PRIMARY PHASE

With respect to validating mathematics education at the senior primary phase Van Den Berg (1978:21) mentions that the programme is orientated towards achieving the following:

- to enable learners to cope with mathematical situations they may be faced with in everyday life;
- to help learners to develop logical habits of thought and systematic, concise expressions;
- to develop in the learner an interest, an appreciation and a love for the unchanging nature of the laws of numbers;
- to prepare the learners to perform calculations which may be needed in other school subjects or in further studies; and,
- to develop in the learners an ability to make calculations accurately and rapidly.

It can be conceded that the role of mathematics as a subject is to build upon, extend and develop values the child already has in relation to numbers and the environment. Its justification as a subject lies in its contribution to the development of a key area of all children's experiences in a world within which they exist and increasingly act. To assist in the attainment of its positive contribution will be the key concern of educators and their knowledge of how children learn. Understanding theories about how children learn and the ability to apply these theories in teaching mathematics are important pre-requisites for effective mathematics teaching. Many people have approached the study of intellectual development and the nature of learning in different ways and this has resulted in several theories of learning. Consequently, at this juncture we need to consider aspects of learning psychology with particular emphasis to mathematics education.

2.11 DEVELOPMENT IN THE FIELD OF LEARNING PSYCHOLOGY THAT CONTRIBUTES TO MATHEMATICS EDUCATION

Mathematics education has had the benefit of the thinking of mathematicians, educators and psychologists. For the purpose of this study, consideration will be focused only on the work of psychologists. In particular, the contributions of Skinner, Gagne′, Piaget and Bruner who seem to have had an impact on the trends of mathematical education. It is imperative that the researcher firstly outlines two opposing learning theories that will illustrate the different perspectives from which these psychologists derived their viewpoints.

2.11.1 LEARNING THEORIES

Bell (1978:9) argues that a sound knowledge of mathematics is necessary for good teaching, but understanding of content is not sufficient. Outstanding educators will know, understand and apply various theories about how learners learn mathematics in their teaching and will evaluate the success of each application of a learning theory. In the light of this, the researcher chose to outline the following two opposing learning theories, behaviourism and constructivism.

2.11.1.1 BEHAVIOURISM

Nichols and Behr (1982:451) indicate that from a behaviouristic point of view, the educational environment is highly structured. The central question for educational experience begins by specifying behaviours in terms of behavioural objectives. Once behavioural objectives are specified, learning programmes and activities are carefully structured to guide learners to the specific objectives.

Bell (1978:195) maintains that the behaviourist theory of learning relates to an empiricist philosophy of science, that all knowledge originates in experience. Behaviourism also assumes that all learners learn what they are taught, or at least some subset of what they are taught, because it is assumed that knowledge can be transferred intact from one person to another. The learner is viewed as a passive recipient of knowledge, an 'empty vessel' to be filled (Bell, 1978:195).

The behaviourist theory sees learning as conditioning, whereby specific responses are linked with specific stimuli. Copeland (1982:2) in this regard comments:

> *'Provide the proper conditioning and you can get human beings to behave in almost any way you want. Hence the name 'behaviourists.'*

2.11.1.2 CONSTRUCTIVISM

Njisane (1992:28) believes that in order to throw light on what constructivism seems to be, it is important that he refers to Labanowicz (1985) who stated that:

> *'We see what we understand rather than understand what we see. Man's drawings on reality and interpretations of situations reflect the internal organization, of his network of ideas.'*

These statements emphasise that learners construct understanding. Njisane (1992:28) states that 'to construct' implies that the structures the learner ultimately possesses are built up gradually from separate components in a manner initially different from that of an adult. He also refers to Bodner (1986) who emphasises the constructive view of learning as:

> ***'Construction is a process in which knowledge is both built and continually tested. Individuals are not free to construct any knowledge, their knowledge must be viable, it must work.'***

These statements imply that concepts, ideas, theories and models that learners construct in their minds are constantly being tested by their experiences and they last as long as the experiences are interpreted by the learners. No lasting learning takes place if the learner is not actively involved in constructing knowledge.

The different types of construction are distinguished by the way reality of knowledge is viewed. Empiricists maintain that reality exists independently of a person's cognitive activity. To them knowledge is in the world before man's actions give meaning to the world. Mathematical knowledge is ever true and it is the educator who provides learning materials that will bring the learner to appreciate this knowledge. On the other hand radical constructivists argue that mathematics does not exist pre-packed but has to be created constructively (Njisane, 1992:36).

Bell (1978:196) in evaluating the learning theories states, that, to the constructivists, learning is not, as for the behaviourist, a matter of adding and of stockpiling new concepts to existing ones. Rather, learning leads to changes in the unit of interrelated ideas in the learner's mind, which he refers to as schema. Having outlined the learning theories, the researcher will now examine the contributions of psychologists to mathematics education.

2.11.2 PSYCHOLOGISTS THAT CONTRIBUTED TO MATHEMATICS EDUCATION

The reforms in the teaching of mathematics were associated with the development of psychology and took account of the psychological findings and insights (Connel *et al.*, 1967:181). The following conceptualisations are significant for this study, as clearly indicated.

2.11.2.1 B.F. SKINNER

Postlethwait *et al.* (1977:59–60) suggests that Skinner is widely known for his work with 'operant' behaviour which is behaviour that is initiated by an organism, the results of which affect the organism in specific ways. The discovery of this mechanism, they believe, provided the theoretical framework upon which to build new approaches to investigating and understanding what organisms can do and will do.

They state further, that material can be presented such that the learner can be positively reinforced by immediate feedback to the correct responses to questions. The learner is then encouraged by one's own behaviour to proceed. According to Postlethwait *et al.* (1977:59-60) Skinner maintains that the art of using this knowledge lies in the ability to arrange appropriate contingencies for the establishment and maintenance of desired behaviour.
Bell (1978:148) in referring to Milhollan and Forisha (1972), pithily comments that:

> ***'Skinner's system probably represents the most complete and systematic statement of the associationist, behaviourist position in psychology.'***

Copeland (1982:5) asserts that Skinner emphasises the importance of carefully sequenced instructional experiences through maximum guidance by educator or instructional material. Basic association of facts is stressed. The term association refers to the familiar stimulus-response or S-R mechanism. Control the stimulus to get the desired response. It is a psychology applied to teaching learners, with positive reinforcement of praise, a good grade or a gold star for the right response. The reward is external, that is, provided by the educator (Copeland, 1982:5).

Bell (1978:148) states that a study of teaching and learning depends primarily upon the observable behaviours of educators and learners and he is of the opinion, that, nearly all identifiable human behaviour can be categorised into the following:

- **Respondent behaviours** : Involuntary reflex behaviour that result from special environment stimuli. In order for the respondent's behaviour to occur it is firstly necessary that a stimulus be applied to the organism. Skinner feels that only a few of the behaviours are respondent behaviours.

- **Operant behaviours** : Behaviours that are neither automatic or predictable, nor related in any known manner to easily identify stimuli. The word 'operant' describes an entire set of specific instances of behaviour that operate upon the environment to generate events or responses within the environment. Skinner suggests that if these events or responses are satisfying, the probability that the operant behaviour will be repeated is usually increased.

Skinner argues that reinforcements are happenings or stimuli that follow a response and which tend to increase the probability of that response, thus facilitating learning and changes in behaviour. He believes that reinforcements fall into the following two categories:

- **Positive reinforcements** : Stimuli, which, when presented following a behaviour by the learner, tends to increase the probability that, that particular behaviour will be repeated. The behaviour is strengthened.

- **Negative reinforcements** : Stimuli whose removal tends to strengthen behaviours. For example, many times, the learner's behaviour of attentiveness to appropriate classroom activities can be increased by removing distracting stimuli such as undesirable noise and a disruptive learner. Skinner regards punishment as the deliberate presentation of negative reinforcement.

The researcher is of the opinion that Skinner's research on the science of learning and the art of teaching can suggest the following reasons why some learners fail to learn certain mathematical skills after repeated attempts.

- Instead of studying mathematics in order to obtain positive reinforcement, learners do their mathematics to avoid negative consequences, such as the educator's displeasure, ridicule from fellow classmates, poor results leading to punishment from parents or poor results in competition with other learners.

- In the event of reinforcement occurring, the reinforcement may be given minutes following the learner's response. In this regard, Skinner maintains that even a time lapse of a minute or two between a response and a reinforcement can, at times, remove much of the positive effects of an immediate reinforcement.

- The frequency of reinforcement is inadequate.

The researcher being a mathematics educator, is of the firm belief that educators are often concentrating on completing their work, thus neglecting the need to reinforce responses. At this juncture, it is also important to note that Skinner's theory has relevance to mathematics education. The following examples will highlight this point.

When a chosen stimulus, for example, 5 x 3 is given by the educator, the learner would immediately respond and if the response is correct the learner would be reinforced in some way such as praise. However, if the response is incorrect, the educator would construct sufficient cues and prompts to elicit the correct response or may correct the incorrect response. The numerical example quoted above is of a very simple mathematical skill, but it is rather important for educators to know ways by which simple skills can be effectively learnt because the absence of the mastery of simple skills often puts a learner at a disadvantage as they proceed to more complex mathematics.

Mathematical skills can also be taught by rote learning which is by repetition of facts that are not understood, until they can be correctly written down or repeated. This method is often used in the senior primary phase by which multiplication tables are taught. The stimulus might be 'say your three times table' and the correct response would be, 'One three is three, two threes are six' and so on. Reinforcements are then awarded accordingly.

In the case of a mechanical process, for example, subtraction, a learner can be given a drill which shows how to set the sum out and how to 'borrow one' from the previous column if need be and the learner is then given several exercises on which to practise the drill.

Another occasion when S-R learning seems to be effective is when carefully designed sequences of tiny mathematical units of work are used. Learners work through these mathematical units to achieve knowledge and understanding and each tiny unit is an effective stimulus. The correct response leads to the next mathematical unit. This type of learning is successfully used by mathematics learners in the senior primary phase to obtain the lower level of Bloom's taxonomy of educational objectives which is knowledge and comprehension. The important goal for the mathematics educator is to give all learners an amount of practice that they need to allow them to move confidently to the next stage in the mathematics teaching.

It can thus be conceded that Skinner's work is of great benefit to mathematics education. Mathematics educators can create more effective learning situations by using appropriate techniques to elicit desirable behaviours from learners.

2.11.2.2 ROBERT GAGNE′

The American psychologist, Robert Gagne′, suggests that there are eight types of learning which he calls signal learning, stimulus-response learning, chaining, verbal association, discrimination learning, concept learning, rule learning and problem solving. Gagne′ believes that these eight learning types occur in the learner in the following four sequential phases as described by Bell (1978:110–111):

- ***The apprehending phase*** : Refers to the learners' awareness of the stimulus or a set of stimuli which is present in the learning situation. Awareness will enable the learners to perceive characteristics of the set of stimuli. What the learners perceive will be uniquely coded by each individual and will be registered in their minds. The way in which learners apprehend given stimuli results in a common problem in mathematics teaching and learning. When educators present mathematics lessons or stimuli they may perceive different characteristics of the content of the lessons than are perceived by learners. Each learner may have a different perception from other learners.

- ***The acquisition phase*** : Refers to attaining or possessing the fact, skill, concept or principle that is to be learned. Acquisition of mathematical knowledge can be determined by observing or measuring the fact that a learner does not possess the required knowledge or behaviour before an appropriate stimulus is presented, however, the learner attains the required knowledge or behaviour immediately after presentation of the stimulus.

- ***The storage phase*** : Refers to the retaining or remembering of a newly acquired capability. The human storage facility is referred to as the memory and research indicates that there are two types of memory. Short-term memory has a limited capacity for information and lasts for a short period of time. Long-term memory is the ability to remember information for a longer period of time and much of what is learnt is stored permanently.

- ***The retrieval phase*** : Refers to the ability to recall the information that has been acquired and stored in memory. To assist learners in progressing through these four stages in learning, for example, the square root algorithm, the educator firstly evokes apprehension by working through an example on the chalkboard, secondly the educator facilitates acquisition by having each learner work out an example by following, step-by-step, a list of instructions, thirdly assists storage by giving problems for homework and finally evokes retrieval by giving a quiz the next day.

As a mathematics educator it is also important to understand Gagne'’s eight types of learning that were mentioned earlier. Knowledge of the learning types will enable the educator to select teaching strategies and classroom activities that promote each learning type when that particular type seems appropriate for learning the mathematics topic being taught. The types are defined in summary form as described by Walklin (1990:11–14):

- **Signal learning** – this involves the learner in responding to a signal, it is a form of classical conditioning of behaviour.

- **Stimulus-response learning** – sometimes also called trial and error learning, operant learning, instrumental learning, instrumental conditioning or need reduction.

- **Chaining** – response chains and learning sets are learning structures in which elementary steps are mastered and linked together to form a procedure; having once acquired the knowledge, a learner will be able to carry out routine sequences almost automatically.

- **Verbal association** – one example of verbal association is naming; in order to be able to name an object, such as a cone or cube, the observer must see the object, recognise its shape and know its name.

- **Discrimination learning** – is the act of discerning that which constitutes a difference between two or more objects; it involves making judgements or observing characteristics.

- **Concept-learning** – groups of objects with common features are known as classes, while general ideas about classes are known as concepts.

- **Principle learning** – general ideas and concepts formed when different objects are seen to possess common features which should be forged into a well linked chain making up the principles; having once acquired a number of principles relevant to a given problem, the learner can combine them in order to solve the problem.

- **Problem solving** – is the most complicated form of learning behaviour, it leads to the formation of new principles of a higher order where the learner is required to consider the problem and to organise knowledge of several principles at one time in order to reach a successful solution

Gagne′ suggests that each type of learning is of a different order of complexity from the others, and all eight may be arranged in a hierarchy, starting with signal learning at the bottom and culminating in problem solving at the top. He also maintains that each type of learning should be mastered before tackling higher levels. This entails competence in seven types before attempting problem solving at the highest level.

The following mathematical example of teaching learners in grade 4 (standard 2) about triangles will illustrate what, according to Gagne′'s theory of learning, is an appropriate order of experiences. The learners should be given a sequence of experiences going from lower to higher orders of learning, which will probably extend over a period of time.

The educator will start by showing models of triangles and saying the word 'triangle.' After a while the educator will hold up a triangle and wait, expecting the learners to produce the word, whereby helping the learners to make a verbal association. Next the learners are shown a number of models of triangles and some models of non-triangles, for example, squares. The learners are asked to make two classes, assisting as necessary. This enables the learners to learn to discriminate among the properties of triangles and non-triangles. The learners are then given a collection of triangles with many different features, large ones, small ones, ones with right angles, ones with an obtuse angle and triangles turned in various positions. This is to help learners with concept learning. The learners then experiment with various models of triangles, with instructions to put the triangles together into sets, so that every triangle in each set is the same size and shape. In this way the learners will learn the principle that two triangles that are the same are congruent and finally the concept of triangle can be carried further into a problem solving situation.

It can be conceded that Gagne''s division of learning into eight types from the simplest through the progressively more complex types to the higher order types is a useful and valid way to view mathematics learning as clearly indicated in the example illustrated. However, it is important that educators acknowledge that learning does not usually progress in a sequence of easily definable and identifiable steps and the various learning types do not occur in chronological sequence. All of these eight learning types can occur nearly simultaneously. As was mentioned earlier, what is important for the mathematics educator, is to carefully select teaching strategies that promote each learning type when appropriately required to teach a particular mathematics topic.

2.11.2.3 **JEAN PIAGET**

In order to teach mathematics effectively, it is essential to understand how a learner thinks and learns. Piaget, a Swiss psychologist, was the first to make a systematic study of the acquisition of understanding in children. He is regarded, by many, to have been the major figure in the field of 20th century developmental psychology.

In Piaget's theory, human intellectual development progresses chronologically through four sequential stages. The order in which the stages occur has been found to be invariant among people. The ages at which people enter each higher order stage vary according to each person's unique hereditary and environmental characteristics.

Table 2.1 on the following page outlines Piaget's stages of intellectual development in children.

TABLE 2.1 OUTLINE OF PIAGET'S STAGES OF INTELLECTUAL DEVELOPMENT IN CHILDREN

STAGE	APPROXIMATE MENTAL AGE RANGE	SCHOOL PHASE
1. Sensori – motor	0 - 2	
2. Pre-operational		
a) Pre-conceptual thought	2 - 4	
b) Intuitive thought	4 - 7	Junior Primary Phase
3. Operational		
a) Concrete Operational thought	7 - 11	Junior and Senior Primary Phase
b) Formal Operational thought	11 - 16	Senior Primary and Junior and Senior Secondary Phases

Source : Behr (1980:23)

From the table above, it will be seen that the thinking of senior primary phase learners will be largely at the concrete operational level. If such stages of development as indicated in Table 2.1 are accepted in a general way then an understanding of the concrete operational stage by all senior primary mathematics educators is imperative. The researcher chose to discuss the concrete operational stage in particular as it is most pertinent to this study.

This developmental period is called concrete operational because psychologists have found that learners between seven and twelve years have trouble applying formal intellectual processes to verbal symbols and abstract ideas. The learner's ability to reason is almost totally dependent on concrete experience. By the age of twelve, nonetheless, most learners have become quite adept at using their intellect to manipulate concrete physical objects.

Piagetian theory explains intellectual development as a process of assimilation and accommodation of information into the mental structure. Elliot (1984:86) claims, assimilation is an absorption of new experiences and accommodation is the restructuring of the mind as a consequence of new information and experiences.

Bell (1978:100–101) maintains that the following factors influence intellectual development:

- The physiological growth of the brain and nervous system is an important factor in general intellectual progress. This growth process is called maturation.
- Experience in mental development. Experience has been identified in two types. Physical experience is the interaction of each learner with objects in their environment. Logico-mathematical experiences are those actions performed by individuals as their mental schema are restructured according to their experiences.
- Social transmission is the interaction and conception of a learner with other learners and is quite important for the development of logic in a learner's mind.
- Equilibration is the process whereby a learner's mental structure loses its stability as a consequence of new experiences and returns to equilibrium through the process of assimilation and accommodation.

Piaget believes that these factors account for intellectual development and that each one must be present if a learner is to progress through the four stages of intellectual development. At this point, it is important to consider the application of Piaget's stages of intellectual development within the context of the learning of mathematics in the senior primary phase. The following discussion will illustrate this.

Most of the school situations in which learners find themselves contain a large verbal element. This emphasises the need for mathematics educators to match instruction to the learner's level of thought.

Learners are expected to make judgements and inferences in mathematics, but they are still bound in such situations to a concrete thinking process. Handling models and materials in mathematics would provide the concrete experience necessary for learners to progress to the stage of being able to reason more formally.

Since the mental growth of learners advance through qualitatively distinct stages, the selection of mathematical experiences should be experiences for which the learners are ready. These experiences should also help prepare the learner to advance to the next stage.

Before a new concept is introduced to learners, it is important that they are tested to ensure that they have acquired all the pre-requisites for the thorough understanding of this concept. If they are not ready for the concept, they should be provided with the necessary experiences that will enable them to become ready. The mathematics educator must keep in mind that an answer or action that seems illogical from their point of view on the basis of their extensive experiences may seem perfectly logical from the learner's point of view on the basis of their limited experiences.

Learners' thinking is more flexible when it is based on reversible operations. Educators should teach pairs of inverse operations in mathematics together. For example, subtraction and addition nullify each other and division and multiplication nullify each other.

Lastly, in order for learners to learn effectively, they must be participants and not spectators. To develop their concept of number and space, it is not sufficient that learners merely look at things. They must also touch, move, turn, pull apart and put together things. For example, to pave the way for the concept of an angle, learners should be given opportunities to turn a hand of a clock or a pointer of a dial. However, the learners' activity should not be kept forever on the level of physical action. Physical action is merely the foundation for the mental operation that needs to be developed.

It can be conceded that Piaget through his simple studies of child development and his theoretical activity has produced a vast treasury of ideas on how learners learn and think. The task of drawing on this treasury for the benefit of teaching mathematics at the senior primary level will be the onus of the mathematics educator.

2.11.2.4 **JEROME BRUNER**

Whereas Piaget indicated that mental development must pass through the three stages of sensori-motor, concrete operational and formal operations, Bruner on the other hand, saw the human mind as having evolved three modes for representing the environment and events in it. Bruner calls these three modes the enactive, iconic and symbolic.

With respect to these three modes, Charles (1973:6) comments that the enactive mode is where the learners manipulate materials directly. The learners then progress to the iconic mode, where they deal with mental images of objects but do not manipulate them directly. Finally the learners move to the symbolic mode, where they strictly manipulate symbols and no longer mental images of objects. Charles (1973:6) states further that this sequence is an outgrowth of the development work of Jean Piaget.

Bell (1978:141–142) maintains that Bruner believes that any theory of instruction should have the following four major features that prescribe the nature of the instructional process:

- A theory of instruction should specify the experiences which predispose or motivate various types of learners to learn; that is, to learn in general and to learn a specific subject such as mathematics.
- The theory should specify the manner in which general knowledge and particular disciplines must be organised and structured so that it can be most readily learnt by different types of learners. Before knowledge is presented to learners, it should be organised so that it relates to the characteristics of learners

and embodies the specific structure of the subject, in this case mathematics at the senior primary level.

- The theory should specify the most effective ways of sequencing material and presenting it to learners in order to facilitate learning. The problem of sequencing material in mathematics is very complex and is closely related to each learner's individual learning characteristic.

- The theory should specify the nature, selection and sequencing of appropriate rewards and punishments in teaching and learning a discipline.

These four features of a theory of instruction suggest corresponding activities, which mathematics educators should engage in when preparing to teach their lessons. The method of teaching based on Bruner's theory provides a great contrast to those based on the S-R theory that was mentioned earlier under Skinner. Instead of providing a stimulus and teaching the learner to make the correct response the educator is now faced with the need to provide an investigatory activity and teaching the learner to relate experiences in a mathematical way. The activity provided by the educator must obviously be carefully chosen if the teaching and learning is to be effective.

In concluding this section it is important to note that as educators approach their work in the classroom, they should attempt to organise their understanding of classroom processes and plan learning activities in the light of concepts they have gained from their previous experiences. Due to their concern with human behaviour and learning they will find concepts and principles derived from psychological approaches to human behaviour and learning particularly pertinent to their work. Empirical studies of classroom processes and conditions affecting learning help the educators in planning their work in the classroom. Hence, it may be argued that educational psychology bears a significant relationship to methods of teaching. However, at this juncture it becomes important for us to consider the didactical perspectives pertaining to mathematics at the senior primary level.

2.12 DIDACTICS WITH PARTICULAR REFERENCE TO MATHEMATICS TEACHING AT THE SENIOR PRIMARY LEVEL

The researcher believes that it is imperative that prior to describing various ways of teaching, a discussion on curriculum models should be presented. Reason being, that for any teaching to be of value, it must be seen to be resulting in meaningful learning. In this regard Monica *et al.* (2000:95) maintain:

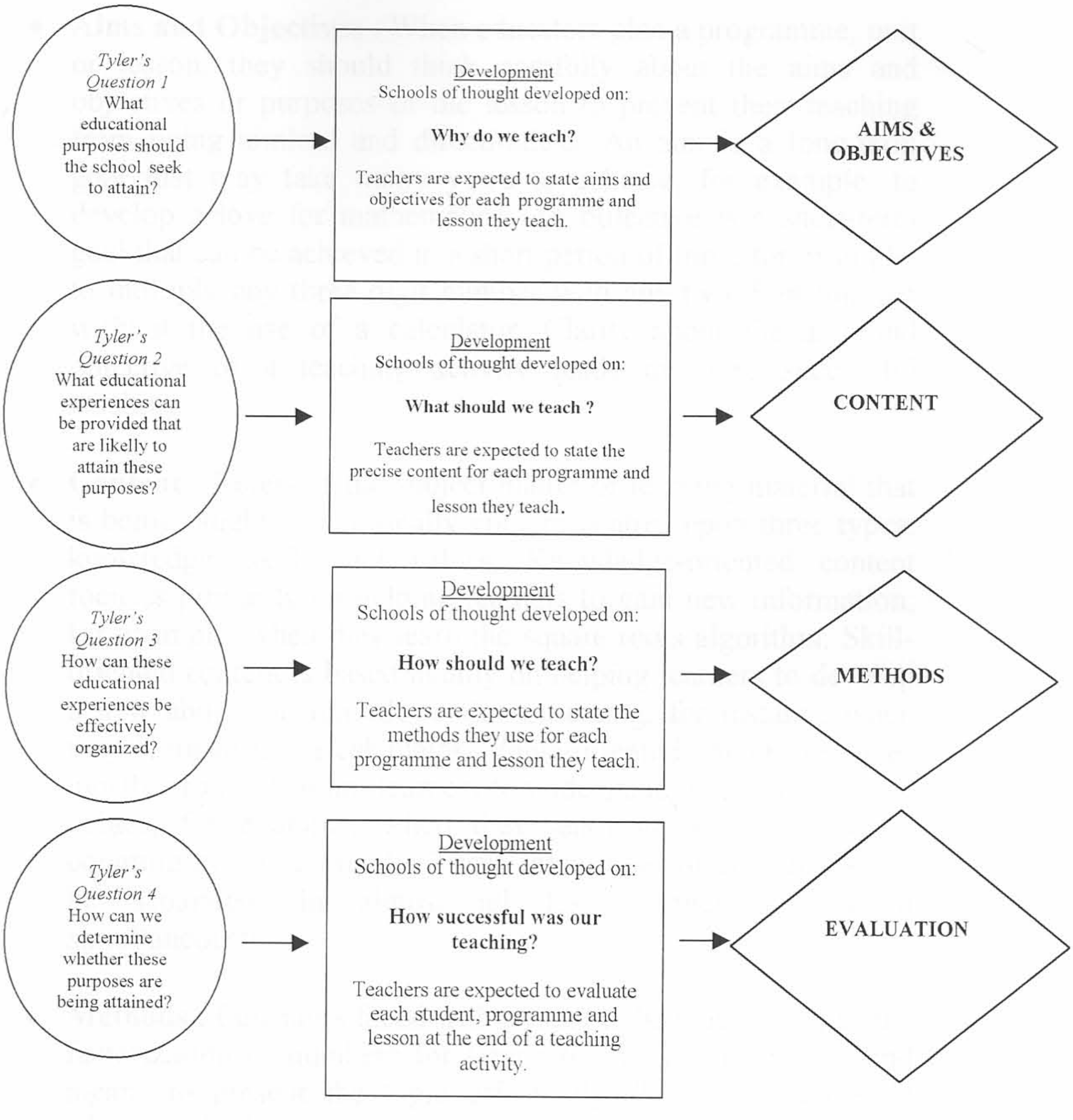
> ***'Curriculum models guide the process of decision making in designing learning programmes, because curriculum development should be perceived as a task that requires orderly thinking when one examines both the model and the learning that has to be accomplished.'***

2.12.1 THE PERENNIAL CURRICULUM MODEL

Perennial means evergreen, unchanging, recurrent, timeless and long-lasting. The Perennial Curriculum Model therefore means a timeless plan that most qualified educators use when they design a lesson, unit or programme. Four important concepts, namely aims and objectives, content, methods and evaluation together have become known as the Perennial Curriculum Model (Monica *et al.*, 2000:95).

The chief initiator of the Perennial Curriculum Model was Ralph Tyler. Tyler based his curriculum plan on four fundamental questions which curriculum planners should consider when they design a curriculum, as shown in figure 2.1.

Figure 2.1 Development process from Tyler's Rationale to the Perennial Curriculum Model



Monica *et al.* (2000:97)

It is important to look at the following four concepts outlined by Monica *et al.* (2000:96–97) that play an important role when educators plan curricula:

- **Aims and Objectives** : When educators plan a programme, unit or lesson, they should think carefully about the aims and objectives or purposes of the lesson to prevent their teaching from being aimless and directionless. An aim is a long-term goal that may take many years to achieve, for example, to develop a love for mathematics. An objective is a short-term goal that can be achieved in a short period of time, for example, to multiply any three digit number with any two digit number without the use of a calculator. Clarity about the aim and objective of a teaching activity leads to more successful teaching.

- **Content** : Refers to the subject matter or learning material that is being taught. Traditionally content centres upon three types: knowledge, skills and values. Knowledge-oriented content focuses primarily on helping learners to gain new information, for example, when they learn the square roots algorithm. Skill-oriented content is based mainly on helping learners to develop a new ability or aptitude to do something, for instance when they learn to use a calculator. Value-oriented content revolves mostly around helping learners to understand and acquire good values, for example, when they learn to be honest when counting money correctly. These three types of content cannot be separated. In almost all lessons they are learnt simultaneously.

- **Methods** : Educators faced with a topic to be taught such as the factorization of numbers for Grade 6, should find ways and means to present the topic effectively. They should decide which methods to use.

- **Evaluation** : Educators assess how effectively the learners have learnt as well as the weaknesses and strengths of the lesson, unit or programme. During this part, educators determine whether the curriculum aims and objectives have been met. Evaluation is not only done at the end of a lesson, it is a continuous process conducted before, during and after the lesson has been implemented.

2.12.2 OUTCOMES BASED EDUCATION (OBE)

The new democratically elected government of South Africa has, since its inception in 1994, worked towards the transformation of the system of education. A major change has been the formation of the South African Qualifications Authority (SAQA) a body constituted of various stakeholders in education and responsible for the establishment of the National Qualifications Framework (NQF). Table 2.2 on page 53 illustrates the structure of the NQF.

Table 2.2 National Qualifications Framework

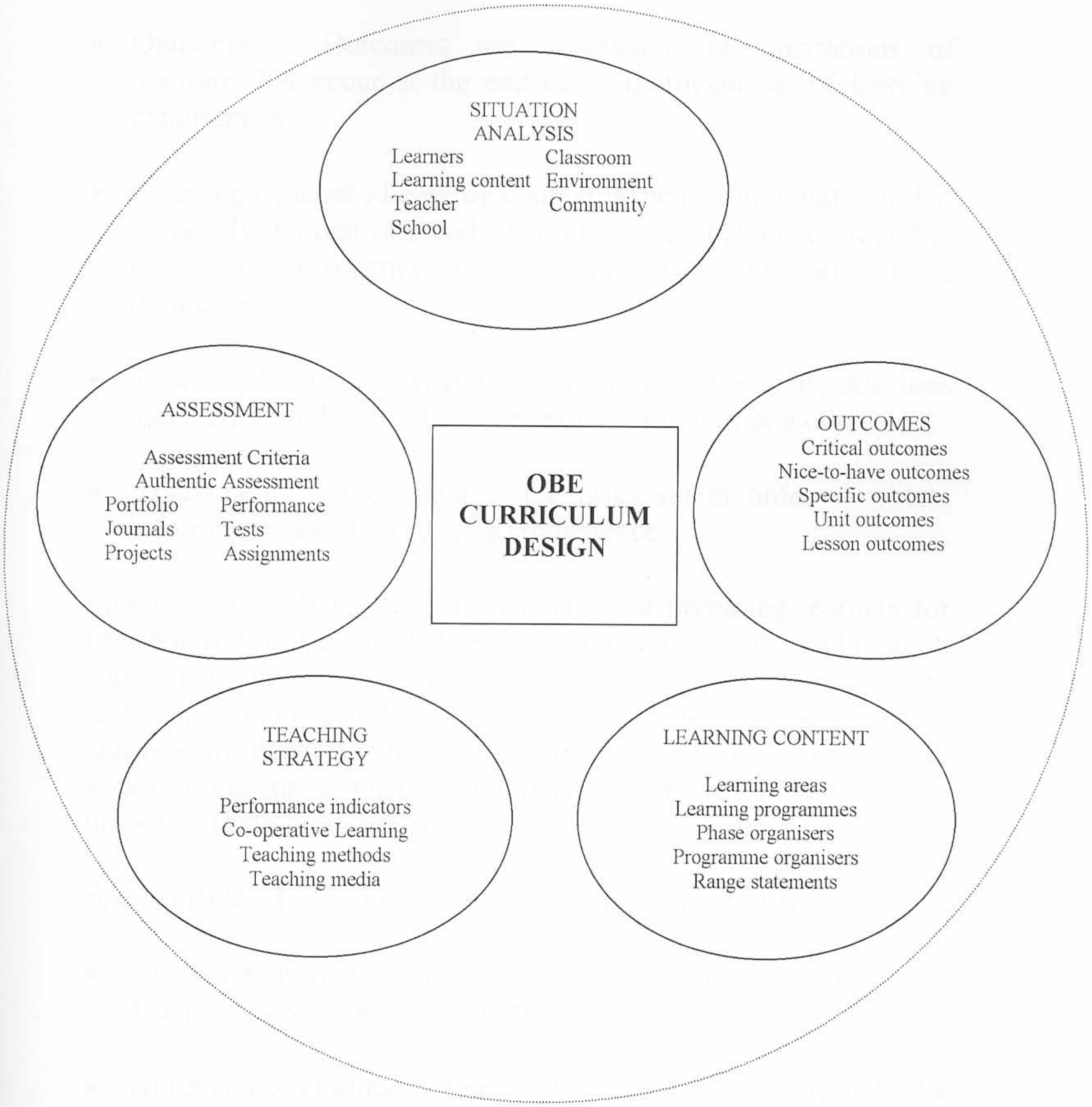
School Grades	NQF Level	Band	Types of qualification & Certificates	
	8	Higher Education and Training Band	Doctorates Further research degrees	
	7		Degrees, Diplomas & Certificates	
	6			
	5			
Further Education and Training Certificates				
12	4	Further Education and Training Band	School/College/NGOs Training certificates, Mix of units	
11	3		School/College/NGOs Training certificates, Mix of units	
10	2		School/College/NGOs Training certificates, Mix of units	
General Education and Training Certificates				
9 8 7	1	General Education and Training Band	Senior Phase	ABET 4
6 5 4			Intermediate Phase	ABET 3
3 2 1			Foundation Phase	ABET 2
R			Pre-school	ABET 1

Monica *et al.* (2000:701)

The NQF reflects the nature and quality of all qualifications attainable in South Africa.

Along with these changes, a new curriculum, based on the OBE Model of teaching has been introduced and is currently in the process of being phased into the education system. Figure 2.2 illustrates the Model of OBE Curriculum Design.

Figure 2.2 Model of OBE Curriculum Design



Monica *et al.*, (2000:109)

Monica *et al.* (2000:128) highlight that in designing a programme, unit or lesson, educators need to make decisions about the following five components in the Model of OBE Curriculum Design.

- Situation analysis : Situation analysis is an examination of the contextual factors that have a bearing on the programme.

- Outcomes : Outcomes are observable demonstrations of learning that occur at the end of a significant set of learning experiences.

- Learning Content : Learning content is the learning material that is loosely divided into eight learning areas, but linked together in classroom practice by phase organisers and programme organisers.

- Teaching Strategy : Teaching strategy is the methods, activities and media used when the programme is put into practice.

- Assessment : Assessment is the tasks set in order to obtain information about a learner's competence.

Spady (1993:2) believes that OBE is about preparing learners for life, not simply getting them ready for university or employment. This means focusing and organising a school's entire programme and instructional efforts around clearly defined outcomes which learners are expected to demonstrate when they leave school. He states further that in OBE the intended learning results are the start up points in defining the system.

Spady (1993:21–22) outlines the following aims of OBE:

- To create more flexible delivery systems so that learners of different ages are learning co-operatively.

- To replace averaging systems and comparative grading with the concept of culminating achievement.

- To ensure that all learners experience success.

- To avoid a process whereby 'passing' requires a given amount of time to be spent attending a particular class.

- To equip educators to focus more on the learning capabilities of learners and less on covering a given amount of curriculum.

- To focus all instruction on a higher level of learning and to make accessible to all learners the methods used in gifted and talented programmes.

- To place less reliance on norm-referenced standardised tests as indicators of either learner or educator accomplishment.

Olivier and Van Schaik (1998:37–38) state that outcomes based learning signifies the approach whereby the curriculum design process, planning of education, assessment of the learning and advancement of learners is based on the achievement of outcomes. He claims further that since the outcomes based curriculum emphasises an integrated approach to learning, entailing content, competencies and processes, the approach towards learning has significant influence on how and what learners will learn.

Olivier and Van Schaik (1998:39) outline the contrast between the traditional and the outcomes based learning systems as indicated in table 2.3 on page 57.

Table 2.3 Difference between the traditional and the outcomes based learning systems.

Old	New
(a) Rote learning (b) Syllabus is content driven and broken down into subjects (c) Textbook/worksheet-bound (d) Teacher centred (e) Syllabus is rigid and non-negotiable (f) Emphasis on what teacher hopes to achieve (g) Curriculum development process not open to public	(a) Critical thinking, reasoning (b) Learning is process and outcome driven, connected to real-life situations (c) Learner- and outcome-centred (d) Teacher is facilitator (e) Learning programmes are seen as guides (f) Emphasis on outcomes – what learner achieves (g) Wider community involvement is encouraged

Source: Olivier and Van Schaik (1998:39)

At this point, the researcher believes that it is important to differentiate between OBE and Curriculum 2005 which will be discussed in Chapter 4. In this regard Monica *et al.* (2000:102) comment that OBE is a much broader concept than Curriculum 2005. The new school curriculum, Curriculum 2005, is only one way in which OBE manifests itself in South Africa, because OBE is not confined to the school sector only. OBE is entrenched in all types of formal education and training that takes place in this country such as teacher education, nursing studies, medical schools and as in the case of this study, in-service courses.

The foregoing has provided the theoretical foundations of the curriculum models. It is now important to focus on the practical implementation of these models.

2.12.3 TEACHING METHODS OF MATHEMATICS AT THE SENIOR PRIMARY LEVEL.

Prior to describing the different teaching methods that an educator can implement, a viable concept of a teaching method must evolve. In this connection Monica *et al.* (2000:210) maintain that:

> ***'A teaching method is a particular technique a teacher uses to help pupils get knowledge which they need.'***

They state further that educators also have to be flexible. From time to time there is need to experiment with different teaching methods.

2.12.3.1 **DEDUCTIVE AND EXPOSITORY METHOD**

Moodley (1997:36) suggests that expository approaches are essentially deductive methods in which facts, concepts, relationships and generalisations are described by the educator or printed in a textbook with a view to learners understanding or assimilating them. In this regard, Dean (1982:78) claims that expository methods transmit information in one direction only, that is, from the educator to the learner. He also provides the following four reasons as to why the expository method is popular with mathematics educators:

- They are mathematically neat and complete as each lesson contains a presentation and explanation of mathematics that leads to a conclusion.
- They boost the educators' self esteem as they are the fountains of knowledge.
- An educator can get satisfaction from presenting a complete syllabus in a sequence of lessons.
- The educators have themselves, often successfully learnt school mathematics in this way and expect their learners to do likewise.

Bell (1978:130–132) in this respect, comments that Ausubel presents a powerful argument that expository teaching was the only efficient way to transmit the accumulated discoveries of countless generations to each succeeding generation. Bell (1978:130–132) also maintains that Ausubel believes that good expository teaching, whereby an educator structures and explains a mathematics topic so that learners can organise the topic and relate it to previous meaningfully learned topics, can result in efficient and effective mathematics learning.

Monica *et al*. (2000:236) in their contribution on expository methods concur that this method can be used to great effect in OBE. The educator is still responsible for the planning and the organisation of classroom activities. While OBE may stress learner centred methods, the educator still needs to explain facts, concepts and generalisations either verbally or in written form. However, they believe that educators can use the expository method in conjunction with other teaching methods that involve learners more actively.

2.12.3.2 **INDUCTIVE AND DISCOVERY METHOD**

Eggen and Kauchak (1988:109) declare that the inductive method is a straight forward but powerful method designed to develop the thinking skills of observation, comparing, finding patterns and generalising while at the same time teaching specific concepts or generalisations. He also states that this method has the intrinsic advantage of promoting high levels of interaction and increased learner motivation.

Furthermore, Stuart (1986:72) comments on the discovery method thus:

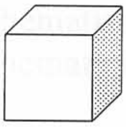
> ***'This method helps to combat the passive lack and listening role of the pupils. They are expected to do their own searching and research and must try to discover the concepts, rules and definitions of matter.'***

Dean (1982:70) in associating the discovery method with mathematics teaching refers to the following four discovery methods:

- Directed discovery

The method of teaching mathematics by directed discovery can be explained by the following example. The educator would have given every learner a copy of the partially completed table as shown in figure 2.3.

Figure 2.3 Partially completed table

SHAPE	NAME OF SHAPE	F NO. OF FACES	V NO. OF VERTICES	E NO. OF EDGES
	Cube	6	8	12
	Tetrahedron			
	Square based pyramid			

Source: Dean (1982:71)

The educator would also have put out on the desks several physical models of nine shapes including the cube, tetrahedron and square based pyramid. The educator will then direct the learners to investigate the number of faces, vertices and edges on these shapes and to fill in six more lines of the table. While the learners are doing this, the educator will walk around the classroom giving instructions to learners who are not certain about the next thing to do. Towards the end of the lesson, the educator will probably go to the chalkboard and write 'Discover a formula to connect the number of faces, vertices and edges. Check that this formula is true for every shape you have used.' At the close of the lesson, learners who have not managed to discover the formula will probably be told to write

$$F + V - E = 2$$

This method contains a small element of discovery and requires learners to be prodded along.

- <u>Guided discovery</u>

The use of this method can again be illustrated by a classroom where the nine geometric shapes are put on the desks, but the learners are not directed stage by stage. The educator starts the lesson by saying, 'Discover some relationships between the faces, vertices and edges of these shapes.' The learners then handle and compare the shapes.

This guided discovery method allows learners to make significant mathematical discoveries. After the start of the guided discovery lesson, the learners have to use their own initiative in making a mathematical investigation so that they are expected to act as mathematicians.

- <u>Exploratory discovery</u>

In the exploratory discovery method, the educator structures the learning activity by providing or approving the objects or ideas which the learners use, but does not give instructions even as to the aim of the lesson. This method enables the educator the opportunity to discover how learners learn when they are not restrained.

- <u>Free discovery</u>

Free discovery comes from the natural curiosity of the learner, about any object or idea. It is not initiated by the educator, but they do have a teaching role to play. The educators must show interest, give encouragement and provide advice if they think that it will help the learner to learn more from the discovery.

Dean (1982:74–75) claims that the use of the discovery method has the following properties:

- an increasing element of learner initiative;
- a reduction in the equality of learners' attainment;
- the educator's role changing from director to advisor;
- the educator's image changing from one who knows everything to one who has to search for information;
- a decreasing efficiency in transmitting knowledge; and,
- an increasing difficulty in assessing and planning progress towards a defined point.

Finally, it can be conceded that any choice of one teaching method above the others will be determined by, the nature of the content to be taught, the readiness of the learners' previous knowledge and the particular abilities of the educator.

Although educationists from time immemorial have attempted to stress the importance of the inquiry or discovery based methods in order for learners to learn effectively, the expository method seems to be the commonly used method in mathematics teaching. Mathematics educators seldom use the discovery method as it is time consuming and educators believe that it is difficult to employ in the primary school. Besides an effective teaching method in improving the quality of learning, there is a strong body of research to suggest that learner achievement can be further enhanced by the consistent and strategic use of specific teaching strategies (Hopkins *et al.*, 1996:18). Reference will now be made to selected strategies.

2.13 TEACHING STRATEGIES ASSOCIATED WITH MATHEMATICS

There are many strategies of teaching designed to bring about particular kinds of learning to help learners become more effective. For the purpose of this study the researcher chose to discuss the following four teaching strategies, namely, the use of games, problem solving, groupwork and calculators and computers. The researcher having discussed the OBE Curriculum Model believes that a discussion of the above mentioned strategies is imperative.

2.13.1 THE USE OF GAMES

Coombe and Davis (1995:18) stress that games are used variously as ice-breakers, to introduce new concepts, for the consolidation of ideas, for removing the drudgery from drill and has been seen as important in creating a positive and enthusiastic atmosphere in workshops and classrooms. They also claim that a review of literature on the use of games in classrooms have led to a wide ranging though rhetorical series of arguments for their usefulness.

Coombe and Davis (1995:18) offer the following attributes pertaining to the use of games:

- generates enthusiasm, excitement and the total involvement of learners;
- helps to vary the curriculum;
- generates learner-learner and educator-learner discussion and encourages co-operation;
- are useful devices to help learners to gain new concepts, practice and reinforce skills and develop problem solving strategies;
- requires learners to use trial and error methods, simplify difficult tasks, search for patterns, make and test hypotheses and to prove and disprove conjectures;
- provides a vehicle for many mathematical situations – an external concrete situation in which manipulation makes sense; and,
- can be used by educators to assess learners.

In an OBE workshop held for Grade 7 educators in the Durban South Region from 19 October to 25 October 2000, reference was made to the following three quotations with regard to the usefulness of games in the classroom:

> ***'In games, feedback comes from other children and oneself. Children check each other's thinking and learn that they can figure things out for themselves. When worksheets are used, teachers often have to correct the same errors day after day. The reason is that this feedback is both distant and delayed. In games by contrast immediate feedback comes directly from friends.'***

(Kamii and De Clark, 1985:35)

> ***'…whilst playing games children are relaxed and have a good learning disposition. Games which become familiar and loved help create a confident and secure atmosphere in the classroom and may even bring the isolated child into social interaction with other children.***

(Williams and Somer Will, 1982:8)

> ***'Students receive positive reinforcement more frequently because, using a learning game in the classroom provides immediacy of feedback to the pupils because each pupil is informed immediately after each game whether he won or lost.'***

(De Vries and Edwards, 1973:308)

In the workshop the following types of games were classified as being useful in the mathematical classroom:

- puzzle-type games
- games to reinforce concepts
- games to practise skill
- games to stimulate mathematical discussion
- games to encourage the use of strategies
- multicultural games
- mental games
- computer games
- calculator games
- collaborative games
- competitive games
- games for emphasising underlying mathematical structures

The workshop also highlighted the following aspects with regard to the use of games in the classroom:

- Games should be chosen and played with a specific purpose in mind, for example, dice games are particularly good for consolidating number bonds. Learners should be aware of these purposes and why they are playing the games: it is not only to have fun!

- Games should be selected according to the needs of the learners. There is no point in playing a game that consolidates the number bonds up to 10, for example, if the learner is quite competent in this area.

- Games should be played at the 'right time', that is, when the ideas or skills involved in the game are being taught or reviewed.

- Games may be used to extend the learner's learning. This may be done by the educator or the learners, with good reasoning, for example, multiply the dice together instead of add, because we are happy with adding and feel we need multiplication practice, it will enhance the learning experience.

- Commercial games such as Snakes and Ladders, Bingo and Maths 24 can be used and adapted for use in the classroom.

- Games should not be overdone, for example, if they are played too often they may become boring and no longer serve their purpose.

- Games should be explained clearly. Explanations can be done by learners as well as educators.

- The importance of learning something from playing the games should be emphasised. For instance, in follow-up or feedback sessions the learners could be encouraged to share what they have learnt.

Although games can be valuable activities for learning mathematics at the senior primary level, Bell (1978:255) believes that games are not an educational panacea and do have the following limitations. These are, *inter alia*: Involvement in games can become too intense. When playing a game results in winners and losers, unsuccessful learners may avoid participating in the game or may participate half-heartedly. Furthermore, the objective of winning may overshadow cognitive objectives and denigrate the value of mathematical objectives.

Playing certain games may encourage inappropriate values such as winning at any price or refraining from co-operation. Among the less tangible limitations of games is the fact that some learners enjoy games to such an extent that any other teaching strategy appears uninteresting when compared to game strategies.

The greatest intangible limitation of games results from the manner in which they are viewed in our society. Games tend to be regarded as diversions and not serious mathematics. Many educators who use games regard them as purposeless diversions. Educators who do use good games to meet sound learning objectives rely too heavily upon games as a source of teaching strategies. Their learners, who have been conditioned to regard games as diversions, may feel that they are not learning any mathematics because the educator is always playing games.

In view of the above it can be conceded that games can be very effective when judiciously selected and used in moderation. Involvement in mathematical games undoubtedly enhances mathematics learning for most learners.

2.13.2 PROBLEM SOLVING STRATEGIES

Ferrucci *et al.* (2001:26) stress that recent studies demonstrate the importance of including mathematical word problems in the primary school to develop learner's understanding of how to apply solution strategies to real-world problems. This coincides with what Copeland (1982:215) meant when he stated that problem solving includes a wide variety of routine and common place functions essential in the day-to-day living of every citizen. Problem solving applies mathematics to the world around us.

Copeland (1982:215) maintains that a full range of problem solving includes:

- traditional concepts and techniques of computation applied to real-world problems;
- the use of mathematical symbolism to describe real-world relationships;
- the use of deductive and inductive reasoning to draw conclusions;
- methods of gathering, organising and interpreting data; drawing and testing inferences; communicating results; and,
- the visualization and use of spatial concepts related to problem solving.

Van Der Horst and McDonald (1997:139) provide the following advantages of using problem solving as a teaching strategy:

- it provides a challenge for the learners;
- it engages learners actively in learning;
- it helps learners to develop new knowledge and to feel responsible for their own learning;
- it shows learners that mathematics can be viewed as ways of thinking and doing things that make sense;
- it develops critical thinking skills;
- it keeps learners' natural curiosity alive;
- it helps them to make informed judgements;
- it gives learners the opportunity to apply their knowledge and see that the knowledge has some real-world applications;
- it helps learners to integrate the knowledge they gain from the different subjects;

- it engages them in learning long after the formal lesson is over; and,
- the familiar learner question "Why do we need to know this?" is often replaced with "What do we need to know?" or "What do we need to find out?"

Bell (1978:313–314) comments that the techniques for problem solving involve the following steps:

Step 1 : Presenting a problem in a general form. It needs to be emphasised that while this study pertains to primary school learners who are in the main in the concrete stage of intellectual development nothing prevents the educators from extending these learners. This will involve the educators using their discretion in providing examples that the learners are ready to handle.

Step 2 : Restating the problem so that it is solvable. The following set of questions can be of use in formulating a solvable restatement of a problem:

- Does the problem make sense?
- Is the problem worthwhile or interesting?
- Do I understand the problem?
- Is the problem too general?
- What does the problem mean?
- What is known?
- What is unknown?
- Is there enough information in this statement of the problem?
- Can the problem be stated in a more meaningful way?

- Can the problem be broken into sub-problems?

Step 3 : Formulate alternative hypotheses and procedures for attacking the problem. The following strategies assist in carrying out this step:

- What is given, that is, what do we know?
- What is to be found?
- What activities might lead to new information?
- What speculations appear to be reasonable?
- What procedures can be used to solve this problem?

Step 4 : Involves the testing of hypotheses and carrying out procedures to obtain solutions to problems. This provides the actual solution to each problem that is solved.

Step 5 : Involves the evaluation of the solution.

Van Der Horst and McDonald (1997:144) stress that motivation is a key element to problem solving. Unless learners want to solve the problem and believe that they have a chance of success, they are unlikely to persist and therefore are unlikely to learn so that they can achieve the solution. Motivation can be reduced to learners requiring to know why they are learning whatever it is that they are learning and they need to see some value in this learning. This can be attributed to problem solving leading to purposeful and useful learning. In conclusion it must be acknowledged that :

> *'... the importance of problem solving in mathematics and the fascination that mathematical problem solving holds for many people have been illustrated throughout the history of mathematics and mathematical education.'*

(Bell, 1978:308)

2.13.3 GROUPWORK

An important aspect of reconstructing education in South Africa is the transformation of classroom practices to include approaches to learning and teaching which are 'learner centred and non-authoritarian' and encourage an active participation of learners in the learning process. One possible approach is small groupwork which is beginning to be used more widely in mathematics classrooms in South Africa (Brodie, 1995:7).

Brodie (1995:7) argues that as a learner centred practice, small groups are expected to create time and space for individual learner participation in discussion and activities and, hence, for the construction of knowledge. Interaction with different points of view may increase possibilities for conceptual development. As a democratic process small groups provide learners with opportunities to learn from and value their peers' ideas and experiences.

In addition, Brodie (1995:7) believes that small groups also remove the educator from most of the learners' discussion. Research in classrooms has shown that certain kinds of educator control over the discourse and knowledge generated in the classroom can be detrimental to learning. For example, educators tend to ask mainly questions to which they already know the answers. While such questions may be an appropriate means for assessing learners' knowledge, they also have the effect of encouraging learners to try to guess what the educator is thinking, rather than to express their own ideas.

Peer groups are expected to provide more equality in interaction and to allow learners more control over the learning situation and the knowledge developed. For example, they may have more opportunities to ask their own questions and to answer genuine questions from their peers about their developing knowledge.

However, Brodie (1995:12) warns that the educator can and should be a powerful enabling influence, mediating both interaction and conceptual development in small groupwork. Mediating implies closer educator direction and guidance. In this regard, Bell (1978:354) comments that the most important function of the educator during small groupwork is to observe the activities and progress of each group and keep learners informed about the strengths and weaknesses of their procedures. The educator's role is thus that of monitor and facilitator. Facilitator in this context will call for educators to allow learners to develop and express their own ideas.

Bell (1978:360–361) mentions the following problems educators may encounter when working with small groups and recommends the following suggestions to counteract these problems:

- At times groups may become polarized into two competitive factions, each one of which attempts to impose its will upon the other. Educators need to remind learners that the purpose of the group activity is to inquire into the nature of mathematical principles and not to win a debate.

- Groups may become unresponsive due to reluctance to discuss mathematical concepts or not understanding the task. The educator can temporarily become a member of the group and get the discussion started through questions and suggestions

- Groups may become unproductive due to being unable to stay on the topic. The educator can usually find the source of a group's statement by observing the group members' activities for a few minutes, then offer suggestions to facilitate progress towards the objectives of the lesson.

2.13.3.1 **SUMMATION**

Even though a primary objective of the grouping method is to help learners become independent inquirers, carefully planned activities, constant monitoring of learners' groupwork and judicious participation within groups are a necessary part of an educator's role in learner centred learning strategies. Since the educator has less control of a group activity, even more careful planning and anticipation of learner difficulties must be carried out when the groupwork method is being used.

2.13.4 COMPUTERS AND CALCULATORS IN THE PRIMARY SCHOOL

The researcher believes that of the most recent developments that have important implications for mathematics education, is the calculator and computer. These technological developments are urgent because computers and calculators are so important in business and everyday life and growingly more in education and will become even more so, as greater numbers of learners and young people use them. They are also important, because the technology is available, in use, and has potential to effect major changes in the teaching and learning of mathematics, because some people have fear that learning basic mathematics will be undermined. The full potential of the calculator, however, cannot be realised without a change in both teaching styles and educators' conceptions about their use. Groves and Cheeseman (1993:21) argue that apart from the calculator being used to just check answers, its most important use is to be found in the following:

- helping children to decrease computation time and effort in order to concentrate on the core of a problem and to enable performance with large and messy numbers;
- facilitating the exploration of numbers and operations with numbers;
- encouraging inquisitiveness and creativity through experimentation; and,
- developing estimation and mental computation skills by checking reasonableness and exploring features of the calculator itself and the advantages of its use in different situations.

However, Groves and Cheeseman (1993:22) also warn that the training of basic mathematical skills and abilities should not be replaced by the premature use of the calculator.

With regard to the use of computers, Kaput (1992:533) highlights several constraints such as, an insufficient number of computers, limited access to software and inadequate preparation of educators that restrict the use of this device. Nevertheless, computers have the following to offer:

- they can be used in conjunction with all parts of the constructive learning process, when embedded in a classroom culture where there is communication and co-operation;

- they can be used in the practising of skills in a way that incorporates understanding or in simulations that enhance concept building; and,

- they can provide learners with new tools for learning in an exploratory environment.

It can be conceded that while the potential of the calculators and computers for enhancing learning in mathematics can be demonstrated, it remains the crucial task of the mathematics educator to develop the use of these technological devices in their teaching. The standard of mathematics education should be the guideline and not the technical limitations and possibilities.

2.14 CONCLUSION

This chapter opened with relevance to theory in providing a theoretical framework. This was followed by the researcher establishing a framework for INSET. Thereafter, the objectives of INSET were discussed, followed by a discussion of the INSET Models. The researcher then provided a brief overview of the theory of change.

It was against this background that the researcher discussed the theoretical constructs of mathematics at the senior primary level with the intention of providing a framework for mathematics education. The framework will enable mathematics educators to cope with the changing needs of mathematics education at the senior primary level.

The next chapter opens with a brief review of the history of mathematics followed by a presentation of the evolution of mathematics teaching and INSET provision of educators of mathematics in primary schools in a selected developed country.