

CHAPTER 3

THE STRUCTURE OF LIFE SCIENCES AND BIOLOGY AND ITS INFLUENCES ON THE FACILITATION OF LEARNING FOR BLIND LEARNERS

3.1 INTRODUCTION

After the careful study and critical analysis contained in this chapter, it is hoped that valuable knowledge will be obtained about the nature and structure of biology and will be available to the likely readers of this study, including educators, researchers and biologists or other scientists, et cetera, who will be equipped with essential skills for the identification, differentiation, evaluation and analysis of various biology concepts. Furthermore, the reader will be exposed to various biology activities such as observation, testing the validity of collected data, experimenting, inquiring into and assessing data. All people with a keen interest in biology will be exposed to the principles and standards that biology has to satisfy as a natural science subject. The reader should understand more fully how the nature and structure of biology impact on the learning mediation of blind learners. Finally, the reader will be able to understand the relationship between natural sciences and biology.

In this chapter, the researcher places emphasis on the exposition of issues regarding the nature and structure of biology itself, rather than on life sciences as a broad theme encompassing agriculture, biology, physiology, zoology, botany, and so on. Biology has simply been extensively used as a good example of the life sciences. In addition, the researcher shows the relationship between biology and natural sciences. Furthermore, the chapter covers both substantive and syntactical structures, the nature of the subject of biology and the importance of natural sciences to the human being.

As a point of departure, we should understand the relationship between biology and natural sciences. This means that there are most certainly specific requirements, principles and characteristics that biology should exhibit in order to qualify as a natural science course or subject.

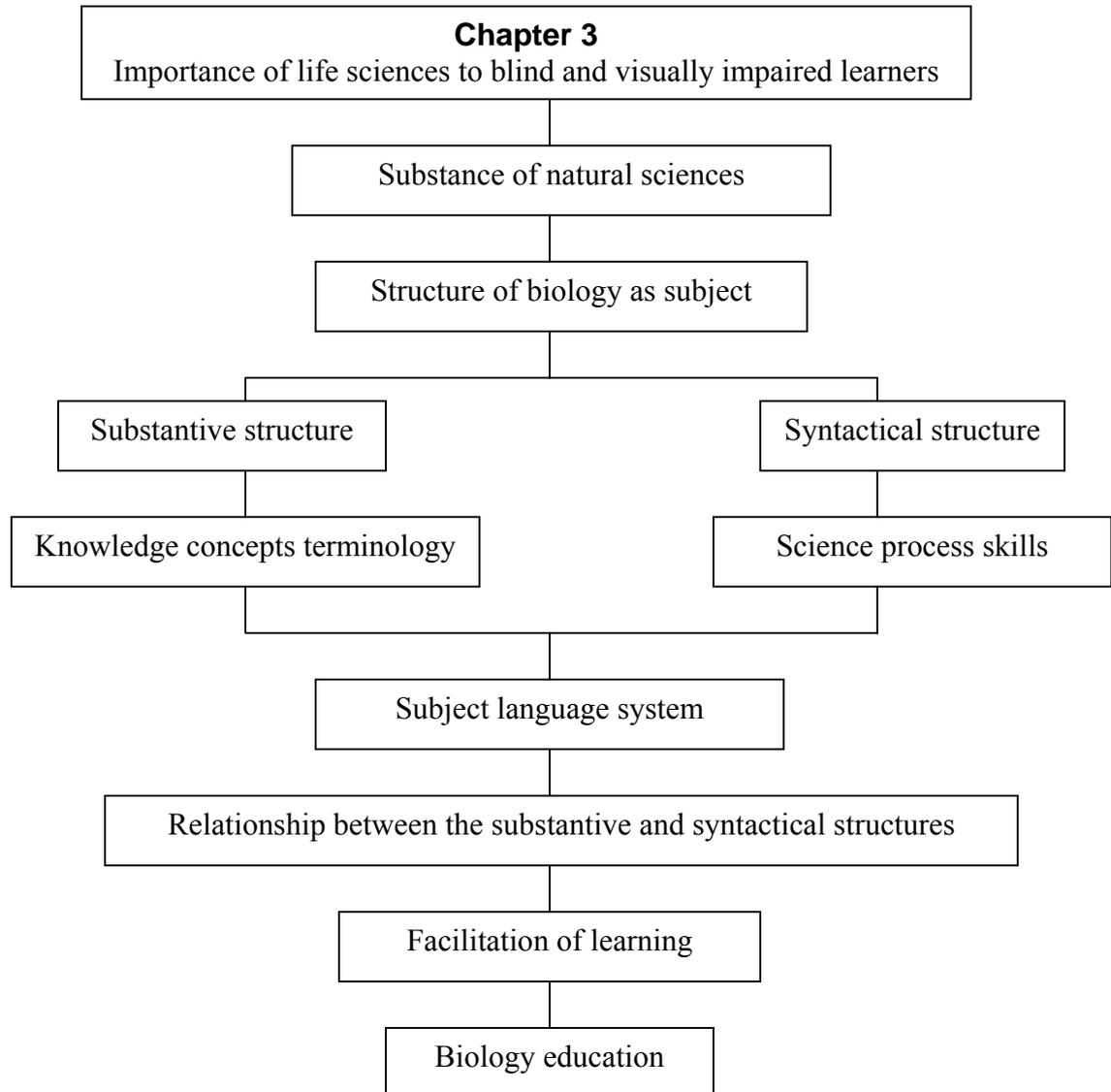
What is biology? Why does it fall under the natural sciences? What role do the natural sciences play in biology? Can biology not be independent from natural science and vice versa? These and other related questions are answered in the discussion that follows.

Liberty Independent Newspaper [s.a] [s.p] argued that natural sciences is the systematic study of the material universe - including natural and human-made environments - as a set of related systems. A variety of methods, that have in common the collection, analysis and critical evaluation of data, are used to develop scientific knowledge.

Collette (1989:5) defined science as a body of knowledge, a way of investigation or method, a way of thinking in the pursuit of an understanding of nature. Science as a discipline is characterised by a body of

information obtained by exacting individuals (scientists) using whatever proof is in existence, specifically the various scientific methods. In reality, quite a number of types of scientific knowledge exist. These include facts, generalisations, concepts, principles, and theories, all of which are subject to error and change.

FIGURE 3.1: THE OUTLINE OF THE ISSUES DEALT WITH IN CHAPTER 3



On the other hand, Carin and Sund (1989:4) defined science as a system of knowing about the universe through data collected by observation and controlled experimentation. As data are collected, theories are advanced to explain and account for what has been observed.

Carin and Sund also made mention of the fact that the true test of a theory in science is threefold:

1. Its ability to explain what has been observed;
2. Its ability to predict what has not yet been observed:
3. Its ability to be tested by further experimentation and to be modified as required by the acquisition of new data.

Owing to the above definitions, the researcher concludes that science is a discipline characterised by inquisitiveness and therefore by many questions that compel scientists to probe into the universe by collecting data, experimenting and observing, in order to expand their scientific horizons.

All science disciplines (physical, earth and biological disciplines) qualify as science disciplines because of the following elements indicated by Carin and Sund (1989:4-5).

(a) Human attitudes:

These comprise certain beliefs, values, opinions, for example, the suspension of judgment until enough data have been collected relative to the problem. The researcher constantly endeavours to be objective.

(b) Process or methods:

This involves certain ways of investigating problems, observing, for example, formulating an hypothesis, designing and carrying out experiments, evaluating collected data, measuring, and so on.

(c) Products:

Facts, principles, laws, theories, for example, constitute these, according to the relevant scientific principle, e.g. metals expand when heated.

Natural sciences encompass three main disciplines of science, namely: physical sciences, earth sciences and biological sciences.

Physical sciences concentrate largely on what Van Aswegen, Fraser, Nortje, Slabbert and Kaske (1993:2) refer to as the “non-living-matter-and-energy universe” and cover both the subjects of physics and chemistry.

The question “what is physics”? might arise here. The researcher considers the following to be a good description of physics. It is the science that concerns itself to a large extent with properties and the nature of matter in general, all forms of energy, and most importantly, the mutual interaction-taking place between energy and matter.

Biology, defined as the “science of physical life of animals (Zoology) and plants (Botany)” (Hornby 1987:82), belongs to the discipline of biological sciences. Its sister subjects are Botany (the study of plants), Zoology (the study of animals) and Biochemistry.

As its principal purpose, biological science studies the structure and life processes of all living things in nature. Van Aswegen *et al.*, (1993:1) asserted that it comprises human activity which is directed towards seeking knowledge about living matter.

Having carefully scrutinised the above definitions of both natural sciences and biology, it becomes evident that they are even more closely related than one might have thought. Biology is a natural science, and

natural science sets norms, standards and values for biology to strictly comply with. Biology, as a part discipline of natural science, has the task of collecting, analysing and critically evaluating data for the major purpose of developing scientific knowledge. Those common methods indicated above, employed by both biology and natural sciences, strengthen and support their relationship and dependency on each other.

3.2 THE IMPORTANCE OF LIFE SCIENCES (BIOLOGY) AND NATURAL SCIENCES TO BLIND AND VISUALLY IMPAIRED LEARNERS AND SOCIETY IN GENERAL

Having perused sources like Collette 1989:5; Wellington 1994:33-34 and the Department of Education Senior Phase Policy Document 1997, the researcher concludes that the following explains the importance of life sciences (biology) and natural sciences to blind learners and society at large. Life sciences (biology) is important to both blind learners and society in general because it is a close and appropriate study of the physical life of animals and plants.

On the other hand, natural sciences is instrumental for:

- (a) The development of appropriate skills, interest, knowledge and attitudes as well as an understanding of the principles and processes of the natural sciences;
- (b) The stimulation of human activity which leads to the development of responsible, accountable, sensitive and scientifically literate citizens who can engage themselves fruitfully and constructively in scientific debates.

Collette (1989:5) is of the view that scientifically literate learners and citizens in general are able to identify that which is supported by strong evidence and that which is mainly speculative; both groups should be conscious of the ever-changing nature of science.

Wellington (1994:33) concurred with Collette when he commented that learners explore the nature of science and are able to distinguish between claims and arguments based on scientific considerations and those which are not (the limits of science) and that they should study examples of scientific controversies and the way in which scientific ideas change.

- (c) Encouraging the public (including sighted and blind learners) at large to participate and contribute in an informed way in democratic decision-making processes. Degenaar (1989:13) indicated that "... students who have progressed through the nation's school systems should be able to use both knowledge and products of science, mathematics and technology in their thinking, their lives and their work. They should be able to make informed choices regarding their own health and lifestyles based on evidence and reasonable personal preferences, after taking into consideration short and long term risks and benefits of different decisions. They should also be prepared to make similarly informed choices in their social and political areas."
- (d) Encouraging people's positive contribution and participation in both creating and shaping work opportunities;
- (e) Equipping people with proper methods and approaches for conserving, correctly managing, developing and utilising natural resources in order to ensure the survival of both local and global environments;

- (f) Providing blind learners and the society at large with direct experiences of natural phenomena as well as of the collection and acquisition of knowledge;
- (g) Helping people organise, and logically and sequentially interpret the information collected;
- (h) Constantly equipping the society itself with innovative, creative and critical thinking skills.

In addition to the above, the researcher believes that natural sciences and life sciences (biology) are also crucial for:

Making blind and able-bodied learners aware of “(t)he benefits and drawbacks of applying scientific and technological ideas” and ensuring that they ... begin to understand “how science shapes and influences the quality of their lives (limits and context)” (Wellington 1994:33).

The benefits of scientific inventions are manifold. One example of the benefits people receive from science is the invention of drugs that prevent unborn babies from being infected with HIV/AIDS. This is but one of the major scientific contributions that has played a role in the development of the world. However, scientific inventions also have drawbacks. Examples would be human cloning and the chemical and biological weapons of mass destruction. In the hands of lunatics, they could be cataclysmic. Through natural sciences and biology, both blind and able-bodied learners could fully develop a knowledge of how scientific ideas change through time. Blind and able-bodied learners are exposed to and are given the opportunities to understand the limitations of scientific evidence and the provisional nature of proof. Natural sciences and biology equip learners with skills that are crucial for examining “the power and limitations of science in solving industrial, social and environmental problems ...” (Wellington 1994:34).

Finally, *Liberty Independent Newspaper* ([s.a.] [s.p.]), suggested that in view of its potential to improve the quality of life, learning in the natural sciences must be made accessible to all South Africans. The investigative character and the acquisition of knowledge in the natural sciences should be mirrored in education. Learners should be active participants in the learning process in order to build a meaningful understanding of the concepts, which they can apply in their lives.

3.3 THE SUBSTANCE OF NATURAL SCIENCE

The field of natural sciences is both intriguing and extremely challenging. It always strove and it still strives to give an in-depth understanding of nature and all its complex phases.

Van Aswegen *et al.*, (1993:2) stated that science will only be a complete discipline if it pays attention to the following three dimensions, namely:

- (i) The body of knowledge (substantive structure);
- (ii) The process by which knowledge is acquired (syntactical structure); and
- (iii) The way of intense thinking that will lead to a better understanding of nature.

3.4 THE STRUCTURE OF BIOLOGY AS A SUBJECT

At this juncture, an attempt should be made to provide answers to the question: how is biology structured? Its structure comprises two major components, namely: its substantive and syntactical structures.

3.4.1 THE SUBSTANTIVE STRUCTURE

The substantive structure entails to a great extent the content of the subject of biology: the body of knowledge that is characterised by the facts, concepts and generalisations of this subject. Collette (1989:5) maintained that a number of types of scientific knowledge exist and that these include facts, generalisations, concepts, principles, and theories, all of which are subject to error and change. These types of scientific knowledge are centred around and depend on and are influenced by "... a way of investigation or method, a way of thinking in the pursuit of an understanding of nature".

(a) Facts

Collette (1989:5) views scientific facts as truth, reality, actuality, and as reflecting the state of things as they are. In a more strict sense, facts are unchanging and indisputable and are a product of a single observation. They are data from the world in which we live.

However, facts are subject to error. Two criteria could be employed to distinguish scientific facts from general or unscientific facts. First, scientific facts are directly observable and can be demonstrated at any time. When these two criteria are applied accordingly and accurately, objective discrimination between facts and relative uncertainties is possible.

Van Aswegen *et al.*, (1993) is of the view that facts should be characterised by:

- Name/s of the scientist/s,
- dates,
- events,
- terminology (etymology),
- conventions,
- taxonomical categories,
- propositions of rules,
- laws,
- theories, et cetera.

The previously stated co-authors (1993:4-5) stressed the importance of facts as an integral element of the substantive component of the structure of the subject of biology when they commented, "(w)hat is of utmost importance about facts is that ... facts, as isolated fragments of information, are meaningless and are not useful to the scientist or science student. Facts must be related to concepts and principles if they are to be meaningful." Facts, as the raw material, trigger the development of concepts and generalisations, which

would eventually attach meaning to the unifying themes and by so doing, promote and enhance a better understanding of nature.

(b) Concepts

What are concepts? Are they of any significance in the structure of the subject of biology? Hornby (1987:175) explained the term “concept” as an idea underlying a class of things, or that it could be a general notion. The researcher believes that this meaning could further be stretched to encompass generalisations of science data and experiences, constructed through the reasoning power and the imagination of the individual, in a continuing attempt to make sense of the object and events around him or her.

Collette (1989:6) wrote, “(a)s facts accumulate, they begin to show certain relationships and patterns. The explicit description of the patterns or relationship is commonly referred to as a concept.” A concept should also be understood as really an abstraction of a class of events, objects or other phenomena having in common particular characteristics.

According to Van Aswegen *et al.*, (1993:5) some constancy or permanency of both an object or event should first of all be identified, with the aim of categorising it into some class. The above-mentioned authors consider concepts to be building blocks for coming to terms with the structure of the subject of biology. Concepts may be either abstract or concrete.

(c) The importance and relevance of concepts

Having read Collette 1989:6 and Van Aswegen *et al.*, 1993:5, the researcher concludes that concepts are important for the following reasons:

- (i) Condensing masses of raw data (carefully selected facts) into more strong and convincing and manageable clusters of information.
- (ii) Concepts play an instrumental role in organising science into a comprehensive description of the world and nature in general.
- (iii) Concepts are important because they serve as springboards for further and future investigations by first verifying and determining the range of concepts and, second, trying to find explanations for the relationships discovered.
- (iv) Concepts make, or always endeavour to make, both predictions and speculations possible.

3.5 SYNTACTIC STRUCTURE OF THE SUBJECT OF BIOLOGY

A clear distinction has to be made between syntax from the linguistic point of view and syntax from the biological point of view. The former implies sentence construction, while the latter implies the description of the way in which the knowledge (substantive structure) of the subject is obtained. Both kinds of syntax are governed by ground rules.

The syntax of the subject of biology involves both the methodology and processes of the subject. This structure contains certain competences that have to be mastered. Van Aswegen *et al.*, (1993:6) aptly stated,

“(a)ll competencies described by Gardener (1975:8) have their foundation in another more basic and fundamental classification.” Stemming from this classification, the researcher distinguishes three kinds of competences, namely: sensorimotor skills, cognitive skills and techniques.

Biology, like any other subject or course, should act in accordance with all principles as laid down by the discipline itself. However, cognisance should be taken of the fact that biology possesses its own unique nature and structure, which gives it its distinct character from any other science. Van Aswegen *et al.*, (1993:3) state that the nature and structure of biology should not be tampered with. It should instead remain intact and its nature has to be reflected during learning mediation.

In reality, it is the nature of the subject that makes it teachable, understandable and learnable. Van Aswegen *et al.*, (1993:3) argued that without thorough knowledge of the structure of biology, it cannot be taught and learned according to the requirements it sets.

Additionally, the above authors (1993:3) are also of the view that no methods linked to biology are complete without a substantial devotion of effort to the development of some appreciation of the structure of biology as it is related to teaching. The researcher concurs.

Biology was and is still able to explain and predict scientific findings and the data acquired. Wellington (1994:33) argued that biology as a science subject is further characterised and affected by its social, moral, spiritual and cultural contexts. It is a subject that can thoroughly analyse the power and limitations of science in solving industrial, social, economic, technological and environmental problems. It is explorative in nature, hence claims, counter-claims and arguments based on scientific considerations and those which are not, can be distinguished.

Apart from the above-discussed features, this subject possesses other equally important features, namely: extensive and intensive testing, observation, evaluation, assessment and discovering. In very unsophisticated terms, the nature and structure of the subject biology could best be described as the collection of data and objective knowledge, obtained through tested and retested processes which always appear to be reliable; but this is in one way or another, subject to continuous change because of the never-ending search for meaning, further evidence and at times the solution of scientific puzzles.

3.5.1 SENSORIMOTOR SKILLS

Carin and Sund (1989:22) consider a sensorimotor child as someone who is stimuli-bound and as a result would not be able to imitate and initiate internal thoughts. According to these authors, a sensorimotor child who is both stimuli-bound and is also unable to imitate and initiate internal thoughts, will not or will to a lesser extent develop basic scientific skills, because the physical environment is the provider of such skills. The under-development of those skills hampers, at a later stage, the development of advanced science skills, since basic science skills serve as the foundation of advanced science skills. For children to internally imitate and initiate thoughts, they have to start building their own “... structures of thoughts”.

Learners will only be able to learn and internalise biology thoughts if they are able to actively, purposefully and meaningfully interact with stimuli from the physical environment, so as to internalise those acquired thoughts. As a result, the blind learners' remaining senses need to be used to gather instrumental information.

The above authors (1989:22) further noted that through physical action, children slowly construct physical knowledge and begin the life process of developing action schemes. Those schemes help them adapt their behaviour so that they can interact more appropriately with their environment. Lack of visual ability deprives the blind learner of the opportunity to interact comprehensively with the environment. Due to this, the blind child's physical actions will be limited and often impeded by the lack of visual ability. As such, according to the researcher, the development of the blind child's action schemes will be much slower than those of the sighted child. The blind learners' interaction with the environment will, as a result of the lack of visual ability, not always be carried out appropriately. The blind child's remaining senses will not be in the position to accumulate all the information the mind clearly needs in the construction of schemes, and in the interpretation and integration of the acquired information necessary for perceptual depth.

Carin and Sund (1989:22) argued that Piaget believed that cognitive mental structures originated from physical action. These co-authors, in support of the previous statement, wrote that children later use what they have learned to solve practical problems. As they develop and use their minds, children are finally able to recall mentally. This is how all children, including blind children, should begin to acquire basic science skills.

Sensorimotor skills play a cardinal role in the acquisition of basic science skills, leading to both the acquisition and, most importantly, the integration of information or knowledge. Sensorimotor skills entail all the primary reception of sensory impressions from the environment, including looking, hearing, touching, feeling, tasting and smelling and the execution (expression) "...(o)f the most basic spontaneous motor movements" (Van Aswegen *et al.*, 1993:6).

3.6 THE SCIENCE PROCESS SKILLS IN THE LEARNING MEDIATION OF BIOLOGY

In order to understand the importance of the science process skills, terms such as process should be explained. The term process here refers to the development of or a practice leading to a course of action. In addition, Van Aswegen *et al.*, (1993:15) maintained that the term "process" encompasses the mediation which is in line with what scientists do mainly, that is, the processes they carry out in their own scientific activities. Through this process, scientists gain valuable information through observing, classifying, inferring, measuring, using space or time relationships, using numbers, communicating, hypothesising, and performing experiments. According to Erwin *et al.*, (2001:338), "(s)cience is an exciting process that involves observation, discovery, critical thinking, and reflection about the environment. Science education presents the opportunity to forge an interactive relationship between children and the world around them."

These authors further stated that “(i)f the primary focus of science education is to help children make sense of their world then teachers have an enormous responsibility to design learning opportunities and experiences that foster children’s natural inquisitiveness and thirst for knowledge.”

In support of the above perception, Van Aswegen *et al.*, (1993:15) commented that “process” refers to human intellectual development, which involves the complex way of thinking characterised in the individual’s growth, encompassing all concrete and abstract knowledge. Furthermore, of great significance to the present study, these authors (1993:15) indicated that the process approach makes it possible for all learners to “... develop a sound knowledge of science and its methods.”

In addition, Erwin *et al.*, (2001:339) commented that learners who have acquired basic science process skills “... (h)ave positive, frequent, and successful experiences in science that will allow them to explore, discover and ask questions about the world in which they live, so that they can develop deep respect not only for the environment in which they live, but all living things.”

Basic science process skills are a prerequisite for advanced science skills, which, in the researcher’s view, should be phased in and integrated only once the learner has mastered the basic process skills.

The researcher views the commencement of the learning of basic science skills, through sensorimotor and cognitive skills, as of great significance because this leads to the development and enhancement of other advanced science skills such as discovery, observation, inquiry, investigation, experimentation, analysis, measurements, prediction, problem-solving, evaluation, and so on. As pointed out by Land and Fotheringham (1999:70) these skills influence learning mediation because, if both science educators and learners are unable to direct and monitor Outcomes-based Education activities, especially at special and inclusive schools, they will fail dismally to control the learning mediation that is supposed to happen. This also means that scientific errors may not be instantaneously corrected. As such, learning will be negatively influenced.

This further means that some of the aspects of learning formulated with unambiguous purposes of learning mediation might not be realisable, or effectively used in the science curriculum and assessment. Van Aswegen *et al.*, (1993:14) in support of the previous statement remarked, “... (e)ffective biology teaching and learning is only possible if both the product and process dimensions of science are stressed.” The aspects indicated above include but are not limited to: the nature of science, the need for science education, the approach to science education, and the essential science competences, attitudes and values which learners in the Natural Sciences should acquire and develop.

The researcher concludes that a failure in the acquisition and development of science attitudes and values will result in blind learners being not able to make an effective and positive contribution to education and biology as a discipline. All learners’ acquisition of knowledge and conceptual development will be hampered. If this keeps on happening, it will then be extremely difficult to challenge the perception that biology is predominantly a sighted discipline. Furthermore, Outcomes-based Education and Training, as outlined in the *Curriculum 2005 Lifelong learning programme for the 21st Century* (1997:9), would not be

realisable. It should be borne in mind that Outcomes-based Education and Training aims at increasing the general knowledge of the learners as well as developing their skills, critical thinking, attitudes and understanding. As a result of this, too many blind learners would be “...(d)eprived of too much for too long” (*Curriculum 2005 Lifelong learning for the 21st century* 1997:9).

This further means that if blind learners do not acquire basic science process skills they will only possess superficial knowledge instead of a knowledge that is profound. For example, let us just imagine how gratifying, informative and edifying it is for a sighted learner to visually experience the movement of a frog jumping, a bird flying, a fish swimming in the water, a flower bud opening, et cetera. This will unquestionably give the sighted learner an edge over the blind learner during the learning mediation of life sciences (biology) and will further result in blind learners lacking scientific experiences and data gathered through observations, predictions, experimentation, measurement, problem-solving, communicating, inferring, evaluating, et cetera. Lack of basic science process skills will deprive blind learners of the stimulation and motivation which are crucial during learning mediation. Lack of these skills will deprive blind learners of the enhancement afforded by the provision of inquiry activities that are crucial for helping all learners to develop problem-solving skills.

Problem-solving skills are crucial in science because learners become creative, initiative and innovative. Authors such as Van Aswegen *et al.*, (1993:14) and Erwin *et al.*, (2001:339) argue that these skills enhance the development of higher thinking skills in learners; thus, the main goal of biology teachers should be to make pupils effective problem-solvers. These authors state that biology inquiry activities help learners enormously to develop questioning and problem-solving abilities in a methodical, scientific manner, through the use of science process skills.

Blind learners always enjoy investigation if and when material is accessible and the climate is also favourable. In support of this argument, Erwin *et al.*, (2001:351) commented as follows: “(o)ne of the most important responsibilities that teachers of students who are visually impaired is to create a climate of inquiry that is both accessible and meaningful for all the students. Given that children learn by doing, they need multiple and consistent opportunities to engage in hands-on, cooperative, and fun activities that are driven by their own interests and questions. Creating an accessible and meaningful learning environment that balances student-driven and teacher-guided opportunities enables children to follow their own natural curiosity and assume responsibility for their own learning. When children are active participants in their own learning, important science-related outcomes can be achieved. These and other skills are vital because they serve as the knowledge base that children can use throughout their lives.”

Basic science process skills are essential because they enable learners to acquire the necessary background knowledge and experience to understand the purpose and procedure of practical work, which also encompasses the performing of experiments. Therefore, when conducting experiments, according to Erwin *et al.*, (2001:348) educators should encourage blind learners to “... decide for themselves the ways in which they wanted to experiment with the materials, by saying “you can decide what you want to do” or “what would you like to do to finish this activity?” Such learners are able to make meaningful decisions about their own learning. In addition, learners are encouraged to ‘have a say’ and to give voice to their own

opinions, engaging in what often appeared to be a classroom in which children's voices, strengths and wishes are ... taken seriously."

In addition, Van Aswegen *et al.*, (1993:151) strongly believe that learners equipped with basic science process skills are able to determine the validity of the explanations that are in the process of being formulated.

They maintain that such skills further help learners to:

- Be able to give practical meaning to practical science activities;
- Be curious and knowledgeable about recent issues and problems;
- Use each others' comments, questions and activities as possible resources to motivate each other.

Basic science skills also have the ability to make learners curious and as a result, to follow up on this.

Learners are therefore more willing to work, as "... (o)pposed to mainly giving them instructions" (Van Aswegen *et al.*, 1993:14).

Basic science process skills, according to the above mentioned authors (1993:14), have the ability to address the unique needs of the learners (very important for blind learners in an Outcomes-based Education and Training classroom) "... (a)s they become adults functioning in and shaping society." These skills help learners in the acquisition of "... (f)acts that inspire imagination, reflection and investigation in science classes" (Van Aswegen *et al.*, 1993:14). The acquisition of these skills helps and encourages learners to develop critical thinking skills and increase their understanding of the "... social, technological and natural environment in which they live and work" (Van Aswegen *et al.*, 1993:14).

Furthermore, blind learners should strive to acquire such skills, as failing to do so would have an effect on their mastery of concepts, as it is believed that they master ideas by being involved in activities and that they could learn successfully by practising. It is argued in the Senior Phase Policy Document (1999:9) that learners should be active participants in the learning process in order to build a meaningful understanding of concepts which they can apply in their lives.

Blind learners could be active participants if they occupy themselves in the following basic science process skills or activities:

(a) OBSERVATION

Observation is the cornerstone of the basic science process skills. It involves collecting data, observing the process, observing the product, conversing and conferencing, and organising the collected data.

Observing the process

When one observes the process, one does so driven by intuition and as a result, one wants to give a response to the process observed. Observation might be done spontaneously or deliberately. Engelbrecht, Green, Naicker and Engelbrecht (1999:117) state that a deliberate observation is a conscious analysis where we

question our snap judgments and plan ways of verifying or negating them, rather than jumping to conclusions without real evidence.

Carin and Sund (1989:4) took this argument a step further when they maintained that processes are ways of investigating problems, observing, formulating hypotheses, designing and carrying out experiments, evaluation of collected data, measuring, and so on. Furthermore, this entails demonstration of an event or activity, from which and about which the biologist learns.

Both blind and able-bodied learners and scientists alike are able to reflect on the process observed and, by so doing, they gain the gist of what has been noticed; hence, patterns of performance begin to be recognised. Engelbrecht *et al.*, (1999:117) are of the view that in an inclusive classroom or Outcomes-based Education classroom, observation should become a deliberate, skilled tool - a conscious gathering and systematic recording of information in class. Metaphorically speaking, observing the process should strive to sharpen the totally blind learners' eyes, their ever-interested ears and most importantly, inculcate a sound memory in order for observation to be relevant and worthwhile doing.

Engelbrecht *et al.* (1999:118) further held that observing the process should encourage all learners (the totally blind included) to:

- (i) Look until they see or notice.
- (ii) Listen until they thoroughly hear.
- (iii) Discuss until they know and thoroughly understand.

Erwin *et al.*, (2001:343) challenge and encourage blind learners to persist in trying "...(e)xperiments in spite of unexpected outcomes or wrong turns. Persistence is also evidence of meaningful engagement and active participations." Furthermore, these authors (2001:344) maintain that inquiries instil in learners "...(a) sense of pride in their work and their discoveries."

Observing product

Product comprises facts, principles, laws and theories. The things that are done or created are the source of vital information. They, in most instances, reveal patterns, style, form, character, nature, structure, type, quality, shape, appearance, et cetera, that the scientist wishes to know, learn, understand and correctly apply in life sciences/biological activities.

Conversing and conferencing

In the researcher's estimation, constructive, enriching chats with peers in the same discipline offer people ample opportunities of collecting data. People discover what others think and know through positive and constructive talking. Conversing and conferencing could provide a researcher with a wealth of information about developments in the discipline. Interpersonal relationships comprise one of the best ways to keep abreast of developments in one's field. They promote like-mindedness, the sharing of vital information and of resources available to colleagues. They stimulate interest and constructive discussions based on the discipline. This researcher, for instance, could obtain clarification of issues through contact with colleagues.

Organising the collected data

It is mandatory that data collected should be organised, logically, sequentially and meaningfully. The organised data will help the researcher in making informed decisions and reaching sound conclusions. In addition, the researcher is more likely to make correct evaluations.

As indicated above, observation involves noticing facts or finding out about matters. Therefore, in the biology context, the biologist should observe natural phenomena. The natural science outcome in the Senior Phase Policy document (1999:11) urges all learners to use observation, which is one of the basic science process skills, to investigate phenomena related to the natural sciences. By so doing, learners will be able to demonstrate an understanding of biology concepts and principles, and acquire knowledge in natural science and biology in particular. Furthermore, this skill should encourage learners to constantly, resourcefully and significantly apply scientific knowledge and skills to problems of any nature and complexity in innovative ways. The previous statement has been fully supported by Van Aswegen *et al.*, (1993:6) who assert that scientific knowledge is about the sensible world, originates in science experience and is ultimately tested against the standard of science experience. Furthermore, they are of the view that thinking in biology begins, continues and ends in the area of observation.

Land and Fotheringham (1999:71) pointed out that observation will only be possible and learners will learn best when their needs, concerns and issues, which are important to them, are addressed. Emphasising this point, they claimed (1999:71) that, in that way, learning would become meaningful and relevant. Life sciences (biology) educators should endeavour to address the blind learners' needs, concerns and issues so that observation does become meaningful to them. The observation should be adapted in such a manner that the blind learner is active.

Observation as one of the basic science process skills is the initial step in the chain of events. It precedes leading scientific discoveries. Observation employs all senses in its quest for scientific discoveries, namely touch, sight, hearing, taste and smell. Observation concentrates on the identification and classification of the objects or processes under investigation into known categories. Through observation, scientists are able to distinguish and systematise the scientific data obtained from such observations.

Blind learners learning life sciences (biology) in an Outcomes-Based Education and Training classroom could observe to a limited extent, from either a natural (spontaneous) or experimental point of view. Van Aswegen *et al.*, (1993:15) asserted that natural or spontaneous observations are aimed at the identification of general elements in a natural environment without being contaminated by natural manipulation or other limiting control measures. Through natural observations, blind individuals will be able to record similarities and differences between organisms, samples and populations. Blind learners could also, through adapted devices, measure and count. Experimental observations take place in scientific environments. Such observations are characterised by testing hypotheses "...under experimental conditions involving different variables" (Van Aswegen *et al.*, 1993:15).

Both natural and experimental observations improve learners' ability in the following manner:

- ❑ Natural and experimental observations improve accuracy if what is being observed proves to be accurate;
- ❑ Learners are able to decide whether the data that is to be observed is relevant or irrelevant;
- ❑ Observations give learners the opportunity to observe the actual objects;
- ❑ The selection of practical work, new experiments, et cetera, relating to the past experiments and experiences (prior knowledge), enables learners to comprehend science more fully than before as this fosters an understanding of the things to be observed;

Observation enhances and stimulates interest because learners experience, experiment and investigate in a challenging and interesting way. Further, as far as the importance of observation to learners is concerned, Van Aswegen *et al.*, (1993:16) mentioned that learners will "... find an experiment or investigation interesting if it is understandable, has importance, is useful to them and stimulates or satisfies their curiosity."

The biology educator should undoubtedly endeavour to make the goal of observation to all learners as clear as possible. If biology observation activities are adapted, and the learners are aware of the different biology goals, blind learners in an Outcomes-based Education and Training environment will be able to demonstrate and contribute through their scientific understanding the proper management, development and utilisation of natural/biological and other resources. Adapted scientific observation would enhance blind learners' opportunities to support decision-making. Observation should concentrate and promote meaningful learning mediation, which is characterised by in-depth knowledge, the application of that acquired knowledge, awareness of the relationship between science and other learning areas, and so forth. Observation, which is important for learning mediation to take place, should include a variety of skills, specifically seeing, listening, speaking, smelling, writing, and so on.

This will however, depend on the type and nature of observation. In most observations, the educator should be the facilitator. Observation should be done in a professional and accommodating manner so that it will inspire confidence in the blind learner, who will therefore be able to demonstrate an understanding of the changing and ferociously contested nature of knowledge in the life sciences.

Observation, because of its significance, should employ all the senses of a human being. The importance of senses in observation cannot be accurately over-emphasised. Pauw (1990b:20-21), in order to show the importance of observation, cited the following: "...(i)n taking its first breath, a baby immediately has the ability to make contact with its environment through its senses: The central nervous system of the human organism is so constituted that it experiences a continuing hunger for stimulation through the sense organs in order to establish contact between the body and the external surroundings."

Pauw (1990b:21) further pointed out that "(a)s sensory experiences are repeated, they begin (vaguely at first) to acquire meaning (perception)." Gradually, perception becomes involuntarily grouped and stored in the memory (conceptualisation).

The question that needs to be answered is: how can observation be effective? Only if relevant, observations are made in both breadth and depth. Further, observations are effective if and when learners are able to demonstrate an understanding of the interaction between the natural sciences and socio-economic development. As a prerequisite for observation, life sciences/biological issues have to be communicated in great detail in order for biology to have significance for and contribute to society in general, above all amongst those who study science in particular.

(b) USING SPACE OR TIME RELATIONSHIPS

Pauw (1990b:156) commented that all objects which people observe, experiment on or investigate, including fixed and unfixed objects, are in spatial relation to each other. He further pointed out that everything that people observe or accept, as material reality exists in space. Even human bodies are surrounded by space. And, as such, our bodies feel part of space itself.

Erwin *et al.*, (2001:344) concurred with Pauw when she too maintained that blind learners make important connections to the world in which they live in many ways. They not only master the new vocabulary associated with the activities, but they often generalise the new vocabulary and concepts across time and contexts.

Objects that are in space are near, far, higher, lower, before, behind and next to other things. In addition, Pauw (1990b:156) maintained that space includes what is alongside and close to us, but also what is far and even at infinity. Blind learners should be encouraged to employ the use of investigation and the use of shapes, direction and spatial arrangements, motion and speed, symmetry and the rate of change during biology learning mediation.

Blind learners could find the above-mentioned process to be useful in the study of the shapes of plants and animals, changes in positions, movement of objects or the determination of the speed of motion in various directions. Blind learners might, however, encounter technical hitches when it comes to spatial awareness, as visual ability is in most instances the right tool for recognising and determining space. According to the researcher, the ear also plays a meaningful role in spatial awareness. However, for it to work appropriately, audible disturbances of any kind should be avoided, minimised or eliminated.

It should be understood that blind learners do not experience things in the same way sighted learners do. Exceptional methods such as walking short distances, feeling objects, using ladders to reach out to high objects, using tactile maps and tactile graphics, could for example be employed so that blind learners can become aware of the space in which they live. as pointed out by Pauw (1990b:162) biology educators should help blind learners to become acquainted with the environment themselves. But the environment should be such that it encourages them to do so. Sometimes the environment has to be structured in order to stimulate the children.

Space should encourage and allow blind learners to constantly search for more scientific knowledge by independently moving around in different conditions and environments. Moving around enhances

exploration because blind learners “...(a)lso discover objects which they were not looking for” (Pauw 1990b:163).

Siekierska *et al.*, (2003:491) pointed out that the availability of tactile and audiotactile maps is crucial for enabling blind and visually impaired learners to understand and make use of geospatial information. Tactile maps and graphics are therefore important mediation tools because of their ability to encourage and allow blind and visually impaired learners to obtain images of the world, thus becoming acquainted with the changing (geographic and spatial) realities. They argued further that ideally, all of the types of maps available to sighted users should also become available in the tactile format, including thematic, reference and mobility maps. Reference and thematic maps are required for educational purposes (primarily for children but also for adults).

Maps could significantly help blind and visually impaired learners, because these learners would under normal circumstances have no access to standard learning mediation aids, including maps and atlases, to learn subjects such as geography and earth sciences. These co-authors further noted (2003) that in addition to helping one to learn about distant environments, tactile maps could also provide blind and visually impaired learners with the proper development of an understanding of their immediate surroundings. Mobility maps, for example, could help learners navigate both interior and exterior environments by depicting the space in a simplified, readable format that includes the necessary location cues. The use of geospatial technology can help blind and visually impaired users become aware of their immediate environments and live more independently by allowing them to negotiate these environments without assistance. These environments need not only be those pertaining to a user’s residence or place of work. Visually impaired tourists, for example, would also benefit from tactile maps of their destinations. Maps make it easier for learners and other users to learn spatial information by encouraging interaction with the maps themselves. Finally, tactile maps allow blind and visually impaired learners “...(t)o access the vast amount of real-time data that are available to sighted persons ...” (Siekierska *et al.*, 2003:491).

Blind learners should also understand the use of time, as time controls our daily activities. Pauw (1990b:166) stated that “(t)he organisation of modern society depends on detailed timing.” Educators should expose blind learners to situations where they will become familiar with time through experience. Biology educators should use Braille or talking watches when timing is needed for certain experiments to be conducted. Blind learners can discover time in various ways. Sounds, weather, distance, et cetera, could help them discover time. Awareness of agricultural products, birds, traffic congestion, rain, snow, wind, could tell blind learners whether it is during the day, during peak hours, during the night, whether it is winter, summer, autumn, or spring. Blind learners can understand that time is constituted by events/concepts such as now, then, when, before, after, immediately, later, et cetera. Time could be learned in two ways, namely the sequence of events in time and duration. Pauw (1990:166) argued that blind learners in both cases (sequence of events in time and duration) are part of the experience, just as sighted learners are.

(c) USING NUMBERS

According to Van Aswegen *et al.*, (1993:16) educators should make blind learners aware that numbers form an integral part of any scientific activity. Blind learners should be encouraged to use numbers when measuring in home environments, school environments, social environments, scientific environments, et cetera. Measuring involves counting, drawing graphs, classifying objects, or working out equations. Blind learners should be trained to use numbers “...(b)efore they are needed for exercise in the other processes” (Van Aswegen *et al.*, 1993:16).

(d) MEASURING

Measuring will allow blind scientists to express their observations in more precise terms. Measuring is crucial for scientists because they acquire quantitative data, “...(w)hich can be dealt with graphically and statistically” (Van Aswegen *et al.*, 1993:16). Blind learners should be provided with tactual, Brailled or voice synthesised measuring instruments in order to be able to perform scientific measuring tasks. In all situations, quantitative data are based upon scientific measurements through the use of measuring devices with equal intervals.

According to these authors examples of quantitative data include the reaction rate of enzymes in seconds, the mass of rabbits in kilograms and the temperature of water in degrees Celsius. Blind learners, like their sighted peers, in order to acquire this basic science process skill should “...(b)e given practice in quantifying their observations by using the proper measuring device” (Van Aswegen *et al.*, 1993:16).

(e) CLASSIFYING

Blind learners should be taught how to group together objects, organisms, events or ideas in terms of selected features or criteria. By so doing, blind learners will be able to arrange, group or classify objects. For example, blind learners could group air, water, road and rail transport by sound, plants (for example citrus trees or flowers) by smell, animals by odours or the different sounds they make, or fur and fabrics by texture, scientific apparatus by size and shape, et cetera. It should be emphasised to blind learners that classification is crucial for bringing order to their inquiries about nature. They should also be involved in both formal and informal classifications.

Formal classification involves the sorting of organisms into groups on the basis “...(o)f their overall evolutionary relationships” (Van Aswegen *et al.*, 1993:16). On the contrary, informal classification is based on non-evolutionary considerations or on one or a few characteristics, for example, “...(t)he characteristics used to describe leaves, compound, lobed, serrated or simple” (Van Aswegen *et al.*, 1993:16).

(f) COMMUNICATING

Blind learners should continuously be encouraged to communicate about what they do and what they observe to fellow learners and their teachers. They should be given unrestricted opportunities to think, analyse and communicate their thoughts in spoken and written words, diagrams, drawings, graphs, illustrations, pictures and mathematical equations. Thoughts could be communicated on an individual or group basis.

(g) PREDICTING

Prediction, to scientists, is of immense importance because they ask themselves questions that trigger predictions. Predictions are the results of people beginning to wonder about observations and measurements. Predictions also encourage validation. Blind learners should be encouraged to predict and verify or validate what they predicted.

(h) INFERRING

Inferences are valid explanations or interpretations, based on observations, for making proper connections with other ideas or information. Inferences as basic science process skills, according to Van Aswegen *et al.*, (1993:16) are effective in motivating and stimulating learners to think clearly, logically and meaningfully when making observations.

When learners have acquired and mastered basic science process skills, they should be introduced to sophisticated skills (advanced) skills, which integrate basic science process skills and significant complex skills. These skills are useful to Senior Phase and Further Education and Training Band learners. For a learner to meaningfully use these skills, s/he should be cognitively developed. Through these skills, learners are able to arrive at operational definitions and state problems. Learners who have mastered these skills are able to learn, identify, distinguish and interpret definitions that are functional and those that are non-functional.

Advanced science process skills are essential because they equip learners with the ability to communicate and reason both logically and scientifically, "... using terms that have definite operational meanings" (Van Aswegen *et al.*, 1993:17). These authors further argue that these skills assist learners to identify, explain and mention what they regard as being necessary conditions for an experiment in order for the experiment to be repeated successfully. It is further argued that if learners encounter educational as well as scientific problems, those learners will develop the ability to construct operational definitions in problems that are new to them.

Furthermore, worth noting is that learners, as future scientists, formulate hypotheses characterised by explanations and theorems of what they think the outcomes of their research will be. Learners who have acquired advanced science process skills are able to speculate or assume. They then test all their assumptions/speculations through experimentation. Tests are done in order to verify or falsify speculations through the evidence obtained, which either supports the hypothesis or does not.

Blind learners should be able to interpret collected data on their own or be helped by peers. They should become used to both qualitative and quantitative data. Interpretation as an advanced science process skill enhances the learners' ability to determine the validity of a hypothesis. This skill accords the blind learner the opportunity to organise information logically and sequentially. The end result is generalisations supported by experimental findings.

Learners with advanced science process skills are in a position to control independent/manipulated, dependent/responding and controlled or fixed variables. Independent/manipulated variables are always expected to produce outcomes. They are deliberately controlled because they are always under the control of the experimenter. They are independent of dependent variables.

What characterises dependent variables is their dependency on the treatment they receive. In other words, dependent variables represent the outcome/effect in response to the treatment or cause. On the other hand, fixed variables are characterised by conditions which could in many ways affect the outcomes of experiments but do not actually affect them because "... they are deliberately held constant" (Van Aswegen *et al.*, 1993:17). Blind learners should acquire both basic and advanced science process skills that will help them to grow mentally: an element crucial for identifying, quantifying, qualifying, verifying, interpreting, analysing and explaining data.

Blind learners should experiment, since experimenting is the ultimate process that combines basic and integrated science process skills. Blind learners should be encouraged to compile and submit written reports, assignments, homework, classwork, exercises and projects. They must strictly follow the steps sequentially, including stating the problem, formulating a testable hypothesis, identifying and controlling variables, making observations and measurements, interpreting data, communicating procedures and drawing tentative conclusions. However, it should be borne in mind that their lack of visual ability will adversely limit the experiments they can conduct.

It is stated in the Senior Phase Policy Document (1999:32) that advanced science process skills provide learners "... (w)ith opportunities to acquire, develop a range of more advanced knowledge, understanding and skills". Furthermore, these skills ensure that learners are given "... (a) sound basis from which to take advantage of choices ...". According to the researcher, these skills have the capability to motivate learners to perceive objects in broader, deeper, more analytical and meaningful ways. They take learners to a scientific destination where their knowledge of scientific options is evaluated.

In addition, it is maintained in the above-stated work (1999:32) that this is done to ensure that the scientific decisions at which these learners will arrive concerning their future choices, are informed ones. Advanced science process skills make it possible for learners to become more self-reliant and clearer about their own scientific aspirations. These skills consolidate, reinforce and support the observational, experimental, analytical, problem-solving, hypothesising, measuring and innovative abilities of learners.

Learners with these skills mature cognitively and also develop self-reliance. This is due to the development of abstract thinking. The Senior Phase Policy Document (1999:33) aptly stated that learners have to concentrate on thinking in abstract terms and in terms of hypotheses and on the use of lateral reasoning. At that level sophistication of thought processes really begins and with appropriate support, the learner could analyse events and have some understanding of probability, correlations, combinations, positional reasoning and other higher-level cognitive skills.

In instances where the sensorimotor skill is guided by thinking (the mind), the process encompasses cognitive skills. For example, seeing is, a cognitive skill since what we perceive (perceptualisation) is both guided and interpreted by the mind. That is, the cognitive skill enables learners to learn and interact positively in an environment comprising both direct exposure to stimuli and Mediated Learning Experiences. This skill further enhances the learners' ability to mentally digest information in a more sophisticated manner. Van Aswegen *et al.*, (1993:14-16) further elaborated that the more complex cognitive skills such as classification, for example, are derived from a combination of sensorimotor skills, such as looking at objects as well as touching them, with the aim of putting them into groups.

Feuerstein (2001:4) believed that cognitive skills have the power to empower people mentally because they enable individuals to acquire behaviours, learnings and operative structures that allow those individuals to enjoy “...(t)he greatest benefits from direct exposure.”

The cognitive skill plays a paramount role in all learning areas. How the learner interprets, processes information, integrates information, attaches meaning, associates or classifies types of information, and so on, reveals to the educator an idea of the background knowledge comprising the basic science skills the learner possesses in a subject, the rate and level at which the learner is able to express the subject's principles, the learner's intentions about the subject, the learner's general attention, how the learner could be evaluated or assessed, and the progress the learner is making in that particular subject.

To all learners, the physical environment is the source of vast unrefined information. Pauw (1991c:92-93) observed, “(t)he brain receives information (data) from the outer environment by means of the sensory organs and interprets it partly as a result of data previously received and registered. The registration and reactions of the brain constitute what is known as the perceptual process.”

Therefore, the researcher regards perception as the conscious deliberate mental registration of a sensory stimulus. After an individual has perceived, what follows next is conceptualisation, depending largely on the ability of the brain to both process and integrate data. Van Aswegen *et al.*, (1993:7) stated, “(t)he complexity of the thinking activities which have to be executed determines the complexity of the cognitive skill.” It is also possible for the cognitive skill to consist only of an activity of the mind and in no way to have a complementary sensorimotor skill to accompany it.

It is also indicated in the Senior Phase Policy Document (1999:33) that learners with advanced science process skills have the ability to perform controlled experimentation. Furthermore, they are able to hypothesise variables before experimentation, in order to “...(r)everse direction between reality and possibility.” They could, in addition, “...(u)se operations, combining propositions by conjunction, disjunction, negation and application.”

These skills ensure that learners remain focused as far as their attitude, development and understanding towards science is concerned. They also know and understand the special role they should play as young and budding scientists. In the researcher's view, these skills make learners aware of scientific challenges and aspects having an influence on scientific concepts.

Advanced science skills enable learners to learn by “using” rather than only “knowing” what is theoretical about objects. Some of these skills, more especially for the blind, encourage the determination and recognition of their needs, concerns and challenges. If blind learners’ needs are met, concerns and challenges addressed, learning mediation takes place accordingly.

Other advanced science process skills learners should acquire are called techniques. Techniques should be understood as mechanical skills executed when for example, a technological instrument, apparatus or machine is used as an extension of the human body. A microscope, to cite just one good example, extends the optical observation of people and includes the sensorimotor skill of perception and the cognitive skill of registering and interpreting what has been seen. Van Aswegen *et al.*, (1993:6) pointed out, “(T)he technical manipulation of the instrument, apparatus or machine is added as a cognitive skill to form a technique.”

It should always be borne in mind that inclusive education is constituted by able-bodied individuals, as well as by differently-abled, such as blind, learners. Engelbrecht *et al.*, (1999:72) observed that “(l)earner diversity is inevitable in any classroom and teachers can expect variation in the pace and style of learning.” They added, “(i)n the inclusive classroom some learners have special educational needs for a variety of reasons, either intrinsic or extrinsic, which have to be accommodated. There may be learners with physical or sensory disabilities who require assistive devices in order to learn.” Through the inclusion of blind learners in an Outcomes-based classroom, they might or might not, depending on circumstances, develop useful skills and life sciences (biology) concepts that could to a great extent assist them in living more productive lives.

An educator faced with this situation has to cater for these individuals in such a way that all benefit equally. This means that, for the blind person to learn and develop the advanced science skills referred to above, s/he should be exposed to and be provided with special modified learning mediation material. According to the researcher, modifications are of cardinal importance because they make the facilitation of learning or learning mediation by blind learners effective, goal-directed, meaningful, idealistic and so on. Blind learners learn and benefit from reading machines, talking machines, speech-time compressors, paperless Braille machines for taking notes, talking calculators or talking science apparatus. Collette (1989:282) maintained that blind learners learn and develop advanced science process skills through both the materials and experiences that are commonly used in hands-on approaches during science teaching and learning mediation.

Blind learners also learn and enjoy the psychosocial atmosphere of both special and inclusive schools, as well as classes which do not in any way hinder but rather promote successful life sciences/biology facilitation and learning mediation by providing a safe and ever-supportive atmosphere where all learners are prepared to take life sciences/biology risks and “...(l)earn from their own mistakes without being reprimanded or ridiculed” (Engelbrecht *et al.*, 1999:72).

By so doing, emphasised Bertram *et al.*, (2000) learners would be adhering to Outcomes-based Education and Training's key principles, which encourage that:

1. Learners should at all times be active.
2. Learners should be competent, and this is the main goal of Outcomes-based Education.
3. Learners have, as a matter of fact, to experience and must always strive to put emphasis on meaningful learning mediation.
4. All learners are able to read, listen, speak and write during learning mediation.
5. Learners should use life sciences (biology) grammar or vocabulary as essential tools for learning mediation.
6. Learners are constantly prepared to consider error as a sign of development and not failure.
7. The educator fully knows and understands his/her role as a facilitator.
8. Learners are encouraged to do self-directed learning mediation.
9. Learners are encouraged to be critical, innovative and creative.
10. Educators inspire confidence in learners.

There are some instances where individualised or differentiated instruction and learning mediation should occur. Educators should, however, also allow the blind learners together with sighted learners to work in groups. This is crucial because "(l)earners work in ... groups to help each other learn,..." (Engelbrecht *et al.*, 1999:75). Learning mediation in this regard would allow equal opportunities to take place and should be non-competitive. Peer tutoring is also vital to both the sighted and blind learner as they help each other along the learning mediation path.

Blind learners learn from objects or tactile sketches. Collette (1989:282) suggested that when teaching blind students about an object, it is advisable to begin with the actual object so that the student can experience the actual size, shape and feel of the object. "(t)his will minimise the possibility of the blind person incorrectly generalising from a small, hard, cold model of an object to the real thing." This will also provide the blind learner with tactile experiences of the object. Thus, models could be used to reinforce concepts. However, the danger of models or tactile sketches is that they either exaggerate or compromise veracity in terms of size, texture, and so on. Please see appendix A where the size of an Amoeba in a tactile format is exaggerated. Furthermore, the blind learner will then never feel colours, behaviour of living animals, and so on.

In addition, the blind learner will not even be able to "feel" most experiments or observe them tactually. A good example would be that of conducting an experiment to determine the effect of a temperature change on the size of a metal sphere. In this experiment, a metal sphere at a room temperature "...(s)hould pass freely through the ring".

However, when the metal sphere is heated, the sphere does not pass through the opening when it is hot. Its size has increased. The blind learner will not be able to observe the heated sphere tactually when it is still hot. The blind learner will only be privileged to observe and take part when the metal sphere is not heated. When it is hot, s/he will not be able to experiment with it because his/her fingers will be burnt.

Another example is that of testing the degree of acidity or alkalinity. The scientist, on a numerical scale called the pH scale, indicates both the degree of acidity and alkalinity it was pointed out that to each acidic or alkaline solution a number is given which is known as the pH of the acid or alkali solution [s.a.] [s.p.] Acids have a low pH value and alkalis have a high pH value, ranging from 1-14.

The colours of universal indicators depend largely upon the pH of the acid or alkali to which they are added. The main problem with an experiment of this kind is that the blind learner cannot observe the colour change. The blind learner's learning mediation might be restricted to knowing and associating the colours with the numbers and he/she will not be able to visually observe the experiment. These are some of the problems often posed by Outcomes-based Education, which lays much emphasis on visual ability. The question arises: is this not indicative of the fact that the blind learner might not achieve some of the Outcomes-based Education outcomes?

Blind learners will also learn from and benefit from raised and tactual diagrams, which are important learning mediation aids. According to Collette (1989:282), objects and diagrams have limitations because they cause blind learners not to "...(p)erceive the same things as individuals without visual handicaps do when they see an object."

Blind learners learn more effectively in and prefer an environment that is not full of gestures, complicated symbols and phrases like "this and that". The educator has to mediate looking directly at the blind learner. Furthermore, the educator has to be selective and use words such as "see and look" with care. Such learners will learn better if their needs, concerns and challenges are taken into account. They should be encouraged to use tactile examinations if it is safe and beneficial to do so. Diagrams, experiments, observations, and so on should not be detailed as those students might fail to grasp the anticipated message or results. They will also learn better if they are given additional time to complete their projects.

The blind learners will learn, and appreciate learning, if an inclusive Outcomes-based Education environment is able to foster appreciation, acceptance, tolerance and caring in all learners and educators. This is what Engelbrecht *et al.*, (1999:73) refer to as the psychosocial environment. Hence, the educator's chief duty should be finding ways and means to create an atmosphere conducive to nurturing the personal, emotional, cognitive, and social development of all learners.

In the researcher's opinion, blind learners learn best where there are few or no physical and information barriers. Lack of physical barriers ensures the accessibility of the classroom for "...(l)earners with disabilities" (Engelbrecht *et al.*, 1999:73). Learners who are blind might, in most instances, be able to learn if they are provided with instruction in Braille, audiotapes, computers with speech synthesisers, and so on. As far as the classroom learning mediation environment is concerned, equipment and material relevant to the learning mediation needs of the blind learner should be provided.

Inclusive education and Outcomes-based Education learning environments should be modified in order to accommodate blind learners. Failure to do this, in the researcher's view, could lead to:

Blind learners being passive during science or biology activities. Blind learners will be less competent; hence learning mediation would be meaningless to them. Modification/adaptation of environments encourages learners' critical and creative thinking. If advanced science skills are not modified, blind learners will not benefit from self-directed learning mediation, hence they could experience inclusive education to be unfriendly or hostile.

3.6.1 THE DEVELOPMENT OF THE SUBJECT LANGUAGE SYSTEM

Before the researcher discusses the development of the language system of biology, it is imperative to highlight the importance of language.

According to Higgins and Ballard (2000:164) the acquisition of language is instrumental because:

- ❑ It allows the individual to objectify and typify his/her subjective experience;
- ❑ Language transcends the here and now; and,
- ❑ Language builds up meanings and a social stock of knowledge, which is distributed and passed from generation to generation. According to the above-stated authors (2000:164) "(l)anguage thus apprehends and produces the world and conversation is the tool used to maintain this world. Conversation, written or oral, helps to legitimate societal institutions that are dialectically formed to control individuals and which also, through the socialisation process, provide individuals with roles and identities that maintain society."

The following two questions are central in helping us understand how and why any subject language system (of biology in this case) develops.

1. How does the subject language system develop? and
2. Why should the subject language system develop?

It is worth noting that the development of the subject language system happens when the observer starts to attach meaning to an observation. The major reason for the development of the subject language system for biology and other subjects is to enable learners to learn, as well as getting them acquainted with the culture, values, norms, ground rules/principles, practices, beliefs and habits relevant to biology.

Therefore, according to Land and Fotheringham (1999:71), learners will be able to learn the biology language system through a conscious study of its rules and careful practice of them. The biology language should positively reinforce the proper use of the language amongst all learners. These co-authors are of the view that learners master things, including language, by being involved in activities and that rules ought to be laid down for practising such activities. As a result of this action, the subject language system originates. The observer takes trouble to name the observation precisely according to his or her own conceptualisation. Furthermore, the observer, in addition, takes the trouble to critically compare and contrast his or her own personal meaning (concept) with those already existing concepts (labels) about the subject which constitute the subject norm.

The issues discussed in 3.3.1 are still pertinent here. In the development of the subject language system, the observer tries her best to find the subject language system's place in the conceptual framework, or to expand or change the framework to include the new observation and new concepts in the framework. Hence, the subject language system of biology is composed of its unique terminology as well as of various means of communication including, but not limited to, aspects of visual presentations (illustrations, sketches, diagrams, photographs, et cetera) and mathematical ways and means of both recording and representing observed data, such as: tables, symbols/patterns, graphs, and histograms. The vocabulary of learners expands through communication. Hence, learners "...learn ... best by using ... rather than knowing only about ... rules" (Land and Fotheringham 1999:71).

Various learning mediation strategies play a pivotal role in the development of the subject language system. For example, the audio-lingual method advocates and views language learning as a matter of habit formation. This method absolutely reinforces the use of correct language and immediate correction of errors. Biology, as does any other subject, expects of all learners to adhere to its language's rules and regulations.

The other equally important learning mediation strategy is the grammar or language based method. This simply means that all subjects have their unique languages. Through the conscious study of biology rules and careful practice of these rules, learners and educators alike will use, effectively and appropriately, biological terms, concepts, phrases, and so on.

A communicative approach is crucial in the development of the subject language system because learners learn by constructive talks, debates, discussions, and so on. This approach promotes good sentence construction, logic and sequence. The approach allows learners to use the language with confidence, rather than knowing only about the biology language's rules.

The popular education approach is also one of the best learning mediation strategies. In this approach, the needs, concerns and challenges of learners are addressed. It is also the belief of the researcher that the learning mediation of each subject also depends on, and is also influenced by, the fact that its issues are also addressed. These might include observations, the collection of data, interpretation of data, analysis of data, testing and retesting, evaluation and assessment of experiments, and so on, because all these contribute to the development of the language system of biology.

Exposition of the science learning mediation approach is also an important approach to the development of the subject language system. Though educators are the primary focus in expository science mediation, by being the doers, their learners are also mental participants. In some instances, this approach is appropriate in the presentation of information to one's learners directly. One could do this by telling them, demonstrating or making use of science apparatus, carrying on a discussion, reading to learners, showing learners a film, filmstrip, slides, or television presentation, or having a resource person present something to them. Of vital importance to the mediator, "...is to know how much your children know before you present any scientific concepts to them" (Carin and Sund 1989:100).

Inquiry or free discovery learning mediation develops the learner's ability to manipulate, control and process information from a wide range of sources. This should, indeed, be done academically, socially and experimentally. Inquiry allows learners to identify and determine problems, generate hypotheses about likely answers, test and retest hypotheses in the light of available data, attempt to apply conclusions arrived at to the new data, problems or situations. All these activities are crucial for the development of the subject language system of biology.

Discovery enables learners to internally rearrange data so that all learners can go beyond the data and form concepts new to them. Discovery concerns concentrated efforts to find or seek to find the meaning, organising and structuring of ideas, interpreting, and so on. Through their discovery, learners are able to recognise the relationship between an idea and an observation, or, "...between two ideas, or between two observations" (Carin and Sund 1989:103).

Other additional methods crucial for the development of the language system include but are not limited to such methods as the inductive and deductive, cooperative, narrative, discussion, question and answer, non-formal and formal biology learning, drill and thinking aloud methods. Carin and Sund (1989:100) advised that a variety of these methods have to be used during instruction "(b)ecause each of your children is unique, there is no one best way to teach everyone."

Due to biology's dynamic nature, it would be extremely difficult, if not impossible, to confine it to descriptive terms. It has to abide by the most recent discoveries.

3.6.2 COMPETENCES NEEDED FOR DISCOVERY

The competence for discovery is interdependent with the first two competences: observation and the development of the subject language system. These three competences jointly describe what is called methodology, which in turn comprises the following activities: the identification and the formulation of the problem, obtaining all existing information about the problem, formulating of an hypothesis (possible solutions to the problem, designing the execution of investigations, interpretation of data and reaching conclusions), et cetera. The competences for discovery enhance participation and to a large extent promote active learning mediation. Discovery assists learners to pursue valuable knowledge. According to Collette (1989:50) the competences for discovery involve learners "...in exploration, questioning, problem solving, inductive reasoning, invention, labelling and discovery." Through their competence for discovery, scientists try as best as they can to reconcile and associate concepts and biology rules.

3.7 THE RELATIONSHIP BETWEEN SUBSTANTIVE AND SYNTACTICAL STRUCTURES

The relationship between the substantive and syntactical structure of biology is considered by Van Aswegen *et al.*, (1993:7) to be of paramount importance because that is where the crux of its consequences for learning excellence lies. This relationship can, furthermore, be noticed in the fact that the syntactical structure is responsible for both the generation and understanding of substantive structure while, in one way or another, the substantive structure directs and to some extent induces the course of the syntactical structure.

This means that people should exercise some caution, by not falling into the trap of viewing theory and practice as if they are two separate and totally independent entities.

Therefore, the facilitation or mediation of biology would be most effective only if biology is presented:

- firstly as a product,
- secondly as a process and,
- thirdly as a way of intensive thinking.

Van Aswegen *et al.*, (1993:7) argued that science as a body of knowledge (product), a way of investigation (process) and a way of thinking should, therefore, be stressed in biology instruction and learning mediation activities since this has the potential to provide an opportunity to involve pupils/learners in the scientific enterprise.

Not only do people acquire valuable knowledge from biology. Biology, in most instances, also strives to equip people with certain desirable qualities such as objectivity, careful and accurate observations, the use of inductive and deductive approaches, and, of equal importance, the ability to arrive at tentative as well as valid and sound conclusions. The biology syllabus will only achieve its envisaged goals if much emphasis is laid on the understanding, interpretation and application of biological data.

3.8 THE FACILITATION/MEDIATION OF LIFE SCIENCE (BIOLOGY) THROUGH INQUIRY

According to the researcher, enquiry anywhere in the life, learning mediation, political, religious or economic situation, for instance, plays an instrumental role because it stresses the investigative aspects of this activity. The key features of enquiry are to ask questions and figure out things for oneself. Enquiry reflects the scientific enterprise. In addition, as pointed out by Collette (1989:48) enquiry emphasises the fact that knowledge is acquired through investigation and that knowledge contains discrepancies and is subject to change. The same applies to the facilitation or mediation of biology. It stresses the investigative aspects of science and also how through investigation, knowledge can be acquired and / or altered.

3.8.1 THE IMPORTANCE OF INQUIRY SESSIONS

In specific terms, enquiry sessions are crucial because they present “... science as a way of looking at the world around us, a way that one seeks knowledge on one hand and questions knowledge on the other hand” (Collette 1989:48).

Generally speaking, enquiry sessions are instrumental in encouraging pupils to:

- Think logically and creatively.
- Speculate, question and attack problems.
- Discover, problem-solve, deduce and induct reasoning and discrepant events.
- Build the self-concepts of pupils, because mediating through inquiry is always pupil-centred.
- Develop and nurture talents and skills that are necessary not only for their development of cognitive structures but also for their powers of reasoning.

They also:

- Give learners intrinsic rewards because when learners are engaged in enquiries, they begin to consider success and failure as information rather than as rewards or punishment from the educator.
- Give learners self-satisfaction.
- Enable learners to discover the heuristics of discovery learning. Collette (1989:50) argued that an effective practice of this process should enable students to develop the ability to sense the relevance of variables, make intuitive leaps, and cast problems into forms with which they know how to work.
- Aid one during the memory process. This is to say, when learners integrate material into their own cognitive structure, “... the material is made more readily retrievable” (Collette 1989:50).
- Familiarise and make learners comfortable with science.
- Allow learners to become scientifically literate and able to solve problems by actually participating “... at their appropriate level in ... activities with ... assistance” (Carin and Sund 1989:103).
- Help them to acquire knowledge that is uniquely and exclusively theirs because they discover it themselves. As such, learners should be able to determine and distinguish their expectancy levels of achievement and performance. Learners are also capable of assimilating and accommodating what they encounter in the environment.

Carin and Sund (1989:106) acknowledge that if learners’ self-concepts during inquiry sessions are positive, the following things happen:

- Learners feel psychologically secure.
- Learners are open and exposed to new experiences.
- They are willing to take risks and develop the interest to explore.
- They tolerate minor failures relatively well.
- They become more creative, innovative and initiative.
- They generally find themselves in good mental health. And
- They eventually become fully functioning, competent, educationally productive and confident individuals.

Enquiry sessions in inclusive education and the facilitation or mediation of biology in an Outcomes-based Education learning environment might pose numerous, even endless, difficulties to both the educator and the learner if they lack innovative, creative and initiative problem-solving skills. Problems encountered during enquiry sessions by blind learners might emanate from a lack of adapted learning mediation support materials and apparatus with which they can test and explore their ideas, dangerous or complex experiments, inadequate enquiry approaches, and so on. However, the general and special educators (if available at an inclusive school) should “(t)hrough the process of problem-solving, ... use their collective expertise in a collegial, equal-status relationship ... This partnership allows special education teachers to propose alternative teaching strategies or supplementary instructional material as a result of suggestions generated by the general education teacher” (Engelbrecht *et al.*, 1999:163).

3.9 FACTORS INFLUENCING THE FACILITATION OR LEARNING MEDIATION OF BIOLOGY AMONG BLIND LEARNERS

3.9.1 INTERACTIONAL/SOCIAL-EMOTIONAL ENVIRONMENT

All learning mediation, whether formal or informal, takes place in a social-emotional or physical environment. The learner is a social being. By interacting with fellow learners, parents, educators, scientists, et cetera, she will know what the society expects of her. The interactional environment should always provide learners with adequate support in their daily learning mediation activities. This kind of environment not only nurtures learners but also, to an extent, the educator as well, personally, emotionally, cognitively, socially and otherwise. Prospects are good for both learners and educators to broaden their horizons by being exposed to new scientific experiences, information and ideas during interaction. Experienced biology educators might serve as blind learners’ mentors or consultants during these kinds of interactions. Through interaction, learners can receive continual feedback regarding their learning mediation and, as such, be in a position to determine and strive to improve their participation, innovation, creativity and effectiveness.

The interactional/social-emotional environment, to a great degree, depends on and is also influenced by how the educator interacts with her learners. Any educator who is at ease with her learners, who loves his/her subject and is highly competent, will do everything to the best of his/her ability to create a healthy and constructive learning mediation environment. That is, he/she will always and by every possible means endeavour to accurately identify and determine services needed and educational priorities of every blind learner under his/her supervision.

Furthermore, the biology educator should also be able to recognise the various complex needs of his/her blind learners and if possible, do his/her best to design what would be a more comprehensive and effective facilitation or learning mediation atmosphere. By so doing, s/he should also be able to set both idealistic and realistic goals for his or her learners.

Van Aswegen *et al.*, (1993:10) noted that “(a) pupil’s academic performance and ability to adapt socially depend to a large extent on the social-emotional environment of the classroom.” They further argued that this kind of environment not only affects how much is learned and retained, but also influences future attitudes towards learning mediation. Therefore, any environment that is tremendously hostile, and not conducive to learning mediation in any way, encourages learners in Van Aswegen *et al.*’s terms to “disengage” rather than “engage”.

The mutual support much needed by both the educator and other staff members will be wanting in such a situation. Hence, the blind learner might perform dismally during learning mediation. This negative type of environment will discourage blind learners from maximising their full potential for useful and meaningful participation in the learning mediation environment. A healthy learning mediation environment greatly helps the blind learner to achieve important outcomes and the educator’s experience, personal growth and satisfaction are, without any reasonable doubt, also increased.

Van Aswegen *et al.*, (1993) further indicated that effective facilitation and learning mediation of biology depends on both the educator and the interactional environment in which the mediation and learning processes daily take place. On the other hand, Engelbrecht *et al.*, (1999:72) held that interaction either promotes or impedes successful learning mediation. Both the facilitation/learning mediation and environment factors help shape biology as a subject in order to make it a very interesting, variable and pleasant learning experience. It is this interactional environment that promotes and enhances a facilitation or learning mediation situation that is safe for and supportive to all learners in the sense that these learners become thoroughly prepared to take learning mediation risks.

3.9.2 THE INCLUSIVE OUTCOMES-BASED EDUCATION LEARNING ENVIRONMENT

The researcher argues that the atmosphere that should prevail in this learning environment, in the form of a classroom for example, should be one that allows and fosters appreciation, acceptance, accommodation, tolerance, dedication, determination, love and care in all learners. This is crucial for creating an atmosphere conducive to nurturing the personal, emotional, cognitive and social development of all learners. Blind learners do best in an environment which is not hostile.

It is expected of this environment to have available readily adapted material that meets the learning mediation needs of blind learners. Educators should supplement regular facilitation of biology with individualised learning mediation to help blind learners catch up with their work, which in most biology assignments requires the visual ability of learners. Learners should constantly be encouraged to help each other during learning mediation.

In the inclusive environment, the role of the educator is threefold. First, he should be able to assess the knowledge of learners or check it from time to time, in order to inform the development and growth of the inclusive programme. Second, the educator should adapt and promote the accessibility of the inclusive

programme and also provide relevant and adequate support to blind learners. Third, the educator should embark upon processes for the recognition of blind learners' prior knowledge.

3.9.3 THE PHYSICAL ENVIRONMENT

The physical environment refers to learning mediation facilities or infrastructure. For learning mediation to be appropriate and effective, all the learning mediation environments have to be accessible to all, that is educators and learners alike. By accessibility the researcher means the ability of all people to approach, enter and effectively use the facilities to the maximum. This should address all the environmental as well as architectural barriers, which might, in one way or the other, be discriminatory. Without proper access, there will be no equal participation.

The positive or negative conditions of the facilities influence the learning mediation that is to take place. It has been argued by (Van Aswegen *et al.*, 1993:10 and Engelbrecht *et al.*, 1999:73) that the physical environment plays an important role in promoting positive learning attitudes among learners, by stimulating their interest and curiosity in biology.

In instances where there are physical barriers, changes should be made to certain dimensions for the sake of eradicating those barriers for blind learners. Aisles should be made available to allow and promote free movement by blind learners while using their white canes. There should, as a priority, be landmarks comprising cues and clues to help them find their way while walking independently. Blind learners should be provided with assistive devices and learning mediation support material transcribed into Braille. These are the major factors to be considered in the facilitation or learning mediation of biology.

For educators to be able to create a physically conducive environment, the following factors have to be considered:

- ❑ Attractiveness and neatness of both the classroom and laboratory: effective learning mediation takes place in a well-organised and neat classroom.
- ❑ Movement of learners in classroom and laboratories: Rules and regulations for entry and leaving both the classroom and the laboratory have to be laid down and followed exactly. In other words, movement in laboratories should be controlled at all times: “(n)o running, rushing or pushing should be permitted” (Van Aswegen *et al.*, 1993:10).
- ❑ Seating of learners: Seating in class should be determined by learners' needs. For example, learners with sensory problems (sight and hearing) should be accommodated near the front of the classroom. Those with photophobia (sensitivity to light) should not be seated near windows without blinds or where there is excessive light. Those with Attention Deficit Hyperactivity Disorder should not be seated next to the door or windows, to avoid distraction.
- ❑ Light, temperature and ventilation: “(m)uch of the work done in the science department is visually more exacting than work done in the ordinary classroom” (Van Aswegen 1993:10). This is an indication that lighting plays an instrumental role when microscopes are used or during dissections. Collette (1989:289) maintains that electricity is also essential for many laboratory activities, for

example, running microscopes, refrigerators, hot plates, centrifuges, clocks, variable power sources and electric meters. Efficient ventilation will help curb or regulate unpleasant odours. It will be advisable always to keep windows open in laboratories during warm or humid days in cases where thermostats do not control temperatures. The researcher is of the view that the regulation of temperature in laboratories will be much improved only if aircon is installed, though.

3.10 QUALITIES OF A BIOLOGY EDUCATOR

As indicated in this work, blind learners are a heterogeneous group with unique needs and demands. They learn at different paces and employ different styles and techniques. What complicates this situation further is that some are good in certain multiple intelligences (such as music, languages, mathematics, et cetera). While others facilitating learning for the blind is a more sophisticated, complex and demanding task than most people anticipate. Educators should become aware of the potential of their learners so that they can develop it. This compels the researcher to conclude that blind learners deserve to be taught by educators who understand their conditions. They need educators who understand what it implies to significantly and reasonably accommodate and facilitate learning in a way that will educationally be profitable to them. Such educators have to be thoroughly prepared to dedicate their hearts, minds, time, effort and energy to this cause, for proper facilitation or mediation to materialise. This is why educators in both special and inclusive settings should possess most of the qualities discussed hereunder. Apart from understanding the plight of blind learners, biology has its own demands, which educators have to consider when facilitating learning to make it more meaningful, challenging and interesting.

Duminy, Dreyer and Steyn (1990:66) stated, “(i)t is unfair to expect that teachers should be perfect. They are ordinary human beings. They have their ideals, their capacities and faults. Not every man or woman will be a successful teacher. Any profession has its demands.” Biology also makes its own demands: it requires of educators to do their utmost during the facilitation or learning mediation. Proper facilitation qualities will help educators to act competently. Killen (2000:189) argued, “...(a) person who is acting competently will integrate knowledge with skills and values, and will do so in diverse situations.” In addition, according to the above-referred author (2000:189), such an educator will be able to “...(p)repare students for their future life roles (self-directed learner, collaborative worker, complex thinker, community contributor and quality producer).”

Duminy *et al.*, (1990:66) further stated that “(t)he most important demand of teaching is a positive attitude.” Any educator without the proper qualities will not be effective as an educator. Poor facilitation qualities impact negatively on learners whereas the proper qualities impact positively on learners. Qualities have an enormous power to make facilitation and learning mediation successful, or might cause it to fail dismally.

To avert this kind of predicament, the biology educator should possess at least some of the following qualities:

Interpersonal relationships

The biology educator should be in a position to establish good interpersonal relationships with peers and colleagues. These should be extended to communities, organisations and workplaces. The personal bond should always prevail. This kind of quality is crucial for teachers in mentoring one another, advising, supporting and encouraging each other. Through exercising it, the biology educator will develop what Webson (1997:40) called “like-mindedness”. By means of interpersonal relationships, the biology educator will, most probably, gain new ideas, discover new abilities, et cetera. By so doing, s/he will start to expand his/her horizons. Furthermore, through this relationship, biology educators could share vital information about, for example, resources available to them, new biology publications, discoveries, and so forth. Finally, the biology educator may be able to assess himself/herself in comparison with others.

The biology educator should be an assessor

Assessments will help the biology educator in instances where s/he should give helpful feedback to blind learners. Both formative and summative assessments will enable educators to acquire valuable information about blind learners’ needs. Detailed and diagnostic records of assessment should be kept so that the educator can acquaint himself/herself from time to time with blind learners' needs, the outcomes achieved and those still to be achieved.

Love for one’s work

Any educator who loves his/her work generally shows enthusiasm for it. Collette (1989:162) maintained that “(p)ersonal enthusiasm ... is a great asset to science teachers. If they react to ... activities with interest and excitement, the prospects are good that their students will do the same.” Such an educator tries to be perfect and does not mind walking an extra mile. Duminy *et al.*, (1990:66) warned, “(a) teacher who does not love his or her work, will never be a real educator.”

The biology educator should be involved in a programme/s design processes

The educator should design research programmes, with national or local needs and standards as well as the needs of target learners and employers in mind. S/he should design programmes with outcomes, learning mediation and assessment strategies that are apposite to the process of qualification. S/he should frequently review programmes in the light of new developments in the field, as well as on the basis of feedback from employers, learners, tutors and assessment processes.

Mediator of learning

Any educator who accepts blind learners as they are, who even understands that they have likes and dislikes, who knows their capacities and deficiencies, will in turn be liked by them. They should know, like and above all, trust him/her. Their likes, dislikes, capacities and deficiencies are features contributing to learners’ uniqueness. Engelbrecht *et al.*, (1999:70) cautioned that educators whose professional education takes place “...(i)n a climate which views intelligence as fixed and unmodifiable are likely to have limited expectations about learners’ capacity or propensity for learning and to be pessimistic about their progress.” Therefore, biology educators should understand, like and view each individual learner as unique and as

having the potential to benefit from learning mediation. In addition, an educator who understands, likes and views each blind learner as a unique individual, will not have negative attitudes towards disability.

Biology educators should exhibit positive attitudes towards disability and possess the responsibility to accommodate and tolerate inclusive practices. Killen (2000:190) maintains that the educator should “...(m)ediate learning in a manner that is sensitive to the diverse needs of learners; construct learning environments that are appropriately contextualised and inspirational; and communicate effectively, showing recognition of and respect for the difference of others.” The educator should “... demonstrate sound knowledge of subject content and various principles, strategies, and resources appropriate to teach in various contexts.” It should, however, be borne in mind that biology educators, like other educators, “...(a)re human beings with individual attitudes to difference and disability, formed in a context of prevailing social attitudes” (Engelbrecht *et al.*, 1999:71). It is a truism that many educators might initially resist the notion of inclusion and the mediation/facilitation of biology to blind learners in an Outcomes-based Education classroom.

The previously mentioned co-authors (1999:71) pointed out that research conducted internationally has shown that educators with little or no experience of people with disabilities are likely to have negative attitudes to inclusion, which of course also applies to biology facilitation and learning mediation. If educators change their attitudes to accommodate learners with a diverse range of needs (including the blind), such learners will benefit from biology facilitation and learning mediation.

Basing their argument on the issues of educators' lack of experience and negative attitude, Engelbrecht *et al.*, (1999:71) advised that “(t)o support ... learners with special educational needs teachers have to be sensitive, not only to the particular needs of individual learners, but also to their own attitudes and feelings.” This would be possible if biology educators were to receive training in how to identify and address special educational needs. Above all, biology educators should strive to develop a positive and critical understanding of common stereotypes and prejudices related to disability, and time and again reflect on how these could negatively or positively influence their own attitudes as educators.

The biology educator should have an appropriate personality

It is an indisputable fact that a healthy personal relationship between the educator and his/her pupils fosters positive learning mediation and creates a pleasant educational climate. The educator with an appropriate personality should at least be enthusiastic, motivated, lively, interested in his/her subject and work, have a good sense of humour and be both fair and consistent in his/her judgment.

The educator should be equipped with both professional and academic qualifications

It is of paramount importance that the biology educator be both academically and professionally qualified so as to educate his/her blind learners with greater confidence. According to *Norms and Standards of Educators* (2000:30), “... the roles and competences (norms) for educators and the provision of a qualification structure and specialists requirements (standards) are fundamental to the development of educators.”

Educators' qualifications are instrumental in describing their roles, specialities, their level, the learners they can educate, their employability and articulation routes. Qualifications should be in line with local, national and international needs. Training should offer educators many scientific experiences. An educator who is both professionally and academically qualified could be an excellent source of ideas and information for all learners. Collette (1989:162) supports this view by maintaining that such educators serve as consultants to their learners. If possible, their academic and professional training should include special education. If those educators are acquainted with instructional approaches meant for blind learners, they will be better able to accommodate them during instruction and learning mediation.

Collette (1989:57) further maintained that educators always have to learn specific skills and techniques before they can successfully include any content in their mediation. Being academically and professionally qualified, will allow biology educators at inclusive schools to develop biology curriculum guidelines, and see to the construction and modification of tests to accommodate blind learners, the development of proper laboratory activities, the handling of controversial scientific issues in classrooms, and so on.

Furthermore, blind learners will in turn have confidence and trust in the educator who shows competency in his/her subject field. This implies that the educator's task is to guide all learners along the educational path. In order to do this, s/he needs knowledge of the subject matter as well as educational "training". Killen (2000:190) maintains that educators who are professionally and academically qualified will "... achieve ongoing personal, academic, occupational and professional growth through pursuing reflective study and research in their learning area, in broader professional and educational matters, in their related fields."

Educators should be scholars that are always in pursuit of new knowledge. *The Educators' Voice* (September 2001:21) maintained that educators who are scholars never stop challenging themselves, so that they can do the same for their students. They never stop learning, because they are educationally and academically addicted to it. Such educators should improve their mediation strategies and, therefore, should study new approaches in the field of education. Any educator should constantly search for new meaning and should always create new possibilities for learners also to discover something of the wonderful world in which they are privileged to live. The educator could always improve his/her academic and professional qualifications by reading the subject literature, enrolling with institutions of higher learning, following a course of his/her own choice, receiving in-service training, attending biology seminars, symposia, conferences, and the like.

Pauw (1984a:11) argued that special and inclusive schools should possess academically and professionally qualified educators in order to help mediate learning to blind learners. They have to be experts in the field of special education and should know and understand the historical background and the pedagogical principles on which the education of blind learners is based. They should constantly be aware of and possess knowledge of the psychological aspects of these learners' development and education.

Mani (2000a:16), as far as training is concerned, argued that "(f)or the effective implementation of inclusive education for all types of disabled children, general classroom teachers need training on understanding the educational needs of these children." This author took this argument a step further when he maintained that

training is ideal for the acquisition of skills and knowledge during the pre-service teacher preparation course itself. He argued that teachers, thus trained, would be in a position to take care of the educational needs of learners, their special needs too, in general classrooms if appropriate disability-specific assistive devices are made available.

Professionally and academically qualified educators should know and understand types and degrees of blindness and the adaptations they have to make for the sake of accommodating these kinds of blindness. They should further understand the implications of ophthalmological and medical treatment of visual diseases and errors. They should fully be aware of a blind person's learning process and specialised didactics. They need to receive training on the use of special apparatus and other appliances, which make education accessible for the blind. According to Mani (2000a:17), professionally and academically qualified educators understand that inclusive education does not mean just enrolling a learner with a disability in the regular classroom. These educators understand that such learners should be given help to cope with their regular classwork. Therefore, in certain instances, they will adopt the learner-centred approach in their quest to mediate learning. Such educators should understand that the quality of their mediation depends upon and is highly influenced by the interaction between them and their blind learners.

In addition, professional and academic training exposes such educators to the incidence, nature, degree and extent of blind learners' learning disabilities. Finally, they should know the sociology of visual handicaps, appropriate learning and mediation strategies, and so on.

On the basis of the factors alluded to above, regarding the importance of professional and academic training, the researcher believes specialised training is important for:

- Ensuring that educators are better qualified and better able to represent, develop and promote this specific branch of the teaching profession "... with due authority and confidence" (Pauw 1984a:12). Educators need to know and understand anomalies of the eyes and how to adapt education according to those anomalies. Educators should also be aware of other learning difficulties, which blind learners exhibit. As such, educators can give appropriate attention and assistance.
- Knowledgeable educators in the field of special education are in a position to adequately help blind learners to find the relevant and vital sources of assistance for their predicaments. According to *Norms and Standards of Educators* (2000:32), specialisation is crucial for embracing context knowledge (knowing that), concepts and theories (knowing why), procedural knowledge (knowing how), strategic knowledge (knowing about why, when, where and who). Specialisation is therefore central to the development of competence and other important educational roles.

The facilitation/mediation approach of the biology educator

The biology educator should be pupil-directed rather than subject-directed. According to Holdstock (1987:101), a facilitator of learning who is pupil-directed will be able to teach learners with natural emotion and "... (a)llow them to externalise their pain, their anger, their grief, (whereupon) they will love to go to school. Learning will be a stimulating, challenging, exciting adventure" In addition, the previously mentioned author (1987:104) asserted that "(S)ince education occurs in the context of other people it is essential that the quality of the interpersonal relationships between the students and teacher be optimised in

order to facilitate the learning experiences. One of the characteristics of the personal-centred approach is the realness or genuineness of the facilitator of learning ...”

A good facilitator of learning always comes to the school or classroom thoroughly prepared. Preparation assists educators in deciding what to teach. Erwin *et al.*, (2001:346) is of the view that additional factors, such as the teacher’s style, history and pedagogical practice, play a critical role in how activities are presented and how the students participate. The educators’ personal perspectives drive the decisions they make about how to teach the science curriculum, which ultimately have a significant impact on how the science activities are implemented.

The facilitator of learning should mediate biology through experimentation and always engage his/her learners in problem-solving activities. The approaches s/he might employ in class may vary significantly and might be influenced by the occasion. This might include whole-class mediation as well as discoveries regarding direct mediation. Therefore, s/he should involve blind learners in these activities by explaining, interpreting, discussing and/or narrating to them the whole process, so that they too could be part of the activity. S/he could also utilise the expertise of the special education educator who could be of tremendous help to him/her in terms of making appropriate accommodations.

The biology educator should be able to stimulate learners’ talents, skills and potential

The educator should be able to stimulate blind learners. Such an educator could be successful in stimulating learners’ talents, skills and potential if s/he is innovative, initiative and creative. Blind learners enjoy being mediated by a creative educator, because not all the biology apparatus especially modified for blind learners is readily available. The biology educator should therefore endeavour to invent the apparatus he/she wants to use, in order to make facilitation or learning mediation easier. By so doing, s/he may save the school’s hard-earned money, time and effort.

The educator should be prepared to adapt to change

Educators might accept change if they are prepared, determined, dedicated and interested in receiving feedback regarding their mediation. Feedback is crucial for helping educators to determine their effectiveness. Adapting to change also implies adopting new curricula, which make new demands on educators and their experience, which is understandably stressful. Educators should change; since they are the people “...(w)ho make learning possible, their own attitudes, beliefs and feelings with regard to what is happening in the school and in the classroom are of crucial importance” (Engelbrecht *et al.*, 1999:70).

The biology educator’s ability to communicate with his/her learners

Communication involves good negotiation skills rather than dictation tactics. A biology educator should make an effort always to be a good listener rather than be a good speaker. If s/he listens intently and earnestly, the learners will listen to him/her too. S/he should endeavour to communicate in the language of learners in such a way that all receive an equal amount of what is being said and an equal degree of attention. Duminy *et al.*, (1990:68) stated that “(t)he teacher can teach and the pupils can learn because they can communicate.” The educator’s speech expresses his or her attitude to the work, to the learners and to life in general. Jargon should be avoided.

The biology educator and his/her preparation

According to Van Aswegen *et al.*, (1993:9) “(g)ood and effective teaching involves careful planning and preparation to make pupils interested while they are learning.” In addition, educators should establish a “presence” in the classroom, listen carefully, be organised, and prepare thoroughly. Preparation is by and large the organisation of the content to be taught. Planning, on the other hand, involves carefully selected methods, approaches, tools, techniques, strategies, and so on during the lesson presentation.

The educator should be a leader, administrator and manager

A good leader, administrator and manager should always make his/her presence felt during activities. It is asserted by Slabbert (1990a:57) that the students must be assured of the teacher’s presence, his proximity and help if a problem arises. “(t)his will ensure that the student will have the confidence to venture into working independently.” The biology educator should consequently be able to command the attention and respect of all learners.

In addition, “(g)ood classroom control and management is important because it contributes towards learner’s achievement. The management of his class and subject starts with the teacher himself (self-management)” (Van Aswegen *et al.*, 1993:9). The educator should always be presentable, punctual, dignified and well prepared. This will earn him/her respect.

A good leader with both administrative and management skills is able to make decisions appropriate to the level, pace and learning styles of learners, manage the facilitation or learning mediation in the classroom, carry out classroom administrative duties efficiently and participate in decision-making structures.

The researcher argues that any educator who has good classroom management and control possesses the following attributes:

- ❑ He/she is encouraging and receptive to learners’ inputs, needs, aspirations, wishes, anticipated problems and concerns. The educator is able to monitor learners’ behaviour and instantaneously end disruptive behaviour. S/he sees to it that classroom or laboratory rules are adhered to strictly. Such educators with good management and control give academic support and academic encouragement. Written work is given regularly to learners. Furthermore, the biology educator with leadership, administrative and management skills is able to implement and perform, at least very competently, the following duties:
- ❑ Running successful, constructive and enriching biology lessons.
- ❑ Being able to develop plans (including a scheme of work, daily lessons, a laboratory timetable if in charge of more than one class).
- ❑ Being able to identify the functions of fellow biology educators, laboratory prefects, and so on.
- ❑ Examine the biology syllabus in order to develop biology activities that respond to the needs, interests, wishes and aspirations of learners.
- ❑ Finally, the biology educator should be able to develop and deliver quality service in terms of education.

The biology educator should never personalise disagreements and controversies

According to the researcher the world of science is full of disagreements and controversies. The biology educator should never personalise those controversies or disagreements; instead, he/she should be strong enough to accept constructive criticism and heated debates.

The biology educator should respect the rights of other people

The researcher further believes that the biology educator should respect the rights, views and feelings of all people, young and old. S/he should know and observe the learners' right to learn and to be educated. Fellow workers have the right to dignity, information, et cetera.

The educator should be patient, possessing personal control and a calm personality

The educator should always be patient with learners. Some of these blind learners might have learning disabilities, which might make it hard to be taught, to be guided or controlled. According to Duminy *et al.*, (1990:68) "(t)he teacher who cannot maintain self-control under such conditions will alarm his or her pupils. A calm personality under tense circumstances encourages the teacher's pupils to behave correctly in crisis." These authors further state that: "(t)he people who cannot control what is under their hats will not be able to control what is under their roofs."

The educator should have manners in the classroom

The biology educator should always be well mannered. S/he is expected to be sympathetic, friendly and trustworthy. Duminy *et al.*, (1990:68) advised, "(i)f children behave irresponsibly, the teacher must still represent responsible adulthood."

The educator should have the willingness to accept additional responsibility

All educators who love their work, their learners are eager, enthusiastic and ready to do additional work. These educators experience their tasks and calling as meaningful. Therefore they are always willing to accept additional responsibility. Extra-curricular activities, which at times take place after knocking off time, form an important part of educators' duties.

The general behaviour of the biology educator

The biology educator should at least show the following: courtesy and good manners, loyalty to and respect for those in authority, respect for both public and private property, cleanliness and neatness.

In the researcher's view, however, it would serve no purpose for the biology educator to possess all these qualities but lack the skills to understand blindness as well as to master its facets. It should be borne in mind that general education teachers enhance their chance of success when they have mastered Braille reading, daily living skills, orientation and mobility, and so forth.

3.11 SUMMARY AND CONCLUSION

Biology is an interesting subject, which is dynamic and influential in people's lives. It should be developed and studied because it has and always will have its rightful place in the natural sciences. Its importance to human beings cannot be over emphasised.

Among other things, it plays an instrumental role in:

- ❑ Contributing towards the creation, shaping and the development of work opportunities;
- ❑ Conserving, managing, developing and utilising natural resources to ensure the survival of local and global environments;
- ❑ Collecting, analysing and critically evaluating the data used to develop scientific knowledge.

However, for biology to be effectively and meaningfully mediated, its nature and structure should be understood. The said nature and structure in the learning situation must satisfy all biological requirements and principles as stipulated by the mother discipline of biology. The structure of biology would not be complete if it did not cater for substantive and syntactical components.

The substantive structure concerns itself with the content of biology because that is what learners learn. Facts, concepts and generalisations constitute the content of the subject of biology. If learners can be introduced to these, they will participate competently and meaningfully in biology learning mediation activities. The syntactical structure, on the other hand, should address various skills (sensorimotor skills, cognitive skills and techniques) because they help us to come to terms with learning as we use these skills in various learning mediation situations.

Though this is not a chapter specifically discussing learning mediation strategies for blind learners, the researcher desires to highlight in advance that inclusive education and the mediation of biology to blind learners in an Outcomes-based Education classroom will be possible and effective if:

1. Learning mediation in the life sciences (biology) is made accessible to blind learners.
2. Biology is structured in such a way that it encourages active participation of blind learners in the learning mediation process.
3. It enables blind learners to build a meaningful understanding of the concepts of biology, which they could successfully apply in their respective lives.

Therefore, the learning mediation of biology to blind learners is possible because there are learning mediation strategies with which the educator communicates ideas, intentions and new knowledge to them. The educator will only be successful if s/he possesses proper learning mediation qualities. It is of primary importance to stress that strategies and proper learning mediation qualities will serve no purpose in the learning mediation of biology to blind learners in an Outcomes-based Education classroom if the envisaged learning mediation environment is not conducive. Above all, for learners to comprehend the subject matter, their different needs, wishes, concerns, interests and aspirations should be highly esteemed. Learners should constantly be guided to observe and develop their full potential. By so doing, they will master, and

most likely develop a love and passion for, biology. It is incumbent on all educators to continually improve their qualifications in order to widen their horizons. Learners are more likely to love and trust competent, knowledgeable and enriching educators.