CHAPTER 6

DATA PRESENTATION AND RESULTS OF THE EMPIRICAL INVESTIGATION

6.1 INTRODUCTION

In the previous chapter, the author reviewed the data processing procedure and provided a description of the data techniques and strategies, which he used in data gathering. This chapter discusses the data analysis, based on learning outcomes as appearing on the Revised National Curriculum Statement (Grade 10-12 schools) for biology (life sciences), to consider whether they are achievable by blind learners or not.

The following aspects: descriptive data analysis; educators and learners' profile; interpretation of findings; and the interview questions are discussed.

The chapter deals with the significance of the analysis and its implications. **The chapter further provides important patterns regarding themes based on four biology-learning outcomes, as indicated in the previous chapter, namely:**

- Scientific investigation;
- Constructing science knowledge;
- Science, society and the environment; and
- Science, society, attitudes and values (these were all discussed in chapter 5).

In instances where the actual words of respondents are quoted, they are presented in italic type. Data analysis and interpretations regarding problems experienced by educators and learners in the learning mediation of biology are presented below. Sub-themes are discussed independently, though some questions are treated together in order to make them more significant, coherent and extensive.

6.2 THE LEARNING OUTCOMES PRESCRIBED FOR THE TEACHING OF BIOLOGY GRADE 10-12

The following is an illustration of themes and sub-themes in these outcomes:

SCIENTIFIC INVESTIGATION	CONSTRUCTING SCIENCE KNOWLEDGE	SCIENCE, SOCIETY AND THE ENVIRONMENT	SCIENCE, SOCIETY, ATTITUDES AND VALUES
The conduction of simple tests and surveys Opportunities for distinguishing similarities and differences Acquaintance with, awareness of and application of science process skills during mediation and/or observation Data recording processes and procedures Tabulation skills and techniques Learning mediation strategies	Acquisition of information Investigation strategies Strategies for describing and explaining biology phenomena	Prediction of outcomes Data analysis skills	Expressions and reflections

The main themes highlighted above are also pertinent as far as the focus groups are concerned. Therefore, they will not be mentioned to avoid repetition.

The sub themes for the focus groups are:

- The conduction of simple tests and surveys;
- Scientific educational trips/excursions;
- Acquaintance with, awareness of and application of science process skills during mediation and/or observation;
- Data recording processes and procedures;
- Tabulation skills and techniques;
- Data analysis skills;
- Opportunities for distinguishing similarities and differences;
- Information acquisition during investigation;
- Prediction of outcomes;
- Analysis of programmes;
- Correct and incorrect activities done by educators during learning mediation; and
- Methods and sources of accumulating data.

6.3 DESCRIPTIVE DATA ANALYSIS

6.3.1 BIOGRAPHICAL DATA ANALYSIS

Written permission was sought and granted by the national Department of Education (Inclusive Education Sub-directorate) to the researcher to carry out his empirical investigation at 12 schools for the blind or with sections for the blind (grades 7-12). This permitted the researcher to visit four schools in Gauteng Province, five in Limpopo Province, and one school in each of the Free State, Kwazulu-Natal and Western Cape provinces. Empirical investigation was actually only conducted at nine schools (four in Gauteng Province and five in Limpopo Province) due to the financial constraints the researcher experienced. Two schools offer grades 1-12, two offer grades 8-12, one school offers grades 1-9, while four offer grades 1-7.

6.3.2 EDUCATORS AND LEARNERS' PROFILES

It was indicated in the previous chapter that 17 educators were interviewed because they offered life sciences or they showed an interest in the research itself. One educator refused to be interviewed on the basis that his/her principal did not inform him/her and colleagues in time about the expected date for the interview and that the objectives of the research were unclear. Of 17 educators interviewed, nine were females while eight were males.

104 learners from nine schools were interviewed. Equal numbers of both boys and girls were interviewed.

6.4 DISCUSSION BASED ON INTERVIEW SESSIONS

This section comprises responses given by respondents (educators and focus groups), and relates the findings arrived at as a result of the interviews. The researcher will comment on the quality of the evidence gathered. The implications of these findings will be further explored and relevant recommendations made for further research and development, or for a clear science policy that would address the needs of blind learners.

6.4.1 FEEDBACK AND REPORT ON THE INTERVIEWS

Prior to the conducting of interviews, respondents' fears (educators and learners) were allayed by spelling out the intentions of the study. It was made clear to all respondents that the study was not intended either to assess the quality of education or to find out how much learners knew. The study was designed to look at what they would like to see put in place, at their concerns and at how their needs would be met in future. Learners were advised and requested not to use their real names but rather the grades they represented.

Educators and learners were interviewed separately. Therefore, the first section below will pay attention to educators' responses and the latter part to learners' responses in order to avoid confusion.

6.4.2 FEEDBACK AND REPORT ON THE INTERVIEWS WITH EDUCATORS

This section attempted to establish educators' views on the concerns and challenges regarding the mediation of life sciences to blind learners. The researcher made use of the interview technique because the population interviewed was small and because of the additional reasons given in chapter five. He heeded Rambuda's advice (2002:196-197) that the face-to-face interview is the most effective way of enlisting the cooperation of the participants in a survey because rapport can be easily established. Furthermore, one is able to clarify the meaning of the questions to the respondent and follow up on unclear and incomplete answers. In the interviews, the researcher could pursue all the matters of interest.

Learning outcome 1: SCIENTIFIC INVESTIGATION

The first six questions are based on learning outcome 1: scientific investigation.

<u>The conduction of simple tests and surveys</u>

The first question considered the types of simple tests and surveys, which educators carry out with their blind learners. There is good evidence (both positive and negative) from transcripts, data sources such as photos, and triangulation suggesting that at a few schools simple experiments and surveys were conducted while at the rest of the schools such tests and experiments were not carried out. Please see photo 1.

Photo 1: Apparatus used for the sweet/sour taste experiment.

Photo 1 illustrates the different apparatus used by respondent 1 during the day of the visit to illustrate how a simple experiment could be conducted by blind and partially sighted learners in the biology classroom. This is a classical experiment that could be classified as a 'simple experiment' based on the fact that the experiment is reasonably simple to conduct and also holds very few dangers or hazards to the learners.

The purpose of this experiment was to give learners the opportunity to distinguish between the different taste areas located on the tongue. Harmless chemicals such as a sugar and salt solution, lemon juice and aloe sap were selected by the educator in the investigation. The worksheet used during the investigation is clearly visible on the first photo. On this worksheet the partially sighted learners had to report where the different taste areas were located on the tongue when touched by an ear bud dipped in one of the different solutions.

Photo 1: Apparatus used for the sweet/sour taste experiment

Good evidence supported the idea that certain educators lacked competences and skills to accommodate blind learners during the learning mediation of science. Those educators did not improvise. There is also solid evidence to suggest that blind learners relied on theory and not on good scientific practices only.

One respondent during the follow-up interview stated the following words, *"So the experiment like if they have to do an experiment of, of soil mixing it with water so that we can see types, the different types of soil. It is a very easy experiment but basically they won't be able to see it. Do you get the point, so I have to do an extra explanation that this soil have larger particles. So in a way try to teach them with the aim that they should also use their imagination you can take them to try and feel the soil the different types of soil but doing that experiment practically like I do it with the blind learners is not going to, is not going to help them. You understand, but the only thing that you can do you can take them to feel that soil, the different textures of soil if they … some of them are totally blind, they haven't seen, you understand the only thing that you can do you can take them and try to make them feel the texture of different kinds of soil."*

Another respondent in the same follow-up interview said the following, *"The practical observation? Yes, you see it I in fact a bit of a drawback for a blind learner say for instance we do linear programming like that they don't normally get the whole picture because it is very visual and there are certain things that I normally can't even try and I try to teach them the basic principles because is part of the art and the end of the matric exam so they must just be able to concentrate on certain things but it is really impossible for me to say for instance explain to them the different areas that we use to apply to a linear programming and the stuff like that. So I don't but do concentrate on certain basic principles that they gonna need to answer some of those questions but really ask them to get the whole picture and interpret … a specific problem is very difficult."*

Based on sound evidence, the author argues that, access to the learning mediation of biology including experimentation and exploration is limited. This supports the argument that the learning mediation of biology depends on one's visual ability, thus making it difficult for blind learners to access information through visual observation. The first Working Session on the National Working Group on Curriculum Adaptation (2003:16) stated that, "(o)bserving is a good means for gathering information. Traditionally 'observing' has meant that learners watch what the educator is doing and then copy or model the same. A learner-centred approach to observation would require that learners are expected to analyse their observation …"

Lack of visual ability deprives blind learners of the enjoyment and the advantage of observation. Borg (1987:157-158) indicated that observational processes are essential in enabling individuals to collect direct information. This means that blind learners are deprived of opportunities to study specific aspects because they cannot observe.

This deprivation causes blind learners to be less competitive during biology learning mediation. Blind learners will only be able to be competitive when they are fully exposed to all biology phenomena. Nagel and Stobbs (2003:47) argued that, "…(b)enchmarking against the regular curriculum is extremely important because we've got to foot it with this competitive world that we live in. Like it, or not. And if you want a job you have to compete, you have to be there, you have to develop skills and talents. Part of this is having the ability to know and to deal with others, and to live in the real world. You have to learn to take the knocks and have the ability to deal with prejudices."

The researcher argues that sciences have many advantages for blind learners: for example, their understanding is broadened; many career opportunities (including but not limited to physiotherapists, science educators, biologists, researchers, and the like) are also possible for blind learners. Evidence shows that even if blind learners are not able to observe experiments visually, they still benefit from explanations given by partially sighted classmates and educators. One respondent (R1) argued that, *"yes experiments are done (E.1). Specifically with practicals, because of their complexities and challenges (P.1) that they may pose to blind learners, we encourage teamwork between blind and partially sighted learners so that they could assist one another (T.1)."* All learners are involved in the recording of results as well as the interpretation thereof. For evidence of this, please see photo 2.

Photo 2: Co-operation between learners sharing information when conducting a common experiment.

Noticeable on the second photo (photo 2) is the sharing of information between learners who are visually impaired. Both learners were requested to perform the experiment by stimulating the taste buds with different solutions while the partially sighted learner had to record the information on the worksheet. This became common practice in most cases where partially sighted and blind learners shared the same workstation. The partially sighted learners posed the questions to the blind learners and the answers to the questions were then recorded by the partially sighted learners on the spaces provided on the work sheet.

Photo 2: Co-operation between learners sharing information when conducting a common experiment.

Some educators expressed frustrations regarding experiments since most of their learners need visual ability to perform and observe. Hence, educators resorted to the teamwork approach (pairing blind and partially sighted learners together) so that the partially sighted learners could supply blind learners with visual experiences. This practice is known as cooperative learning, teamwork, group work, collaborative learning, and the like. What complicates the matter is that some schools do not have equipment, such as beakers, cylinders, talking thermometers, barometers, voltmeters, talking liquid jugs, talking balances and other apparatus, to do experiments.

However, Luebbe 2002:52-53) considered observation to imply more than seeing with the naked eye. She noted, " i have also recently encountered a teaching professional prepared to deny my entrance into a degree-completion program because I could not see. She concluded that I would be unable to complete the observation portion of the program. I questioned this instructor, pointing out that a sighted person might see something, but without the knowledge and intelligence to understand and interpret what was observed, the exercise would be worthless. On the other hand, the situation being observed could be described to someone with experience, knowledge, and intelligence; and that person could explain and assess it effectively. Observation is not just seeing; it is listening, asking questions, and understanding what is going on around you."

The unavailability of adapted equipment impacts negatively on the experiences of learners because they only carry out activities theoretically. Some educators feel stretched to the limit because of the lack of equipment to perform experiments. High expectations placed on them (those of mediating learning in all circumstances) are challenging and difficult.

A respondent (R2) stated the following words in frustration: *"Oh! Well. Even if I would like to conduct experiments with my learners, my hands are tied because I do not have even basic equipment like beakers and so forth to do experiments (E.2)."*

Another respondent (R5), supporting the previous view, highlighted the following: *"Experiments in biology are very core (E.3). However, the problem with experiments is that, more often than not, we run short of equipment (E.2). When you deal with blind learners, experiments are even more problematic (E.4). For instance, when you ask blind learners to go and collect the earthworm, in order to know and understand its habitat, they cannot do it on their own (E.4.1). Unavailability or limited resources (E.2) lowers the standard of mediation or that of performing experiments (E.2.1)."*

Another educator (R3) expressed himself as follows: *"With the blind learners we do not do experiments (E.4.2) as we are supposed to do for instance if one needs to separate dissolved substances one has to boil the solution. Instead I give them the background because they will not be able to observe visually (MS.1)"*. This has become a serious problem experienced by many educators, namely the fact that blind learners find it difficult to observe the actual experiment or practical procedures and for these reasons are excluded from further participation. What is experienced here is a classical move away from the practical work to be done in life science education to the verbal explanation of procedures and activities.

One respondent during the follow-up interview stated, *"… physical science is difficult for me … what more about blind people."* Another respondent argued, *"Imm, … in my school … we have field trips with learners. And especially because I'm offering Maths and Science we do involve them a lot. Yes. … let say we are doing distances we have the meter wheels where they do measure their class… they do that. … in our case they do go to the kitchen if it is a practical lesson, …I would say theory is 60% and practical is 40%, ja, this my … observation …"*

Since the bulk of experiments have to be observed visually, respondents felt that they were not blind-friendly. Because of these and other frustrations, one realises that there is a noticeable lack of creative ideas and practices amongst educators of blind learners.

This lack could be attributed to the following factors:

- Educators lack skills to adapt experiments in such a manner that they will accommodate blind learners;
- Experienced educators conversant with the didactics of mediating learning to the blind are retired or occupy senior positions and, as such, do not share their experiences with the current educator generation;
- Educators no longer undergo training in order to be skilled or re-skilled;
- Some educators go to class unprepared and for the first time stumble across experiments and other aspects during the learning mediation activity;
- Some educators believe in technologically adapted learning mediation material/aids; hence they do not try their God-given talents of adapting them by hand, because they continually put the blame on poor resources or on the Government, which did not supply them with material.

Special Education Report (2001:5) argued that educators trying to assist blind learners were worried that the budget shortfall was hurting their mission of teaching and learning. Educators believed that what they did was a public service and, therefore, "…(d)on't believe it's appropriate to be treated in a different manner than other public schools."

The researcher also noticed that some educators had excellent ideas/plans but did not set themselves deadlines to allow those plans/ideas to materialise. Youth Information Guide (2003:74) advised that "(w)hen you have decided on an idea that suits you and that sounds good, you need to draw up a plan."

One also gained the impression that some educators who joined schools for the blind had never thought about the extra things they would have to execute due to the learners' barriers/challenges, calling for, at times, different mediation styles and techniques, accommodation strategies, materials, et cetera. When educators consider becoming part of the staff of a school for the blind, they "…(n)eed to think carefully."

They need to ask themselves sets of questions and must talk about these issues with friends or older persons they fully trust. It is suggested: "(a)sk yourself: What interests me? What are my skills and talents?"

The researcher believes that educators need to ask themselves how efficient they, and the services they and other service providers render to blind learners, are. They need to ask themselves what else is needed and to list all the things they have to put in place, as a priority, to improve the learning mediation situation. They need to ask themselves whether they are capable of producing, say in the absence of tactual learning mediation aids, substitutes that would be better and relevant. Finally, they need to ask themselves whether they will have sufficient energy and dedication should they be employed at schools for the blind.

Opportunities for distinguishing similarities and differences

The second question involves what educators do to give their blind learners opportunities to distinguish between similarities and differences. There is evidence from the data collected and analysed suggesting that blind learners in South African schools for the blind are given opportunities to distinguish between similarities and differences.

In supporting this argument, one respondent (R1) stated, *"When you work with blind learners, use concrete things (MS.2) to show them similarities and differences and avoid abstract things like light and darkness, black and white, beautiful and ugly (MS.3)."*

It is believed that "(p)ersons with visual impairments have been one of the most difficult populations to accommodate …" (Butler, Crudden, Sansing and LeJeune 2002:166). These authors then argued that for the trend to be reduced, it is "…(i)mperative that barriers … be resolved."

Another respondent (R2) stated that, *"Experience has taught me over the years that deep stuff does not work (MS.3) well with blind learners when you talk about similarities and differences. Say, you want to teach them about black and white, refer to the colour black to a coal and the colour white to an ice cube (MS.2)."*

Another respondent (R3) shared his views by indicating the following: *"We should create opportunities for learners to distinguish similarities and differences based on the background these learners come from (MS.4). It is obvious that learners who became blind at a later stage are more experienced when coming to the issue of similarities and differences. When educators expose blind learners to similarities and differences, they have to take their condition into consideration. Comparison and contrast in instances where one has to show them similarities and differences, are significant strategies that one should employ. Blind learners can understand if educators compare 'white' with snow, 'green' with green grass, 'blue' with the sky even if they will never see it visually (MS.2)."*

Basically, biology concepts indicating similarities and differences are used. For example, during an activity that the researcher observed, which concerned respiration and photosynthesis, the educator indicated similarities and differences there. What the educator did not forget was to inculcate in learners information about ordinary and exceptional features of parts, organisms, processes, etc.

The respondent (R4) explained as follows: *"Basically biology concepts (MS.5) indicating similarities and differences are used. For example when one is mediating learning about respiration and photosynthesis, there are similarities and differences there. What one should always bear in mind is to inculcate and introduce to learners ordinary (MS.5) and exceptional features (MS.6) of parts, organisms, processes, etc."*

In addition, educators relied on description and explanation of aspects to blind learners. To support this argument, one educator (R5) elaborated: *"When I describe and explain (MS.1) things to them, they see common and uncommon features. That is how I teach them similarities and differences (MS.1)."*

Description is one of the characteristics of the "telling and talking" method. It was emphasised by educators that one cannot avoid it. One respondent said: *"ahh, I'll say that, … we teachers use the tell and talk ehh, … you cannot avoid it of course …"*

Another respondent said: *"ja, although I don't fully agree with that statement, look the traditional approach was about the teacher giving all the information to the learner and the teacher being the only source of knowledge so we are seldom applying that somewhere somehow we do apply that maybe you find that they have got nothing no background they don't have any concept on that subject that you might be delivering but now we are approaching the outcomes-based one that one is where the teacher becomes the facilitator although we know that we all not doing that at the same level same degree but the approach is different altogether, the approach is like the learners can, I'm making an example with that one, you just give them an example … a topic and you let them to interact you trying to get from them how much they know about the problem, explore the concept with them when they come up without the understanding of what they know …"*

The researcher further discovered that most educators relied on concepts used in everyday life. Examples given above and the following argument bear testimony to this point. One respondent (R6) indicated: *"Concepts (MS.2) such as similarities and differences are used in everyday life (MS.7). What I do, I reinforce it by making use of both concrete (MS.2) and abstract examples (MS.8)."*

Another respondent (R7) added: *"When I teach them about these concepts, I try to be practical (P) than to be theoretical (T). Give blind objects, real things, etc. if it is possible (MS.2). The concepts will be well cemented in their brains."* The researcher supports this idea by emphasising the fact that by touching objects, materials and apparatus, the thought processes are stimulated and learning is enhanced.

Another respondent (R8) cautioned: *"Never underestimate blind learners' intelligence (I). Some understand these concepts far much better than sighted learners (LR.1). If that is the case, build on what they know and understand (MS.4). You will be surprised how they even explain abstract things to you (LR.2)."*

Certain advantages of creating opportunities for blind learners to distinguish between similarities and differences were mentioned. If similarities and differences can be observed tactually, learners have immediate access to information. In addition, learners' ability to describe and explain is enhanced.

However, there is also evidence contradicting the former argument. For example, although a lot of information can be tactually accessed, there are instances where vision plays a critical role. If you have to show learners that spiders have blue blood and not red blood, learners will just rely on theory and not on the reality.

Acquaintance with, awareness of and application of science process skills during mediation and/or observation

The third, fourth and fifth questions based on learning outcome 1 are jointly discussed since they relate to each other, and the information gained from them, for purposes of logic and relevance, should not be isolated. The third question involves whether educators were acquainted with science process skills and goes hand in hand with the fourth question, which asks where educators apply these process skills in the mediation of biology to blind learners, as well as how they create opportunities for blind learners to observe biology phenomena.

Before the researcher puts the views of respondents on paper, we should understand what science process skills comprise, as well as their importance. Halliday, Resnick and Walker (2001:2) maintained that "(p)hysics is based on measurement. We discover physics by learning how to measure the quantities that are involved in physics. Among these quantities are length, time, mass, temperature, pressure, and electric current. The unit is a unique name we assign to measures of that quantity - for example, meter (m) for the quantity length."

In addition, the Department of Physics Laboratory Manual (2003:4) maintained that "(e)very measurement of a physical quantity must be expressed in the applicable SI unit. The SI-system is based on the meter (m) as the unit of length, the kilogram (kg) as unit of mass and the second (s) as the unit of time. It then follows that although measurements in an experiment should be given in the units of the instrument, it is necessary to convert these units to SI units before they are used in calculations."

The data collected and analysed in this study supports the argument that educators are acquainted with science process skills. There is good evidence to suggest that some schools were well resourced with learning mediation aids, including talking thermometers, talking scales, metre sticks/wheels, and so on, while on the other hand other schools possessed virtually no learning mediation aids.

Regarding the issue of whether educators were acquainted with science process skills (SPS) one respondent's (R1) reaction was: *"Of course, I am acquainted with science process skills (SPS.1). Remember, I have 30 years teaching experience. I therefore, know what science process skills are. With regard to what one does when teaching blind learners to measure the distance, the mass, the growth and change in shapes, that is foundation phase work (SPS.2.1). Obviously, we cannot work in millimetres."*

Another respondent (R2) supported the argument as follows: *"I am acquainted with science process skills (SPS.1). Because I do not have equipment (E.2), one uses bottles and other containers if we measure liquids (E.5)."*

A viewpoint worth noting was given by another respondent (R3), who showed the importance of improvisation (E.6). S/he was of the opinion that: *"With shapes, as a teacher, one has to improvise (E.6). One can take a paper and cut it into different sizes and shapes that is, circles, squares, triangles, rectangles, etc. For instance, one can associate or compare a circle with money coins. A circle and a coin are both round. When measuring (SPS.3), of course blind learners cannot measure long distances (SPS.3.1). With short distances of course they can. They are encouraged to use rulers. Regrettably, here at our institution, we do not have adapted apparatuses which blind learners can make use of (E.7). Blind learners cannot observe visually (O.1). But, to compensate or complement what they cannot observe visually, through the sense of smell, touch, hear, feel (O2), prior to that, we prompt them as well as to give them background information (MS.1) so that they can come up with their own predictions, or analysis of the data. For instance, when I teach them about combustion, they know that some gases will be released. However, the intricacy lies in testing the released gases. As a solution to the problem, I encourage my learners to do group work (T). If the class comprises blind learners only, I bombard them with lot of information (MS.1). Clues and cues that I give them, help them in scrutinising the information (MS.1.1)"*.

The researcher gained the impression that where educators did not equip learners with those skills, the latter were given a lot of information to compensate for what they had missed practically. One respondent during the follow-up interview stated that, *"the 'tell and talk' method that you are referring to is the order of the day, …"* Other respondents put the blame on Outcomes-based Education and Training. In describing his predicament, one respondent (R4) stated: *"I am acquainted with science process skills (SPS.1). The advent of Outcomes-based Education has made matters worse (MS.9). It encourages learners to be active participants (MS.10). In the absence of adapted equipment (E.7), how can they measure or observe?"*

Smit (2001:114) argued that lack of resources, especially when the curriculum is changed, brings about desperation. Many teachers cannot keep up, and simply have little or no personal time left; in fact, there appears never to be enough time to implement something new in detail.

Empirical data revealed that in most instances, blind learners struggle with observations (O). One respondent (R5) alluded to this issue as follows: *"I am acquainted with science process skills (SPS.1) and I know that blind learners have to also be equipped with them. In biology for instance, I expect them to measure the presence of chlorophyll in the plant (SPS.3.2). However, lack of appropriate devices deprives them this opportunity (E.7). It is also difficult for my learners to observe (O.1). Observation entails seeing from the start till the process ends. For the blind, I give them a verbal explanation (MS.1) and surely, that is not observation."*

Because blind learners are not involved in observation, as indicated above, educators resorted to question-and-answer sessions supplemented by explanations. To support this argument, please see photo 3.

Photo 3: Blind and visually impaired learners participating in a classical 'question-and-answer' session

Photo 3 reflects the classical problem and strategy so often applied to the teaching of blind and visually impaired learners. In this specific classroom situation, learners are subjected to a number of questions and have to respond to the questions individually. As explained by one of the respondents who participated in the investigation, one has to bombard the learners with information and the only way to determine whether they understood the work, would be to pose questions to the different sections of the work dealt with by the educator. One of the problems with this approach is that it might restrict intellectual development especially when the focus is on the recall of information only.

The view that observation means practical or physical involvement is also shared by the writers of the Department of Physics Laboratory Manual (2003:1), when arguing that "(e)xperimental observations form the basis of physics. Thus an acquaintance with experimental work is essential."

Because of the difficult conditions and situations educators have to negotiate during observations and experiments, some lose their sense of achievement and accomplishment. Smit (2001:142) argued that lack of appropriate resources and lack of materials worsen the possibilities of sound implementation in the

classroom. The researcher concurs with Smit's argument and believes in addition that a lack of resources, materials, creativity and innovativeness, jeopardises opportunities of reaching the desired effect/s in the learning mediation of biology, in terms of outcomes to be achieved. Therefore, something needs to be done to reverse these unfavourable learning mediation conditions and situations.

For the most part, the learning mediation of biology is prone to some debate, particularly concerning observation, mediation strategies, resources, creativeness, innovativeness, and the like. Consequently, if educators are not creative, they are defeating one of the objectives of Outcomes-based Education and Training, which is to eliminate rote learning and promote critical thinking and creative teaching.

Feelings of ineffectiveness, hopelessness, discouragement and/or incompetence in educators may bring about ineffectiveness in practical adaptations (e.g. of experiments). On the other hand, if educators find themselves in supportive work conditions, they gain a sense of achievement and accomplishment.

One respondent (R6), who was in this kind of position, emphasised this argument by stating: *"The availability of adapted learning mediation aids at our institution drastically reduces the need for dependence on both educators and partially sighted learners by blind learners and that these learning mediation aids solve problems encountered in the past caused by lack of resources (E.8). Furthermore, learning mediation aids give blind learners confidence and a sense of self-reliance (E.8.1). With these aids, blind learners can participate in learning mediation freely (E.8.2). Blind learners who have access to the learning mediation aids have an urge over those who do not have them at school. They comprehend things better and they become active during the learning mediation of science (E.8.3)."*

Another respondent (R7) added: *"Should our schools be resourced, blind learners will practically and theoretically be equipped with science process skills (E.2.2). In addition, observations will be possible and meaningful to them."*

This implies that educators can facilitate learning in a poor learning mediation environment. Please see photo 4.

Photo 4: Teaching in a poor learning environment

Photo 4 gives the reader a clear understanding of one of the concerns raised by many of the respondents who participated in this investigation. Many respondents argued that most of the schools were poorly resourced and that little trouble was taken by the educators to stimulate learners through the enrichment of the learning environment of the blind and partially sighted learners. Most classrooms experienced few or no tactile teaching media and in few of the classrooms visited, models, diagrammes or even photographs were used in support of classroom learning. This photo is further proof of the lack of sensory stimulation occurring in many of our classrooms.

Another respondent (R8) replied: *"We have limited resources (E.9). With the little we have, we try our best to make science process skills known to blind learners. Regarding observations, we are still behind from developed countries. I guess we should learn from them (O.3)."*

The unavailability of resources in the form of laboratory equipment, classroom equipment and library equipment obliges blind learners to depend on friends, educators, relatives, and others. Corn and

Rosenblum (2002:9) warned that the existence of such restrictions "…(t)acitly marks the beginning of what might be a dependency career."

Data recording processes and procedures

Relating to the fifth question, what educators do to give blind learners the opportunity to record data correctly, the evidence is encouraging.

The evidence of successful data recording becomes visible when educators inculcate in learners a sense of cooperation and assistance. One respondent (R1) argued: *"I as an educator, in instances where my class comprises totally blind and partially sighted learners, I encourage partially sighted learners to take the readings and blind learners to record those readings on their own (T.1). They then work out the readings and arrive at possible conclusions. Unfortunately, that is the only way to do this (E.6.1) as we do not have apparatuses to take the reading (E.7)s."*

Another respondent during a follow-up interview indicated that combining blind and partially sighted learners does have advantages. *"… those who are partially sighted can help those ones who are blind who cannot see and so they are doing that to help each other."*

The researcher also noticed that respondents used different strategies to encourage blind learners to record data.

The following strategies were listed during the interviews the researcher conducted with the different respondents:

- Telling blind learners the salient points; in turn they transcribe them into Braille using their Braille writers.
- Going all over the process again and checking mistakes in order to fill the information gaps.
- Dictating notes to them.
- Handing-out prepared Braille notes, and so on.

Stressing the point that blind learners can record data, another respondent (R4) argued that: *"Blind learners do not find it difficult to record data correctly (R.1). In order to encourage a proper recording of data, one has to combine blind learners with partially sighted learners (T.1). This is to say, during experiments the partially sighted learners will observe visually, describe all the proceedings to the blind learners and the blind learners would record the data in Braille and later, interpret it."*

The researcher is of the view that if team work is advantageous to blind learners as far as experiments and data recording are concerned, then the practice is appropriate. He therefore suggests that because teamwork is advantageous to blind learners during these situations, the practice should be pursued. This normally happened during the course of the research when the groups were small and the grouping per se had not been based on educational arguments. However, the researcher has also observed that in other special schools for the blind, the blind learners and the partially sighted learners are separated.

According to educators, allocating separate classrooms to blind and partially sighted learners has its advantages too. Supporting this statement, one respondent during a follow-up interview stated, *"… most of the blind ones are disadvantaged because … we write it on the board or some diagrams we do them on the chalkboard …"*

Another respondent said, *"Oh, the disadvantages obviously will be that they can be neglected sometimes especially when the partially sighted are demanding and you can't get time to present to them because for instance now say I've got a grade 10 mathematics class here then I've got only one blind but the others are sighted …."*

Tabulation skills and techniques

The sixth question relates to the techniques and skills educators apply to help or make it possible for blind learners to carry out tabulation on their own. Regarding tabulation skills, only a few respondents were enthusiastic, while the majority felt stressed and expressed their concerns about the difficulties they experience when trying to make such skills meaningful for and possible to blind learners. There is strong evidence supporting the argument that the making of tables is difficult for blind learners.

One respondent (R1) responded as follows: *"Drawings (MS.11) are an inherent part of mathematics and physics: whether the educator presents them to the learner or whether the blind learner has to make them. This poses a problem in mathematics and science even though such problems could be resolved by opting for the use of technology (T). Educators could employ the zytec method whereby diagrams and drawings are generated by a computer programme such as CorelDraw, printed and then photocopied onto Zytec micro-capsule paper (also called swell paper). It is then put through a "Zytec" machine', which raises the drawn lines. Some of the advantages of this method are: educators are able to create drawings for immediate use instead of having them done by producers in some centralised places; Braille characters could be included in graphic material (MS.12) for labelling, etc.*

"Disadvantages include: the Zytec copying machine and paper as they are imported, are very expensive (T.1.1). This technology makes it hard to have the graphic material included as part of the textbook. Braille produced on Zytec paper tends to smudge, making it more difficult to read. The technology does not enhance blind learners' independence when making graphs. Over the years, I have realised that an effective means of teaching blind learners to make their own drawings is to use the drawing set available from the Depot at the SA National Council for the Blind, designed to draw on Braille paper (MS.13).

"At our school for instance, in mathematics, blind learners are taught to plot the critical points, of which the co-ordinates were calculated previously, onto a pre-printed axis-page by means of pushpins. The pushpins are then connected by an elastic band and the elastic band followed with a pen or pencil. Then, the drawing is removed from the drawing board, entered into a Braillewriter and the co-ordinates then written in Braille onto the pages. With a little practice, blind learners are able to feel the rut (groove), which was made by the pen when the curve was drawn. However, certain sections for mathematics

concerning linear programming are very difficult since several straight lines could be necessary to complete the drawing.

"In physical science the main area where learners have to draw, concerns vector physics. As far as this is concerned, blind learners are taught how to use a Braille ruler, Braille protractor and triangle, and again how to use pushpins and elastic bands to produce straight lines. At a very young age as possible blind learners should have a good grounding which would be essential by the time they need to manipulate such tools."

Another respondent (R4) argued as follows: *"I don't expect blind learners to make tables on their own as they are complicated. I give my learners ready-made tables (MS.1.2) and ask questions based on the tables handed to learners (MS.15)."* This respondent believed it was difficult for blind learners to make tables. If possible, and time permitting, he made tables for them. The malfunctioning of their thermoform machine was letting him down because he could no longer give them ready-made tables. Since this problem had occurred, his learners' lives had become even more dejected.

Regarding the ability to make drawings by blind learners, one respondent during the follow-up interview said, *"Okay, right I'm gonna answer that one in two ways, the first well sometimes it does not make sense to actually engage them in drawings normally in some cases we all go for an alternative …"*

Another respondent said, *"Well, in case of drawing ja, … blind learners are not drawing … The challenge here is that there are no mechanisms that we can employ to draw; we do not have the equipments that we can use also."*

These observations and concerns of the researcher are supported in the literature. Kashmer, Gupta, Geiger and Weaver (1999:2) emphasised the fact that it is a challenge to mediate learning to blind learners in science, mathematics, engineering and technology. They argued that "(o)ne of the greatest challenges to the visually impaired student in science and mathematics disciplines is reading and writing complex mathematical equations or having convenient access to information based tools such as the World Wide Web ."

The above authors added that the lack of quality academic access for blind learners is particularly felt in the study of SMET (Science, Mathematics, Engineering and Technology) "…(b)ecause of the difficulty in rendering technical material accessible. Consequently, there is a strong need to provide quality to SMET subjects for students with visual impairment. Another concern is student-to-teacher communication since few of the SMET faculty know anything about Braille and other alternate media. Mathematics access must be two-way. The visually impaired student must be provided with quality tactile materials in a timely manner as well as produce correct print output for a sighted instructor."

In addition, one respondent (R7) argued that he/she was still new in the field of blindness (HR.1). Maybe he/she would discover ways and means to make blind learners do tables. He added that everything is possible if one tries hard.

Trying hard always should bring about equal educational experiences for blind learners and this is very important. In order for one to attempt one's best in ensuring quality education for blind learners. Charles and Yewpick Lee (2003:84) advised that "(a)s these children are devoid of visual experiences, the teachers and other personnel involved in serving them should understand the techniques of providing the best possible experiences to optimise their learning. It is in this context that efforts are needed at all levels to improve the capacity of teachers and other personnel working with children with visual impairment."

The fact that blind learners are not taught tabulation skills brings out an even more fundamental shortcoming. This particular shortcoming (lack of creativeness and innovativeness) depicts qualities that are missing in educators, such as those of being researchers, sources of knowledge, scholars, et cetera, because if they possessed these qualities, they could have seen, heard or read about ways of accommodating blind learners in mediating tabulation skills.

Learning mediation strategies for blind and visually impaired learners

The seventh question addresses the learning mediation strategies educators have developed to inculcate the science process skills. There is good evidence that some respondents have developed particular strategies which are necessary for the acquisition and application of science process skills. However, there is also anecdotal evidence that other respondents have not developed such strategies.

Comments to support the first point came from one respondent (R1), who shared positive sentiments as follows: *"The fact that blind learners are taught to plot critical points (LR.3) of which the co-ordinates were calculated previously, onto a pre-printed axis-page by means of pushpins which are then connected by an elastic band followed with a pen or pencil proves that there are strategies that some of us have developed. For instance, I cut the two-litre bottle into halves, quarters and eighths (E.5), which blind learners use to fill the uncut two litre, bottle up (LR.4.1). That gives the blind learners an idea or experience of how long it takes to fill a two-litre bottle with halves, quarters and eighth sizes (SPS.3.3)."*

As alluded to earlier, evidence of lack of creativeness and innovativeness amongst educators is visible in tangible results such as frustrations, incompetence with regard to adaptations, and the like. The problem is further complicated by the lack of communication, networking and support from other "sister schools" for the blind. Schools seem to solve learning mediation problems independently or in isolation.

Though some educators have not developed new strategies, they do improvise according to situations and conditions. The other group of respondents comprises those who lack particular skills and techniques to mediate learning to blind learners. They only improve what is already existing.

One gains the impression that respondents exhibit decreased productivity. Decreased or poor productivity can be attributed to one or more of the following factors: poor mediation quality, lack of creativeness and innovativeness, little care, and so forth. Statements coming from one respondent (R6) like: *"No! No! No. I have not developed any particular skills and techniques to teach blind learners",* give one the impression

that he is not prepared to walk the extra mile in accommodating blind learners (E.6.2). This is what Smit (2001) calls an "I am not going to do more than what I have to do, attitude."

This type of attitude is normally displayed by educators who do not want to embrace changes with vigour and a willingness to give such changes a chance to prove themselves and, if necessary, to modify them. Educators need to understand that "(h)andling involves the interaction and proactive response of … professionals. When change is occurring around you, look at the issues, examine their impact on others, and get involved. Even if you cannot prevent the adaptation of new ideas, you can affect your ability to use those changes as an opportunity to learn and grow" (Beedles and Robert 2003:52).

Other reasons why educators cannot improvise might be the fact that they do not attend workshops for special education, where new learning mediation techniques could be shared with them. During the follow-up interview, it was revealed that they are not invited to such activities. One respondent stated, *"Not invited at all, we have never been to any … most things we get are for the normal people only and not blind people."*

Another respondent added, *"Particularly, you mean for the blind learners, not necessarily but there are educators from our school who attend such workshops but they come back and share that with us."*

Most educators receive specialised training at the South African National Council for the Blind. Such training initiatives are made possible by donor funds, but such workshops are not conducted regularly because of financial problems. One respondent indicated that he attended one workshop as follows: *"Oh, well … you see we attended that one you were there as well last year at the blind conference and Mrs Viljoen went to Holland few years ago and she came back with a book on adaptations that can be made. … in my learning area I had to do everything on my own well you more or less sometimes develop a sense to know how to adapt things for the blind.*"

LEARNING OUTCOME 2: CONSTRUCTING SCIENCE KNOWLEDGE.

Acquisition of information during investigations

Question eight concerns the methods and sources educators use to access information in unfamiliar and complex settings. Evidence gathered and analysed shows that respondents use a wide range of methods and sources to obtain information in such settings.

It is illustrated in the empirical data that textbooks, magazines, periodicals, co-workers, newspapers, radio, television and scientific videotapes, experts, the environment itself, the internet, computers with text-to-speech software, science conferences, symposia, and seminars comprise most of the respondents' sources of information.

One respondent (R4) indicated that he could log on to the Internet and acquire as much information as he needed (KA.1): *"Personally I use the computer with text-to-speech software. Therefore I can log on to the*

Internet (KA.1) and acquire as much information as I need. What I am appealing for is that blind learners should also have access to computers (TEC.1.2)."

He urges that blind learners should have unlimited access to computers, which are a valuable source of information. This problem is highlighted by the researcher's personal experience when he discussed the issue with a fellow teacher working within one of these schools. This specific school possessed 15 computers but only one teacher used the computer/s for his personal needs. He was the only person who had access to these computers.

The argument is supported by another respondent (R5), who had the following to say regarding the use of computers in the teaching of the blind: *"Other than the books we use daily, we have been using the Internet (KA.1), although we have problems with it. Of late, it is not working (KA.2)."*

Strategies for describing and explaining biology phenomena

Question nine focuses on what educators do to give blind learners an opportunity to describe and explain concepts, principles, laws, theories and models in unfamiliar and complex settings. There is good evidence showing that blind learners can carry out such activities in these settings.

One respondent (R1) argued that: "*Blind learners are capable of describing and explaining (LR.3) depending on the situation they find themselves in. If you want them to describe or explain, first give them a real thing or, a model (MS.2). You will be stunned by how much knowledgeable they are. Remember, the key is to give them something tangible (MS.2)."*

Another respondent (R2) added: *"Often people conclude that blind learners are unable to describe or explain because the problem is that when experiments are done, they do not observe things visually (EP.1). However, if things are explained to them in great detail (MS.1.2), they comprehend and are therefore, capable of describing, explaining, analysing and interpreting concepts, laws, theories, principles, models and processes (LR.5)."*

Since blind learners are a heterogeneous group with different intellectual abilities, they at times explain matters far better than some of the people who are fully sighted. This is because the visual ability does not play a major role particularly in explanations. What is required here is intellectual capability. Blind learners with adequate mental capabilities can therefore manage such tasks very well.

The connotations of the word blindness, taken to mean "total darkness", often give individuals wrong impressions. Luebbe (2002:48) posed a question and answered it as follows: "(w)hat do you think when you hear the word 'blind'? If you are like most of society, you think of blindness as total darkness, and the dictionary will support that belief with its definition of 'lack of discernment, lack of sight. Actually blindness has a range of meanings from total absence of light to the inability to see distinct features. Blindness means that you must use alternatives to sight to complete the activities of daily life."

Is this process of finding alternatives not what educators should be doing during science process skills, observation, data recording, investigating, and so on? The attitude that educators should adopt is that at the beginning, their learners should learn necessary skills to negotiate the learning mediation of biology. Their mission should be to live by in terms of the barrier and educate others about it. This philosophy, according to Luebbe (2002:50-51), should be "…(b)ased on the premise that blindness doesn't have to be anything more than a personal characteristic. It is not a handicap, but merely means that … use alternative methods to complete the same tasks that sighted people do."

Investigation strategies

Question ten focuses on the strategies educators apply in their classrooms to give blind learners opportunities to accumulate information for investigation purposes. There is convincing evidence that educators encourage their learners to gather information for these purposes.

One respondent (R1) stated: *"I encourage learners to peruse their textbooks (MS.15), lend 'talking books' from Tape Aids for the Blind and Print Handicapped (MS.13.1), books from South African Library for the Blind on specific topics, Braille encyclopaedias, electronic and print media, etc. (MS.13.1)."*

However, another respondent (R3) cautioned as follows, that in order for blind learners to be engaged in investigation activities, *"The learning mediation field has to be level in order for blind learners to access information (MS.13.2). That is, before one recommends whatever format, one should ensure that it is indeed accessible."*

This respondent was actually saying that whatever is recommended for blind learners in order to enhance their "quality of learning" has to be available in the first place. It is of little value if recommendations are made but the media and resources are not available.

However, the fourth respondent (R4) had the following to say: *"How learners access information for investigation purposes is actually not the problem of the teacher (KA.3). The learner himself or herself should search for information, figure out the information, select the relevant information, analyse it and compile it (LR.6). Because our media centre is poor in terms of reference work and because newspapers and magazines are inaccessible (E.9.1), what I normally do, I go to the Internet (KA.1) and print it in an accessible format and give them to read (KA.1.1). By so doing, they will present their findings to me."*

This respondent makes the valid point that learners too have the responsibility of accessing information for investigation purposes. Learners could employ various strategies in acquiring information such as discussing things among themselves, consulting their books and educators, listening to both the radio and television, and the like. The learner himself/herself should search for information, figure out the information, select the relevant information, analyse it and compile it. Pierce (2001:31) argued that blind individuals should be engaged in activities and "… programs that will challenge the assumptions that others have about us and sometimes challenge those we have about ourselves."

She also argued that the blind should "…(e)ngage in adventure; … climb the highest peaks; … scale the ivory towers of academe; … apply inventive imagination to the everyday problems confronting us all. If we expect the blind to achieve in ways defined by the most exalting standards, we must demand excellence. Those who believe the blind have little capability expect little, … they get it." She added that if people expect productivity, productivity is what they get.

LEARNING OUTCOME 3: SCIENCE, SOCIETY AND ENVIRONMENT.

Prediction of outcomes

Question eleven discusses the things educators do in learning mediation to give blind learners the opportunity to predict the outcomes of a certain intervention. It became clear that, in order for blind learners to predict the outcomes of an intervention, educators have to give them the background knowledge which they mostly need before they can embark upon an experiment.

Supporting the previous argument, one respondent (R1) noted that: *"Prediction to an extent has to do with one's understanding and intellectual ability (SPS.4.1). Any learner with low intellectual ability would possibly find it difficult to predict outcomes of an intervention whereas someone with high intellectual ability would find it simple and easy to do predictions (I.1). The same applies to blind learners. However, one is tempted to say sighted learners' way of making predictions seems to be easily and comprehensively done because hearing and seeing what the educator say gives them an edge over blind learners."*

On the other hand, another respondent (R3) indicated that *"At times, when I give my learners all the relevant information, they are able to predict (SPS.4.2)."*

The researcher's impressions are that blind learners either can or cannot predict, depending on the type of intervention by the educator. If educators make every effort to explain to them the intention of an intervention, steps to be followed, etc., they may accurately predict the outcome. Predictions of outcomes are also influenced by their simplicity and complexity.

Another respondent (R8) argued that: *"At times predicting means making a wild guess (SPS.4.3). One could be right or wrong. Blind learners can do that."*

According to another respondent (R6) the nature of the prediction will once again be determined by the type of intervention conducted by the educator: *"Blind learners can or cannot predict depending on the type of intervention (SPS.4.4). If as an educator you explain to them the intention of an intervention, steps to be followed, etc., they may predict the outcome."*

Data analysis skills

Question twelve discusses how blind learners analyse collected data. The ability of blind learners to analyse data emerged prominently from the answers. Most respondents were of the view that blind learners are able to analyse data the way sighted learners analyse data.

In supporting this argument one respondent (R1) stated, *"Analysing data to an extent has to do with one's intelligence (SPS.5.1). Any person who does not experience an intellectual barrier, would find it easy to analyse data whereas, any person experiencing an intellectual barrier, would find it extremely hard to analyse collected data (I.2). The same applies to a blind learner. One is also tempted to say because blind learners are not disturbed or distracted by things during the learning mediation; they have an edge over sighted learners. Because they listen attentively, they absorb that information and understands it better (LR.7)."*

The researcher discovered that other responses pertaining to this question were not different from the previous answer. Another respondent (R2) noted: *"Some blind learners can analyse data while others cannot. That ability, is, influenced and depends on their levels of mental growth (SPS.5.1.1)."*

As was the case with predictions, where it was clearly indicated that blind learners need adequate information to predict the outcomes of an intervention, the same applies here. The moment educators explain different things to blind learners, they comprehend and are, therefore, capable of describing, analysing and interpreting concepts, laws, theories, principles, processes, and so on, at times better than some people who are fully sighted.

According to one respondent (R5), when blind learners are given models (MS.2), they are able to describe and explain them. They can also tell the differences between biology phenomena. Other respondents also echoed the same sentiments.

LEARNING OUTCOME 4: SCIENCE, SOCIETY, ATTITUDES AND VALUES

Opportunities for expressing and reflecting on the mediation of science process skills

Question thirteen is centred on the strategies educators apply in their classrooms to give blind learners the opportunity to express or reflect on the mediation of science process skills. There is persuasive evidence to suggest that blind learners are capable of doing so.

One respondent (R3) attributed this capability to the fact that Outcomes-based Education expects educators to play a more passive role and learners a more active role. Because he encouraged class discussions, blind learners interacted and shared knowledge. His role was only to facilitate and prompt correct responses.

The respondent (R3) emphatically stated, *"Remember, blind learners enjoy talking as it is one of the ways to express themselves (LR.8)."*

Another respondent (R5) advised, *"If you want to know how much the blind could express themselves or reflect on what you were teaching, employ strategies such as discussion, narrative, question and answer, etc. (MS.15.1)."*

From the sentiments echoed, one concludes that blind learners can express and reflect on things verbally and in writing.

When respondents were asked what they would love to see put in place, one respondent (R1) said: *"I would like to see a very simple laboratory with the essentials for example, a burette that is marked so that blind learners could feel it (E.9.2). Also, a laboratory tailored to the learning needs of the blind."* The respondent (R1) added, *"I would like to see that there are far more descriptive video services rendered to the blind (MS.13.1). Should all these things be put in place blind learners could benefit a lot."*

6.4.3 FEEDBACK AND REPORT ON THE FOCUS GROUP INTERVIEWS

The focus group interviews attempted to establish learners' views, concerns, challenges and needs during life sciences learning mediation.

The conduction of simple tests and surveys

There is solid evidence that some learners do conduct simple tests and surveys, while others do not.

To support the first argument, one respondent (Focus Group 1) stated, *"Yes, we do conduct simple tests and surveys (E.1.1). For instance, today's activity was about indicating areas on the tongue where different tastes take place. I guess that was a simple experiment. Wasn't it?"*

Another respondent (Focus Group 2) stated: *"Mainly with practicals, we are encouraged to work in groups comprising both blind and partially sighted learners (T.1). This arrangement is crucial in terms of assisting each other. We as learners, we are encouraged to take the readings together, but, we interpret them independently."*

Contrary to this, the majority of respondents (including Focus Group 4) indicated that they conducted no experiments (E.4.2). In support of this remark it was stated: *"No we do not do experiments because we do not see and, again, our school does not have a laboratory and equipment that blind learners can use."*

In addition to that, it was also argued by (a learner in Focus Group 5): *"Though we know the importance of tests and surveys which is to provide us with new insights and a better understanding, we do not do them (E.4.2)."*

Other respondents indicated that they do not do simple tests and surveys and suggested that this area urgently needs a solution.

If it is true that at some schools for the blind learners do not conduct experiments, this means that those learners do not enjoy or do not have the same rights to receive the education available to their sighted peers; that is, the right to equal opportunity in and equal access to all aspects of education, access to a visual world, access to information, access to curricula, access to knowledge, and access to human relationships.

One gains the impression that once again, educators and learners are not creative and that they, therefore, give excuses for not doing tests and surveys. Environments for excellence are not created. Educators doubt blind learners' ability and blind learners are also guilty of under-estimating their ability. Blind learners lack determination and the right spirit to conduct tests and surveys. They seldom try, seldom work and infrequently believe that they too, can make it and must contribute positively to the innovation of strategies to accommodate them.

The impression that the researcher also gained from responses is that lack of visual ability makes blind learners feel inadequate and inferior, and gives them low self-esteem so that in certain instances they may be depressed and could exhibit perceptions of unhappiness. Van Huijgevoort (2002:59) argued that people who have problems adjusting to their visual impairments may have responses such as "(I) feel that my visual impairment forms an obstacle to my development"; "(I) want to live independently, but I'm scared because I'm blind"; or "(I) want to go to a mainstream school, but I'm afraid my classmates won't accept me with my visual impairment."

He added that blind learners are justified in doubting their abilities because "(s)ociety appreciates a sound and perfect body, physical attractiveness, independence, and achievement. Since people with visual impairments cannot meet these values, society downgrades them to a lower position."

In addition, the researcher further gained the impression that the difficulty in conducting simple tests and surveys could be attributed to the fact that educators tend to expect blind learners to experience events in the same way as learners without visual impairments. Ferrell (2002:83) commented, "(b)ut it is false to think that children with visual impairments experience events in the same way as children without visual impairments. While the learning of children without visual disabilities is often reinforced by visual input, whether repetitious viewing of the act itself or the expression on an adult's face, children with visual impairment often miss out on both the visual feedback and the visual reinforcement. Learning occurs too often by chance, and it occurs in discrete, fleeting pieces that cannot easily be combined into concepts. Learning for … children with visual impairments has to be more deliberate: not a structured, stimulus-response approach, but a thoughtful and planned use of the time available to increase the chances for success by mediating an environment that cannot be experienced visually."

In addition, Erwin *et al.,* (2001:348) maintained that, "(i)n many ways, children who are visually impaired have limited access to opportunities for self-direction both within and outside the school."

As a solution to the problem highlighted above, it is advisable that educators seek blind learners' opinions in order to grant them full participation opportunities during classroom activities. Baxter (2003a:120) commented: "(c)hildren who are capable of forming views have a right to receive information, to give an opinion and to have that opinion taken into account in any matters affecting them."

Where there is creativity, determination, excellence and talent, nothing is impossible. Pierce (2001:32) enquired, "(h)ow can we foster creativity? Nobody knows for certain. However, some of the elements are obvious. We must believe in our talents, and we must demand first-class performance. We must not accept excuses, and we must never quit trying to be all that we can be.

"Most of us will never make it to the top of a mountain or to the winner's circle in the competition for the Nobel Prize. However, each one of us has a contribution to make. If we expect excellence in ourselves, we will create the environment for excellence in others. I am not talking here only of intellectual pursuits, though that is a part of it. If we believe in each other, support each other, dream of a brighter tomorrow, and work to bring it into being, we will ensure success for ourselves and those around us. Nobody, we are told, is indispensable. However, we need everybody with determination and the right spirit. We cannot change the past, but tomorrow is ours, for we will never stop trying, never stop working, never stop believing until it is."

Acquaintance with, awareness of and application of science process skills during mediation and/or observation

The second and third questions are dealt with simultaneously because of their close relationship. The second question determines whether learners are acquainted with science process skills while the third question requests examples where learners go about measuring distance, mass, growth and changes in shapes.

There is convincing evidence (contained in the focus groups' responses) suggesting that learners are acquainted with science process skills, but because of the subjects they are doing and a lack of resources, they rely on theory.

In support of this argument, one respondent (Focus Group 1) stated:*"We know and understand science process skills (SPS.6). However, in physiology, we do not use most of them (SPS.2). What the educator does, he gives detailed information including sizes, shapes, growth, etc., but we do not literally measure things (SPS.7)."*

While some respondents did not engage themselves practically in science process skills, it was encouraging to note that others acquired them and practised them to a limited extent. Those respondents (Focus Group 3) stated: "*We only measure the distance, mass, growth and changes in shapes to a limited extent (SPS.2.2). Our biggest problem is that, our school is poorly resourced (E.2). We do not have enough textbooks (MS.13.3), let alone instruments that blind learners can use in science process skills."*

The position that blind learners have limited access to subject-related material, such as data available on computers, recent publications and encyclopaedias, was strengthened by one respondent during the follow-up interview when he said: *"… we are getting there we are still struggling … computers … I think is of a tremendous help to them if they can get access to the internet and make use of that information from the internet. … Ja but at present we rely on the textbooks and the notes that we … try to convert … and try to make …"*

Another respondent said: *"And so far what I've discovered is that our computers for totally blind learners are not in a good number we have 1 or 2 which are talking which … all the total blind learners can use. But for partially sighted ones we have about 8 computers and they use them in the afternoon …"*

Photo 6: Sources of information

Photos 4 and 6 support the previous argument.

Photo 6: Sources of information.
This photo is a reflection of limited sources of information used by blind and visually impaired learners during learning mediation. Appearing on the photo are Braille textbooks, a Braille machine and a file. What is also clear, is that, the learner is writing with that machine.

The photo (photo 6) further supports the notion/observation of the researcher made during educator and Focus Group interviews that there is limited access to subject-related information with specific reference to computers, encyclopedias and recent publications.

One of the members of Focus Group 4 mentioned that because most of the lessons are based on theory (MS.14), they are not certain whether they are able or unable to conduct experiments practically. The respondent continued to argue that *"One will only be sure the day he is required to show his practical skills."*

Scientific educational Trips/excursions

The fourth question determines whether learners undertake field trips. There is good evidence, supported by information obtained from respondents, that scientific excursions are not habitually taken by learners. The fact that of nine respondent groups, only one group (Focus Group 7) undertook one scientific excursion to Pretoria Museum is indicative of the fact that field trips are not taken as often as possible.

One respondent representing Focus Group 2 indicated: *"We do not undertake scientific trips at all (MS.16.1). We would like to undertake them (LR.9) because we could acquire knowledge and information through them (MS.16)."*

Another member from Focus Group 3 said the following about the importance of scientific trips: *"We hardly undertake field trips* (MS.16.1). *They are extremely important because they are full of new knowledge and new discoveries (MS.16)."* Their educator indicated that they are rarely taken on such trips.

Focus Group 7 had the following to say about the scientific excursions: *"Scientific excursions are important because you always stumble across new information* (MS.16). *Nevertheless, we don't undertake such trips quite often* (MS.16.1)*."*

Opportunities for observing biology phenomena

The fifth question determines whether opportunities are created for learners to observe biology phenomena. From the researcher's observations, there are schools where opportunities are created and others where they are not created.

At two schools, learners experimented by tasting different things and felt a living dog respectively. At other schools learners were only given theory and not practice.

The Department of Physics Laboratory Manual (2003:1) argued that observation is essential for acquiring information, especially during experiments. Observations are important for encouraging learners to collect data and to learn effective procedures and practices for making relevant and accurate observations. It is further argued that when blind learners are not observing, they are deprived of the advantage of learning to order things logically and "… (p)resenting it concisely in a report."

It became clear that learners thought and felt that vision was important for observations. However, with the help of educators, they brought the situation under their control.

One respondent representing Focus Group 3 argued as follows: *"Most of the experiments are complex (E.4.3). They require one to have sight. As such, we are unable to observe them (O.1). However, our teacher compensate for that by giving us a detailed description and explanation (MS.1.2)."*
Also see photo 3. Blind and visually impaired learners participating in a classical "question-and-answer" session.

Other respondents from Focus Group 4 indicated that they use alternatives to circumvent their disability. "*Because we know we are unable to see most experiments (O.1), we also use other senses like listening, feeling, smelling (O.2), etc. Where that is not possible, we listen attentively (O.4) to our teacher's explanation."*

Burke argued that (2001:64) it makes sense to use any legitimate means you can to be as successful in school and later in your career as your natural talents allow.

Likewise, Luebbe (2002:56) maintained that, "(t)hese alternatives make … life every bit as good as those of sighted people."

There was an instance at one specific school where the teacher responsible for one of the subjects arranged a scientific field trip for the learners and requested that learners should contribute financially towards the trip. The learners refused to pay for the excursion, arguing that they were "Government's children", and that as the Government was subsidising special schools, their contribution to the excursion should also be subsidised.

Regarding this specific occurrence, one is of the opinion that some blind learners might be using the fact that they are blind as an excuse not to participate in certain activities.

Data recording processes and procedures

The sixth question concentrates on how blind learners plot and record data correctly. There is solid evidence that blind learners are able to plot and record data. In order for them to do so, they need to be given models and sketches. Their role is that of identifying parts and discussing them thoroughly. In instances where experiments are conducted, educators explain to them and they write down the most salient points during the explanation. By so doing, they record data. Burke (2001:67) noted that "(t)aking notes … is a good idea …"

There is also good evidence that recording data in tables with columns is difficult. One respondent from Focus Group 1 said that blind learners are often required to mention or list things in their chronological order.

The respondent added*: "If that is not possible and allowed (SPS.4.4), one could ask the assistance of the educator (T.2) to do it on one's behalf. However, we the learners, we are duty bound to furnish any assistant with relevant information (LR.5.1)."*

Another respondent from Focus Group 2 gave the following comment regarding the drawing of sketches: *"Most of us do not draw sketches at all (LR.10). We make use of sketches made by our educators (MS.11.1). Remember drawing is an art and it is never simple to blind learners. Even the sighted practise a lot to perfect this artistic skill. No wonder it is not simple to blind learners (LR.10)."* The fact that blind learners experience difficulties with drawing was supported by educators during follow-up interviews. They indicated that, thus far, they do not know how to teach blind learners how to draw.

Tabulation skills and techniques

Question seven discusses the techniques and skills blind learners apply when they are required to perform tabulations. Regarding this, respondents from only one group indicated that they use pushpins and elastic bands attached to pre-printed axis-pages. There is evidence that at other schools learners do not do tables on their own.

In showing the difficulty of executing this task one respondent from Focus Group 2 uttered the words:*"Tables are a difficult task to execute (SPS.4.5.1). As learners who are doing science, we are interested in doing everything that sighted learners do (LR.8)."*

On the other hand, another respondent from Focus Group 3 asserted: *"We do not make tables (SPS.4.2.2) because our educator is not Braille literate (ED1). Therefore, adapting tables is a problem."*

The conclusion at which one arrives is that, should schools be better resourced, some of the problems will disappear. Educators and blind learners will be able to make and convert complicated diagrams into a tactile format. Burke (2001:68) argued that, "(g)raphics printers are increasingly effective for rendering maps, math, and complicated diagrams and graphs. If you have access to such technology or materials, your competitive equality is literally at your fingertips."

A conflicting statement is, however, that an educator interviewed at one of the schools stated that she used last year's common task assessment graphs, which were already adapted. This remark may be linked to the observation by one of the learners from Focus Group 4, who stated that *"We only depend on what has been handed out to us by our teachers (LR.12)"*. Another respondent from Focus Group 6 mentioned that *"We are not taught how to make tables (SPS.4.5.3), however, we believe that with practice we can be perfect (LR.11.1)."*

Interpretation of data

Question eight addresses the way blind learners go about interpreting data, since interpretation of data requires the investigator to draw conclusions from the acquired data and/or results of calculations, and also

that the investigator "…(m)ust be able to test the reliability of these conclusions" (Department of Physics Laboratory Manual 2003:1). There is good evidence that blind learners are able to interpret data, depending on the type of information that has been gathered.

Evidence from empirical data suggests that blind learners do not have problems in interpreting data.

One respondent (Focus Group 1) regarding this matter stated: *"We do not take the readings but we instead record them (R.2). Recording readings is a fairly simple thing to do."*

Similarly, another respondent from Focus Group 2 agreed that blind learners are able to interpret (R.3) the information because they can write statements on their own and according to their own understanding. According to that respondent, being able to do that surely indicates that blind learners do what interpretation requires and expects of everyone. In addition, as that respondent sees it, that is what interpretation means and entails.

A member of Focus Group 3 stated: *"As blind learners we can analyse (SPS.5) and interpret (SPS.8) information. As far as designing things is concerned, I think it would be a daunting task if not an impossible thing to do (SPS.9). Furthermore, the simplicity or the difficulty depends on different conditions and situations (LR.13) under which one has to do those things*".

One of the members of Focus Group 5 remarked that: *"Interpretation does not depend on the visual ability (SPS.8.1) but the intellectual ability (SPS.8.2). As blind learners, because there is nothing wrong with our intellect, we can interpret data."*

Strategies for describing & explaining biology phenomena

Question nine addresses blind learners' ability to explain concepts, principles, laws, theories and models in unfamiliar and complex settings. There is sound evidence to support the view that blind learners are capable of carrying out these tasks.

For instance, one respondent from Focus Group 1 stated that: *"The information in Braille is similar to that in print (MS.12.1). Hence, one uses the same information that sighted learners use in doing exactly that".*

In the same vein, Corn and Wall (2002:8) argued that access to developmental and educational services to blind learners should include "…(a)n assurance that instructional materials are available … in the appropriate media and at the same time as their sighted peers."

Another respondent from Focus Group 2 confidently said the following: *"Yes, we can (SPS.8). Remember, a description is all about the characteristics of something while an explanation is about giving as much information as possible to someone the way you understand it (LR.14)."*

Description and explanation depends mainly on one's understanding of different meanings and connotations and on one's being able to describe and explain without any difficulty. A description considers the features of something (specifics), while an explanation involves talking in great detail (generalities) about something.

In addition to the previous evidence, another respondent from Focus Group 4 stated: *"I prefer to be given models (MS.2) or taken to the real thing (MS.2.1) for me to describe or explain. With models in my hands, I can tell their differences as well as their similarities. This is to say, I like describing what I feel and thereafter, I can explain at length about what I felt."*

Opportunities for distinguishing similarities and differences

Question ten focuses on blind learners' exposure to similarities and differences. In this regard, there are conflicting arguments. Some respondents indicated that they are exposed to similarities and differences while others dispute this.

As evidence for the fact that blind learners are exposed to similarities and differences, a respondent from Focus Group 1 stated: *"We are indeed exposed to similarities and differences (SPS.11). Our educator uses comparisons and contrasts (MS.17). Models and shapes are also important to a blind person in knowing differences and similarities (SPS.11.1). Surely, a square and circle are shapes. However, they are different in that one is round and the other one has four equal sides. The same applies to a fish and a dog. They are all animals with a different body structure and a different habitat. Through those models, one can tell that they are different."*

Another respondent from Focus Group 2 added: *"We are able to tell similarities and differences because the process involves telling common and uncommon things as far as biology phenomena are concerned (SPS.11.2)."*

Contrary to the above evidence, other respondents from Focus Group 4 indicated that they were not exposed to similarities and differences. There is evidence to support this because one respondent argued that they were not exposed to similarities and differences (SPS.11.3). According to this respondent, *"If learners were exposed to similarities and differences, that was infrequently done (SPS.11)."* One is convinced that this response was given as a result of not understanding the "similarity and difference" concepts.

Information acquisition during investigation

Question eleven focuses on the strategies that blind learners apply in the classroom to create opportunities for themselves to accumulate information for investigation purposes. There is solid evidence that blind learners do everything possible in this regard.

One respondent from Focus Group 3 argued that opportunities could or could not be created (SPS.12), depending on particular situations and conditions, the environment, effort and dedication. The respondent

went further, arguing that opportunities to accumulate information require one to consult experts (SPS.12.1), peruse one's prescribed and reference books (SPS.12.2), listen to radio and television news, browse the internet (SPS.12.3), borrow Braille books or talking books (MS.13.1) on a particular topic, and so on. However, the respondent indicated that the opportunity to accumulate information for investigation purposes was hampered by a grave shortage of Braille material (E.9.3). Please see photo 4 discussed previously.

Corn and Wall (2002:6) indicated that the present generation of learners is more advanced than those in the past. They stated, "(t)oday's students … use textbooks and instructional material that have little physical resemblance to the textbooks of years past, which were in black and white or had only a few coloured pictures and diagrams. Students may now receive electronic versions of textbooks, with moving pictures, and links to information not contained in the primary source book.' Classrooms are no longer limited to the use of textbooks and worksheets found in textbook storerooms and/or copied. Rather, information has few boundaries; when students use textbooks on CD-ROM, they may be asked to seek information through the Internet and to receive and develop their assignments as multimedia presentations."

These authors further (2002:10) suggested that blind learners be encouraged and allowed to access and use information by means of technology so that they can "…(u)nderstand the same information presented to sighted students in a … presentation. For example, screen readers and screen-magnification software provide access to information presented on computer screens."

Similarly, Pierce (2001:17) argued that "(i)f you are on the right side of the divide, meaning that you have access to technology and access to those who can teach you how to use the technology, your future as an individual, a community, and a country is bright."

For learners to be able to access information through technology, they have to become more technology literate. According to Neibaur, Day and Sebastian (2002:102) the creation of a community of learners using multiple connections and multiple ways of communicating creates the sense of a more personal education, as well as autonomy in learning.

Because most blind learners reside in hostels, it is difficult for them to use different methods to accumulate information though they know that the methods are extremely important. One respondent from Focus Group 2 pointed out that accumulating information involves reading books in the media centre (SPS.12.2), watching TV, listening to the radio (SPS.12.3), requesting information from friends (SPS.12.4), surfing the internet and undertaking science field trips. The phrase "watching TV", in the researcher's view, implies listening to it. The blind are accustomed to using ordinary terms or phrases like "watching TV", "I see" (implying "I understand") and many more phrases.

Another respondent from Focus Group 7 remarked that acquiring information for investigation purposes was rather difficult (SPS.12.5). Because they lacked books in Braille (E.9.3), they were depending on partially sighted learners (T.1). At times, partially sighted learners read to them (T.3). On other occasions, partially sighted learners refused to read to them (T.3.1) either because they were busy writing their

classwork or because they felt it was not their duty to read to blind classmates. Wall and Corn (2002:60) argue that even if Braille books are available, this does not guarantee "…(t)hat students who use Braille will receive the appropriate quantity or quality of Braille necessary to access their educational curricula." Because blind learners do require accessible and appropriate Braille learning materials, it is imperative that all stakeholders in education do address the provision of these resources.

The same respondent from Focus Group 7 elaborated as follows: *"Furthermore, when one reads to you (T.3.1), it is totally different from reading on your own. If you read on your own, the advantage is that you have time to digest (MS.18.1) what you read, you could revise it and you are also sure about spellings."*

Respondents in the remaining focus groups also mentioned the same techniques as far as the accumulation of information is concerned.

Prediction of outcomes

Question twelve concerns the methods the learners' educators use when they create opportunities for the former to predict the outcomes of a certain intervention. There is in fact little evidence suggesting that opportunities are created for blind learners to predict in this way (SPS.4.4.1).

In support of this finding, one respondent from Focus Group 1 indicated: *"We are given background knowledge (MS.1) before we could do experiments".*

In contrast to what this particular respondent had stated, another respondent from the same Focus Group mentioned that because the learners themselves do not do experiments (E.4.2), they therefore cannot predict the outcomes of an intervention (SPS.4.4.2). What they think the educator should do is to verbally tell them all the steps involved in doing that experiment (MS.1.4). Perhaps they could then predict the outcome.

What emerged from the interview, particularly in answer to this question, is that blind learners could predict or could not predict the outcomes of an intervention, depending on the type of experiments conducted. If their educators explained to them the intentions of the experiment, the steps to be followed when conducting such experiments, and so on, they might be in a position to predict the outcomes of an intervention. However, if the environment is optimum, yet does not address differences in blind learners' learning styles, predictions will be difficult to make (Ferrell 2002:83).

There are, however, according to one respondent from Focus Group 5, instances where blind learners use common sense to predict the outcomes (SPS.4.1.1) of an intervention. If an intervention happens to be complex, common sense does not work. Therefore, blind learners will rely on the information furnished by the educator (MS.1). Other respondents were also of the same view.

Analysis of programmes

Question thirteen determines how simple or difficult it is for blind learners to analyse, synthesise, hypothesise, design, interpret and evaluate life sciences programmes.

There is sufficient evidence to demonstrate that blind learners are able to carry out these tasks. Furthermore, they do not do this differently from their sighted counterparts. However, for blind and visually impaired learners to interpret, analyse, et cetera, Erwin *et al.,* (2001:339) advised that it is necessary for educators "…(t)o provide access to new content within the environment, guide exploration and discovery, and encourage interpretation."

One respondent from Focus Group 4 maintained: *"Analysing data depends strictly on the type of information (SPS.5.1.2) one shall have gathered. Because most of the time we do not take the readings (SPS.13.1) but are required to record them, (SPS.13.2), that is a fairly simple thing to do."*

In addition to this, another respondent from Focus Group 5 maintained, s/he can interpret data as long as the information gathered, in whatever form, is adequate. However, other respondents considered the process of analysing, interpreting, et cetera, to be expressing one's opinions both verbally and in writing and according to one's own understanding (SPS.8.3). One respondent even stated, *"surely that is what interpreting means".* The researcher is of the view that the previous respondent lacks an adequate understanding of the activity of interpretation. Interpretation implies having the ability to analyse and give a sensible explanation of events, situations, aspects, et cetera.

Another respondent from Focus Group 8 also indicated that blind learners could analyse, interpret, evaluate and hypothesise. However he warned: *"… Designing things I reckon would be a daunting task if not an impossible thing to execute (SPS.9). Furthermore, the simplicity or complexity of things depend and is as well influenced by situations and conditions under which one has to execute the task."*

The perception that the researcher was left with is that if blind learners understand the information, then it is simple to analyse and evaluate collected information.

Correct and incorrect things done during the learning mediation

The fourteenth question concerns what is correctly or incorrectly done during learning mediation in the classroom. There is good evidence to demonstrate that there are a number of activities that are correctly or incorrectly performed.

One respondent from Focus Group 2 expressed the view that she thought models are not enough (MS.2.3). Some of the sketches are too detailed; hence (MS.11.2) she is unable to comprehend them (MS.11.2). According to her, blind learners have not yet found a way to make tabulations independently, although (SPS.4.5.1), as such, blind learners are fully aware of the important role they play in their education. This, in her opinion, should be explored.

Another respondent from Focus Group 9 argued as follows: *"What we think is correctly done, is Braille notes that our educator gives us (MS.1.5). You know, half a loaf is better than no bread. But, we would appreciate if we are supplied with our own books (MS.13.4) as this gives one independence as well as enhancing one's self-reliance (MS.1.3.5)."*

Another respondent from Focus Group 6 stated: *"Things that are correctly done include giving us notes in both Braille (MS.12.3) and enlarged learning mediation material (MS.19). In terms of things that are incorrectly done, I tend not to like it when our science educator write on the chalkboard and forget to tell me what is written. That style, makes me lose focus as there are also learning gaps in what I am learning. I would prefer that the educator either gives me notes or verbally tell me what he wants me to know (MS.1). Discussion of issues instead of writing is better for me as a blind learner (MS.20)."*

Photo 5: Educator writing on the chalkboard.

Photo 5: Educator writing on the chalkboard.
Photo 5 is an illustration of the science educator writing on the chalkboard. His back facing the learners is evident of his action (writing) phrases such as mixture and compound. Those phrases are visible on the photo. Some low vision learners are writing in their notebooks while blind learners are just sitted. This is a classical example of educators displaying their skill of writing at the expense of blind learners who cannot follow or make sense of what has been written. A learner in one of the focus group interviews vehemently opposed print since it is a nightmare to blind learners. According to that learner, meeting their needs of solving the "print nightmare" involved the provision of prepared Braille notes or dictating such notes so that they could independently record them with their braillers.

Methods and sources for accumulating data

The final question discusses the methods and sources blind learners use when accessing information in unfamiliar and complex settings. Blind learners use a wide variety of these. Such methods include Braille textbooks, talking books, sighted people, electronic media including internet, radio, television, Braille magazines, educators, objects, real objects, and so on. However, the socio-economic factor counts when it comes to the availability and accessibility of sources and methods. The previously disadvantaged institutions and learners are still disadvantaged; hence, their methods and sources will be fewer than those of previously advantaged schools.

6.5 GENERAL COMMENTS OF RESPONDENTS

Natural science, biology and physiology are subjects mediated to blind learners at various schools in the ways described by individuals and focus groups during interview sessions and observed by the researcher. There is a reasonable number of educators with extensive knowledge of science subjects. Some schools are better resourced, while others are under resourced. For example, one school in the vicinity of Pretoria has better facilities than those of the other eight schools studied, whether in townships or in rural areas.

The Education White Paper 6 of the Department of Education (2001:5 and 8) similarly argued that some schools were extremely resourced while others are systematically under-resourced. Schools which are extremely well resourced possessed the best human, physical and material resources.

The researcher was also informed by a member of staff at one of the schools that their institution offered physiology, mathematics and physics up to grade 12 level. Other schools where this research was conducted were not yet offering these subjects at this level: however, they showed interest in offering them. This implies that blind learners who are doing life science subjects up to grade 12 are in the minority, because there are three, or maybe four, schools offering life science subjects at this level in South Africa. In addition, career opportunities for blind individuals are limited. Therefore, this also implies that blind learners have only a few education streams from which to make their choices.

Learners who possess background knowledge in life science related subjects are likely to continue with them up to tertiary level because life sciences offer career opportunities and the learners are interested, and as such, they can cope with the demands and challenges of life sciences.

In addition, blind learners' understanding of, love for and interest in these subjects can be broadened. When asked whether blind learners should also take life sciences at school one respondent from Focus Group 8 said: *"Why not? Nobody should be discriminated against. After all, science is very useful."* Another respondent from Focus Group 7 supported the previous view by saying *"I love science."* As a further elaboration that respondent stated: *"The only thing that discourages me is the fact that here at our school, it is only offered up to grade 9. Why should one bother learning something useful, which will discontinue?"*

While all respondents agreed that science related subjects are useful, not all were pleased with their schools' situations. Displeasure was highlighted in the following ways: *"Science make sense when you have Braille books (MS.12.3), when you do experiments (E.1.2), when you undertake trips for investigation purposes (MS.16.2) and, when you have dedicated educators (ED.2)."*

Closely related to the former argument, another respondent from Focus Group 2 expressed his reservations in the following manner: *"We use old and worn out Braille books (E.8.4). It's high time that we also get recent publications."*

It was further revealed that blind learners use different methods in order to benefit from life sciences. Learners from better socio-economic backgrounds, or well-resourced schools, use computers with special software such as JAWS, Zoom text, Internet explorer, Duxbury translator, and the like. However, many of the respondents do benefit from Braille textbooks, educators, partially sighted classmates and adapted learning mediation aids.

Abner and Lahm (2002:98), in supporting the point that blind and visually impaired learners benefit or obtain information from various sources and technology, declared that "(o)ver the past decade, advances in technology have provided new opportunities for people who are visually impaired (that is, are blind or have low vision) to be independent at work, school, and home. These advances have allowed them to compete successfully with sighted people and to have equal access to printed information … Optical scanners; closed-circuit television systems (CCTVs); optical magnifiers; note-taking devices; and technologies that produce large print, Braille, or speech are examples of technologies that enable individuals who are visually impaired to write and edit papers, conduct research, gain access to information, and develop job skills."

One respondent from Focus Group 1, regarding this point, declared: *"I often ask my classmates, my friends or my relatives and I say … can't you read me information which is in print (T.3)."*

However, it seems Braille is the primary source of information for many blind people. According to Dr. Euclid Herie, the then president of the World Blind Union (2000:4), Braille plays an immense role in the life of a blind person. He noted, "(e)very life tells a story and for those of us who are blind, our stories are told in Braille." He further argued, "(t)ruly Braille equals equality. When Braille leads, literacy follows."

Dr. Rajinder Singh Sethi (2000:65), in the same publication, also stressed the importance of Braille in the following manner: "(a)sking what Braille means to me is akin to asking what fuel means to an automobile, what the binary digits mean to a computer, what water means to a fish, and what freedom means to a Nelson Mandela who was incarcerated for the better part of his life. It means freedom to me. It is platform of equality for me - equality with my sighted counterparts. It means oxygen for me. It is my life blood - my life support system. It makes no demands; it doesn't require electricity. I can read in a dark room as easily as in a crowded train. My thirst for information and sharing it with others would have remained unfulfilled had it not been for Braille."

Blind learners in South Africa could use other services to acquire information. Institutions like Tape Aids for the Blind and Print Handicapped could lend them talking books, while the South African Library for the Blind could lend them Braille books and talking books as well.

Some respondents had reservations about the services rendered by printing presses and other service providers offering a talking books service to the blind and print handicapped. They indicated that they received material from these services but sometimes it was of no use. Almost all the respondents preferred receiving information or documents in Braille because, according to them, data written in Braille showed the value of Braille to blind people. Data in Braille enhanced their independence and self-reliance. It is argued by Dr. Rajinder Singh Sethi in World Blind Union (2000:65) that modern technology has provided various gadgets that seek to help the visually handicapped, like tapes and speech synthesisers. But nothing can give blind people the kind of freedom that Braille has given them and will continue to give them. He added that "(m)odern technology is fast, functional and advantageous. With tapes and speech synthesizers, a blind person can collect lots of information, but listening is not the same as reading, and talking is not the same as writing."

The present study has also revealed that blind learners in South Africa are more excluded from doing biology in the Further Education and Training Band than their fellow sighted learners. When learners (in focus groups) were asked if they thought and felt that they were more excluded from doing biology or life sciences than their fellow sighted learners, their responses were as follows:

"We are really excluded" - Focus Group 2.

"It is absolutely correct" - Focus Group 4.

"Undoubtedly yes" - Focus Group 5.

"I definitely think so" - Focus Group 9.

The statements recorded above indicate that blind learners are not held "…(t)o the same academic standards as all students, …" (Special Education Report November 21 2001:5).

6.6 REASONS WHY BLIND LEARNERS THOUGHT AND FELT THEY WERE EXCLUDED FROM DOING BIOLOGY

These reasons include (the researcher's comments in brackets):

- Lack of accessible reading material. (The advent of Outcomes-based Education and training brought along with it problems as far as mediating learning to the blind is concerned. Material has become too visual. Books are now selected by cluster-schools, making it impossible for Braille printing presses to transcribe a few books into Braille, as this is not cost-effective for them. In addition, even if they are transcribed into Braille, such books are used only for a short period. Some small schools for the blind cannot cope with this practice (changing prescribed books after a short space of time) because of their small budgets.)

- Adapted equipment to conduct experiments. (Some schools do not have equipment such as computers, thermoform machines, tactile image enhancers and the like, that educators could use to adapt learning mediation material. On the other hand the unavailability of equipment such as: talking scales, meter sticks, volt meters and talking calculators make it difficult for blind learners to independently conduct experiments. This makes it even harder for the blind to do experiments practically when adapted equipment is not available. It is argued by Spungin (2003:15) that "(i)f these students do not receive appropriate instruction designed to develop competencies that meet the sensory deficits of blindness … critical learning opportunities will be lost, thus diminishing the potential for future accomplishments.")

- Inadequate laboratory facilities. (The fact that most schools lack adapted equipment is indicative of the fact that laboratories (if available) are ill equipped. Because of this, no blind learner could conduct experiments in a laboratory that does not cater for his/her laboratory needs.)

- Sketches that are always omitted from textbooks. (Sketches form an integral part of the mediation of learning to all learners. Because of a lack of experts, who can make sketches, at Braille printing presses, or because sketch-making into a tactile format is a time consuming process, they are in most instances omitted from Braille books. As a result, blind learners only depend on theory and not on practice. In addition, they do not possess any background regarding how such sketches are produced. This limits their education and skills, which implies that blind learners will not develop fully in education. It is argued in the first Working Session on the National Working Group on Curriculum Adaptation (2003:28) that "(s)kills development relates to areas whereby learners can gain new skills and/or practice, as well as to maintain, combine, refine, transfer or generalise existing skills. It might also involve reactivating skills that have been acquired previously." It should be borne in mind that people are often influenced by others' artistic work in order to develop artistic skill. So should the blind also be.)

- Lack of visual ability. (Vision complements and supplements hearing. Lack of vision causes blind learners to miss many things that are difficult to explain, for example intricate and dangerous experiments. Important visual events or images that people can see are ineffaceable from one's mind, unlike second-hand information. This is a problem when it comes to the blind because they depend on second-hand information during experiments and the mediation of biology. Dyer (1979:188) argued that experiments are critical because they yield "…(i)mportant and unique information.")

- Incompetent educators. (Some educators have not received specialised training in how to mediate learning to blind learners. They lack appropriate learning mediation strategies, strategies to accommodate learners in different learning mediation environments, proper subject knowledge, and so on. This impacts negatively on the education of learners. The Report of the National Commission on Special Needs in Education and Training (NCSNET) National Committee on Education Support Services (NCESS) (1997:19) stated that "(t)he development of educators, service providers and other human resources is often fragmented and unsustainable. The absent of on-going

in-service training of educators, in particular, often leads to insecurity, uncertainty, low self-esteem and lack of innovative practices in the classroom. This may result in resistance and harmful attitudes towards those learners who experience learning breakdown or towards particular enabling mechanisms.")

- Lack of in-house machines to produce material that cannot be sent to external printing presses. (Not every type of learning mediation information that blind learners need, can be sent to printing presses. In order to make each and every little detail available to blind learners, since they do not have newspapers, periodicals, journals, and the like, the school should provide them with such information. There should be machines to produce or duplicate material, in what is called in-house production. Some schools do not possess them. This implies that blind learners miss out on the acquisition of information.)

- Inaccessible public libraries. (Most public libraries do not have accessible reading material and assistive devices that blind learners can use to access information. Because of this, blind learners do not find them useful.)

- Educators' perceptions that blind learners lack the mental capacity and skills to do and excel in science. (Some educators still believe that science-related subjects, because of complex experiments and other challenges including drawing, having to use microscopes, and other issues are not meant for the blind due to the fact that they lack visual ability. The Report on the National Commission on Special Needs in Education and Training (NCSNET) National Committee on Education Support Services (NCESS) (1997:15) argues that "(n)egative and harmful attitudes towards difference in our society remain a critical barrier to learning and development. Discriminatory attitudes resulting from prejudice against people on the basis of … disability … and other characteristics manifest themselves as barriers to learning when such attitudes are directed towards learners in the education system.")

- Rationalisation and redeployment. (Some schools have lost educators owing to redeployment and rationalisation processes; but those who replaced them do not necessarily possess the competences and skills to mediate learning to blind learners. One respondent (R2) remarked that *"Facilitating learning to blind learners is a tedious process (ED.3). One cannot use any visual learning mediation aids like, you know, screens to project pictures or word next to it, microscopes, certain acids, etc."* Furthermore, another respondent (R3) suggested that science is not supposed to be offered to blind learners, as it is just a waste of precious time. Insinuations like the ones stated above, further lessen blind learners' interest in and opportunities to do biology.)

- Inflexible curriculum. (Barriers to learning can also be attributed to different aspects of the curriculum, such as the actual content of the curriculum and how it is being taught. The Report on the National Commission on Special Needs in Education and Training (NCSNET) National Committee on Education Support Services (NCESS) (1997:16) noted that "(o)ne of the most serious barriers to learning and development can be found within the curriculum itself and relates primarily

to the inflexible nature of the curriculum which prevents it from meeting diverse needs among learners. When learners are unable to access the curriculum, learning breakdown occurs. The nature of the curriculum at all phases of education involves a number of components, which are all critical in facilitating or undermining effective learning. Key components of the curriculum include the style and tempo of teaching and learning, what is taught, the way the classroom is managed and organised, as well as materials and equipment which are used in the learning and teaching process.")

Because of the reasons furnished above, blind learners are less likely to do biology. One respondent (R6) stated that: *"I think the majority of our blind learners do not enjoy the learning mediation of biology because of many problems of which lack of resources is the major stumbling block (E.9)."*

Resources will only be available to all children, including the blind, if they "…(o)btain equal education, and the state …strives towards giving all students - whether they are in suburban schools, township schools or farm schools - the same access to resources and to personnel, and the same opportunities to realise their fullest potential" (Wilmot 2001:14).

6.7 CODING AND CLASSIFICATION OF EDUCATOR AND LEARNER INTERVIEWS

A descriptive analysis of educator and learner responses was extensively undertaken above, in paragraphs 6.3.1 and 6.3.2. The researcher carried out triangulation independently, but sought the opinion of his supervisor in order to maintain objectivity.

Objectivity was maintained for the following reasons:

(i) First, to ensure that the data collected and analysed had only one meaning or interpretation.

(ii) Second, to make certain that the influence of the researcher was minimised.

(iii) Third, to strive to maintain the highest quality in the data collected, categorised, reconstructed and interpreted.

The process of coding and classification took place from the beginning of July 2004 and was finalised on 21 July 2004. It resulted in the coding/classification illustrated in the table below.

Cognisance should be taken of the fact that the researcher is not claiming to have identified all the possible themes stemming from the mediation of life sciences to blind and visually impaired learners; neither does the researcher claim to have generalised that the themes featured in this work are typical of all teachers of special schools facilitating life sciences to blind and visually impaired learners. Below is a table illustrating the selected text segments from the educator and learner interviews and their codes, as well as an attempt to show how they link together in the quest for the identification of themes.

EXPERIMENTS – E	
Experiments are conducted by educators and learners	E.1

Simple tests and surveys are conducted by educators and learners	E.1.1
Experiments should be conducted by educators and learners	E.1.2
Lack of basic equipment	E.2
Lack of basic equipment - Lower standard	E.2.1
Resources will improve development of SPS	E.2.2
Necessity of resources	E.3
Problem for blind learners to execute	E.4
Problem that learners cannot operate independently	E.4.1
We (learners) don't do experiments	E.4.2
Experiments are too complex for blind learners	E.4.3
Use of home-made equipment	E.5
Improvisation is conducted by educators	E.6
Lack of innovation by educators	E.6.1
Do not develop innovative SPSs (science process skills)	E.6.2
Lack of adapted material in laboratories	E.7
Value/use of adapted material	E.8
Motivation increases through the use of aids	E.8.1
Aids make them (learners) independent	E.8.2
Comprehend better	E.8.3
Braille books outdated	E.8.4
Limited resources	E.9
Media centre poorly equipped	E.9.1
Need simple laboratory with apparatus adapted for the blind	E.9.2
Lack of Braille material	E.9.3
A lack of laboratories experienced by blind learners	E.10
RACTICAL – P	
Complexities of and challenges to educators regarding the performance of practical work	P.1
TEAMWORK – T	
Blind learners are supported by partially sighted learners	T.1
Blind learners are supported by teachers	T.2
Partially sighted learners read to them (blind learners)	T.3
Partially sighted learners refuse to read to them (blind learners)	T.3.1
MEDIATION STRATEGY OF EDUCATORS– MS	
Transmitting – give notes or oral information to learners	MS.1
Provide cues (prompts) and clues to learners	MS.1.1
Explain things in great detail – compensate for loss of sight	MS.1.2

Educators provide ready-made tables to learners	MS.1.3
Teachers explain all the steps to learners	MS.1.4
Educators provide Braille notes to learners	MS.1.5
Use concrete things such as models during teaching	MS.2
Learners prefer to be given real things	MS.2.1
Models are not enough	MS.2.2
Avoid dealing with abstract things during teaching	MS.3
Recall of prior learning an important strategy	MS.4
Ordinary/basic concepts taught	MS.5
Exceptional features are illustrated by educator	MS.6
Use of common/everyday examples during teaching	MS.7
Use of abstract examples during teaching	MS.8
Problems with OBE often experienced during teaching	MS.9
Activity/active participation encouraged	MS.10
Drawings/Sketches	MS.11
Educators draw sketches for the blind	MS.11.1
Detailed sketches cannot be comprehended	MS.11.2
Link Braille with drawings	MS.12
Blind learners see Braille is equivalent to print	MS.12.1
Blind learners should be given Braille notes	MS.12.2
Use of info from Resource Centre	MS.13
Borrow “talking books” from Tape Aids for the Blind and Print Handicapped	MS.13.1
Blind learners have to be supplied with the same resources as for normal learners	MS.13.2
Lack of textbooks experienced	MS.13.3
Blind learners should be given own books	MS.13.4
Own books contribute to independence and self-reliance	MS.13.5
Theoretical/theory only, with less emphasis on practical work	MS.14
Asking of questions an important strategy	MS.15
Employ narrative strategies when teaching	MS.15.1
Scientific field trips contribute to new info and knowledge	MS.16
Scientific trips not undertaken	MS.16.1 (change)
Scientific trips should be undertaken	MS.16.2
Educators use comparison and controls	MS.17
Reading important (as broad category)	MS.18
Reading on your own gives you time to digest info better	MS.18.1
Learning mediation material has to be enlarged	MS.19
Issues have to be discussed with learners	MS.20
INTELLIGENCE – I	

Intelligence support prediction of SPS	I.1
Intelligence enhances analysis of data	I.2
TECHNOLOGY – TEC	
Adapted technology used during learning mediation	TEC.1
Too expensive	TEC.1.1
Blind learners should have access to computers	TEC.1.2
LEARNER RESPONSE – LR	
Understanding of concepts an important learning principle	LR.1
Explaining abstract things	LR.2
Plotting critical points	LR.3
Performing experiments	LR.4
Filling up bottles with water	LR.4.1
Learners are able to describe and to explain things	LR.5
Explain to assistant what has to be done	LR.5.1 (change)
Learners should search for information on their own	LR.6
Blind learners listen attentively and understand better	LR.7
Blind learners enjoy talking to express themselves	LR.8
Blind learners want to undertake field trips	LR.9 (change)
Find it difficult to draw sketches	LR.10 (change)
Blind learners want to do everything sighted learners can also perform	LR.11 (change)
Blind learners can do everything sighted people can (practice makes perfect)	LR.11.1
Learning depends on what has been handed out	LR.12 (change)
Simplicity or difficulty of performances depend on simple or difficult conditions and situations	LR.13 (change)
Explanation depends on the way we understand something	LR.14 (change)
HUMAN RESOURCES – HR	
New in the field of educating blind learners	HR.1
SCIENCE PROCESS SKILLS – SPS	
Acquaintance with SPS	SPS.1
SPS Not taught	SPS.2
SPS taught at lower levels	SPS.2.1
SPS taught to a limited extent	SPS.2.2
Measurement	SPS.3
Learners cannot measure long distances	SPS.3.1
Learners have to measure	SPS.3.2
Experience spatial relationships	SPS.3.3

Prediction	SPS.4
Prediction has to do with understanding and intellectual ability	SPS.4.1
Use common sense	SPS.4.1.1
Relevant information has to be given to learners as prerequisite in for prediction	SPS.4.2
Prediction depends on guessing and blind learners can do that	SPS.4.3
Prediction will be determined by the type of intervention	SPS.4.4
Few opportunities given to predict	SPS.4.4.1
No prediction when experiments are not done	SPS.4.4.2
Adding information to tables	SPS.4.5
Blind learners find it difficult to draw tables	SPS.4.5.1
Blind learners don't draw tables	SPS.4.5.2
Blind learners not taught how to draw tables	SPS.4.5.3
Analysing data	SPS.5
Analysing data depends on a person's intelligence	SPS.5.1
Analysing data depends on mental growth	SPS.5.1.1
Analysing data depends on type of information	SPS.5.1.2
Blind learners know and understand the SPS	SPS.6
Blind learners informed orally of the SPS	SPS.7
Blind learners can interpret	SPS.8
Interpretation does not depend on visual ability	SPS.8.1
Interpretation depends on intellectual ability	SPS.8.2
Interpretation depends on own understanding	SPS.8.3
Impossible for blind learners to design things	SPS.9
Can describe concepts, principles and laws	SPS.10
Blind learners are exposed to similarities and differences	SPS.11
Models and shapes are used to show differences and similarities	SPS.11.1
One can use common and uncommon things	SPS.11.2
Learners are not exposed to similarities and differences	SPS.11.3
Accumulation of information	SPS.12
Use of experts	SPS.12.1
Use of reference books	SPS.12.2
Use of educational technology	SPS.12.3
Requesting information from friends	SPS.12.4
Acquiring information is difficult	SPS.12.5
Readings: taking readings	SPS.13
Do not take readings	SPS.13.1
Only record readings	SPS.13.2
KNOWLEDGE ACCESSING - KA	
Access Internet	KA.1

Adapt Internet for blind learners	KA.1.1
Internet not functional	KA.2
Not the task of teacher to access information for learners	KA.3
OBSERVATION – O	
Cannot observe visually	O.1
Apply alternative senses	O.2
Learn from other countries	O.3
Listen attentively	O.4
RECORDING OF INFORMATION – R	
Does not find it difficult to record	R.1
Blind learners do not take readings but record them	R.2
Blind learners can interpret information	R.3
EDUCATOR PERCEPTIONS – EP	
Blind learners cannot describe and explain because they cannot observe	EP.1
EDUCATORS – ED	
Educators are not Braille literate	ED.1
Educators should be dedicated	ED.2
Facilitating blind learners is a tedious process	ED.3

6.8 SUMMARIES AND CONCLUSION

Four themes and their sub-themes were discussed. The views of educators and learners in relation to the acquisition of science process skills, strategies for recording data, sources of information, predicting, analysing and evaluating biology programmes, et cetera, were analysed and discussed.

The chapter has shown that much still has to be done in changing educators' perceptions so that they can effectively mediate biology to blind learners. The chapter further revealed that educators' understanding of and perceptions towards biology and blind learners add a complex dimension to the debate that South African blind learners must or must not learn biology.

Educators play an important role in the development of learners in all education settings and in different learning mediation environments. It will be necessary to investigate why they do not mediate learning to the blind as expected of them.

Ostensibly, viewpoints of caution and advice have emerged from the data: that education authorities from national level to local level must not expect miracles in the mediation of biology to blind learners, in the absence of the provision of adequate resources and relevant support. It is necessary and important first to address learning mediation problems, before high expectations and demands are placed on educators of blind learners. This, however, does not suggest that educators have to sit back and wait for all these problems to be solved first, before they use their own dynamism in their attempts to accommodate blind learners.