TEACHING MATHEMATICS TO A BLIND STUDENT

- A CASE STUDY
1.1 Personal Background

I am a Maltese Mathematics teacher. I obtained the Bachelor of Education (B.Ed) Honours degree from the University of Malta specialising in Mathematics Education. The four year course dealt with various units in general and Mathematical pedagogy. At the time this study was carried out - 2006, it was my fifth year of teaching in a Church school in Malta. I teach and prepare students to sit for their Secondary Education Certificate (SEC) examination in Mathematics. It is equivalent to the British Ordinary level examination. I also teach adults at evening classes organised by the Education Department. Through my teaching experiences, I encountered various learning and teaching situations ranging from learning disabilities – slow learners, dyslexic and Down syndrome, to challenging behaviours. One particular situation I met while teaching Mathematics to adults was that of a blind learner (Section 4.3).

As I am motivated to help in such situations and believe that every student is entitled to learn, I accepted this challenge and set to work at trying to make my teaching of Mathematics accessible to this visually disabled student. The idea of writing this dissertation occurred half way through the teaching programme carried out with this student. The research I did in this area, the teaching scheme adopted for this programme and the work done by both the student and myself were my main reasons for choosing to conduct the present study. Another factor that increased my interest was the lack of local research in this area. Thus, I thought that it would be interesting to move into a relatively neglected area of research.
1.2 The Research Area

Mathematics cultivates thinking and reasoning skills. It lays the foundation for systematic thinking through the numerical and spatial aspects of the objects (Agrawal, 2004). As a subject, Mathematics plays an important role in society and the school curriculum is formulated in such a way that Mathematics is given a central and significant place in it. Teaching and learning of Mathematics is compulsory right from the primary level to the secondary level of education.

Mathematics is a field which has often been considered beyond the capacity of the blind to master. Traditionally it has been inaccessible to visually impaired and blind students because its content is rich with visually presented concepts and information (Schleppenbach, 1997). It is true that the concepts of Geometry do not come readily to a blind person, because of its spatial content. Yet there is no overwhelming reason why a person of sufficient ability should fail to become a successful mathematician simply because he or she is blind (Jackson, 1968).

Special Education is no longer the exclusive domain of Special Educators. As mainstreaming efforts expand and instances of blind students in classes are increasing, at some time or another, practically all teachers will face a student with special needs in their classes. However few educators are adequately prepared to teach Mathematics to these students. The presence of one or more blind students in a school system creates challenges for the classroom, the teachers and both the blind and sighted students (Awad & Wise, 1984).
Blind students form a small minority and as such their needs may not be so well known. But they are surely felt by both the student and his or her teacher. Blind students are exceptional students. They deviate from the sighted in their physical, mental and social characteristics. Thus they require modified school practices or special education services in order to develop to their maximum capacity (Kirk, 1963).

1.3 The Research Question

This study therefore deals with this area of learning disabilities. It aims to throw some light on Special Educational Needs and Mathematics. The aims, for which this study was carried out, can be taken from two different points of view. During this study my role was both of a teacher and a researcher. My aim as a teacher was to help and teach the blind learner Mathematics up to Ordinary level so that he could achieve a pass mark in the SEC Mathematics examination. This means learning all the areas as stipulated by the syllabus including its visual aspects (Appendix 1). On the other hand, as a researcher my aim was to explore a teaching scheme through which the blind student can learn Mathematics. Understanding the ways a blind student adopts to learn and to find out whether a blind student can learn Mathematics just like a sighted student. Teaching mathematics to a visually disabled student is different from teaching a sighted student. This study seeks to find in what ways this can be done.

The study focuses on one disability that is Visual Disability. This is done through a single case study in which I taught Mathematical content up to an appropriate ordinary level syllabus, to a blind student in eight months. A detailed account of the methods and tools
used during the teaching programme are also presented. It is hoped that these might serve as a resource for others although developed for this specific case.

1.4 Objectives of the Study

The specific objectives of this study are:

1. To review what is known from the research and professional literature about teaching mathematics to visually disabled students.

2. To develop a scheme with relevant tools and methods for teaching the Mathematics curriculum (including all the four areas of the syllabus: Arithmetic, Algebra, Geometry and Data Handling) to a blind student.

3. To implement this teaching scheme with the blind student during lessons on individual basis for a period of eight months.

4. To evaluate the effectiveness of the scheme by analysing the outcomes.

The main motivating factor of the blind student, participating in this study was to obtain a pass mark in the SEC Mathematics Examination at the end of the teaching programme.

This thus led to a subsidiary objective in this study:

5. To find out a way of presenting a Mathematics examination paper together with the local Maltese Examination board that could meet the blind student’s needs.
1.5 The Structure of the Dissertation

Chapter 1, the present chapter, introduces the study, its motivation, the research question and the objectives of the dissertation.

The next chapter-2 deals with the Educational system in Malta. As the study took place in Malta, it is important that it is presented and understood in its Maltese context. This chapter introduces the Maltese Educational structure and also deals with the issues of inclusion and diversity in education. Further sections in this chapter deal with the provisions for the blind learners in the mainstream and in standard examinations.

Chapter 3 presents a review of literature related to the teaching of Mathematics to exceptional students, and in particular, a review of research on teaching mathematics to the visually impaired. It includes the educational implications of these students, their development of cognitive abilities, tactile discrimination abilities and the use of teaching aids.

Chapter 4 gives a description of the research methodology. A detailed account of the research approach chosen for this study is presented together with the procedures followed in the development of the design of the study, construction of tools used and other preparations carried out during the study.

Chapter 5 includes the results and findings from the study. It presents a detailed account of how some topics were taught and a discussion of their effectiveness is provided. An
interview with the participant was also conducted at the end of the teaching programme so as to elicit his feelings towards Mathematics and the study itself.

In chapter 6, a summary of the findings and educational implications are drawn. Discussion on various aspects and recommendation emerging out of the study is also presented.
Chapter 2:
The Local Scene
2.1 A Brief Note on the Maltese Islands

Malta is the largest island forming part of the Maltese archipelago. It is located in the Mediterranean Sea, just south of Sicily. The group of islands is composed of Malta, Gozo and Comino all of which are inhabited and three other smaller islands. The total area of the archipelago is 320km². The Maltese islands are densely populated. According to the Population census – 2005, the Maltese population was 404,039 (National Statistics Office; NSO, 2006) of which about 70,000 are aged five to sixteen (NSO, 2004).

2.2 The Maltese Education Structure

The Maltese Educational system is regulated by the Educational Act 1988. It provides compulsory schooling for all children between five and sixteen years of age. Education in Malta is offered by both the state and private sectors. The latter falls into two categories: Church Schools and Independent Schools. Both provide education from pre-primary to upper secondary level.

2.2.1 Pre-Primary Education (3 - 5 years)

Pre-Primary education is also known as kindergarten. Attendance at this level is voluntary. It is a co-educational and provided for free in state schools. No formal teaching takes place at this level, but the educational objectives include activities aimed towards the development of the children’s social attitudes, language and communication skills.
2.2.2 Compulsory Education (5 – 16 years)

Compulsory education is sub-divided into a six year primary cycle (5 – 10 years) and 5 years of secondary education (11 to 16 years). The Maltese government is committed to a policy of inclusive education throughout the whole educational cycle. This ensures that children with special needs are integrated into the mainstream. However, parents are left to decide what the best is for their children, particularly when children with severe special needs require specialised services and facilities that are difficult to obtain in mainstream schools.

Primary Education lasts for six years whereby students are taught five academic subjects (Mathematics, Maltese, English, Religious Knowledge and Social studies) in preparation for the Secondary Education.

Secondary Education is sub-divided into two different kinds of State schools: namely the Junior Lyceum and Area Secondary School. There are also Church and Independent Secondary School. Admission into the State Junior Lyceum and into some of the Church schools is controlled by a qualifying entrance examination. Those who fail the examination are admitted to the Area Secondary School. The curriculum for Junior Lyceum students is more academic than that for Area Secondary School students.

Education in the Secondary Schools last for 5 years divided into a two year orientation cycle and a three year cycle of specialisation. At the end of this cycle pupils sit for their Secondary Education Certificate.
2.2.3 Post Secondary Education (16+ years)

Upper Lyceums and Sixth forms prepare students for two years for their Matriculation certificate (A-Level) which gives access to the University of Malta.

2.2.4 Vocational Training

Students who do not want to further their studies at the University of Malta can be admitted to the Malta College of Arts, Science and Technology (MCAST). This college offers vocational training in various fields ranging from Industrial Electronics to Technology, Art and Design to Mechanics. There is also an institute for Tourism Studies (ITS), Hotel Management and Catering.

2.2.5 Special Schools

Although pupils with special needs are generally included within the mainstream education system rather than special schools, a number of special schools still function to cater for the more demanding needs. The state has six Special schools, each of which caters for pupils with the same particular need.

1. The Guardian Angel School caters for children with severe learning difficulties.
2. The Helen Keller School caters for pupils with sensory impairment such as visual and hearing impairment and deaf-blindness.
3. The Mater Dei School caters for boys with emotional, social and behavioural difficulties affecting their school, home and personal lives.
4. The San Miguel Febres Cordero School caters for pupils with severe to profound and multiple learning difficulties. Ages range from 3 to 19+ years.

5. Dun Manwel Attard School caters for pupils with diverse needs and multi disabilities.

6. Sannat Primary School Special Unit caters for all children with special needs in the island of Gozo.

These schools offer quality education provision to students with a disability and also offer selected services to students with disabilities in the mainstream. Students with special needs in mainstream schools are found at every level within the compulsory education age. Special schools tend to cater for a wide range of ages, from 3 to 19+, sometimes up to the late 20's, generally prior to their transition to an adult training centre.

### 2.3 Inclusion and Diversity in Education

The National Minimum Curriculum (NMC) (1999) commits the state to ensure that all students are provided with the best possible educational experiences, irrespective of their social realities and abilities.

All students differ in their abilities, learning ways and cognitive development. There are students who are quick learners whereas others are rather slow in the process. Whenever there has been an attempt to standardise knowledge, where the focus is on content rather than on the learning outcome, numerous students feel marginalised by the system, viewing it as irrelevant to their needs (NMC, 1999).
For this reason the NMC provides space for schools to tackle the educational realities of their students. This means that the schools have specialised provisions catering to the particular needs of specific students to ensure the avoidance of exclusion.

The implications of diversity in education relates to Inclusive education. Every student is entitled to education. Inclusion means young people and adults with disabilities and/or learning disabilities being included in mainstream society (Centre for Studies on Inclusive Education; CSIE, 2006). It helps in reducing barriers to learning and participation for all students, not only those with impairments or those who are categorised as having special educational needs.

The benefits of inclusion are two-way. It contributes to a greater equality of opportunities for all members of society (CSIE, 2006). The issue of inclusion have been enforced into the Maltese educational system to the benefit of all students. Although a lot still needs to be done in this regards, the aim of education for all has been successful in Malta (Ministry of Education, 2005).

### 2.4 Visually disabled Students in the Mainstream

Educational statistics (2004) show that there were forty-four visually disabled students attending the mainstream. Fifteen of these students were at the state primary level schools, ten at secondary education and another nineteen students attended church and independent schools (NSO, 2004).
From personal contact with the Department of Education, it was known that at the time the study was carried out (scholastic year 2005-2006), there were twenty seven visually disabled learners identified within the mainstream and another two students attending the University of Malta reading for a degree. Sixteen visually impaired pupils were at Primary level (ages 5 to 11), fourteen of whom attended a State School and two in a Church School. Whereas eleven visually impaired students were in the Secondary level (ages 11 to 16). Three of these attended the State Junior Lyceum and the other eight attended an Area Secondary School. Only two of the pupils attending the Primary Sector were totally blind. One of whom is a normal academic while the other had more learning disabilities. These statistics were not yet published when the study was carried out.

All this makes the incidence of visually impaired learners in the mainstream very low. Peripatetic teachers support these students. Some learners are visited on regular basis, while others are not, but this depends upon their needs.

2.5 Teaching Mathematics in the Mainstream

I asked for a meeting with the assistant director for special education needs at the Education Department to gather statistics and information about the education of the visually disabled students in the Maltese schools. During this meeting the Assistant Director for Special Educational Needs and three peripatetic teachers were present.

The aim of this meeting was in collecting information on teaching and learning Mathematics to the totally blind students with a special emphasis on Secondary Education
that is Mathematics syllabus that covers the SEC level. But since the visually disabled pupils at Secondary Education were visually impaired and their learning took place in the same context as the sighted students, focus was put on the blind learner in the Primary education.

This student was described as a normal academic and could follow and cover the whole Mathematics syllabus together with her fully sighted peers, including Geometrical topics. During the time the study was carried out, Anne (not her real name) was in year 6 that is the last year of primary schooling and this meant that at the end of the scholastic year she sat for a selective exam known as ‘Junior Lyceum Entrance Examination’ (the students who pass the exam are led to Junior Lyceums whereas those who fail even one of the exams are placed in an Area Secondary School). This meant that the Mathematical experience of this student fits the aims of this study but on a different level. However it was interesting to learn what methods were employed in the learning process.

Inclusive Education is at the heart of the Maltese curriculum. Principle 8 of the National Minimum Curriculum (1999),

recognises that a scholastic environment is characterised by diversity...for example some students communicate through the use of the Braille method...the educational system must ensure the availability of all the necessary facilities so that all those children whose first language is not the spoken language are not excluded from mainstream educational provision (p. 36).

Students like Anne (normal academics) learn and follow instructions together with their sighted colleagues, in the same classroom context. A peripatetic teacher visits these students once a week on a regular basis. During which the special needs learners leave their regular classroom and revise the topics covered during that week with their appointed
teacher. Moreover the peripatetic teacher provides remedial work or extra help in the subject areas that the class teacher points out as problematic for the child in the classroom.

Working on Mathematical tasks is done orally. Every Mathematical question is read slowly and most of the working is done mentally. Diagrams involved are also described orally, without using any tactile methods. In fact, the teacher argued that in due course she had no mathematical tools available to assist learning. These include measuring instruments, textbooks, and embossed diagrams.

This was found to contradict the statement in the Mathematics Syllabus (2003) which states:

> Those students with special interests or exceptional talent in the subject may need enrichment material to challenge and engage them. The school must therefore take care to accommodate the special needs of some students without keeping back the learning of others by providing the necessary human and material resources (p.48).

In fact, lack of resources led the teacher and the learner to automatically skip certain mathematical tasks stated in the syllabus such as measuring angles using a protractor, measuring of objects using a ruler and other similar tasks.

Visually Impaired students learn in much the same way as the sighted however some modifications are taken into consideration. Handouts and exam papers are printed using a large font or enlargements from A4 to A3 photocopying are applied. However in certain cases adjusting the format of the print to Bold is enough. This was preferred to the former modification so that students feel less different than the other colleagues. In the case of the totally blind, during exams, an amanuensis is provided to assist the student in reading and
writing. During lessons at school, not all the visually disabled students are provided with a facilitator to help them as they can cope on their own. Most of them are placed in front row so that they can see the board clearly. The teacher can easily hand materials directly to them (Awad & Wise, 1984) and the student sitting next to them usually helps them throughout the lessons.

Peripatetic teachers working in this field of disability were not given any specific training on dealing with the Blind and Mathematics. However, the Education Department has recently offered a scholarship to two teachers to read a masters degree course in Visual Impairness and Blindness respectively. The Education Department considers it as not financially practical to train teachers in this area and to teach them Braille as the incidence of blindness in the mainstream is very low.

### 2.6 Certification in Malta at SEC level

As one of the main objectives of this study was that the blind student, participating in this study, sits for his Secondary Education Certificate (SEC) Mathematics examination at the end of the teaching programme, it was considered important to know what arrangements and modifications are offered in this regards.

In Malta, there is only one centralised Examination Board to provide a local certification system for Ordinary, Intermediate and Advanced level exams. This is the Matriculation and Secondary Education Certificate (MATSEC) Examinations board which is a subsidiary of the University of Malta.
Similar to most international examination boards, it is the policy of the MATSEC Board to make arrangements to compensate for any certified disability that candidates with special needs may have and which would not permit them to show their true competence in the examination.

The special arrangements that are granted depend on the condition and its severity and include extra time, the provision of a reader, supervised rest periods, a scribe (amanuensis), large print, allocation to a quiet room, modified carrier language of examination paper, special seating and arrangements for taking examinations in hospital (locally and abroad) (Grima et al., 2005).

According to the guidelines for Special Education Arrangements (2002), modifications to the visual presentation of papers, for visually impaired candidates whose impairment is not corrected by spectacles or other forms of vision aid, are made. These include: enlarged/large print papers; modified print (simplification e.g. layout, items of visual complexity); Braille versions of Papers; and Tactile Enhancement.

Since the introduction of these local examinations in the 1990s, the incidence of visually impaired students sitting for the Mathematics examination was very low. On average it is about one candidate per year over these last five years (Grima et al., 2005). Some modifications were made according to their special and individual cases. But on the whole they were all provided with an amanuensis, extra time and large print. Moreover, since the beginning of these exams, there were no cases of totally blind candidates sitting for Mathematics examinations.
In such cases the MATSEC board studies each case individually and check whether it can adopt the methods the student was taught and tools used during the learning process for examination. For example in one of the cases of a visually impaired, the candidate was allowed to use a white board to write down intermediate notes for her workings using a thick black felt pen.

Although, candidates with visual disability sitting for the SEC examination in Mathematics are close rare, the MATSEC board feels the importance of setting up standards in this area of Special Education Needs. This includes the use of appropriate machines for the printing of exam papers, use of computer software with speech synthesisers so that these candidates could proceed with their academic education in subjects of their choice without limitations.
Chapter 3:

Review of Literature
3.1 Teaching and Learning Mathematics

Mathematics has always been given great importance in education. The Cockcroft report (1982) stressed that there is a general agreement that every child should study Mathematics at school. Orton (1994) argued that the teaching of Mathematics is an important and continuous responsibility of teachers to seek out and practice what they believe to be the most effective ways of promoting learning.

The teaching of Mathematics can take several forms and can be carried out through different experiences and situations. Sometimes lessons depend too much on exposition from the teacher’s part and a passive style of learning from the part of the students which promotes rote learning. Traditionally, this method of teaching seemed very efficient especially with large numbers of students as they all proceed at the same time and in the same way (Orton & Frobisher, 1996).

Other forms of teaching mathematics happen through hands on experience, games, experiments and also discussions. Whatever teaching style is adopted, it is important that the teacher should give relevance to topics by referring to applications from within mathematics or outside the subject, and, if possible, add force to an argument or explain more vividly by using aids (Her Majesty’s Inspectorate, 1982). However, classroom realities show that students learn mathematics at differing speeds and the fact that mathematics is a hierarchical subject, in which the ability to proceed to new work depends on the understanding of previous knowledge, makes mathematics a difficult subject both to
teach and to learn (Cockcroft report, 1982). This especially implies to having a special needs student or a student who needs continuous attention in class.

3.2 What is Learning Mathematics?

Every type of teaching aims at some form of learning. The quality of mathematics learning depends on the quality of the teaching. Effective mathematics teaching requires a serious commitment to the development of students understanding of mathematics (Ministry of Education, 2003). Constructivism is a model of learning which suggests that the learner has to construct his own understanding and that only rarely can knowledge be transferred from teacher to learner in an immediate ‘digestible’ form (Orton & Frobisher, 1996). The constructivist teacher designs tasks, assignments, problems and other activities that stimulate thought and mental activity in order to lead the student to the construction of meaning. Learning with understanding makes subsequent learning easier. This method of learning opposes the rote learning model.

Effective learning of mathematics is not due the ability to recall facts by heart. Learning mathematics happens when the learner is able to think and use the relevant prior knowledge to solve the problem at hand with understanding. The teacher can help in this process of learning by providing hints, or better still, ask a question which will promote the construction (Orton & Frobisher, 1996).
3.3 Differentiated Teaching

In the Mathematics classroom, all students have their individual needs and individual learning styles. Effective methods of teaching can support the learning of mathematics by all students. This does not mean that every student receives identical instructions, but that reasonable and appropriate adjustments are made to promote access and attainment for all students.

Some students may benefit from oral assessments rather than written. Others may need more time to complete certain tasks. Other students may require additional resources and individual attention. These are some of the realities in the mathematics classroom. With the implementation of the inclusive policy in education, it is the responsibility of the schools and teachers to accommodate these special needs without keeping back the learning of others by providing the necessary human and material resources (Ministry of Education, 2003). This also applies to blind learners in the mainstream.

3.4 Visual Disability: Definition of Terms

A visually limited student is one whose visual condition is such that it interferes with his efficient learning (Bishop, 1971). There are various categories of blindness and medical terms to describe it. But throughout this study, blindness is subdivided in two categories. It is a sensory disability rendering an individual partially or totally sightless. The term ‘partially sighted’ is used to describe those who are permanently handicapped by defective vision, caused by congenital defect, illness or injury (Evan, 1995). It extends from those with relatively minor visual difficulties to those who are sometimes described as having
low vision (Department for Education and Skills, DfES, 2001). In this study ‘partially sighted’ students are also referred to as ‘Visually Impaired’. The definition of blindness is used to describe individuals who are totally blind and unable to perform any work for which eyesight is essential (Khaw, 1994).

### 3.4.1 How is Sight measured?

A person with normal eye sight can read the Snellen chart’s biggest letter E from 200 feet distance. If the vision of the person is so impaired that to see the Snellen chart’s biggest letter E, he or she has to come within 20 feet or even nearer, then he or she is considered as legally blind and vision is rated as 20/200. This pair of numbers is called Visual Acuity. This is not a fraction of anything. The first number is the distance from the eye chart. The second number is the distance from which a normal eye sees a letter on the chart clearly. Someone with a visual acuity of 20/200 only sees letters at 20 feet that a normal eye identifies at 200 feet. The higher the second number of Visual Acuity, the worse vision will be (American Academy of Ophthalmology, 2004).

### 3.5 Typical Characteristics of individuals with Visual Impairments

Cognitively, the person with visual impairment cannot perceive objects in the environment beyond his or her grasp including those that are too large or too small or are moving (Agrawal, 2004; American foundation for the Blind, AFB, 2002; Chorniak, 1977). The use of other senses enables the student to obtain information about his surroundings. A blind student needs to learn systematically what a sighted person can pick up incidentally from
the environment. If the visual sense is impaired concepts may be incompletely developed or missed entirely (AFB, 2002). Thus, a blind person is limited in the range and variety of his experiences and educational measures are necessary to overcome this limitation (Agrawal, 2004).

Socially, a person with a visual impairment is limited in interaction with the environment. He or she may not see facial expressions fully, may not be able to model social behaviours through imitation and sometimes is unaware of the presence of others unless a sound is made (AFB, 2002). A blind person gains knowledge of the special qualities of objects only by tactile observations in which kinaesthetic experiences play an important role.

### 3.6 Educational implications of Visual Impairments

Objectives for educating visually impaired students have been dealt with and often revised over the years as understanding of the educational implications of the impairment became more universal. Lowenfeld (1971) stated that:

> Education must aim at giving the blind child knowledge of the realities around him, the confidence to cope with these realities and the feelings that he is accepted as an individual in his own right. (p. 158)

This statement embraces the educational, psychological and social aspects of the visually impaired students’ development.

The direct effects of blindness have certain educational implications. Lowenfeld (1973) stated that the blind person gains knowledge but he gains it in a different way and the knowledge itself is sometimes of different nature. For example, the Piagetian notions of
object permanence, conservation of mass and conservation of volume are a few of the developmental milestones that may be delayed for blind students (Dick & Kubiak, 1997). Simple concepts as ‘up’, ‘down’, ‘here’, ‘there’, ‘that more’ and ‘less’ involving direction or quantity may remain vague without spatial efforts to develop a sense of these notions through tactile experience. Blindness is certainly a major sensory impairment. Blind persons gain education by making the best use of their non-visual senses e.g.: hearing and touch. Hearing has its main function as a medium of verbal communication. Since, much knowledge is communicated through language; blindness does not put the individual at a significant disadvantage in this respect (Cutsforth, 1951; Lowenfeld, 1973; Moss & Blaha, 2002).

Among the students who are completely blind, it makes a difference whether the student has been blind since birth or a very early age or has lost visual acuity more recently. Students’ ability to grasp certain concepts will be greatly influenced by whether they have ever had direct visual experience of the world around them (DfES, 2001; Dick & Kubiak, 1997). People who have lost sight recently have some experience of objects and can still draw on visual images in their memories.

Chorniak (1977) points out that an overall consideration for visually impaired students is that they have the fullest possible contact with sighted children. Academically oriented students with visual impairments have been mainstreamed successfully into regular classes for many years. Such contact has the dual purpose of helping them to relate well to the sighted world in which they must function, and of enabling the sighted to appreciate blind children as children with limitations and capabilities (Gage & Berliner, 1992).
Numerous suggestions for teachers are available in specialised texts such as Dick and Kubiak (1997), Osterhaus (2002, 2005), Frampton (2006). These also describe structured curricula designed to enhance the learning skills of students whose poor vision requires individual attention (Jackson, 1968; Whittaker, 1968). Technological improvements and special instructional techniques are also available (Dick & Kubiak, 1996).

### 3.7 Teaching Mathematics to the Blind

Mathematics cultivates thinking and reasoning skills. It helps students learn, seek and discover ideas themselves. Describing and categorising direction, quantity, shape and logical attributes are at the heart of Mathematics. Descriptions of Mathematical concepts that appeal to visualisation may be grasped immediately by the sighted student, but they require significantly more cognitive processing for the blind (Dick & Kubiak, 1997).

Mathematics is more than just the Arithmetic of numbers and the four basic algorithms of addition, subtraction, multiplication and division. It is a study of symbols with respect to quantity, form, algorithms, sequencing, measuring, graphing and the methods for processing these concepts (Rossi, 1986; cited in Agrawal, 2004). The mathematical curriculum for blind students involves the same content areas as for the sighted students. However, the material and methods used are likely to be different (Napier, 1973). This is due to the limitations imposed by loss of sight resulting in more reliance on touch and audition. But often while teaching Mathematics, to visually disabled students, some specific areas considered complicated, are omitted by the teacher. Agrawal (2004) states
that this omission causes discrepancy among the students in learning the subject, leading them to be at a disadvantage if they are not provided with the necessary content to cope with the sighted students in an integrated setting. Mathematics is important for a blind student just as it is for other students.

The outcomes of the experience of visually disabled students at mathematics have often been described as one of poor achievement. It was thought that both the teaching of mathematics to visually disabled children and the learning of the concepts are too difficult (Stevens, 1996). Cawley has studied the needs and problems of exceptional students in Mathematics (1978, 1984). Throughout his research he puts great emphasis on ‘what shall we teach, when and in what sequence’ in passing on the knowledge of Mathematics to the disabled students. He recommends that mathematical structure should be tailored to the students’ particular needs.

Hartley’s study (1963) emphasised that blind students need to be taught according to a unique programme in order to help them learn simple concepts that sighted students develop through incidental learning. This was also emphasised throughout the study carried out by Agrawal (2004) on programmed learning techniques. She found that programmed instructions help in constructing sequences of instructional material in a way that the rate of learning is maximised, motivation of the student is enhanced and understanding is fostered. Research studies, carried out in the same field of special Education, also demonstrated that blind students can learn Mathematics when they are taught in an appropriate manner (Davidson, 1988; Darling, 1985; Kalaiselvi, 1985; Muthaiah, 1984; cited in Agrawal, 2004).
Similar to their fully sighted counterparts, blind learners are traditionally presented with Mathematical expressions through classroom presentations during which they encounter mathematical symbols and concepts without understanding them. Trying to memorise a symbol without visualising it has led the blind students to dread Mathematics as a subject because lacking the ability to read and write its symbols, the field of mathematics is closed to them (Kapperman & Sticken, 2003). Darling (1985) emphasises the need for mathematical text material for effective integration of blind children. But it is noted that provision of mathematical text material would be of less use when the student is not proficient with Mathematical Braille code.

Braille, the dot writing system used by the blind, contains symbols for numbers and allows users to write simple, in-line computations. However, without augmentation Braille code is not sufficient to represent the more complex operations central to higher mathematics. Several researchers have sought to develop methods of representing complex equations to the blind, and Nemeth’s method is one of the simplest and most flexible. Nemeth’s Code, devised by Dr Abraham Nemeth and has been widely taught since 1952. It is relatively simple for a Braille reader to follow and is context independent, so it can be used in connection with any mathematical discipline (King, 2002; Osterhaus, 2005).

3.7.1 Development of Cognitive Abilities

Understanding of any concept depends upon the development of cognitive abilities. Gottesman (1973) found that blind students lag behind their sighted peers in cognitive skills such as in acquisition of mature conservation concept. Other researchers found this
deficiency in classification abilities (Higgins, 1973), use of spatial concepts (Hartlage, 1968, 1969) and many other cognitive skills due to restricted experiences (Stephens, 1972).

Gottesman (1976) found that this inability may be due to the student’s reliance on less sophisticated sensory discrimination abilities, which improves gradually by age because of their increased reliance on integrative processes of cognitive functioning, rather than reliance on the less sophisticated sensory discrimination abilities. Milton Gottesman also conducted an investigation with Piagetian tasks on conservation of mass, weight and volume. Outcomes revealed that the differences on these tasks between blind and sighted students tend to disappear as they grow older.

Similar observations were made by Higgins (1973). In his study he investigated both blind and sighted students on classification abilities. The outcomes showed that the deficiency appeared to be perceptual (figurative) and symbolic rather than of intellectual (operative) origin. Evidently, the loss is found to be at the level of sense perception, the gateway to meanings and knowledge.

Agrawal (2004) suggests that cognitive structures of children are not affected by visual loss. “What they grow deficient in are primarily their perceptions and secondarily their symbolic abstractions which are gained through visual perception” (p.34). If these perceptual inputs are given through touch and more time is dedicated by teachers for effective understandings, visually disabled students should not find mathematical concepts an impossibility or a distant possibility. The blind students’ learning should not be verbal but must be the result of direct observation (Lowenfeld, 1973).
3.7.2 Tactile Discrimination Abilities

Studies and research have also been conducted on tactile discrimination abilities of students, which include cutaneous sensitivity, form discrimination, size, and length and weight discrimination. In general this research suggests that there are no striking differences between blind and sighted students in this regards. Any differences that emerge however are typical, although not in favour of the blind students. Davidson (1976) found that such differences are due to differences in attention strategies rather than to sensory acuity.

Bruner and Oliver (1966) carried out research on the intellectual development through progressive building up of mental images. Images that can be memorised recalled and manipulated. It is here that the visually disabled child is challenged and finds difficulties. This suggests that a stimulating environment and rich experiences need to be provided for learning Mathematics.

3.7.3 Difficulties encountered by Blind Students in Mathematics

As a subject, Mathematics is made up of many different concepts such as those of Algebra and Geometry. Every aspect of mathematics can contribute to the difficulties, visually impaired students encounter in learning this subject. Some of which are the same for sighted people, but not to the same degree (Ernest, 2004).

The visually disabled student is slow to acquire any concept of number. Chorniak (1977) has observed that it is improbable that visually impaired students acquire concepts
vicariously since they lack the opportunities to “see things in groups, to note sets and acquire Mathematics linguistics by seeing quantity, magnitude and number symbols” (p. 314). This leads to difficulties in the ability to handle simple operations. Visually impaired students lose track of groups of objects or pictures that they are working with (Gross, 1995).

Corley (1989) found that it is difficult for a visually disabled student to learn the concept of size, and weight without relying on touch. A sighted student can easily get an idea of the weight of an object just by observing or looking at it. But it is not equally easy for the visually impaired to come to the same conclusion without using his remaining senses. This problem, similarly, applies to the concepts of length and height.

Other spatial concepts, such as the concept of a shape, are the most difficult for the blind students to master. For example, in learning the properties of different shapes, being two or three dimensional, the visually impaired need to tactually explore them. Given extra time to investigate such shapes, the student can discover other characteristics (Chapman & Stone, 1988) such as the lengths of sides and angles. Perceiving angles other than right angles are also difficult.

The use of Braille Code can also pose difficulties. Gross (1995) found that pupils can easily get confused with the pattern of dots and it is quite common for them to have problems with letter multiplication. For example, LM is the same as writing L×M, but some pupils can get mixed up and think the LM is a word which they have not encountered before.
3.8 Aids for Teaching Mathematics

A course in mathematics for the blind becomes increasingly understandable with the greater use of special equipment as teaching aids. As the inclusion of blind persons is increasing and their academic ability is widely recognised, such tools are available. Nevertheless if this material cannot be obtained elsewhere, the teacher must build his or her own (Frampton, 2006). Agrawal (2004) suggests that while preparing material for blind students, suitable principles should be kept in mind. These are the maximising of the duplicated material, the modification of format and content for necessary adaptation, the substitution of ideas and rare omissions under unavoidable circumstances.

The adequate substitution of devices to take the place of the ‘black’ board is a good textbook – one that will give numerous examples of how problem is worked. Many blind scholars believe that, despite technological advances making the printed word more easily accessible, Braille will continue to be of great importance (Corrigan, 1977). Dick and Kubiak (1997) suggest that blind students need to have the bulk of their school texts in Braille, but the provision of some texts may be a problem. Sometimes, even when such a textbook is available, many blind students simply may not be skilled in reading Braille.

Moreover, some mathematical schemes are very visual and impossible to transcribe into Braille in a meaningful way because of the amount of pictorial information. Even when adaptations are made, the result may be too confusing for the student to discriminate by tactile means (Chapman & Stone, 1988). Sometimes when introducing problem-type questions, there would be a quantity of descriptive reading material. This form of presentation has value and can be interesting and motivating, but for visually impaired
students with a slow reading speed the mathematics lesson could largely be spent in reading. To remedy this, the Mathematics teacher can read out loud the problem-type question and what is being put on the blackboard including other descriptions which can be helpful for these students.

Another approach can be that of tape-recording. Even though it is known that mathematics lessons could not be recorded into cassettes as whole, certain steps such as formulae, methods of constructing a diagram in the case of Geometry etc, can be recorded. But taped versions may have drawbacks. They can be difficult to understand because the readers may not pace them appropriately or read with a mathematical interpretation. As a result, a listener may not easily be able to follow how a line-by-line analysis demonstrates the steps taken to perform an operation (Dick & Kubiak, 1997). Moreover, they may also lead to rote-memorisation, learning which does not facilitate effective learning in Mathematics.

Mathematics during the primary years is practical and related to everyday activities, but as concepts become established the nature of work in numeracy becomes more representational. Possibly because they rely on their memories and have little or no reinforcement from visual promptings, students with visual disability excel in mental arithmetic (Chapman & Stone, 1988; Corrigan, 1977). But sometimes calculations can be too long or too complicated for this facility to be relied upon. A Cranmer abacus is a small, handy means of recording number work in a temporary form which can be used as an aid. It performs arithmetic calculations by enabling students to manipulate beads that represent numbers in base ten. This has raised marking and backing that hold the beads in position (Dick & Kubiak, 1996; Corrigan, 1977). The beads on the abacus can be used to represent
quantities in problems involving whole numbers, decimals and fractions (Fisher & Hartmann, 2005).

As the blind student progresses from primary school to secondary school or even higher, computations can become more complicated and ‘Talking’ calculator can be an interesting and a more useful aid. Moreover, written work including intermediate steps taken while working out a mathematical task can be recorded using a Braille Writer, or as commonly known, the Perkins Brailler. The Braille writer has six keys, each representing one of the dots in a Braille Cell (Awad & Wise, 1984). Such aids can be constantly used just like the sighted use paper and ink. But the main drawback is that errors are not easily corrected and tasks may have to be reworked again.

Chapman and Stone (1988) suggest that Braille and other tactile material can be duplicated by using a thermoform machine. This machine softens a sheet of plastic film and moulds it to the shape of a prepared matrix underneath; heat and vacuum processes applied for a few seconds enable the plastic sheet to take a sharp raised copy of the underlying prepared material comprising Braille dots, raised lines, or textured surfaces. This machine was suggested by other researchers in this field of tactile diagrams such as Whittaker (1968), Schleppenbach (1997), Dick & Kubiak (1996).

Geometrical devices can also be adapted to the needs of visually disabled children. For example, in the normal protractor made out of plastic, big wholes can be made for every ten degrees and small wholes for every five degrees (Agrawal, 2004). The same can be applied to rulers. Drawings produced by others for the blind can be made using a compass and
stylus with spur wheels. These produce reverse images. That is the image is impressed on a drawing surface that is subsequently turned over to provide a raised tactile image (Dick & Kubiak, 1996, 1997; Osterhaus, 2005; Whittaker, 1968; Jackson, 1968).

Perhaps the most complex task in secondary education Mathematics is that of Graphing. Detailed descriptions and suggestions of how graphing can be done are given in specialist literature such as Whittaker (1968) and Osterhaus (2005). But special aids need to be available as well. Some time ago balsa wood was introduced as a base for the plotting of points. The idea of sticking pins into some easily penetrable substance is by no means new (Frampton, 2006; Osterhaus, 2002; Whittaker, 1968). Nowadays, some low-technology graphing aids can be very useful. Embossed Braille paper, with rows and columns of raised dots representation grid lines, is available. Embossed graph paper comes in a wide variety of sizes and grid spacing and can be used in several ways. One easy way is to mount the paper on corkboard, mark points with pushpins, and then connect the pins with rubber bands (Dick & Kubiak, 1997).

As computers have become an invaluable tool in all aspects of life, several researchers have worked on and introduced software which could aid visual impaired and blind students in their learning of Mathematics. Computers with voice output, referred to as text-to-speech, have been available since the early 1980s. Software packages, used in conjunction with an adapted computer, have enhanced accessibility for the visually impaired and are available through the Internet at various FTP sites (Dick & Kubiak, 1996).
Recent research in the area of accessible Mathematics is geared toward graphing and Mathematic or Science texts in electronic format. This is a voice synthesiser-based system called AsTeR. This software reads mathematical text, analyse the information, create abstract models, then provide output using pauses, tones and pitch to indicate the type of mathematical information is on screen (Barry et al, 1994; cited in Dick & Kubiak, 1996).

Moreover, a project developed by Robert Stevens (2003) at the University of York called *Mathtalk* has solved difficulties in the learning of Algebra. Sanchez and Flores (2004) for the University of Chile have introduced *AudioMath*. Software that aimed at enhancing visually impaired students’ memory and mathematical skills through audio.

All possible alternatives have to be explored for making the teaching and learning in Mathematics more purposeful. Much of the above mentioned tools have been used, adapted and/or modified for use during the teaching programme presented in this study. A detailed description of how they were used and the outcomes will be discussed in the next Chapter.

### 3.9 Making Mathematics Accessible

Mathematical work in the Secondary school has been concerned with academic attainment leading to examinations in the final school years, and possibly continuation, in higher education, but it has important implications in practical everyday situations. Despite earlier delay in concept formation, outstanding success in Mathematics has been shown by
individual blind students, even though such achievement has been dependent on the use of tactile work and Braille code (Chapman & Stone, 1988; Agrawal, 2004).

But review of literature has shown that blind students can have difficulties with Mathematics too. As Clamp (1981), Kapperman and Sticken (2003) point out, this is likely to be due to underdeveloped mathematical concepts and not due to an inability to achieve. Visually disabled students can be good achievers in Mathematics if an emphasis on concrete experiences is given to be able to develop their skills. This may be the reason why visually disabled students are poorly represented in mathematics at all levels in education and employment.

According to Brown (1983), in his concept on systematic approach to instructional technology, the central focus should be on the students themselves, their needs, capabilities and achievements. There are four fundamental questions that need to be tackled when dealing with these students: First is what goals need to be achieved, secondly is how and under what conditions students aim to achieve these goals, thirdly is what resources are required for necessary learning experiences and finally how far the goals were achieved. Working according to this process, the teacher may be provided with guidance for necessary improvements in instructions regarding what needs to be changed.

Rapp and Rapp (1992) conducted a survey of the current status of visually impaired students in secondary mathematics classes. Their teachers were asked about the services they were provided, mathematics teaching tools and other issues. The results of this survey
showed that teachers encounter continuous difficulties in providing materials and equipment and few students are participating in more advanced mathematics.

The various studies mentioned in this chapter, have revealed the importance of Mathematics for the blind students and it has been very well established that loss of vision does not restrict the learning of Mathematics. As Mathematics is an abstract science its teaching to visually disabled students requires the extensive use of tactile experiences supplemented with suitable instructions. This makes it possible for these students even to undertake the standard examinations curriculum (Chapman & Stone, 1988). It is the objective of this study to explore how effective teaching methods could be helpful to blind students. It is in this scenario that the present study has its relevance in the field of education.
Chapter 4: Methodology
4.1 The Study

The main interest of this study was in exploring details in this educational area, namely teaching the blind, in order to achieve a holistic understanding and look for new insights from other discoveries through literature. To be able to achieve this, I acted as a teacher, observer, and a researcher during the study.

As a teacher, I carried out experiments and found out ways of teaching mathematics, - a subject which depends a lot on the visual aspect. As an observer, I observed the participant very closely. The ways he used to construct his own learning and the methods he adopted to learn and used to work out mathematical problems were investigated. As a researcher, I collected data from the participant, analysed it and did the write up.

4.2 Research Paradigm

The research paradigm which is appropriate for this investigation is the Interpretative Research paradigm. This is because the central concern of this research paradigm is that of understanding human experiences at a holistic level. On the other hand, the Scientific Research paradigm, the other prominent research paradigm, is about the understanding of human beings as individuals in their entirety, but the proper context in which it takes place is neglected. Since the investigative intention of this study was to understand and learn about the Mathematical experiences of the blind, the Scientific Research paradigm did not seem appropriate.
Ernest (1994) states that, the interpretative research paradigm is primarily concerned with human understanding, interpretation, intersubjectivity, lived truth (i.e. truth in human terms). In fact human experiences are shaped in contexts and best understood as they are found, in other words in their natural settings. Maykut and Morehouse (1994) add that the natural setting is the place where the researcher is most likely to discover, or uncover, what is to be known about the phenomenon of interest. Studies concerned with human interaction are often conducted within this paradigm.

Keeping these points in mind, and that the comparison between the intentions of the study and the central ideas of the interpretative research paradigm made me realise that this approach would be useful for this investigation.

Shermann and Webb (1988) identified characteristics of the interpretative research which corresponds directly to the study.

1. Events can be understood adequately only if they are seen in context. Therefore, a qualitative researcher immerses himself/herself in the setting.

2. The contexts of inquiry are not set; they are natural. Nothing is predefined or taken for granted.

3. Qualitative researchers want those that are studied to speak for themselves, to provide their perspectives in words and other actions. Therefore, qualitative research is an interactive process in which the persons studied teach the researcher about their lives.

4. Qualitative researchers attend to the experience as a whole, not as separate variables. The aim of qualified research is to understand experience as unified.
5. The methods used in qualitative research are those that are most appropriate to the aims of such research. There is not one general method of enquiry.

   The main interest was in viewing reality in this specific area of Special Needs and Mathematics and in making comparisons between one case study and another involving different places and people. Another reason why the interpretative research paradigm was chosen is that this paradigm makes it possible to undertake experiments that are not under controlled conditions.

4.2.1 Why Qualitative?

   The importance of qualitative approaches in special education has been stressed by many (Bogdan 1992, Hegarty & Evans, 1985). Since researchers in the special education field are concerned with process rather than simply with outcomes or products, I feel that it is more appropriate to engage in qualitative procedures.

   The qualitative technique used allowed me more freedom and flexibility to focus on complex issues which were discovered only as more and more time was spent with the student. This would not have been possible if a quantitative study was adopted. The methods used for this study were interviewing and participant observation.
4.3 Data Collection

Data collection was carried out in two parts:

1. Records and observations of the teaching programme during which mathematical content was taught to the participant.

2. Interviewing the participant. The first interview was held half way through the programme and the second interview at the end of the teaching programme. In addition to this, a number of informal conversations took place throughout the programme.

The next sub-sections will discuss in detail these two parts and how they were administered.

4.3.1 The Participant

The participant taking part in this study is a 34 year old blind man. I got to know John (the name of the participant was changed due to confidentiality purposes) from evening courses for Adults in Mathematics organised by the Department of Education. These courses cover the Ordinary level Mathematics syllabus in approximately nine months and prepare the students to sit for the Secondary Education Certificate (SEC) examination. At the end of the first session he approached me, as I happened to be the teacher, to ask for lessons on one to one basis, as it was very difficult for him to keep track of what was happening during the lesson. I decided to take on the challenge and later on during the teaching programme he agreed to take part in this research study.
A formal interview was conducted with the participant mid-way through the research process. This first interview was carried out to elicit some personal information and he was guaranteed strict confidence.

### 4.3.2 Interviewing the Participant

While conducting a research study of a qualitative nature, it is of utmost importance to elicit information from the participant about his personal background and also about his motivation for doing this programme.

#### 4.3.2.1 Purposes of the Interview

The purpose of the first interview was mainly:

1. To get to know John. About his background, his experiences of life and education as a blind person.
2. To elicit his ambitions and the motivation for choosing to study Mathematics.
3. His expectations from this programme.

A second interview was carried out at the end of the eight month programme. The purposes for the latter interview were:

1. To elicit some information about his experiences during this programme.
2. To get to know whether he got what he aimed for
3. His feelings towards the subject and its importance to him.
As the purposes of both interviews were both to elicit information about John’s feelings, I decided to design them of a semi-structured nature.

### 4.3.2.1 Why Semi-Structured Interview?

Semi-Structured interviews are conducted with a fairly open framework which allow for focused, conversational, two-way communication (Steele, 1981). Unlike the questionnaire framework, where detailed questions are formulated ahead of the interview, semi-structured interviewing starts with more general questions or topics. Outline of relevant topics of study with suggested questions are initially identified (Kvale, 1996) and other issues become the basis of more specific questions which do not need to be prepared in advance but created during the interview, as areas of interest and importance emerge. Semi-structured interviews focus on collecting and formally capturing details about feeling and experiences. As this type of interview is two-way, it takes the form of a conversation such that it will not only provide answers but the reasons for the answers. This was what I was after.

### 4.3.2.2 The Interview

During the interview focus was put on the style of teaching of Mathematics, the tools used and to some extent, the content of that which was being taught. Questions regarding his attitudes towards Mathematics and the reason why he chose to study the subject were also
treated. These questions were designed in an attempt to discover whether the programme was effective and whether it was of a positive or negative experience.

Besides the set questions for this interview, many other questions were added in the course of the interview, depending on the participant’s responses. The interview was administered in the same environment where he attended the lessons. The setting was familiar to him and presented an atmosphere in which he could feel comfortable. The interview was tape-recorded. The advantage was that the attention was focused on what John had to say. As a backup, I made notes on each response as we progressed. The outline questions set before the interview is shown in Appendix 3. The interview was then transcribed.

The interview was carried out in Maltese. Therefore the analysis of the transcript was in Maltese. However when direct quotes were used in the text, to support my interpretation and ideas, these parts were translated in English. Feeling that the meaning may be lost in the translation, I chose to present in the text quotes in both the original and in the translated form. It is hoped that this may help the reader to appreciate the data as it was collected.

4.3.3 The Teaching Programme

A number of lessons were conducted with the participant on an individual basis. These lessons were carried out twice a week for a period of eight months from October 2005 to May 2006. The duration of each session varied from two to two and a half hours.
4.3.3.1 Syllabus

During these lessons, John was taught mathematical topics and concepts tied up to an appropriate Ordinary level Mathematics syllabus (Appendix 1). The syllabus chosen for this study was that of the MATSEC examinations of the University of Malta 2006-2007.

The structure of the SEC Examination Paper which is equivalent to the British Ordinary level is of two two-hour papers. Regulations state that Paper I is a Core Paper and is taken by all candidates. It may include an oral/aural/coursework component. Paper IIA comprises more demanding questions than Paper I and Paper IIB comprising questions less demanding than Paper I. Within the current system Mathematics is the only one subject with two syllabi (Appendix 1). Students preparing for Paper IIB do not have as demanding a syllabus as those sitting for IIA (Grima et al., 2005). John opted for Paper IIB mathematics exam.

In the SEC certification system, grades are awarded on a seven-point scale with Grade 1 indicating the highest level of achievement and Grade 7 indicating the minimum satisfactory performance. General criteria for the different grades are laid out in the regulations (Appendix 1).

4.3.3.3 The Lessons

In presenting the lessons I exercised care in introducing mathematical concepts to the participant. I decided that it was important to emphasise both the verbal and sensory aspect and that every word and sign was read out clearly so that John had a clear picture of what
the question was about. I also used frequent repetition of key ideas throughout the teaching programme. This was done to make up for his loss of vision. Whereas sighted students can look for key ideas themselves, John needed continuous repetition to memorise ideas.

It was one of the aims of the study that all the four areas of the Mathematics syllabus (Arithmetic, Algebra, Geometry and Data handling) be tackled. In doing so, I experimented and made use of various resources and tactile drawings which will be described later on in this chapter.

4.3.3.4 Language Used

English language is the formal medium through which Mathematics is taught in Malta. This means that examinations, textbooks and work are all carried out in English. However, the delivery of Mathematical lessons and explanations are carried out both in Maltese and English. The language used during this study was therefore both Maltese and English.

The written language used was English but the written code for the participant’s working was Braille. Writing Mathematics is important not only to communicate but as a memory aid to assist while doing Mathematics (writing down intermediate results, for instance). Braille code is made up of a maximum of six raised dots for every letter or number. The position of the different dot represent the different letters of the alphabet or number (Shapiro 1995).
It is important to point out that Braille numbers are identical with the first ten letters of the alphabet and are preceded by a special sign in Braille called the ‘Numeral Sign’. Figure 4.1 shows the first ten letters of the alphabet together with the numbers from one to ten in Braille code.

**Figure 4.1 – Braille Alphabet and Numbers**

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**4.3.3.5 Preparation**

Throughout the lessons, John helped me in learning the Braille code. It was essential that while monitoring his work, I will be able to follow every step he does without interrupting. Moreover it was also necessarily to use and learn Braille for the preparation of the tasks used during the lessons.

**4.4 Apparatus**

I made use of non-technological and low-technological tools to teach. Since the time frame was very limited, it was difficult to find suitable software and to teach both the mathematical concepts and how to use the software at the same time. Moreover if I opted for high technological, the chosen tools had to meet the requisites of the Examination for
which we were ultimately working and which was the chosen final assessment for the study.

The basic tool used throughout the study and also during the exam was a 60cm by 40cm cork board. Working on it was facilitated through the use of pins which the participant attached to it to form letters and numbers in the Braille code where each pin represented a single dot. To facilitate this, four types of pins were used. Each type had different representations. Figure 2 shows the four types of pins used.

**Figure 4.2 – Different Types of Pins**

The first type of pin (a) referred to as the ‘Cubic’ Head by the participant was used to represent letters of the alphabet. The second type of pin (b) the ‘hat head’ was used to represent numbers. It was necessarily to use different pins because, as already mentioned, in Braille numbers are written in the exact way as the first ten letters of the alphabet with a
difference that a numeral sign is written before each number. To avoid the lengthy way of writing down numbers, I decided to represent these using different pins.

The third type of pin (c) was used to attach paper to the board or just in case another representation was needed. The ‘Spherical head’ needles (d) were used for labelling embossed diagrams.

The Mathematical operators used to work out sums were also made tactile. This was done by cutting out pieces of wire and attaching them to small pieces of cardboard. Then the pieces of cardboard were attached to the board.

**FIGURE 4.3 – MATHEMATICAL OPERATORS**

The normal representation of these operators as used by sighted students was used instead of the ‘Nemeth’ Code. This was because the participant never used this code before and he still remembered how these operators looked like before he went blind.
These operators were used in conjunction to the pins and board. Instead of using a paper and pencil to write down intermediate results, the participant attached the pins and operators to the board in the same way it was written on paper. This helped him to ‘visualise’ the written representation of the sum. Moreover, it also helped him to lessen the load from memorising. Figure 4.4 shows an example of the Braille version of a mathematical task.

Together with the above mentioned operators, signs representing the ‘π’ and ‘√’ and other pieces of wires to represent the brackets and divisors in the case of fractions were used.

**Figure 4.4 – Example of a Mathematical Task in Braille**

Another tool which was useful only for simple computations was the Talking Calculator.
It was useful as it made the student work independently. However, since very often questions involved the square root, squaring and trigonometry, I made use of a normal scientific calculator, following the steps indicated by the student. In this case, as the calculator did not have a speech synthesizer, the result was read out for him.

A very useful tool was a spur wheel (figure 4.6). This was used to emboss diagrams from the reverse side to create a raised effect and thus John would be able to ‘read’ a diagram.

A tactile ruler and a tactile protractor (figure 4.7) were used in the course of study. I embossed these two mathematical tools. By making use of the thick ink which is normally
used for stained glass to create a raised effect, I embossed the measurement markings on
the ruler at half unit intervals. It was not possible to emboss the millimetre marking as they
are much closer to each other and would not actually be distinguished by touch.

**Figure 4.7 – Embossed Ruler and Protractor**

With regards the protractor, it was made out of cardboard and the degrees were marked at
multiples of 10 (10°, 20°, 30°, ...). At each degree and at each half unit interval was cut out
to allow the marking of points by pins for accuracy.

Together with these John also made use of normal compass and pencil for constructions
and sometimes also a small ruler to draw straight lines. During the course embossed graph
papers were also used. These were 1cm x 1cm squares.
A graphing aid was also available. This consisted of a jablo’ composition board, which had a grid of 1cm by 1cm made of strings tied by nails on the edge of the board.

A detailed account of how each of the above mentioned tools were used will be given in the next chapter.
4.4.1 Textbooks

John’s main problem in this teaching programme was that Mathematics syllabus carried a long list of terms and formulae, which are a considerable amount to memorise, given that the time allowed was a few weeks rather than the normal five years a student takes to learn terms, definitions, concepts and methods gradually.

This brought the need of finding a way of recording and of having a hard copy of these notes. As no textbooks for the blind were available, I thought of doing them myself. Important notes were printed in Braille using a Braille writer and were then cut out. These cuttings were glued in groups to represent a whole note on a piece of cardboard. Together with this a representation of the shape, the note dealt with, was drawn on the same sheet of cardboard, using flexible wires. Every shape was represented on a single sheet so that it would be clear for the participant and at the top of every sheet, the title/name of the shape was written in Braille for more clarity as layout does not come naturally to the blind (Jackson, 1968).

Finally these sheets were attached to each other to form a booklet which John could carry with him for revision. The use of flexible wires was preferred to the spur wheel because these notes needed to be ‘heavy duty’ and the raised dots obtained by the wheel could be easily flattened due to constant use.

The idea of making our own textbook occurred only half way through the teaching programme and was found to be very useful for revision. Hoard (2006) suggested that
keeping a notebook will help to fix matters in the student’s mind. Similar booklets were later made for the following topics:

1. Angle Properties and Parallel lines
2. Different shapes and their properties (Both 2D and 3D)
3. Areas and Perimeters (formulae)
4. Volumes
5. Trigonometry and Pythagoras’ theorem (angles of elevation and depression)
6. Polygons
7. Angles in Circles

Figure 4.10– Examples of the textbook
4.5 Meetings with the MATSEC board

I had meetings with the local examinations board to get informed on what was available or what modifications were usually provided to accommodate candidates during the examination. Prior to the teaching programme, the board was contacted to clarify various questions, such as what tools were available and what methods were usually used to present diagrams to a blind candidate. The idea was that I could employ the same strategies during the teaching programme.

As there was never an instance where a totally blind student sat for a mathematics examination this meant that there were no tools available, let alone software to work with. My first reaction was to give up but the willingness and determination from the participant’s side made me rethink my inclination. My motivation was further strengthened by the knowledge that through history there were blind people who managed to succeed in Mathematics even at higher levels. The MATSEC board collaborated fully in this work and was interested to know which strategy we were going to employ and whether it would be suitable to use in the future should other instances arise.

The main problem was how to set an exam paper that could be read by the blind student himself. My first try was to use a Braille Printer. Sample exam questions were printed as a trial but it was clear that the problem of representing diagrams was not solved and the idea of providing a paper in Braille was not effective since it took the blind student more time to read than to answer. So it was established that during the exam John would be provided by an amanuensis who would read and write for him.
The two thermoform machines present on the island, which could be used to emboss a diagram, were both out of order. This meant that I had to think of a method in which embossing could be made manually. Given all these factors the MATSEC board suggested that there were two possible options: The first one was to delay the exam by one year that is instead of sitting for the May 2006 session the participant takes the May 2007 session. This would allow enough time to explore ways in which they could present the paper. The other option was to skip the Geometrical parts of the syllabus and the student answers only to other topics which he could work mentally and where no diagrams were involved. The final grade awarded for the second option then would be calculated pro-rata. This meant that it would be mentioned on the certificate that the candidate was not assessed on all the areas of the syllabus. Both these options were not accepted by the participant. He thought that this reaction from the examination board was a way of making him reconsider his idea of sitting for the exam and give up. To the contrary John wanted to prove that he can do it more then ever and wanted to end this ‘challenge’ successfully as was planned.

The MATSEC board liked the idea of using of using the spur wheel for embossing over the other methods (mentioned in the next chapter section 5.1.3) because it was fast and preparation of the diagrams could be easily done before the examination. The main preoccupation was the secrecy of the paper and they did not like the idea of circulating the paper before the day of the examination. This approval was obtained during a meeting in which the Special Needs Committee asked me to present my strategy so that it could be approved by every member of the board. The presented method was accepted and there were several other queries that I had to answer for, to prove the strategy right.
By the end of the meeting several points were raised and agreed upon. It was settled that I will be present an hour and half before the exam sessions to prepare the embossing of the paper. Moreover, it was also agreed that I be present during the exam as a ‘facilitator on call’, should a problem arise, and I should be called to find a remedy.

The participant, given his special needs was also eligible for extra time. Knowing that reading diagrams by touch takes more time than scanning it visually and the methods he used to work out tasks were slow, the board gave him 50% extra time for all the papers involved. Table 4.1 the new timings for the three papers.

<table>
<thead>
<tr>
<th></th>
<th>Usual time</th>
<th>+ 50% extra</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mental Test</strong></td>
<td>20 minutes</td>
<td>30 minutes</td>
</tr>
<tr>
<td><strong>Paper I</strong></td>
<td>1 hour 40 minutes</td>
<td>2 hours 30 minutes</td>
</tr>
<tr>
<td><strong>Paper IIB</strong></td>
<td>2 hours</td>
<td>3 hours</td>
</tr>
</tbody>
</table>

The board also agreed on providing an amanuensis during the exam. The chosen person should be knowledgeable in Mathematics and know how to use the calculator so that the participant would not be at a disadvantage.

Positive outcomes emerged from this meeting. Although, at first, the board seemed sceptical on how this experiment will be a success, they collaborated a lot and were interested in helping us with all our queries and needs.
When the amanuensis was selected, the board felt it was important that I meet her to explain certain methods that the participant uses during the exam. So a meeting was set up prior the exam, where a brief explanation of the tools used and to what extent she will be asked to help John during the exam was given.

4.6 The SEC Mathematics Examination

The Examination Session took place on Saturday 6\textsuperscript{th} May 2006. The morning session, during which the students sat for Paper I and the Mental test, started at 9 o’clock while the afternoon session – Paper II started at 4 o’clock. In both cases I was present at the MATSEC offices to prepare the embossing of all the diagrams involved in the Paper so that the participant could work on.
Chapter 5:

Outcomes
5.1 The case study of John

The purpose of the first interview was to get to know the student, taking part in this study, more closely. He was asked about his personal background and his motivation for the study. John (not his real name) is married, has a full time job and is also leads one of the Maltese societies for the blind. This implies that he is actively involved in various activities and the fact that he is blind does not hinder him from doing what he desires. His wife gives him a continuous support and involves herself in all his activities. As a president of this society, he does not only organise activities to the members but put pressure and awareness on certain issues that concern the blind in society. John argued: “Little has been done locally to accommodate the blind” and as compared to other countries Malta still lags behind in these issues.

He works full time in the production line of a factory. A job that was not easy to get because of his disability. Working in a factory is not easy either, considering the working hours and the amount of work that need to be done to keep up with the production. John’s wish is to change his job. However, he regrets the fact that when he was young he missed various opportunities to learn and consequently not obtaining any qualifications.

John is not congenitally blind. He grew up totally blind since the age of seven due to serious impacts on his head. During that time he was in his second year of primary schooling. Due to these accidents he missed a lot of formal education. Consequently he was transferred to another school for children with special needs. During that time, that is early 1980s, inclusive education was not implemented in the Maltese educational system.
As John argued, this experience was traumatic. He was placed in a class with mentally retarded students of various ages.

Following this, his mother was shocked and worked very hard to put him in a class that catered for blind students. Her efforts, finally led to another transfer, this time to a class with another four blind students in a Special school where he was taught Braille, basic Maltese, English and Numeracy. The Main curriculum was mainly based on the teaching of life skills like using the walking stick.

Very recently, John decided to take lessons in various subjects in order to obtain adequate qualifications maybe one day he will change his job. His dream is to follow a University degree course in Social Work. Throughout the teaching programme, John was highly enthusiastic in learning Mathematics and was very pro-active about getting help. Before opting to learn mathematics, John was already in possession of a certificate in Maltese and English language and ECDL (European Computer Driving Licence). Obtaining a pass in these three subjects encouraged John to proceed with his studies.

5.2 John’s Expectations

John chose to study Mathematics because it is one of the core subjects in academic education and to have enough qualifications to start a course at the University. Mathematics is one of the important requisites in every institution and he feels that having qualifications in other subjects but mathematics is like having something missing. During one of our informal conversations John said:
Il-Maths huwa importanti ghal kullimkien. Jekk ma jkollox lilu qisu ghandek kejk minghajr zokkor jew doża żghira ta’ zokkor. Maths is an important subject and it takes you everywhere. If you do not have a pass in Maths, it is like a cake without sugar or a small dose of sugar.

He started learning Mathematics without being aware of its content and what it involves. When he showed this interest, in studying Maths, to his friends, some of them discouraged him because he can’t see diagrams and graphs. He was mostly disappointed when educators themselves discouraged him to do maths because they told him that he was simply not able to do it.

Biex tistudja il-Maths, trid tkun intelligenti. Barra minn hekk il-Maths fih hafna partijiet vizwali u jekk ma tarax m’hemmx cans li tifhem. Dan qisek qed titghallem tpingi. You need to be intelligent to study Maths. On the other hand, Maths relies on vision and if you’re blind you are not going to understand its concepts. This is like saying, you want to learn Art.

These comments made him more determined to learn Maths.

My first reaction when John approached me for these lessons was that it was impossible for him to learn Mathematics as the subject involves a lot of visually related material. However, after conducting some research on this issue in other countries, I found that there were blind students who managed to study Mathematics and also blind Mathematicians who gave great contributions to the Mathematical field abroad. This information made me take the challenge.

However, I also learned that it was the first time in Malta for a blind student to study Mathematics up to Ordinary level. This meant that I had to create a whole teaching strategy to make this possible.
5.3 The Teaching Programme

The Mathematics syllabus chosen for the teaching programme is grouped into four main branches: - Number Work, Algebra, Shape, Space and Measure, and Data Handling (Appendix 1). All these four areas were covered during these lessons. However as the teaching method was basically the same throughout the course there were some different techniques which were used for different topics.

The following sections will give a detailed account of how this teaching programme was carried out.

5.3.1 Number

Number was the first section out of the four groups that the teaching programme started with. It is usually referred to as Arithmetic and combines in it topics such as the use of operators, BODMAS rule, percentages, ratios and fractions.

This part of the syllabus is not difficult as it consists of mental and practical situations. At the beginning of the programme I did not have any tools to work with, so most of the work was done orally and mentally. But this method could only be appropriate for the initial topics of the programme. As more concepts were introduced, tools and resources were needed. In addition to this it was important to find out a way of recording work both for revision and also for examination purposes.
John suggested his tape recorder which he found very useful in studying Maltese and English languages. At first it was found to be a good idea. Mathematical tasks were tape recorded and John could than work out other tasks on the same lines as the worked example. However, as more tasks were tackled, I found out that John was misusing this tape recording option. He tried to repeat the same pattern used in working out the recorded example, to other situations which were not necessary similar to recorded task, in a parrot like fashion.

My teaching style puts more emphasis on understanding and on encouraging John to focus on each individual example and work accordingly without relating it to other examples. Focus was on constructing his learning through understanding as opposed to the recall of methods.

5.3.1.1 Fractions

John was familiar with the verbal terms such as ‘half’ and ‘quarter’ but not with the mathematical representations of fractions that is using a numerator and a denominator. So when complex fractions like mixed numbers and improper fractions were tackled, he was at a complete loss. It was at this moment that the need for the appropriate tools was crucial.

The use of cork board and pins (figure 4.4) helped John construct an appropriate mental image of how these numbers are represented, with the numerator and denominator and the line in between used as the divisor.
I found out that my way of teaching and introducing mathematical concepts to John, based on my past teaching strategies, relied heavily on the visual aspect rather than on the oral aspect. This may be due to the fact, that it was my first experience in working with a blind person and that I usually base my understanding on the visual aspect of things and through observations. So my emphasis and way of thinking was still based on these lines and tried to create tools that will provide an embossed way of these visual representations as I was used to.

As working with fractions is not as easy as working with whole numbers, it took John some time to understand this concept. So I tried to use various practical examples which he could work out mentally and then show him how they are represented as symbols as it was important for examination purposes. The examples chosen during the lessons were practical ones such as:

Kathleen is cooking a marmalade recipe for which she needs $5 \frac{1}{3}$ cups of water. If a cup holds $\frac{1}{4}$ litre of liquid, how many litres of water are needed for the recipe? (MATSEC Mathematics May 2005 Paper IIB)

Two thirds of all the grapes grown in a village in France are used for winemaking. One fifth of the wine produced is Chardonnay. The rest of the wine is in equal proportions of Merlot and Sauternes. What fraction of all the grapes grown is used to produce Merlot? (MATSEC Mathematics September 2004 Paper I)

These helped John in connecting what he is learning with the actual real life situations and mathematics would not be taken as a subject that is out of context.

The concept of equivalent fractions did not come naturally to John. This topic took more time than actually planned. Consequently, during these lessons I learned a lot on how to deal with teaching techniques to a blind student. First of all I learned to think and
understand things from the blind people’s point of view. For blind students, it is very important to give detailed descriptions of visual occurrences and spelling out a new or technical word. This made me emphasise and put more focus on things that I usually took for granted. Through my teaching experiences I was used to explain things just by making my sighted students look at the way the problem at hand is written on the board. In this case, emphasis was put on the oral aspect.

5.3.1.2 Percentages and Ratios

These two topics were among the easiest topics as they are more practical. John was familiar to these especially to Percentages. As he remarked, he was used to these as he ‘earns a salary and pays taxes, has bank accounts and earns interests and similarly also has bank loans and pays charges’. Working was done mentally or using the talking calculator.

As a topic, Ratios was similar to the use of fractions but less difficult. The emphasis was not on the notation but on the practical situation presented in the question. The participant immediately understood the concept of sharing and working was followed without any particular difficulties.

5.3.1.3 The Use of Negative numbers and Directed numbers

John understood the concept of negative numbers through various examples such as the use of money, and temperature. Negative numbers were introduced by a demonstration of a
number line on the cork board. Through various examples and explanations the participant concluded that a ‘+’ operator means move forwards to the right, while a negative sign means move the opposite way, that is to the left. This was done to remove most of the mysteries associated with these signs which as Jackson (1968) argued arise not from a lack of appreciation of mathematics involved, but from the ambiguous use of the words ‘plus’ and ‘minus’ to mean both the operation of addition and subtraction.

Presenting him with an expression like; \( -5 - (-7) \) was difficult for him to understand because it was out of context. But ultimately it was interesting to note the strategies he used to understand certain concepts. The participant concluded that a term like \( - (-7) \) means the opposite of minus 7 which brings a positive 7. I encouraged such mental strategies because taught strategies may not appeal to the student as much as a self learned or a self constructed one.

5.3.1.3 Addition and Subtraction

Whereas sighted students are used to add, multiply and subtract numbers, using a vertical layout where the digits are placed in their appropriate place value column, it was quite confusing for John. He found it difficult to keep track of the calculation worked out in this way on the cork board. So it was essential for him to write it in a horizontal way and work it out mentally and when possible using the calculator (Whittaker 1968, DfES 2001). These were all new methods for me as mentioned earlier I never thought of things the way a blind person thinks. So when introducing things and found out that they were confusing for him, due to the way they were introduced (focus on visual aspect), I tried to improvise and make
him construct his understanding. Moreover, these procedures take time to master, and to work them out sometimes took even longer because of the use of pins and Braille notations. As Chapman & Stone (1988) remarked: ‘a calculation can take a minute, yet recording it in Braille can take several minutes’ (p. 120).

5.3.2 Algebra

On introducing Algebra, I met almost the same problems as those encountered by the sighted students. That is the understanding of what algebra is all about and why is it so useful. I started this part by introducing the generalised letters $x$ and $y$ through concrete examples so that the participant would not get the impression that they are something artificial.

Algebraic notation is a vital component in mathematical disciplines. It relies heavily on the use of paper and pencil, often using complex structures that lack redundancy. The loss of any one symbol of grouping boundary within an expression can alter its meaning radically (Stevens, 1996). So care was taken in this regard.

5.3.2.1 Solving, Simplifying, Substituting and Subject of the Formula

Different types of pins were introduced to distinguish between a number and a letter (figure 4.2). These were used by John to write and read his algebraic working actively rather than listen passively. Simplification of expressions, solving equations and substituting numbers into equations were taught in the same way as the sighted students. The fact that these are
worked in a horizontal layout made it less difficult for him to work out, starting a new line for every step of working. However, it took more time than expected because John had to repeatedly read from the very start of every line in order to keep in mind what he had written and then proceeds to the next step.

There were no difficulties with collecting like terms and the concept of making a letter subject of the formula. What was important was that he does it in a particular order and as algebraic equations deal with the concept of balance, it was necessary to stress that what he does to the Left Hand Side of the equation, he does it to the Right Hand Side.

5.3.2.2. Indices

Although this topic is quite easy and only deals with notations, John found it difficult he did not like this topic and consequently did not grasp its content. Although it was repeated for several times that $x^3$ means $x \times x \times x$, he continuously confused the whole thing whilst working them out. It is either because he forgot numbers while working or because, he did not respond well to the topic from the very beginning. Moreover, there are also a set of laws that indices carry and as he could not jot down notes he forgot them very easily. I think that this was all due to the limited time frame of the teaching programme. Given the initiate from John’s side, if he were given more time work out and revise, this problem would have been overcome.
5.3.2.3 Graphing

Graphical Representation refers to creating graphs, more precisely drawing graphs. At first I doubted how much these would be appreciated by a blind person. My first reaction was to skip the whole topic and emphasize more on arithmetic and other mental work. However thinking in depth and experimenting, I managed to come up with a working strategy. It seemed that the more the topic involved drawings and creating things, the more John was eager to work, and this proves that graphing was one of the areas that he learned very well. This may be because in working out graphs and drawing, John was actively involved. During one of our informal conversations, he stated that as a person he prefers ‘doing something’ that is using his hands to create something more than working mentally. From observations, I noticed that he took extra care in trying to ‘draw’ graphs accurately as opposed to working out an arithmetic sum, where at times he simply just call out an answer randomly.

Working out coordinates of a line before plotting was similar to the substitution methods described earlier. Instead of drawing a table for values of \( x \), as sighted students usually do, John wrote down the equation of the line on the corkboard and worked out the values for \( y \) by substituting different values of \( x \) one at a time.

On the graphing board (figure 4.9) John attached two perpendicular wires for the \( x \) and \( y \) axis. Using needles, he labelled each axis as appropriate and later by moving his fingers along the strings that form the grid, he marked the relevant coordinates with another pin. Sensible use of hands was thus promoted. When the plotting of the points is ready, their
position on the grid shows whether it is a proper straight line or a curve. This gave him the opportunity to arrange points if they were misplaced. But this method had two pitfalls:

1. The strings for the Grid on the graphing board were not steady and moved with the fingers, this means that a graph could not be made as accurate as possible. This confused John as he was not sure if it is right or wrong despite the fact that he moved along the gridlines as appropriate.

2. The end result of graphing was not a permanent one. Each time a new graph was tackled, the points and markings of the previous graph were removed from the board. This meant that there was no record for examination purposes.

To remedy the first problem, the gridlines of an embossed graph paper (figure 4.8) were found to be steadier and plotting is more accurate. The procedure was to mount the graph paper on the corkboard and mark the axes and points using wires, pins and needles, and then connect the pins with rubber bands.

The main problem however was that of providing a record of the graphs produced. Instead of using strings or elastic bands to tie around the pins, John used a pencil and ruler, in the case of a straight line graphs or freehand, in the case of a curve and drew a line that joined the pins. Of course, a pronounced movement of the pencil was felt, thus knowing that it was marking. But the problem was that a ‘clumsy’ graph was produced. In addition to this, there was the difficulty of trying to read information back from the graph achieved. For this reason the line graph obtained was embossed from the reverse side, so that John
would be able to take readings from the graph. We found this procedure very practical as John could work out without any particular problems. However, before keeping his graph work as a record, it was important to mark the scales and axes of the graph.

One of the barriers in this topic, among others, was that of accuracy that is, the problem of scale. A normal printed graph paper is squared into tenths. The participant could not use a grid which is refined into such detail, as there will be a confusion of too many grid lines. The only remedy to this was to produce an enlarged scale that will in return result in very large graphical representations which although they will be mathematically correct and still a valid graph for the final assessment, yet it would be less effective when considering that reading from it will be taken by touch rather than by sight (Whittaker, 1968). Therefore I opted to work on unit intervals and when the point happened to be on a half unit or less, I helped by reading the scale (the tenths) for him.

Figure 5.1 – Example of the student’s graphical work
5.3.3 Shape, Space and Measure

This area is considered as the part of the syllabus which relies heavily on the visual aspect. Images and diagrams cannot be skipped just because the blind cannot see them. On the other hand the different properties of a shape or the angles involved in a diagram, cannot be understood solely through an oral description. This made me think of other ways of presenting different shapes to John. The first idea was to provide him with the actual shapes to handle and touch such as 2D squares, triangles, polygons and also 3D shapes like cubes, pyramids and so on. However as our objective was the SEC exam, I had to think of other ways of representing these objects on paper, that is embossed drawings, which although John cannot see but touch, he could understand the properties of the shape.

A simple raised line across a page means a lot and gives a lot of interpretation, for example its length, its orientation – horizontal, vertical or slanting, characteristics which are not easily given orally. The real problem aroused in explaining three dimensional objects. This may be because blind students may lack the opportunity to recognise spatial concepts and a 3D object on paper may be meaningless to them. A remedy to this was to present the actual shape in a concrete form together with the diagram for the student to compare.

John is not congenitally blind; he had prior experience of some shapes such as squares, triangles, boxes (cubes). Shapes like trapeziums and parallelograms were new to him. Moreover, there were other shapes like polygons, that he was familiar to but did not know their technical names. For example he could recognise the hexagon and octagon from the former Maltese currency coins, that is the fifty cents coin and the twenty five cents coin respectively. So he continuously referred to them as the 50c and 25c.
Before tackling this part of the syllabus, my first task was to discover which type of embossing was appropriate to use in presenting him with different diagrams, given that it would be the most efficient throughout the whole teaching programme and even during the final assessment. The selection was based on clarity and easy reading. There were four options to choose from.

1. Using a thermoform machine, which given a mould of the diagram needed, it copies it to a raised diagram made on plastic sheet by means of vacuum forming. Using this machine, the diagram output is almost perfect. But as this machine was not available to use and the only two thermoforms machines present on the island were out of order, the idea and choice was immediately rejected.

2. The second option was to enlarge the diagram using a photocopier and trace the outline of the diagram by attaching flexible wires to make the effect of a raised line. But it was not always easy to use this option, because it depended on whether the diagram was complicated or not. If the diagram consisted of overlapping lines, it was definitely not easy to emboss it with wires.

3. A more sensible solution was that instead of using wires, the outline of the enlarged diagram will be raised with a ‘fine liner’ - a thick ink used for stained glass effect that when dried it produces the same effect as that of a wire. But there were two disadvantages; first of all, is that, the ink was not always distributed evenly. As a result it may confuse the student. Secondly the process was very slow as the ink took very long to dry.
4. The fourth option was to emboss the outline of an enlarged copy of a diagram, using a spur wheel (figure 4.6), from the reverse side. The result is a series of evenly spaced raised dots, just like Braille, that form lines and outlines of a diagram. Using this method both the problem of overlapping of lines and the drying up were avoided. This was the most practical option and the accepted one for examination purposes.

All diagrams needed to be are enlarged to a certain percentage depending on their original size. On enlarging, one must keep in mind, that a large plan cannot be understood as a whole by touch in the way that it can be by vision. In fact the eye uses a scanning glance to distinguish shape clearly, and this movement is much more immediate than that of the fingers. The ideal size is that can be taken in as a whole by the fingers of one or both hands (Pickles, 1968). This also depends on the degree of complexity of the diagram.

Using these embossed diagrams and the parallel use of the actual two dimensional or three dimensional shapes was necessary for the participant to understand the general properties of each geometric shape and how to work out the area, perimeter, and volumes.

During the lessons, diagrams were enlarged and embossed using the spur wheel as explained earlier. The embossed version was then attached to a jablo slate and the appropriate labelling and measurements were represented in Braille using needles with spherical heads (figure 4.2). Figure 11 gives some examples of this. This method of teaching and learning is very similar to the conventional way of teaching that is used with the sighted students.
FIGURE 5.3 - EXAMPLES OF EMBOSSED DIAGRAMS
This again shows my emphasis on sighted diagrams. As a sighted person, I found it a bit difficult to think and look at things from the blind person’s point of view. I believe that learning takes places also by observing things besides by describing things. So I put more focus on trying to make John build up a mental image of how certain shapes look like if he could see them.

The topic dealing with Circle Theorems was found to be the most complicated. Diagrams in this topic had so many overlapping lines crossing each other that John was confused to tell which line was a chord, radius, etc. This was facilitated by placing a needle in the middle of the circle to show its centre. Being allowed some time to explore the diagram on his own, before listening to the question was found to be positive as John would be familiar to the diagram and can understand more clearly to what different parts of it the question is referring to.

5.2.3.1 Trigonometry and Pythagoras’ Theorem

Similarly to other topics in this section of the syllabus, Trigonometry and Pythagoras’ theorem relies heavily on vision. It is important to have a clearly labelled diagram to be able to identify which parts and which measurements to pick in order to obtain the required answers. The method employed here was similar to the other topics, where I embossed and labelled diagrams.

It is important to point out that to make the participant familiar with the Trigonometric Ratios and Pythagoras’ Theorem, the importance of jotting down appropriate working
using the cork board and pins was stressed. By writing down intermediate steps while working, John was able to recognise the next steps to take (including subject of the formulae, and substitution) in obtaining the final answer. Certain mistakes were not tolerated from an early stage. Although sometimes it seemed obvious what was meant, I made it a point that to achieve an accurate result, work should be accurately carried out before.

5.2.3.2 Constructions

Constructions are all about drawing accurate diagrams to given measurements and angles. Knowing that it was not easy, John was more than willing to work on this topic. A lot of memorisation was needed to study procedures, rather than formulae or methods. This was even difficult for the student as a Braille Typewriter was not available and he could not write his own notes.

The construction of 30°, 60°, 45° and 90° angles, were explained whilst the student performed the required steps gradually on paper. The adopted procedure was a very simple one but time consuming. The main tools the student made use of were paper, pencil, ruler (figure 4.7) and a set of compasses. John constructed work just like the sighted students do and for every mark he does on paper, I embossed it from the reverse side using the spur wheel (figure 4.6) so that he would know where his pencil markings were.

Care was taken such that the paper was properly attached to the cork board. Using the embossed ruler and compasses, he measured the required radii to work with. Moreover by pinning the compass point to the board, he obtained a steady way of using the compasses to
draw the arcs. John put a lot of effort in studying this topic. It was very difficult for him as it was like, drawing in space.

The final construction, though not accurate and a bit ‘messy’, looked like the proper construction and measurements had a very narrow margin of error. Labelling was then made and it was found to be a suitable way of presenting this work for examination purposes.

It was important that John listens carefully to the whole question being read out before starting his construction so that he could draw a mental picture of how the final construction should look like. He was also encouraged to create a rough sketch using wires and pins on the board. This was to train his listening and memorising skills. Thus he would be able to construct the appropriate angles in their proper positions.

**Figure 5.4 – An example of the student’s constructions**
FIGURE 5.5 – AN EXAMPLE OF THE STUDENT’S CONSTRUCTIONS
5.2.4 Data Handling

The last group of the syllabus consisted of two topics: Probability and Statistics. The major part of these topics could be easily worked out mentally once the concept is grasped.

5.2.4.1 Probability

Among other concepts, this topic involved ‘Possibility Spaces’ in which more than one event is treated. The method of working out these was through the drawing of a two dimensional array (table), in which all the possible outcomes are listed. The same was done by John on the corkboard with the difference that to avoid, the listing of all possible outcomes using pins, he read them out and I wrote them on paper to dictation. This was the most appropriate method, because it was less time consuming and since he could not present the corkboard and pins, it was a proper presentation for examination purposes.

5.2.4.2 Statistics

Like probability most statistical data can be obtained verbally. This was found to appeal and give a lot of confidence to the blind student because he could easily resort to memory work. Lots of repetition and questions giving different statistical situations were treated as the student continuously confused the terms Mean, Mode, Median and Range. It was all a problem of terminology.
Following the methods used to create graphs and constructions, it was not difficult to create pie charts and bar charts to illustrate statistical data. To draw Pie charts, John made use of compasses, paper, pencil, ruler, protractors and pins. He mounted a paper to the cork board and using compasses he drew a circle which was then embossed and a pin was placed in the centre of the circle so that he could draw the radius. The protractor was then placed at the centre and the required angles were marked by placing a pin. Figure 5.6 shows John working on a pie chart. Throughout the construction he continuously needed embossing for every marking so that he could proceed with his work.

**Figure 5.6 – The student creating pie charts**
Working on bar graphs was much the same as creating graphs. The use of embossed graph papers was preferred to the graphing board. The participant proceeded by pinning perpendicular ‘wires’ for the axes and using needles he labelled the scales. The plotting of the bar graph was done by running his fingers on the x-axis and move vertically parallel to the y-axis up to the required reading on the scale and attaches a pin. The same was repeated with the other columns.

Then using a ruler and pencil, the participant drew the column according to the position of the pins. Occasionally I helped him by placing the ruler on the appropriate grid line so that a desirable outcome would be obtained. Figure 5.7 shows an example of a bar graph as created by the participant.

Figure 5.7 – Example of a bar graph
5.2.5 Computer Software

Another part of the syllabus involved the use of two computer software: Spreadsheet and Micro Worlds Logo. Although the use of computers is essential in teaching these topics, to get an instant result, these topics were carried out like the other topics. I taught him the rules so that he could answer the tasks that follow. It is important to note that during the final exam, the students are not presented with computers to tackle these questions.

Micro Worlds Logo is software were an imaginary turtle performs shapes by moving according to a set of commands given by the user. Using a paper and pencil he could easily draw sketches of the shapes. Although not accurate and messy, the sketch always showed the shape that resembled the required one.
However when the sketch was not clear, John enhanced it by moving his finger on the cork board to show the movement by the turtle explaining every step taken. This ability was also demonstrated when he was given the shape and was asked to give the commands for it.

Tasks involving the Spreadsheet package were not difficult. This was because of his familiarity with the package as he holds an ECDL (European Computer Driving Licence) certificate. Moreover the questions involved were more of an algebraic nature and involved substituting numbers into formulae which could be easily worked out mentally.

5.3 During the SEC Mathematics Examination

During the examination, John and the amanuensis cooperated together very well. The latter, whom by profession was a speech therapist and a teacher for students with Special Needs, knew how to deal in these situations and read out each question slowly and twice as necessary. She also got used to the methods and tools used immediately. This was an advantage as time was not wasted and work was flowing smoothly.

As the ‘facilitator on call’, I was placed in an interconnecting room so that I could help should a problem arise. During the examination, I was very nervous and excited. I felt like I was doing the examination myself. As a teacher, who prepared the student to sit for an exam, I found it a bit uncomfortable to hear John, answering questions, sometimes wrongly, and could not correct him, or make him think further before giving out an answer.
The examination papers (Appendix 2) covered almost all the topics in the syllabus. This meant that there were a number of questions that John knew very well and others that he knew less due to the amount of memory work, theorems or formulae involved. In the Mental test he only managed to answer 12 questions out of 20. Knowing that he did not manage to answer all questions, he panicked and this resulted in the paper that followed – Paper I (Appendix 1). On the whole he found this paper ‘difficult’. In fact there were questions which required some drawing and sketching to work out which was a problem for him.

Occasionally I was asked to explain a diagram as it was not clear for him in the embossed version. This was in Paper IIB (Appendix 1). This problem was modified by using pins on the corkboard to represent the given sequence so that he could continue the next step.

Another question referred to an analogue clock, which he could not recognise. He never saw a clock face or forgot how it looks like and mistook the minute hand by the hour hand. So the minute hand pointing at two meant that it is 2 o’clock for him. This shows that although questions were real-life situations and practical, he was still at a disadvantage as he lacks such experiences due to being blind.

John was provided with a 50% extra time in all exam papers. This was to compensate for his loss of vision, the time taken for each question to be read and to exploring tactile diagrams. Although at first it seemed that the given extra time was not enough, at the end it was found to be too long and tiring. John found it very difficult to keep concentrated till the end of the examination.
5.4 The Examination Results

John obtained a grade ‘6’ out of the range of 4 – 7 possible grades for the choice of Paper I and Paper IIB that he opted for. This meant he obtained a pass mark. But John was not satisfied with ‘6’ as a grade because it is not recognised by most institutions as a good pass mark. So he immediately applied for the re-sit examination of the following September 2006, after revising some topics during the summer months. The grade he obtained from the second try was ‘5’ which is a better mark and which he primarily aimed for.

5.5 John’s view about the programme

After conducting the teaching programme and the examination result was published, a second interview was held. Its purpose was to elicit feedback from the participant himself about his attitudes towards Mathematics, now that he has undergone this study. Some feedback about the approach used in tackling the syllabus and experimenting with tools were also considered. The interview involved open questions to ensure that the student’s attitudes are revealed.

On the whole, John’s experience of this teaching programme was positive. This was revealed in the comments he gave during the interview.

Hadt pjacir f’kull lezzjoni. Kull topic li ghamilna ghal kemm kienu hafna, kien interessanti. Qatt ma kont nimmagina li ser jirnexxili nispicca dan il-kors hekk...tajjeb!

I enjoyed every single lesson. Every topic we tackled, although a large number of them, was interesting. I never imagined that I was going to finish this course in this way...successfully.
He was pleased with the progress he made during the eight month teaching programme. He attributes this to both his efforts and mine. He liked the creativity and willingness I showed during the programme, and this made him resume his work till the end.

Minbarra li ridt nuri li jien nista’ nitghallem daqs haddehor, ridt ukoll li ma niddisappuntax lilek ghal effort li kont qed taghmel. Apart from proving myself that I can learn maths just like the others, I did not want to disappoint you for the effort you showed.

John appreciated the fact, that immediately after he approached me to teach him, I set to work by doing research on what resources, teaching techniques and provisions are there for teaching Mathematics. This experience proved his motto to life: ‘never say no, before you try’.

Il-fatt li bdejt tfittex u tistaqsi mal-ewwel, urejt li vera ridt tghin. Barra minn hekk urejt ukoll l-imhabba li ghandek lejn is-sugget. The fact that you started to do research immediately showed that you really wanted to help me. Besides that you also showed your love for the subject.

At the beginning of the programme his aim was to obtain a good result in the examination. For him a grade of ‘6’ in the exam showed that he obtained a good pass mark considering all his restrictions, but he was aiming for a better grade that is ‘5’. However he seemed satisfied that he was able to cover the whole syllabus in a very short period of time and the result shows that he is capable of doing mathematics and even get a better mark. John said that there were some topics during the exam that he could not answer because he did not study them very hard. Moreover he said that during the exam he was very excited, and my presence in the adjacent room did not make him feel comfortable at all. So he decided to do the September 2006 re-sit to get a better grade, which in fact he got a grade of ‘5’.
John appreciated the fact that he was given the opportunity and was encouraged to do what he wanted. He said that all this was possible because he was lucky to meet a teacher who patiently explained, experimented and carried out research to make his dream possible.

Asked whether he thinks that he learned the subject well, John replied that he does not feel he is an expert, but it was enough for him to get to know what the subject is about. If he encounters somebody studying Mathematics, he knows exactly what the other is talking about and what it means.

When I will have children of my own and they start studying Maths, I would be able to understand what they are talking about. It is true that in fifteen years time, things will change but I would be able to follow what they are doing.

During the process of the interview, John was asked whether he finds any uses for Mathematics in his everyday life.

Mathematics is not an everyday subject. It is not like a language that you need to use continuously when you want to show others that you need something.

This comment shows that during the teaching process he never understood the purpose of studying mathematics. For him mathematics is only another subject and deals with the study of shapes, diagrams and the memorisation of formulas that he does not use in
everyday life. Moreover he pointed out that whether it is important as a subject for him or not, Mathematics is still inaccessible for him.

*Jien biex nahdem irrid ingle l-ghodda. U jekk niltaqa’ ma’ xi problema tal-Maths, mhux ser insibha hekk imqabbża u lesta.*

To work out Mathematical tasks, I need to have tools. And if I meet a mathematical problem, it is not going to be embossed and tactile.

John’s main source of frustration during his studies was the recognition of shapes, especially the complicated ones. That is, Angles in Circles and Trigonometric diagrams. Another difficulty was to remember the different formulas required in every topic. It was also difficult to concentrate and learn new concepts after a day at work, given that he wakes up at four in the morning everyday.

Asked about his opinion about the resources available, he said that he did not feel disadvantaged because of the tools. But he thinks that if he had a talking scientific calculator, it would have facilitated more work for him. John also mentioned that lack of appropriate textbooks for him to study from, but he still thinks that he would not do anything on his own at home.

*Kieku kelli ktieb kont naghmel xi haġa id-dar. Imma xorta kont inkun irrid support waqt li qed nahdem. Ghalhekk ma nqisx il-problema tal-ktieb, kbira hafna.*

If I had a Mathematics textbook, I would have revised something at home. But I would still need support during my studies. Therefore I would not consider the lack of textbook as very important.

John did not suggest the use of Braille writer to jot down notes and workings. He preferred the use of cork and pins to it because on a Braille writer one cannot correct errors whereas on the corkboard, it is just removing or adding pins, so it is not time consuming. Moreover the use of pins can be easily read by touch whereas small embossed dots could be very
difficult to read while working. He suggests that if there was appropriate computer software to use, it would have facilitated more work although he does not understand how a complicated diagram can be explained on a computer.
Chapter 6:

Discussion and Conclusion
6.1 Discussion of Findings

Outcomes of the study indicate that it is possible for blind students to study and understand significant elements of Mathematics. John’s work suggest that if provided with the right tools and instructions, potentially every student, sighted or blind, can be engaged in a Mathematical task. This also refers to the geometrical topics of the Mathematics Syllabus. Despite the fact that Geometry has often been removed from the Blind students’ mathematical curriculum because of its visual aspect, this study suggests that these students can be successful in Geometry just like sighted students.

John’s work shows that overall he performed very well. He learned and worked out Mathematics with understanding. This can be seen from the grade he was awarded in the SEC exam. In the second examination, John was awarded a pass mark of ‘5’ from the range of grades 4 – 7 or ‘U’ that are eligible to students sitting for Paper IIB. Thus the whole teaching programme gives an indication that a blind person can learn mathematics effectively and given some more time to revise and work, he is able to obtain better grades.

During this teaching programme, John showed that he is an intelligent person just like the normal academic student. That is, he does not have an exceptional intelligence in academic work when compared to others. The fact that he was successful suggests that the assumption of those educators who believe that Mathematics will only be accessible to the blind if they are bright and intelligent is incorrect (Pickles, 1968).
Throughout the course of study some factors were observed. Although the participant understood almost every concept involved, there were other areas where he was disadvantaged solely because of his disability and lack of experience of sighted things. This was especially evident in dealing with a pack of cards and reading the time from an analogue clock for example. In addition to this, one of the main difficulties was in recognising different representations of various shapes on paper, especially if they were complicated. The ability to comprehend two-dimensional representations of three-dimensional objects is cognitively challenging for all students of Mathematics. However, this is even a greater challenge for John. This was explicitly dealt with, by Fisher and Hartmann (2005). They found that blind students find it difficult to comprehend a three-dimensional shape from a representation of a two-dimensional figure with lines extending out of it.

John also found a difficulty in recognising different representations of the same shape. For example: it was difficult for him to recognise a cuboid orientated to the right, when he was accustomed to cuboids orientated the other way. This difficulty may be because on the ‘handmade’ textbook there was only one representation for each shape. Although various representations were tackled during the lessons, John was only presented with one version to revise and study at home. Fisher and Hartmann (2005) stressed:

The importance for all teachers to understand how to represent geometric objects in multiple ways, as well as how the representations they use can evoke different images for students as they try to use the images to understand the properties of an object. (p. 248)

In his book ‘The Psychology of Learning Mathematics’, Skemp (1971) argued that limited concept generalisations result from experiencing only a single or single type of
representations. Therefore it is very important to present students with various representations of shapes such that:

When we see any object from a particular viewpoint on a particular occasion, this experience evokes a memory of all our earlier experiences of seeing this object – not separately but as an abstraction of something common to this class of experiences. (p. 96)

It seemed that allowing the blind student some time to explore a diagram involved in a Mathematical task was beneficial. During this allowed time, John could tactually scan the given diagram, to get to know its boundaries, what shapes are involved and thus recognising which mathematical topic will be treated in this task, just like a sighted student recognises the shape and what it entails simply by scanning it visually. This was found to confirm what Awad and Wise (1984) suggested:

If complex diagrams are to be used in a lecture, allow the blind student to study the diagram prior to the presentation. (p.439)

The use of Braille code as the medium to communicate Mathematical work and the writing of intermediate results was found to be invaluable during this study. This was confirmed by other researchers in this area: Agrawal (2004), Schleppenbach (1997), Frampton (2006). If John was not proficient in Braille, he would have depended only on memorisation. In addition to this, the use of corkboard and pins facilitated John’s work. It was found to be easier to read by touching pins when compared to small dots. In fact during the final interview John said that he preferred it to the use of a Braille writer. The reason for this was that an error could be easily corrected by adding or removing a pin, whereas with Braille writer, correction is different. Eggleston (2006) argued:

The difficulty with which errors may be corrected in Braille also presents a major problem. The working out of an example in Braille is so long and the errors are so difficult to correct that the pupil often neglects to look over his work… with Braille the whole problem must be reworked. (p.122)
The findings that emerged from this teaching programme showed that some kind of permanent recording of work and instructions were needed throughout the lessons. The methods and tools used for writing were all temporary and John had nothing to take as a record with him besides the handmade notes. Should this programme be repeated with other students it is important to make use of tape-recording or any other effective way with which the blind student could revise his work at home. Such lack of permanent notes could also have some impact on the final grade obtained in the examination.

Outcomes of the study and the responses given to certain mathematical tasks showed that the blind student could comprehend mathematical concepts. The main barrier he had with respect to examination preparation was the time frame in which he was expected to cover the entire mathematics syllabus. Had the student more time to revise and study he would have obtained a better mark. Moreover as John stopped his formal education (studying Mathematics) at the age of 7 and the study was conducted when he was 34 years old, during this long break from formal schooling, he missed a lot and as a consequence this was felt during the teaching programme.

The limited time frame resulted in other factors as well. The speed of calculations and work done by John was very slow. It consumed a lot of time to explain and clarify mathematical concepts. Every question needed to be repeated twice and understanding of a diagram sometimes took longer than expected. These factors made topics such as Fractions, Indices and Geometry take longer to be comprehended because John was not accustomed to the notations used and thus found it difficult to build up a proper mental
image. All this confirm what several other researchers such as Osterhaus (2005) and Chapman and Stone (1988) found in their studies. Sims (1968) found that:

The speed of calculation was far slower, except for work which could be done mentally, and interest in a problem was lost as time went on.

John liked the topic of constructions most. For him it was like doing something which he never thought he could do that is drawing diagrams. The same methods used in teaching constructions to the sighted were adopted for use with John. Each pencil marking he did was raised using the spur wheel. Frampton (2006) gives detailed instructions of how constructions should be done. However, even though John managed to produce constructions and sometimes almost accurate, the results were a bit ‘messy’ to present for examination purposes. But when considering that this was the result of a blind person, one would appreciate the effort. Jackson (1968) argued that:

As an exercise for its own sake, accurate geometrical construction is impossible for the blind…the sense of touch is so inferior to that of sight in this respect, that any results obtained by the blind could not be fairly compared with those obtained by the sighted.

John was always trained and used to resort to solely memorisation and mental work. Throughout the programme he was more willing to reason out tasks logically without following any particular method. This is the best way of learning mathematics that is with understanding, in this way one could apply his mathematical knowledge in practical situations. It is the contrary to what Sims (1968) found in her study that:

Most girls were more willing to learn facts and techniques parrot-fashion than to think logically.

Algebraic expressions, especially geometric questions involving algebraic expressions were the participants’ main source of frustration. Sometimes it was very difficult for him to work out, simplify or solve an equation because of its length considering that he had to
write every term on the corkboard using pins. It took him a lot of time to write down, the expression/equation and re-read it over and over again so that he would not forget a term out. Some of the frustrations were also expressed by Helen Keller (1958) in her book ‘The Story of My Life’.

This teaching programme also showed that a blind learner, in this case John, can take examination in Mathematics up to SEC level and even higher if given the appropriate training and encouragement. But in such cases as individuals with special needs differ from one person to another, it is important that as Chapman and Stone (1988) suggested,

The syllabus will need to be scrutinised carefully so that difficulties attendant upon the visual nature of work can be taken up with the appropriate examining board well in advance. (p.123)

At the end of the programme, John showed an interest in taking lessons in Mathematics in Advanced level. The local realities show that as there were difficulties and no provisions for the Ordinary level, it is less likely that there are for A-level unless someone creates their own. However, such interest showed that the whole experience was a positive one for John as he considered furthering his studies in the subject.

The study discussed in this dissertation provides new insights in the Special Educational Needs field with particular emphasis on the Blind Students and Mathematics. The use of the methods discussed in this study has allowed the student to study and make observations and comparisons amongst a wide variety of mathematical topics whose nature was formerly less keenly investigated and remained only superficially examined. The methods outlined have presented much work for the student. A lot of thought, carefulness and creativity
were also promoted in due course. Overall the student has demonstrated a surprising ability in this regard.

6.2 Implications of the Study

6.2.1 Implications for Teachers

The most imperative conclusion which emerges from this dissertation is that although visual impairment and blindness affect student’s learning of Mathematics, as many authors confirm, it is not an impossible task to help these students overcome their difficulties. Perhaps the worst situation which may arise is where teachers give up on a student from the very start and no form of help is offered. This is why it is of utmost importance that the awareness of this area of special needs increases, such as to avoid labelling these students as not able and being unable to ever succeed in mathematics.

As mainstreaming and the policy of inclusion are increasing, it is very probable that a teacher may encounter a student with special needs in class. It is important for teachers to be aware of these students’ condition and the implication on the teaching, learning and the classroom in general. This helps the teacher in preparing him/herself better and to prepare tasks for the individual student.

It is evident from this study that a blind student can study mathematics. Mathematics learning is not very difficult but is a long process and makes the child and teacher feel that it is difficult. This cannot be achieved overnight, it needs continuous effort. In short with
proper material, co-ordination, thorough follow-up and stressing on reasoning rather than
on memory, learning of Mathematics could be made possible and rapid strides can be made
in this subject (Agrawal, 2004; Hoard, 2006).

6.2.2 Implications for School Practices

Research showed that students attending Special Schools study Mathematics up to a
different level than those in the mainstream. Students at Special Schools have multiple
disabilities that restrict them from coping with the demanding content of the mathematics
syllabus. Thus only those blind and visually disabled students attending the mainstream
can follow mathematics syllabi that lead them to sit for standard examinations. But it
seems that there is a gap between the policy of inclusion and the reality in which these
schools are operating.

Schools lack the appropriate resources and materials, which help the visually disabled
students, learn mathematics. If they are provided with large print textbooks or Braille print
textbooks, writing equipment, calculators and shapes, the students can comprehend
mathematical concepts and achieve better in the subject. These can be put in a resource
room run by a resource teacher, who as Corn and Martinez (1977) suggested, will be based
in the school premises and offer consultations, special teaching methods and supply
adapted visually-impaired materials.

This study showed that blind learners are able to follow instructions given during a lesson.
Therefore it seems that a blind learner can cope in a classroom environment learning
Mathematics with his sighted peers. But it is important that he or she will be supported by a facilitator who preferably is present during the lessons to help him with the tasks carried out in class. The facilitator can also help by providing remedial work or extra help in the subject areas that the class teacher points out as problematic for the blind learner in the classroom. Such tuition can be done on a withdrawal basis from the class.

Moreover, it is important that the facilitator or peripatetic teacher know in advance which books will be needed for the scholastic year, if they are to be ready in time. The class teacher needs to keep close contact with the peripatetic teacher and facilitator to supply the syllabus as to envisage plans for necessary materials.

6.2.3 Implications for the National Context

The Maltese Educational system has adopted the policy of inclusion and diversity in schools. Reports have shown that the high rate of inclusion was a great achievement in the educational system (Ministry of Education, 2005). Outcomes from this study, show that this case study, though conducted on one-to-one basis, visually impaired and blind students can both academically and socially gain a lot if they are educated along side their sighted peers. However, a lot still need to be done in this regards so as to achieve better results. Among these are the appropriate resources, textbooks, trained teachers and better ways for assessing and examining these students.

Research carried out during this study, shows that the local examination board offers lot of assistance to candidates with special needs, but in this area of visually disabled students they lack the adequate resources and provisions because the incidence is very low. It was
found that the board adapts the learning methods of the candidates for examination purposes so that the latter feels familiar. This is found to be a good method since there are no standardised methods used in schools. It would be by far better if appropriate methods and advanced tools are first adopted and implemented in schools, when these students are introduced to these subjects. Then having a learning method that is standard to all visually disabled students (let alone exceptions), the examinations board can invest and work on standardising these methods and set up examination papers.

6.3 Personal Reflections on this Teaching Experience

6.3.1 As a Teacher

On the whole, this teaching experience has given me an extremely valuable insight into one of the many different disabilities that teachers meet in class. Through this study, I did not only enrich my knowledge on the blind, but also explored ways of helping blind students. It made me think and experiment with various teaching methods and make them accessible to John. This will surely enhance my performance as a teacher.

John helped me feel at ease while teaching him. He was highly enthusiastic and very proactive during the lessons. Above all he gave continuous feedback of his progress in the tasks carried out. This is highly appreciated by every teacher during his or her teaching. In addition to this, John’s appreciation to my efforts in finding out ways to facilitate his learning made me proceed with my work.
At the beginning the teaching programme produced within me a critical attitude of any steps towards imposing such things upon the blind student. In fact I began working from the point of view that ‘sighted’ topics such as graphs and geometry were needless for blind students.

This point of view was no longer held as John was strong in his determination to do these topics despite the use of tools available. In fact these ‘visual’ topics have a great deal to offer to blind students. The benefits obtained from such work extend beyond the value of the actual mathematical content involved.

One of the major doubts was whether or not the work needed to produce graphs and to study geometrical facts would be worth for the student to appreciate. What sense do certain shapes and diagrams make for a blind student? The participant in this study has shown that he is quite capable of understanding the drawings involved. If shapes and diagrams are clearly produced, a blind student can comprehend them just like a fully sighted student. It is only a wrong perception of the sighted to think that a blind cannot understand and master a diagram. As Whittaker (1968) states:

The degree of astonishment [of the sighted] is only the measure of the degree to which their [the blind] ability is underestimated.

The methods employed for presenting diagrams to the student were among the other doubts which accompanied the development of the teaching methods used during the study. Doubts that ranged from the clarity and accuracy of the diagrams involved to whether they would be accepted during the SEC examination. Nonetheless the other major doubt that there might be some other effective methods which are less troublesome for the blind
student. The methods used however proved that they were effective since John managed to comprehend the concepts and carried out tasks successfully.

6.3.2 As a Researcher

The methods used for data collection (section 4.3) were found to be appropriate as they led to successful results and also yielded the necessary information for this study. However, as a researcher, I feel that there were factors that could effect the results obtained in this study. The next paragraphs will discuss these in detail.

The time frame set for this study was very restricted. The whole ordinary level mathematics syllabus that is usually covered in five years at secondary schooling had to be covered in eight months. This restriction made it less possible to carry out as many explanations and experiments. However, if more time was allowed, the participant would have revised and worked on more examples than actually covered.

The blind student in this study was thirty four years of age. This does not imply that he is not entitled to learn, but in this study age means experience and this makes an effect on the learning of mathematics. If the student was younger, the study would have provided a different experience. Moreover, John attended lessons after a day at work so he couldn’t concentrate as much as he liked because he was already tired.

The teaching programme took off without having the exact idea of what tools to use and from where to get them. Investigations and experiments in this regard were carried out
during the teaching programme. Should this research have been carried out before, there would have been less wastage of time during the lessons. Moreover if the tools were bought and not hand made, they would have been more accurate. Similarly if the diagrams were made using a tactile printer, it would be much better.

The study made use of non technological tools. Nowadays almost everyone is computer literate and blind people can benefit from various tools, for example speech synthesisers. If the time was not restricted, research and investigations would have been expanded to explore available computer software.

As in all other subjects the use or availability of textbooks is highly recommended while learning an academic subject. Unfortunately during this case study no textbook which could be used by the participant was available. So every question or explanation was made orally. This meant that the student did not have notes, so he could not reinforce what he did during the lesson at home. Besides this the student did not have a Braille typewriter which he could carry with to write notes in very much the same way as sighted people use ink. The idea to make embossed notes occurred half way through the programme therefore notes were made for only a small selection of topics.

This case study was carried out with only one student. Although it is the most appropriate situation in such cases to teach these students individually and lessons to be carried out on one to one basis, if this case study involved another blind student, other factors, ideas, and issues should have emerged and appropriate conclusions and perhaps generalisations could have been drawn out.
It is also important to point out that I have put an exceptional amount of time in this teaching programme because I was highly motivated due to two reasons. First, it was my desire to help John in achieving what he wished. That is, obtaining a pass mark in Mathematics Ordinary level examination. Secondly, I had a personal interest in collecting data for my M.Ed. dissertation.

This implies that, it would be rather unusual for another teacher, to invest the same amount of time and effort in teaching mathematics to a blind student. Therefore the same degree of success achieved in this teaching experience cannot be guaranteed to other teachers in the same situation. However, some of the resources I developed can potentially be used by others, thus reducing the time commitment in repeating such a teaching programme.

### 6.4 Contributions of the Study

Perhaps the most obvious follow up on this dissertation would be to compare the results obtained from this study to others which could be obtained by studying other blind students in Mathematics both locally and abroad. Also if sufficient studies are made with an adequate number of students, it might be useful to put together a mathematics resource pack for the blind. This would offer teachers the opportunity to have at hand different strategies which may help in their work with the blind students.

This study can contribute a lot locally, as there was never a study carried out on this issue. It will thus give an insight into the present situation and may also give some ideas to
teachers who are currently dealing with blind students. However, although the study made use of simple methods and no computer software was used, it may act as a stepping stone to further and more intense research in this area. Maybe in the future there won’t be anymore discussions on these issues as remedies are already established.

6.5 Final Thoughts

In the present scientific world mathematics has a very important role to play in the building up of each individual’s personality. School curriculum is formulated in such a way that Mathematics finds very important and significant place in it. Learning of Mathematics can be effective only when the subject is made interesting by making use of different strategies of instruction that are matched to the students’ abilities, and using the appropriate tools that help in achieving the desirable results.

This study is a small but significant contribution to the field of teaching of Mathematics to the blind students. The study aimed at emphasising the fact that the blind students can be and should be taught Mathematics and the need is to look for methods, which would give them greater tactile experiences to compensate for their loss of sight. There are various strategies in this regards, which need to be explored.

There is no reason why blind students should be exempted from Mathematics. Only modifications need to be made in the process of teaching and taking examination. On assessing these students’ abilities, emphasis should be put on their understanding of
concepts and skills in using these concepts to work out tasks rather than on accuracy in
drawing diagrams and answering problems.

The special challenges faced by visually impaired students in learning mathematics pose
special challenges to teachers, too. One may find that the efforts made in helping visually
impaired students in learning mathematics can shed new light and insights on difficulties
shared by all students.
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Appendix 1:

MATSEC

Mathematics Syllabus
Appendix 2:

Mathematics

Exam Paper
Appendix 3: The Interview
The prepared questions for the interview

1. Why did you choose to study Mathematics?
2. How do you describe your experience after this programme?
3. Do you feel you achieved what you aimed for?
4. What is your reaction for the result you obtained in the SEC examinations?
5. What did you like most during the programme?
6. Do you think you learned the subject well?
7. What difficulties did you encounter during the process?
8. What do you suggest?