Insights from training a blind student in biological sciences

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Higher education institutions have a constitutional obligation to provide reasonable accommodation to students with disabilities. Although the teaching and learning of students with blindness and low vision in STEM disciplines are well documented abroad, to date, there are no published studies in South Africa on successful teaching and learning strategies for students with blindness and low vision in STEM fields, specifically in science disciplines. Therefore, in this paper, we report on how teaching, learning, and assessment were adapted to make science disciplines accessible to John, a blind student enrolled in a biological sciences degree at a research-intensive university in South Africa. Several factors contributed towards the successful completion of John's bachelor's degree. These factors include the availability of tutors who committed a large amount of time to help John understand content presented in lectures, tutorials, and practical sessions; a well-resourced and effective Disability Unit; lecturers who ensured that John was well accommodated in lectures, tutorials, and practical sessions; and, finally, John's commitment and dedication towards learning.

Significance:

- This is the first study to report on successful teaching and learning strategies for a blind student in the natural sciences in the South African context.
- The study provides a guide that scholars, educators, university managers and policymakers can use to ensure that mathematics and science subjects are accessible to blind students and that teaching strategies allow them to perform to their potential.

Introduction

Research has shown that there is an underrepresentation of students with blindness and low vision (BLV) in STEM fields in many countries.[1-3] The few students with BLV who enrol in STEM disciplines are usually frustrated and lose interest in science-related pursuits mainly because they always have to depend on their sighted peers to conduct laboratory activities, report observations, and interpret or understand visual material.[4] Furthermore, students with BLV tend to perform poorly in comparison to their sighted peers.[2] The latter may be because science teachers are not trained to teach students with BLV[5], and STEM subjects mainly depend on visual representations to explain complex concepts or processes[2]. The teaching and learning of students with BLV in science disciplines have been well documented abroad.[6-11] However, to date, there are no published studies in the South African context related to the enrolment of BLV students, specifically in science disciplines, and successful strategies for teaching students with BLV in this domain. The challenge of accommodating students with BLV in science disciplines is compounded where resources are constrained and funds for specialised support are limited. Therefore, in this paper, we report on general support and discipline-specific adjustments that were made to teaching, learning facilitation and assessment to make STEM disciplines accessible to a blind student to ensure that he could perform to his full potential. We expect that our experience will make a significant contribution to current knowledge about the training of blind students in STEM disciplines in South African higher education institutions.

Literature review

The new Constitution of post-apartheid South Africa entrenches equal rights and freedom from discrimination of any kind for all its citizens as a foundational principle for building a new society. The Constitution stipulates that 'Every person shall have the right to basic education and equal access to educational institutions'[12]. Several policy documents were developed by the South African Department of Education after the dawn of democracy to facilitate access and participation of disabled students at all levels of the education system. These policies include the *Education White Paper on The Transformation of the Higher Education System*[13], the *National Plan for Higher Education*[14] and the *Education White Paper 6: Special needs education: Building an inclusive education and training system*[15]. These policy documents subscribe to the social model of disability that sees the problem as located not in the individual, but in the system or culture that fails to meet the needs of these individuals.[16] This stance countered the prevailing philosophy which reduced disability to a medically defined impairment that required the disabled person to adapt to fit into the system. South Africa was one of the early signatories of the influential United Nations Convention on the Rights of Persons with Disabilities and its Optional Protocol in 2007, and is thereby obligated to ensure 'the development by persons with disabilities of their personality, talents and creativity, as well as their mental and physical abilities, to their fullest potential', and that they are able to 'access general tertiary education … without discrimination and on an equal basis with others'.[17] This means that the provision of high quality and equal education for persons with disabilities is not only a moral concern, it is also a constitutional obligation.[18]

Despite the progressive nature of these policies and their good intentions, the literature abounds with studies indicating that the goals of a truly inclusive education system have not been realised.[18-23] Research has shown that not many people with disabilities consider enrolling at institutions of higher education and the few that do enrol face challenges in terms of physical and curricular access, inadequate support, negative attitudes and crippling perceptions.[21,24] Access to tertiary institutions is still available only to the few students with BLV who were fortunate to have attended one of a handful of schools that were able to prepare them for tertiary studies and even in these schools they had limited subject choices.[18,23] The majority of schools for learners with special needs are so poorly resourced that the South African government is implicated as being 'complicit in exclusion', denying these learners their basic human rights in terms of quality education and equal opportunities. Furthermore, Donohue and Bornman[19] estimated that up to 70% of children of school-going age with disabilities do not attend school at all. These findings highlight the urgency of ensuring that, at the very least, the learning environment in tertiary institutions in South Africa meets the needs of students with disabilities. The majority of studies pertaining to disabled students in tertiary institutions concentrate on students' experiences, as will be discussed below.[24-30] There is therefore a need for education management information to assist decision-makers when it comes to accommodating students with BLV, especially in the natural sciences.

Students with disabilities require special convenient access to buildings and facilities on university campuses to make learning possible. However, research has shown that access continues to be a major problem that limits the students' mobility, hinders their learning and may even endanger their lives. In their study, Phukubje and Ngoepe[24] evaluated the accessibility of library services for disabled students at the University of Limpopo. Results revealed that only one librarian was assigned to manage library services for the disabled; as a result, the librarian was not able to individually train each student on how to search the catalogues and shelves for books, how to reference, and how to photocopy and use the printer. Similarly, Ntombela and Soobrayen[25] learnt that most of the visually impaired students at the University of KwaZulu-Natal's Edgewood campus, did not receive mobility training due to understaffing at the Disability Unit (DU). In a study conducted by Engelbrecht and de Beer[26], disabled students complained about architectural constraints which hindered their mobility and access to services. Such constraints included steep ramps which sometimes had potholes, and heavy building doors which the disabled students could not open without the assistance of other students. In another study, Losinsky and colleagues[27] reported that wheelchair-bound students were unable to get to class on time because of the short break between classes.

Scholars have also evaluated the various support mechanisms provided to students with disabilities by the specialised student support units at tertiary institutions. DUs are meant to provide both logistical and academic support services.[28,29] Logistical support services include assisting the students with campus challenges and communicating students' needs to their lecturers. Academic-related services include providing Braille and tape-recorded readings, sign language interpreters, alternative assessments, and assistive technology such as Job Access With Speech (JAWS) software. Students viewed DUs as an irreplaceable source of academic information; they appreciated their contribution to orientate them in their new environment, and to make them feel welcome, comfortable and part of the university.[29]

According to Mutanga[20], lecturers' support of students with disabilities is crucial for the students' academic achievement. However, students have reported mixed experiences of lecturers' support. Some lecturers were amenable to curriculum flexibility, provided alternative styles of teaching and assessment, and responded favourably to requests from either the students or the DUs.[28,30] However, other students experienced an indifference from lecturers[31] and an unwillingness to adjust teaching methods to accommodate disabled students because lecturers did not consider disability support as their responsibility.[28] Students pointed out that some lecturers lacked understanding of disability support needs; however, good communication often resolved the issues at hand.[30]

Assistive technology, such as JAWS, is an important support mechanism as it enhances access to learning, specifically for students with BLV. JAWS is a computer screen reader programme that delivers text-to-speech output or a refreshable Braille display. Although many students indicated that assistive technology was beneficial for their learning[30], JAWS can also restrict the learning of students because it is unable to read graphical material, mathematical and scientific symbols[32], and it is not compatible with African languages such as Zulu[25].

Apart from these studies on the needs and experiences of students with BLV at South African tertiary institutions, there are no reports specifically related to the involvement of students with BLV in a science faculty. There are international studies, however, that report on strategies for teaching students with BLV in science disciplines. A brief summary of the findings of international studies is presented next.

Various adaptable low-cost audible instruments and tactile tools have been developed to increase accessibility to experiments[8,9,33] and promote independence[34] in laboratories, and to enable BLV students to visualise organic chemistry[35]. Examples of such instruments and tools include talking calculators, thermometers and balances[9], colour identifiers, and handheld submersible audible light sensors. Tactile molecular models have been used to aid students to visualise mechanisms and predict products of chemical reactions. Adaptive teaching aids such as magnetic boards, letters and numbers have been used in teaching to assist students to write and balance chemical reactions, and draw Lewis dot structures.[11] Harshman et al.[7] pointed out that chemistry instructors ought to experiment with different teaching strategies as it is not always easy to know which strategy will work best for teaching students with BLV. Guidelines have been developed for physics instructors to adapt class sessions, curricular materials, tutorials and demonstrations to make physics accessible to students with BLV.[36-39] Similarly, in mathematics, effective methods for delivering instruction to students with BLV have been published.[38,39] There are several literature reports on hands-on summer enrichment programmes[33,40] to promote BLV students' interest in STEM education. Lastly, research pertaining to teachers' experiences of teaching science to students with BLV has revealed learning traits portrayed by these students – for example, that students with BLV learnt more effectively when working collaboratively with sighted peers.[41] As science is highly visual, teachers found it challenging to teach science because students with BLV could not visualise abstract concepts without the use of tactile teaching aids. Other scholars reported a lack of confidence of teachers to effectively teach students with disabilities[42]; hence there was need for continuous professional development in 'effective strategies for teaching students with disabilities'[5].

Tertiary institutions are obligated to achieve inclusivity and equity in terms of access to education; however, they need to draw on experiences within the fraternity to guide them regarding the special needs of students with disabilities. This study seeks to address the lack of information on the accommodation of disabled students in science faculties in South Africa. We report on the curricular adjustments that were made to support the teaching and learning of a blind student, called John (pseudonym), who studied biological sciences at our university. John had limited vision at birth, but was functionally blind from the age of about 12.

Background

John passed his National Senior Certificate and achieved seven distinctions with an average of 84% for the final examination. John's Grade 12 subjects were English, Afrikaans, Mathematics, Physical Sciences, Life Sciences, Computer Applications Technology, and Life Orientation. John applied for admission to the Faculty of Natural and Agricultural Sciences at the University of Pretoria with the objective to major in biological sciences. The Faculty had experience in training a blind student to the level of PhD in statistics, but not in biology. The decision to admit him to biological sciences was not taken lightly. Discussions were held between John, his parents and the Faculty to match interest with training demands of specific disciplines and future career possibilities. The latter was supported by John's psychometric test results which confirmed his cognitive ability and his interest and suitability to pursue a scientific investigative career. Special consideration was given to safety (it would not be possible to offer chemistry beyond the first year), the inexperience of the student and staff to deal with the challenges of the situation (his progress would be assessed after the first academic year) and future career prospects for a blind graduate in biology. The DU agreed to provide the following services: to support academic staff in meeting the needs of John; to monitor the situation and alert the Faculty if problems arose; to meet with lecturers before the start of the semester to advise and assist in preparation; to take responsibility for the conversion of study materials, test and exam papers into a format accessible by John; to provide mobility training and supervision during formal assessments; to provide office space for John's tutoring and self-study; and to carry most of the costs of tutor support and of the conversion of study materials to accessible formats. The Faculty agreed to admit John to his degree programme of choice with the proviso that the first academic year would be spread over two calendar years to allow for adjustment, refinement of procedures and exposure to a wide range of disciplines. John was offered a choice of two curriculum packages; both were enriched in the first academic year with mathematics, computer science and/or informatics, to cater for future specialisation in bioinformatics or biological mathematics. This would give John the opportunity to proceed with a mathematics-intensive programme rather than biological sciences in the second academic year if he wanted to do so. In the interest of safety, the practical components of first-year chemistry modules would be replaced by assignments, but John would not be able to enrol for any higher level courses in chemistry. Before admission was formalised, the Faculty also sought written commitment from all discipline departments that would be involved in his training to ensure that they accepted the responsibility for the provision of an enabling environment that would be conducive to his success.

In his first academic year, spread over two calendar years, John completed one semester course of each of the following disciplines: mathematics, physics for biology, biometry, a foundational course in molecular and cell biology, microbiology, genetics, botany and zoology. He also completed two semesters of chemistry and achieved distinctions in all but one first-year course. John decided to spread his second academic year over two calendar years as well; his curriculum included two semesters of microbiology, biochemistry, human physiology and genetics, all passed with distinction. He added two first-year courses in Sepedi but dropped second-year mathematics and biometry courses because of the logistical challenges posed by those disciplines and his lack of interest in them. He completed his third year in one calendar year and graduated *cum laude* in BSc Human Genetics. He also graduated *cum laude* in BScHons in Bioinformatics at the end of the following year and subsequently enrolled for an MSc in Bioinformatics.

Adjustments made to learning support, teaching, lab training and assessment

In this section we report on general support as well as discipline-specific adjustments that were made to accommodate John. We collected data from several sources, namely the DU, library, lecturers and tutors, and from the student himself. Three interviews were conducted with John at different stages during his undergraduate and postgraduate studies, and questionnaires were sent to all his lecturers and tutors to request information on their approaches and experiences ($N = 61$; response rate 53%). Data collected from the interviews and questionnaires were analysed for emerging themes and for information specific to each discipline. The findings were triangulated with information obtained from the DU, the library and the student. The trustworthiness of the findings was confirmed through member checking. Neither of the authors of this study was involved in any way in John's training. At the time of the study, the first author was a postdoctoral researcher and the second author was responsible for education management in the faculty. Ethics approval was granted by the NAS Research Ethics Committee at the University of Pretoria (NAS121/2019). Informed consent was obtained from the participants.

Table 1 provides an overview of findings that were specific or unique to each discipline. It is followed by a discussion of general themes that emerged from the feedback received.

Specialised learning support

The DU provided logistical support such as mobility training, shared office space where the student could work or be tutored, and assistance to address any campus-related challenges the student might have experienced. The DU also assisted with converting course materials to either Braille or a format that is compatible with JAWS. The choice of format depended on the type of course materials submitted by the lecturers. If the course content was mainly text, it was converted to a format that is compatible with JAWS. However, if the content was mainly visual, it was converted to Braille in the form of tactile pictures and sketches. The DU had one printer for printing of text in Braille and acquired a second printer for converting pictures to tactile representations. At the beginning of each semester, the DU held meetings with course coordinators to inform them about the support services offered, that is, what the DU could and could not do; to alert lecturers about the potential need for adaptation of the curriculum; and to plan for upcoming challenges. John completed the majority of his formal assessments electronically, for which the DU provided the venue and the necessary equipment. Because John's tutors were allowed to be present during tests and exams to explain visual material, the DU arranged for invigilation to make sure that test and exam conditions were adhered to. The DU also provided funding for the appointment of personal tutors who assisted John with the learning of content, especially visual material.

The pivotal role of dedicated tutors

Personal tutors were appointed for all the courses in which John was enrolled. At the start of a course, John met with lecturers and requested a personal tutor. The tutors were usually postgraduate students who were doing their MSc or PhD and were thus knowledgeable in the subject areas. The tutors acted as the interface between the student and the lecturer – an arrangement which relieved the pressure on both the lecturer and the student. Each tutor met with John on a weekly basis to go through the lecture material and explain visuals that were discussed in lectures. They typically sat next to John during class tutorials and assisted him by describing any visuals included in tutorial questions. They also assisted during summative assessments and often served as invigilators as well.

Lectures

John attended normal lecture sessions and made sound recordings of the class for use later if required. He sat in the front row where the lecturers could see him. This alerted the lecturers to his presence and often prompted them to make a special effort to speak more slowly and clearly to ensure that John followed what was being taught. They provided detailed verbal descriptions of visual content to help John form mental models of what was being discussed. In cases where lecturers used clickers to record class attendance, John would simply press any button on the response device. However, if clicker exercises counted for marks, another arrangement was made beforehand: either the lecturer or the tutor sitting next to him would read the questions and the answer options so that he could respond appropriately. Mathematics posed the biggest challenge because the lecturer typically worked on the board solving problems which John could not follow. This meant that he relied heavily on his mathematics tutor to provide detailed explanations of the content after class.

Laboratory training

Discipline departments adopted a range of approaches depending on the nature of practical training, the extent of practical work included in the curriculum, and safety considerations. In courses such as chemistry, the student was not allowed in the lab due to safety considerations. The practical sessions were replaced with a research assignment on related content. In courses such as microbiology and physiology, John worked with either a tutor or a lab technician who performed and explained the tasks, and made observations and measurements which John processed for his experimental report. Similarly, in biochemistry, the tutor familiarised John before the practical session with the equipment and the experiments that would be performed. He obtained real experimental data from another student to incorporate in his lab report. In courses like physics for which practicals were undertaken in groups, John was included in a group with sighted students. This arrangement was not beneficial for his learning. Fellow students could not assist him because of their inexperience and time constraints for the task to be completed. In bioinformatics, the lecturer set up a shared terminal from his teaching computer to the student's laptop, which allowed John to 'read' everything the lecturer was typing during online tutorials. Finally, in botany, the lecturer explained the structural features of plants to him personally to ensure that he understood the concepts.

Table 1: Discipline-specific arrangements made to accommodate blind student John

Courses	Curriculum component	Number of lecturers (tutors) who participated*	Discipline-specific arrangements/challenges
Chemistry	First year, both semesters	1 (–)	No training in laboratory. Practicals were replaced by assignments on the chemical industry. The second semester course consisted of organic chemistry and physical chemistry. The building of models in organic chemistry consumed a lot of time: therefore, John wrote the exam sections on separate days.
Physics	First year, Semester 1	1 (1)	Lab sessions: Group work with sighted students did not support his learning.
Mathematics	First year, both semesters	– (1)	Assessments were provided in LaTeX format. John needed the LaTeX source for the textbook to be able to 'read' mathematical expressions and equations.
Molecular and Cell Biology (first course in Biology)	First year, Semester 1	3 (1)	Key visuals from the textbook were identified and submitted in advance for conversion to tactile form. Practical sessions: John was supported by the Disability Unit assistant to make the measurements and observations and to fill out the lab report. Lecturers spoke more slowly, provided full details of visuals displayed on lecture slides, and read aloud clicker questions and their answer options.
Zoology	First year, Semester 2	1 (–)	Lecture notes were sent to the Disability Unit for translation to Braille. The library was unable to obtain the electronic textbook. Practical sessions: John attended more than one of several repeat sessions. He listened to the presentations, but could not study the organisms by viewing them through a microscope or looking at preserved specimens.
Statistics	First year, Semester 2 Honours module (3 weeks)	1 1	Lecture notes and assessments were provided in LaTeX format. Practicals involved coding in statistical language and interpreting the results. Honours: Practical training involved coding with *R* software; however, without the use of graphical presentations. The lecturer taught him how to use summary statistics to deduce specific features normally presented in graphs.
Plant Science	First year, Semester 2	1 (–)	Practical sessions were used to demonstrate differences in the morphology and anatomy of plants: the lecturer taught John personally to make sure that he understood the concepts.
Computer Science	First year, both semesters	2 (–)	Lecturer made an effort to provide extensive verbal descriptions of visual representations in class. A dedicated teaching assistant was appointed to assist John and assess his practical assignments.
Microbiology	First year, Semester 2	1 (–)	Tutor built small models to enable touch, for example to demonstrate the shape of microbes growing on agar plates. A demonstrator performed the experiment on the student's behalf and explained the visual results.
Genetics (major)	First year Second year Third year	2 (1) 1 (2) 2 (1, same tutor for all third-year modules)	First year: Tutor built models with clay and glitter glue for tactile learning e.g. of the chromosome. Tutors learnt through trial and error how to describe visual content so that the student could understand.
Biochemistry	Second year	3 (–)	Practicals: John visited the lab beforehand with the tutor, received experimental results from other students and prepared his own lab reports afterwards.
Human Physiology (major)	Second year Third year	1 (1) 1 (1, same tutor for all third-year modules)	3D prints were made to support learning; however, time demand and cost limited the use of this option. Tutor carefully explained tables, figures and diagrams during one-on-one sessions. For practicals that required physical activities, an alternative essay form of testing was used to test the same content.
Bioinformatics	Honours level	1 (1)	All practicals were computer based. The student shared a terminal with the lecturer so that he could access everything directly from his laptop.

**Number in brackets represents the number of tutors who participated in the study*

Tests and exams

John completed all assessments on his laptop; therefore, assignments, test and exam papers were sent to the DU beforehand so that they could check if the papers were compatible with JAWS. John was allowed the standard amount of extra time granted to students with special needs, except for mathematics for which the time was uncapped due to the tedious process associated with mathematics (see below). Other exceptions were chemistry, physics, and population genetics, because mathematical calculations are used extensively in these modules, and biochemistry, where John had to provide a description of complex chemical structures instead of chemical drawings. All official tests and exams were written at the DU and were invigilated by the tutors who would assist John by either explaining any visuals included or would, under John's directions, draw the required visuals. Official UP invigilators were always present.

The special case of mathematics and statistics

Mathematics and statistics present unique challenges to BLV students because they are abstract, information dense and rich in symbolic expressions with a strict code for presentation. In general, mathematics lecturers followed the traditional style of developing theorems and demonstrating problem solving on the board or on a device that projected on the board, which meant that a blind student could not follow the teaching. Also, the JAWS software program cannot 'read' mathematical expressions in electronic textbooks. The way around this conundrum is for the student to obtain the LaTeX source of the textbooks in order to decipher the mathematical expressions and equations. Similarly, lecturers had to set their test and exam papers in LaTeX format to make it accessible. LaTeX is a high-quality typesetting system that allows for the creation of technical and scientific documentation with precise control over layout and formatting. Assessment in mathematics and statistics was a cumbersome process because John had to read the question in LaTeX format, type the problem on his Braille machine, work it out and then type his answer with its stepwise development in LaTeX for the lecturer to read and evaluate. This, according to John, was tedious and time consuming.

Textbooks

Librarians assisted John to obtain electronic copies of the various textbooks that he needed for his courses. In order to comply with copyright requirements, John had to buy the textbook and present proof of payment to a designated librarian. The librarian included the proof of purchase in their application for an electronic copy of the textbook. Upon receipt of the electronic copy from the publisher, the librarian would copy it to a CD in a format compatible with JAWS. This electronic copy is not the same as an eBook; it is a PDF version of the book which is not available on a virtual platform, as are eBooks. In cases in which the publisher could not be located or electronic copies of the textbooks were not available, the DU scanned sections of the textbooks to an electronic text format (MS Word or PDF) using Optical Character Recognition software (ABBYY FineReader). It has since become much easier to acquire electronic textbooks than at the time when John was an undergraduate student, because many electronic textbooks are now freely available for purchase.

Student reflection on his experience

In general, John was satisfied with the assistance that he received from the Faculty, DU, lecturers and tutors. He graciously acknowledged the efforts of everyone who tried to assist him. In hindsight, as a master's student, he realised the need to include more statistics in his undergraduate curriculum. The BSc Honours programme included a short course offered over 3 weeks on basic statistical knowledge for research in biological sciences, but the format was not conducive to learning for a blind student. The intense block-week presentation did not allow enough time for John to immerse himself in the dense mathematical notations and concepts of the discipline.

John provided the following advice to blind students planning to study science:

- Be prepared: Mobility training provided by the DU at the beginning of each semester is important as it teaches you to find your way around campus and to get to lecture venues. It is also essential to contact the lecturer and make arrangements well in advance, because some processes, such as getting a personal tutor and obtaining textbooks, may take longer than expected.
- Attend classes and make voice recordings for later use, if necessary.
- Motivation is key to being successful in a science discipline: it is important to study what you are interested in and what you will enjoy, otherwise the effort required will be too much.

Discussion and conclusions

More than 7 years have passed since we embarked on a journey to train a blind student in biology. The apprehensive start stands in stark contrast to the celebrations when John graduated *cum laude* 2 years in succession with his first and second degrees. As we reflect on the journey, several critical issues stand out in terms of the demands of the science domain and the team effort required for a blind student to navigate it successfully.

STEM subjects are highly visual[1], which presented lecturers and tutors with a significant challenge to determine how John could be supported to build mental models of sub/micro- or molecular level phenomena, despite a severe handicap on observation (macro-level) and restricted access to the symbolic level of representation. To overcome this handicap, lecturers and tutors had to invest more effort to substitute sensory input from sight with sensory input from touch and sound. The tutors provided verbal explanations of visual representations, built models using everyday materials or molecular model kits, and used tactile artefacts produced by the DU. Mental images are believed to be 'constructed from different sources of sensory information, including sound and touch, that interact with the brain's network of spatial subsystems and visual areas'[1]. These substitutions were clearly beneficial for John's learning, as evidenced by his excellent academic performance.

The successful training of a blind student in science requires a team of dedicated individuals in which the student is the lead player. The demands of such a pursuit require that student interest, cognitive ability, emotional make-up and personality are perfectly aligned. In our case, John's motivation, work ethic and persistence were paramount to his success. Thus, before the admission of a blind student to a science faculty, it is essential to seek professional advice on whether the student's psychometric profile matches their study and career choice and then to engage with the prospective student in an advisory capacity to ensure that they have a reasonable chance of success in their chosen field of study. Secondly, our findings confirm that tutors played a major role in this success story. Curricular demand and large class sizes at the undergraduate level rule out the active involvement of the lecturer in the provision of support to a blind student. This necessitates delegation of the task to dedicated tutors. Tutors spent a large amount of time helping John to understand subject content presented in lectures, tutorials and practical sessions, and visuals included in assessments. Tutors advocated for the needs of the student which informed the lecturers of appropriate special arrangements and relieved the student of the responsibility and discomfort of having to repeatedly explain themselves.[22] Tutoring a blind student is a specialist assignment – one that sighted peers cannot reasonably be expected to do. It requires someone with a solid knowledge of the discipline and an empathic nature. Another essential role player is an effective and well-resourced DU without which the training of a blind student would not be possible. In our case, the DU supported the project through generous tutor funding; guidance for the lecturers and tutors; essential resources such as Braille, 3D printing and JAWS; and academic and non-academic support for John. The Unit provided space for tutoring and study and ensured the integrity of assessments conducted on its premises. Lastly, John was also supported by lecturers who sought to accommodate his needs as far as possible in lectures, tutorials, and practical sessions. All these role players, with the exception of the DU, acted out of goodwill and were largely unaware of John's rights and their legal obligation to provide reasonable accommodation of his needs. While their goodwill is commended, it is not sustainable or scalable. Our experience highlights the need for raising disability awareness in the sector if progress is to be made to improve access and success of disabled students.

John is nearing completion of his master's degree, which testifies to the quality of his undergraduate and honours training. Our 'experiment' has demonstrated quite convincingly that the high demands of STEM disciplines do not render them inaccessible to blind students. However, we do acknowledge that John was an exceptional student and his success cannot be interpreted as evidence that our measures to accommodate him would be sufficient to ensure the success of other students with BLV. Being exceptionally gifted, both mentally and emotionally, should not be a prerequisite for a blind person to succeed in STEM education. The South African education system must urgently address the broad pattern of social exclusion of BLV students that has been prevalent until now. This success story represents a small step towards the goal of greater equity in STEM education.

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Competing interests

We declare that there are no competing interests.

Authors' contributions

M.P. was responsible for the conceptualisation of the project, validation of the findings, writing of the manuscript, project leadership, and funding acquisition. R.T. was responsible for development of the methodology, data collection, data analysis, writing of the manuscript, and project management.

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