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Overcoming Barriers in Math Teaching and Learning: The Case of a Visually Impaired University Student

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The study explores the effectiveness of teaching and learning practices of math related content for visually impaired learners, based on the case of a Management student at a University in Mauritius. Traditional teaching methods for mathematics and related subjects are heavily reliant on written text, graphical and tabular representations, equations and other visual aids. Learning or practicing mathematics therefore demands highly visual abilities, posing significant barriers for visually impaired learners. The primary focus of this study is to assess the teaching and learning practices and uncover the instructional barriers of math related content of visually impaired learners with the aim of enhancing inclusive and equitable education in line with the SDG 4, of the United Nations Sustainable Development Goals. The research adopts a case study approach where data is collected through interviews, focus group, observations and documents A purposive sampling strategy is used and the sample comprises the visually impaired student, four lecturers who have taught the math-related modules, the programme coordinator and the Examinations officer. Data has been thematically analysed and reveals significant barriers for the visually impaired student, including inadequate resources and assistive technologies and lack of adapted teaching practices and assessments. Furthermore, lecturers are found to struggle with uncertainty and lack of specialized training, while the student faces anxiety and disengagement. The findings underscore the need for more effective policy implementation to improve inclusivity. The outcomes provide insights for capacity building and the setting up of a more supportive learning environment for the visually impaired.

Keywords: Math teaching and learning, Visual impairment, Inclusive Education, University Education.

1. Introduction

Traditional teaching methods for mathematics are heavily reliant on written text, graphical representations, equations and other visual aids (Stone et al.,2019). Learning or practicing mathematics therefore demands highly visual abilities, posing significant barriers for visually impaired students (Rule et al., 2011). The primary focus of this study is to delve into the teaching and learning journey of a visually impaired undergraduate student enrolled in management studies, more specifically for math related content at a University in Mauritius. The primary focus of this study is to assess the teaching and learning practices and uncover the instructional barriers of math related content of visually impaired learners with the aim of

enhancing inclusive and equitable education in line with the SDG 4, of the United Nations Sustainable Development Goals. The specific objectives are to identify the challenges faced by the visually impaired student in learning and the assessment of math-related content at the university level, examine the effectiveness of current teaching practices, explore the role of resources and assistive technologies in facilitating math learning for visually impaired students and recommend corresponding measures to enhance the inclusivity and accessibility of math-related teaching and assessment practices.

The research adopts a case study approach and the data is thematically analysed to uncover patterns and insights into best practices for teaching and learning math related modules, as well as providing more adapted assessments as an alternative to visually impaired learners. The deployment of the intervention strategies underscores the need to foster an inclusive learning environment with more adaptive and holistic approach for students with impairments. The study also provides insights for capacity building of instructors and the development of more comprehensive and inclusive instructional materials and methods.

The rest of the paper is organised as follows: Section 2 briefly overviews the background literature. The methodology is described in section 3. The data analysis and discussion appear in section 4. The concluding remarks are formulated in section 5.

2. Background Literature overview

Effective teaching methods for the visually impaired include the use of tactile learning tools such as the braille, tactile graphics, and manipulatives. The Nemeth Braille Code is a specialized system used for mathematical and scientific notation (Kapperman & Sticken, 2003). Tactile graphics use the concept of line drawings, graphs, and charts allowing students to feel the visual elements in mathematics while manipulatives are objects like tactile rulers, abacuses, 3D geometric shapes, that can make abstract mathematical concepts more concrete for the learner (Strobel et al., 2006). Another category of assistive technologies is audio-based comprising screen readers, audio books and talking calculators with appropriate instruction to enhance the mathematical understanding (Brawand & Johnson, 2016).

Technological innovation has broadened the spectrum of assistive technologies (Smith & Kelly 2014). Kathiria et al (2024) surveyed the different types of assistive technologies with enhanced features, camera scanners, text-to-speech tools, smart- phone text recognition, notetakers, screen magnification, graphing tools and math software that incorporate advanced accessibility features. Shoaib et al. (2023) explore the mobile devices as well as the app-based interventions which use hearing, haptic and multimodal combinations of senses to help the visually impaired and the blind learn mathematics. For instance, some audio description tools can now detect complex equations with specialized math-to-speech technology. Graphing calculators allow blind students to explore graphs through sonification while Math software allow users to input math equations using voice commands. Furthermore, with the rapid development of e-learning, LMS platforms that are compatible with screen readers are also being developed to ensure equal access to materials (Kathiria et al., 2024).

While the benefits of assistive technologies for students with visual impairment have been unanimously highlighted in literature (for example, Smith & Kelly 2014, Kathiria et al. 2024,

Godfrey & Loots, 2015), Zhou et al (2011) pinpointed to the relatively low rate of adoption by these students. While the primary reason being accessibility and awareness by the students, the inadequate knowledge and training of the mainstream instructors is also highlighted. Significant gaps were identified in the instructors' understanding of adaptive teaching strategies such as braille literacy, instructional skills for assistive tools, and the ability to provide accessible information.

It is equally important to consider the limitations of the commonly used teaching methods related to math (Brawand & Johnson, 2016). Math textbooks and resources available in Braille are limited due to the complexity of their production with the consequence that Braille versions of these textbooks are often outdated since books with mathematical content very often review the practice problems across different editions (Moço & Archambault, 2004). Significant challenges pertaining to screen readers have also been reported. Despite significant technological progress in the area, Shoaib et al. (2023) highlight the fact that some screen readers' auditory working memory might incorrectly read mathematical content such as equations and formulae as they do not necessarily detect open parentheses, subscripts, superscripts and other symbols. Stone et al. (2019) found that the best solution was to write out the formula and then describe it with plain text just below. There is an additional barrier in working with large data sets using spreadsheets and statistical software for quantitative research methods. In fact, statistical software like R, SAS, Minitab, and SPSS vary in the level of accessibility support they provide. For instance, SPSS Software is found to work smoothly with a specific reader called JAWS but not others. The former also present limitations such as accessing output and interacting with graphs and tables (Godfrey & Loots, 2014).

A large strand of literature focuses on the decisive role of the instructor in the learning process of the visually impaired student. Marson et al (2013) uncover the additional workload implications for the instructor to modify lectures, rethink the explanation of illustrations, amend and adapt lecture notes, homework assignments, and rewrite examinations. Stone et al. (2019) refer to simple steps to make power point slides more compatible such as adding titles to slides to create a heading structure that screen readers can interpret more clearly. Supportive measures from the instructors benefit students who have expressed appreciation for providing learning materials, in their preferred accessible formats and in a timely manner (Whitburn, 2014). Subsequently, the role of a teacher assistant is fundamental to provide support to the main instructors and the students as reported by Mendonça et al. (2021). Instructor attitude and behaviour is also found to be crucial (Pinho et al. ,2016). Instructors teaching mathematical topics often rely on gestures for their verbal explanations, which can be challenging for blind and visually impaired student to follow (Quek & McNeill, 2006). However, there are strategies instructors can adopt to mitigate these challenges. One approach is to verbally and explicitly describe graphs and diagrams displayed on slides or drawn on the whiteboard using a multi-sensory approach(Whitburn, 2014). Marson et al. (2023) point out to a phenomenon called countertransference in teaching which refers to the emotional reactions, thoughts, or behaviors that an instructor unconsciously directs towards the students and project their feelings onto them. In the case of students with impairment, it has been observed that instructors may overestimate their abilities or lower standards out of sympathy.

In a nutshell, the literature emphasizes that effective teaching methods for visually impaired students in mathematics include tactile tools, assistive technologies, and adapted instructional

strategies. While technological advancements offer significant benefits, challenges remain, including limited Braille resources, screen reader inaccuracies, and instructor knowledge gaps. Instructor attitudes, proper training, and support are crucial for creating an inclusive learning environment.

3. Research Methodology

The research adopts a case study approach which enhances one's comprehension of a complex phenomenon and provides insights into an issue within a real-life context (Harrison et al., 2017). The design was chosen to allow the researcher describe the phenomena in detail within the present context as well as holistically. Data was gathered through documents, interviews, focus groups and observations. The use of multiple methods was driven by the need to ensure the data's rigor and relevance, and to provide a means of corroboration. Purposive sampling is well-suited for this study because it targets a specific group who has relevant experience and was directly involved (Patton, 2014). The sample therefore comprises the visually impaired student, the four instructors (lecturers) who have taught the student the math-related modules namely Statistics, Quantitative techniques and quantitative research methods, as well as the administrative staff including the Coordinator and the Exams officer. This non-random sampling method allows the researcher to select participants who have unique, relevant insights into the topic studied based on their lived experiences. After obtaining the ethical approval from the relevant authorities, the data collection process was initiated with the stakeholders after obtaining their informed consent.

The research questions that this study seeks to address are as follows:

- What are the specific barriers visually impaired students encounter in learning math-related modules?
- How effective are the current teaching methods in supporting visually impaired students?
- How do existing resources and assistive technologies support or hinder the learning experience of visually impaired students in math-related courses?
- What strategies can be implemented to improve the inclusivity and accessibility of teaching and assessments in math-related modules for visually impaired students?

Semi-structured interview protocol was developed to collect qualitative data from the interview and focus group. The student was interviewed three times at different stages of the semester and interviews were conducted individually in a face-to-face or online manner. An online focus group was planned with the four lecturers who taught the math related modules as well as the two administrative staff. Interviews and focus groups facilitated probing of information.They were recorded for accuracy with participants' permission. Furthermore, a total of 3 classroom observation sessions were held with the student, each lasting approximately forty minutes. Data were recorded mostly in the form of field notes. For the document analysis the policy on Special Education Needs of the institution and the policy documents and information obtained from the website of the Special Education Needs authority of the country were retrieved and scrutinised.

Data was analysed for content, eliciting themes related to the four research questions.The process of coding and categorizing the content contributed in bringing meaning to the data collected.In line with Braun and Clarke (2006), the conduct of the thematic analysis involved the following systematic steps: familiarizing with the data through multiple reading and scrutiny, followed by coding significant lines and paragraphs. The codes were then grouped into themes, refined and and named. A review of the data was carried out to ensure no important information was missed.

4. Data Analysis

The findings are presented under the following four themes: (a) Learning journey (b) Teaching practices (c) Assistive technologies and (d) Assessment practices. In the following sections the themes will be interpreted and discussed in relation to the research objectives.

4.1 Learning journey

The student is currently in his second year of studies in marketing management and has encountered four math related modules so far. The student informed that he "has chosen the desired field of study but was apprehensive of the math content". In fact, the student highlighted that he has been facing difficulties with Math since primary school days as there were no adapted textbooks for math content and "had to drop the subject in high school". The student situation aligns with the global trend whereby students with visual impairment face difficulties in learning Mathematics since a very young age with increasing learning gaps as they move to upper primary and secondary school (Pinho et al 2016).

For all the modules, the student asks permission for recording the lectures and requests the lecturers to send the materials prior to the lecture. However, as far as math related modules, the challenges are even more important. His current personal screen reader is unable to read graphs, statistical tables, equations and other visual representations which are common in math related modules, creating a serious barrier in the learning journey. While doing math related modules he feels that there are "gaps in the learning" and is unable to "connect the dots" making the overall learning experience "challenging and stressful rather than enjoyable or appealing". While he acknowledges that mathematics is an important and necessary subject, as well as helpful in developing critical thinking his personal experience with math is quite strained. It is reported that there is "low enjoyment and confidence in math-related activities", expressing "significant anxiety and confusion". The student stated that he "feels uncomfortable asking questions or seeking help" from his maths-related modules lecturers when having difficulties with the material. Class observations confirmed that there was some level of reluctance from the student to participate in the class discussions and he tends to respond systematically with a "yes" when asked if he has understood all the concepts.

4.2 Teaching practices

Teaching mathematics to visually impaired students presents a unique set of experiences. The four lecturers informed that it was their first experience of teaching a blind learner and agreed that it was a challenging experience that required thoughtful adaptation and a deep understanding of both the subject matter and the specific needs of the student (Stone et al., 2019). Lecturer 1 pointed out that "teaching math to a blind student is complex and requires

specialized training“. All the academics and administrative staff unanimously welcomed the newly introduced policy as a positive step towards creating an inclusive environment for students with disabilities. The coordinator stated that the policy will have to translate into “actionable measures and hands on solutions for the student and lecturers”

The primary challenge was that visual information in math such as graphs, tables and equations posed a significant barrier as the student could not read it through the screen reader. This situation triggered some heightened level of responsibility for the lecturers as there was determination to help the student overcome the barriers. Lecturer 2 explained that she allows the student to “record the whole class sessions and I send all the notes in formats that was requested by the student and post on the LMS platform”. Lecturer 3 elaborates along the same line “I tried to give the student a bit of one to one attention but then I could not dedicate my whole time to him because I had to cater for the whole class”. Lecturer 4 further explained that “I had too many calculations on the whiteboard and realised he was having lots of difficulties to follow” and said that she tried to “approach to explain the concepts in a different way but still it was challenging for both” Lecturer 1 agreed and added “I am not sure about the pace I have to use when explaining. When shifting from one slide to another I do not know whether the student is able to follow in that pace.”

The knowledge gap of the lecturers can be captured from the following statements: Lecturer 2 explains that “we don’t know the real feedback of what we are teaching to the blind student” while Lecturer 1 states that ”there are details about how the screen reader works which I personally feel would help” . Class observations also uncovered some degree of hesitance from the lecturer during explanations although the willingness to help the student was present. Lecturer 4 raised concerns about the output from statistical software: “ I do not know what exactly the student can hear when the screen reader is translating the graphs and tables” in line with the concerns about the compatibility of screen readers with statistical software packages (Godfrey & Loots, 2014).

The above findings point out to some level of frustration with the challenges of finding or developing appropriate teaching materials and methods as the student progress is slow and resources are limited. The resource persons expressed “uncertainty”, “self doubt” and “helplessness” as they were not sure about whether the student fully understand the material or if the teaching methods were effective. This observation is in line with Marcone and Penteado (2013) who reported that instructors expressed frustration with the amount of effort required to adapt lessons, often with unsatisfactory results leading to a sense of burnout.

The students' responses, while acknowledging "the efforts put in by the lecturers," also indicate a certain limitation in the teaching practices within the math-related modules. The student expressed neutrality about the effectiveness of the teaching methods to accommodate different learning styles and abilities. The student also finds the overall classroom atmosphere and level of engagement to be inadequate. He further stated that he “prefers working individually without much assistance from lecturers after receiving the notes and audio recordings” The above may reflect a desire for independence and control over the learning process for the student or it may also suggest that the student may feel less pressure or anxiety when working alone, free from the immediate oversight of a lecturer (Whitburn,2014)

4.3 Assistive technologies

The student expressed gratitude to his family for equipping him with a screen reader. The screen reader has allowed access to digital content, websites, and applications. The synthesized voice reads out the content of the screen, allowing the user to listen and comprehend what is displayed. The main concern of the student's current reader is that it does not detect the content related to math as reported by Shoaib et al. (2023).

The student reported that he "made some research on the tools available and found that there are some that could help. One is tactile graphics for reading graphs and also a Math software for calculations". The student however informed that he is not capable of investing in other specialised tools as these are costly. Accessibility of the appropriate assistive technologies remain a concern as highlighted by Kelly (2009). Some dissatisfaction was expressed about the lack of the institutional support to access such specialised equipment and corroborates with the statements from the coordinator about the "limited help provided for the lectures"

The lecturers expressed curiosity about how the screen reader works and were eager to understand how the blind student interacts with digital content. Lecturer 2 revealed that "I would like to experience using the screen reader just to understand better how the student is perceiving the lectures" The lecturers' unfamiliarity with assistive technological devices is indeed a hindrance to the effective teaching and learning which is in line with the findings from Zhou et al. (2011).

The student, the lecturers and the Administrative staff agree on the essential role of teacher assistants to complement the assistive technologies as a human could "adapt in real-time during explanations" Furthermore it is believed that the teacher assistant would help in "bridging the gap" between the lecturer and the student through communication and emotional encouragement. This is in line with the student thoughts that current "assistive technologies used for maths teaching and learning have not really made maths learning more engaging and interactive"

4.4 Assessment Practices

The assessment at the university comprises class tests conducted by the lecturers within normal class settings and a final end of semester exams coordinated by the Exams officer. For the continuous assessments during the lectures it is worth noting the statements of Lecturer 3: "I did several tests and what I've noticed is that the student is able to tackle theoretical questions as he just had to type the answers. As for the math computation parts he "was unable to answer the questions". Lecturer2 added "Even if he uses excel provided for class test only the basic calculation is carried out. Lecturer 4 added that the student is "not able to generate graphs as per the question requirement".

The exams officer provided information about the special arrangements for the semester exams. "The student is seated in a different exams room alone so that he can use the audio content and screen readers freely. He is also given extra time for typing the answer in a laptop provided by the university. same paper is set but with extra time" While these arrangements aim to accommodate the student's needs in line with Marson et al. (2023), some concerns are raised about whether the same paper content is suited to the student for more equity. In fact, the Exams officer further explained that during the exams for statistics module, "the student

informed the invigilator that the screen reader was not detecting the statistical tables, graphs and formulae content". Adaptive formulae with written text explaining the formulae proposed by Stone et al. (2019) emerges as a quick win in the present context.

The student emphasised on the added strain and anxiety during the statistics tests and exams. "I have failed the statistics module twice but have passed all other modules so far." All the respondents expressed concern over the assessments modes. Lecturer 2 stresses on the fact that there should be a "fair evaluation" of the student's understanding and skills while achieving the same learning outcomes while and Lecturer 3 added that "exams flow should be least affected by the visual impairment." All the respondents agreed that the focus should be on assessing conceptual understanding rather than numerical calculations if this becomes a barrier, since reading equations and graphs poses difficulties. The following suggestions were put forward by Lecturer 1 "Breaking down problems into step-by-step instructions to show understanding of processes like the simplex method, even if exact calculations cannot be shown", Lecturer 3 suggested "Using a case study approach" and Lecturer 4 proposed "to discuss concepts in applied scenarios rather than performing calculations"

All the participants concur with the programme coordinator who stated that "the lessons learnt from previous exams sessions should help us set more equitable assessments" . In a nutshell, while provision for equitable assessments are made in the policy documents, it is yet to be completely translated into reality.

5. Conclusion and Implications for policy

This study provides valuable insights into the learning journey of the visually impaired student in math-related modules at the University and highlight the numerous challenges he faced. The study has also uncovered the complexity of adapting the teaching methods and the lack of resources. While the university's policy on special education needs is a commendable step towards creating an inclusive environment, its implementation requires more concrete actions and continuous collaboration with Special Education Needs Authority (SENA).

The findings indicate that current assistive technologies, while beneficial, are insufficient on their own. The student's struggles with mathematical content, especially where visual representation is required, underscore the need for specialized support that goes beyond technology. Lecturers, while eager and willing to assist, face significant challenges in adapting their teaching methods and materials to meet the student's needs, often feeling unprepared and uncertain about the effectiveness of their efforts.The absence of teacher assistants and the inadequacies in assessment practices further exacerbate the student's difficulties, leading to anxiety, low engagement, and academic setbacks, particularly in statistics. The case study reveals that while the student strives for independence, the absence of timely and appropriate support has made his learning journey stressful rather than fulfilling.

The policy for students with disabilities and Special Needs adopted by the university is a positive step towards creating an inclusive environment for students with disabilities and special needs. While there is an acknowledgement of the diverse needs of students with disabilities and the need for tailored support in teaching, learning and university life, the policy aims at fostering cultural change, aligned with international standards. Based on the findings

from the case study, several implications for policy implementation can be identified to enhance the experience for the visually impaired students at the university. The policy stresses on the need for providing adapted learning materials. However, there are limited provisions on the implementation process. For example, while reference is made to "appropriate arrangements" and "assistive learning devices," there are lack of details about how the policy mandates the availability of these resources in a timely manner to prevent gaps in learning and not leave the burden of acquisition on the students. It is of crucial importance to institutionally support and train lecturers and other staff for a better understanding on how to effectively use assistive technologies, adapt teaching methods and pace lessons appropriately and provide adequate support during the university life.

While technology development has provided affordable and accessible solution for the visually impaired, teacher assistants remain important, to help bridge the gaps in the learning pathway. Teacher assistants are able to adapt instruction dynamically based on the student's progress, questions, and challenges, crucial for understanding complex math concepts. The emotional and motivational support, which can be particularly beneficial for students facing the additional challenges of learning with a disability is also non-negligible. The mental distress and isolation in the struggle expressed by the student could potentially be attenuated with specialist human support through the university life. This is in line with the study by Shoaib et al. (2023) which uncovered the critical importance of academic and specialised support, over and above adapted assistive t6echnologies for effective math learning for the visually impaired

The lesson learnt is that it is imperative to set an ecosystem for the students with special needs in a proactive manner right at the beginning of their journey in the institution starting with an evaluation of their specific requirements. It is it essential to engage in a deeper reflection on how to effectively accompany the blind students in their math learning journey by ensuring that adapted learning materials and assistive technologies are available, accessible and properly utilised. Capacity building for all lecturers on the use of assistive technologies should be part of the continuous professional development requirements and incorporating teacher assistants in the equation could significantly enhance the teaching and learning experience. Such measures would not only help bridge the current gaps but also foster a more inclusive and supportive learning environment, aligning with the university's commitment to equity and accessibility in education. In a nutshell, this study has shed some light on the gaps in this area, and open avenues for future research which could explore a comprehensive approach to improving the learning experience for visually impaired students, addressing both technological gaps and pedagogical challenges.

References

1. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative research in psychology, 3(2), 77-101.
2. Brawand, A., & Johnson, N. (2016). Effective Methods for Delivering Mathematics Instruction to Students with Visual Impairments. Journal of Blindness Innovation & Research, 6(1).
3. Godfrey, A. J.R., and Loots, M.T. (2014), "Statistical Software (R, SAS, SPSS, and Minitab) for Blind Students and Practitioners," Journal of Statistical Software, 58, 1–25.

4. Godfrey, A. J.R., and Loots, M.T (2015), "Advice From Blind Teachers on How to Teach Statistics to Blind Students," Journal of Statistics Education, 23, 1–27.
5. Harrison, H., Birks, M., Franklin, R., & Mills, J. (2017). Case study research: Foundations and methodological orientations. In Forum qualitative Sozialforschung/Forum: qualitative social research (Vol. 18, No. 1).
6. Kapperman, G. and Sticken, J. (2003). A case for increased training in the Nemeth Code of Braille mathematics for teachers of students who are visually impaired. Journal of Visual Impairment & Blindness, 97(2), 110–112.
7. Kathiria, P., Mankad, S. H., Patel, J., Kapadia, M., & Lakdawala, N. (2024). Assistive systems for visually impaired people: A survey on current requirements and advancements. Neurocomputing, 606, 128284.
8. Kelly, S. M. (2009). Use of assistive technology by students with visual impairments: Findings from a national survey. Journal of Visual Impairment & Blindness, 103(8), 470-480.
9. Marcone, R., & Penteado, M. G. (2013). Teaching Mathematics for blind students: a challenge at the university. International Journal for Research in Mathematics Education, 3(1), 23-35.
10. Marson, S.M., Harrington, C.F. & Walls, A. (2013). Teaching Introductory Statistics to Blind Students. Teaching Statistics: An International Journal for Teachers, 35(1), 21-25. Retrieved October 3, 2024 from https://www.learntechlib.org/p/132800/.
11. Mendonça, C. R., Souza, K. T. D. O., Arruda, J. T., Noll, M., & Guimarães, N. N. (2021). Human anatomy: Teaching–learning experience of a support teacher and a student with low vision and blindness. Anatomical sciences education, 14(5), 682-692.
12. Moço, V., & Archambault, D. (2004). Automatic conversions of mathematical braille: A survey of main difficulties in different languages. In International Conference on Computers for Handicapped Persons (pp. 638-643). Berlin, Heidelberg: Springer Berlin Heidelberg.
13. Patton, M. Q. (2014). Qualitative research & evaluation methods: Integrating theory and practice. Sage publications.
14. Pinho, T. M. M., Castro, H. C., Alves, L., & Lima, N. R. W. (2016). Mathematics and blindness: let's try to solve this problem. Scholedge International Journal of Multidisciplinary & Allied Studies, 3(10), 215-225.
15. Quek, F., and McNeill, D. (2006), "Embodiment Awareness, Mathematics Discourse, and the Blind," Annals of the New York Academy of Sciences, 1093, 266–279.
16. Rule, A. C., Stefanich, G. P., Boody, R. M., & Peiffer, B. (2011). Impact of adaptive materials on teachers and their students with visual impairments in secondary science and mathematics classes. International Journal of Science Education, 33(6), 865-887.
17. Shoaib, M., Fitzpatrick, D., & Pitt, I. (2023). Assistive technology-based solutions in learning mathematics for visually-impaired people: exploring issues, challenges and opportunities. Multimedia Tools and Applications, 82(29), 46153-46184.
18. Smith, D. W., & Kelly, S. M. (2014). Assistive technology for students with visual impairments: A research agenda. International review of research in developmental disabilities, 46, 23-53.
19. Stone, B. W., Kay, D., & Reynolds, A. (2019). Teaching visually impaired college students in introductory statistics. Journal of Statistics Education, 27(3), 225-237.
20. Strobel, W., Fossa, J., Arthanat, S., & Brace, J. (2006). Technology for access to text and graphics for people with visual impairments and blindness in vocational settings. Journal of vocational Rehabilitation, 24(2), 87-95.
21. Whitburn, B. (2014), "'A Really Good Teaching Strategy': Secondary Students with Vision Impairment Voice Their Experiences of Inclusive Teacher Pedagogy," British Journal of Visual Impairment, 32, 148–156.
22. Zhou, L., Parker, A. T., Smith, D. W., & Griffin-Shirley, N. (2011). Assistive technology for students with visual impairments: Challenges and needs in teachers' preparation programs and practice. Journal of Visual Impairment & Blindness, 105(4), 197-210.