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Pedagogical and Technological Accessibility Barriers faced by Undergraduate Students with Visual Impairments in Natural Sciences and Quantitative Reasoning Courses under the HEC Undergraduate Policy 2023

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ABSTRACT

The implementation of Higher Education Commission (HEC) Undergraduate Policy 2023 has made Natural Sciences (NS) and Quantitative Reasoning (QR) a compulsory part of the undergraduate education in Pakistan. These courses are very visual, however, resulting in significant obstacles for students with a visual impairment (SWVIs). The purpose of this study was to explore the pedagogical and technological challenges that SWVIs encountered in their required General Education courses What is Science? and Exploring Quantitative Skills and Tools for Quantitative Reasoning. A quantitative descriptive survey design was used. The data were obtained from 122 visual impaired undergraduate students using multistage sampling technique from selected public and private universities of Lahore, Pakistan. The barriers to pedagogical, technological and institutional accessibility were measured using a 26 item researcher developed questionnaire. The internal consistency of the instrument was excellent (Cronbach's α = .925). Descriptive statistics, independent samples t-tests and one way ANOVA were used to analyse the data. The results showed that the pedagogical, technological and institutional barriers were considerable. The most common pedagogical problems were the use of visual explanations in the classroom, which were unavailable for students with dyslexia and inaccessible for those with other disabilities; the most common technological problems were inaccessible scientific symbols and notations. The most highly rated institutional barrier was a lack of adaptation of laboratory activities. Significant differences were found based on degree program, type of visual impairment; but not across gender, age, or institution type. The study concludes that to achieve effective implementation of the HEC Undergraduate Policy, universities must increase the availability of accessible instructional practices, provide assistive technology, enhance faculty preparation, and adapt the assessment and laboratory procedures. The findings in this paper offer evidence-based recommendations to support equitable participation and academic success of students with visual impairments in compulsory science and quantitative reasoning education.

Introduction

Natural Science and Quantitative Reasoning (QR) courses What is Science, Exploring Quantitative Skills and Tools for Quantitative Reasoning are now required for all undergraduates under the Undergraduate Education Policy (UEP) 2023, passed by the Higher Education Commission. Their instructional design uses heavily visually mediated techniques: graphs, diagrams, charts, demos in the lab, diagrams of physical processes, tasks involving spatial, geometric reasoning. This immediately poses a pedagogical question: How will undergraduate students with visual impairments (SWVIs) read content and how will SWVIs be taught content that is, by design, visual? What instructional technology is available to close this gap?

These courses are made compulsory because they build critical thinking, data literacy, and scientific reasoning as skills tied to graduate employability (Raffaghelli et al., 2020; Sarkar et al., 2020), and intensive study in mathematics and science is linked to improved employment outcomes and to readiness for emerging fields such as technology and healthcare (Black et al., 2021; Tijani & Adeduyigbe, 2025). These national-level rationales, however, are delivered through classroom-level teaching methods and materials and where the mode of instruction itself excludes a group of learners, the intended benefits are withheld from precisely the students who stand to gain the most from them. This makes pedagogy and instructional technology, and not only curriculum content, the immediate site where accessibility either succeeds or fails.

The concern is not marginal. The WHO (2019) estimates that 246 million people worldwide live with visual impairment, nearly 40 million of them legally blind, and in Pakistan, SWVIs face a persistent shortage of adapted learning materials, limited access to assistive devices, and negative attitudinal barriers that compound the academic and psychological difficulties of pursuing higher education (Ali et al., 2025).

These barriers have been weakened particularly in the science side as this subject area is adopted the most and has more abstract and high visual content (Opie, 2018; Ürey & Gulers, 2018). A diagram of a cell, a graph of a function, or a geometric proof is typically only 'taught' by what the teacher sees, there is no implicit oral or tactile way that it is taught (although the teacher may have a former student that can do it orally, it is not necessarily done that way); the change to accessible form is a decision made by the teacher and not assumed. The translation from visual scientific representations to other non-visual formats (Rosenblum et al., 2019; Rule et al., 2011); the challenges of translating 2D representations of 3D concepts; and diagrams with little or no textual information, but predominantly visual, have thus been linked to lower achievement for SWVIs.These design deficiencies are compounded in the teaching practice. In the case of SWVIs, hands-on experiments and practical activities are not even mentioned in science lessons (Nakajima & Goode, 2019) and this is particularly critical since students can move the apparatus with their hands and feet that cannot be performed in a lecture. Science and mathematics education continues to be largely visual, which is a barrier for those with visual impairment to participate in the subjects at university, and therefore also in STEM careers (Yusof et al., 2019). At a higher level (mathematics and science), in contrast, the difficulty would not be mathematics or science, but the visual conventions in which these are introduced, and the difficulty can be overcome by the pedagogical intervention which addresses the visual conventions. Technological availability is an indirect contributor to these learning problems. However SWVIs can be effective in post secondary programmes in science and mathematics if there is trained personnel to teach SWVIs, nemeth code (code used to write mathematics and science content in braille), and supervision of production and distribution of books in science and mathematics (Ookeditse 2018, Vandana 2022). The types of assistive technology screen readers, refreshable braille displays and tactile-graphic production equipment also vary based on the format of the teaching materials. A diagram which is exported as a flat image is not usable for the assistive technology devices. A pedagogy that is need-responsive and relies on individual student strengths is considered a major factor to achieve genuine inclusion, as the concept of one size fits all teaching and testing has been found to have limited ability to cater to individual student differences (Pekrun et al., 2017; Arshad et al., 2024).

Where instructional resources are made accessible through alternative text, screen-reader-compatible formats, and adapted digital materials students with varied learning requirements become more active and productive participants in their own learning (Naz et al., 2024); Where such measures are absent, digital barriers become an active driver of educational inequity rather than an incidental gap (Almalky & Qaysi, 2025). Taken together, the evidence points to accessibility as something produced, or withheld, at the level of everyday teaching decisions and technology choices decisions largely left to individual instructors with little structured guidance on how to make visual science and mathematics content accessible.

Despite this body of evidence, research specifically examining how pedagogical approaches, instructional technology, and course materials interact to create or remove barriers for SWVIs within Pakistan's compulsory Natural Science and QR courses remains limited. Existing studies on disability and accessibility in Pakistani higher education tend to address technological access or institutional policy in general terms, without close attention to the specific teaching methods, materials, and assistive technologies used in What is Science, Exploring Quantitative Skills, and Tools for Quantitative Reasoning under the HEC policy 2023 framework. This study addresses that gap by examining the pedagogical and technological difficulties experienced by visually impaired undergraduates in these compulsory courses.

Objectives of the study

1. To identify the pedagogical challenges faced by students with visual impairments in accessing the courses 'What is Science?', 'Exploring Quantitative Skills', and 'Tools for Quantitative Reasoning'.
2. To examine technological barriers (e.g., lack of screen-reader-compatible materials, Braille support) that hinder equitable participation of students with visual impairments in these courses.
3. To find out if there are significant differences in pedagogical, technological and institutional access barriers among undergraduate students with visual impairment (gender, age, program or field of study, type of institution and type of visual impairment).

Literature Review

The undergraduate policy of the HEC requires all undergraduate students to take courses in natural science and quantitative reasoning. It is intended to create a level playing field for students but disadvantages students with a visual impairment because it may lead to a lower knowledge and understanding of science and mathematics at the beginning of higher education, as it was not always accessible to students in the past. Typically, teachers assigned to these courses have good knowledge of the content, but they lack pedagogical knowledge in teaching the content to blind and low vision students and specialized materials relevant to other students often are the first point of entry for pedagogical and technological barriers discussed later. One of the recurrent issues is the poor quality of preparation of science and mathematics teachers.Fraser (2018) also said that the pre-service training is generally lacking in science teachers and Islek (2017) said that VI teachers during in-service are often not confident in teaching the VI learners. At the tertiary level, Masuku et al. (2024) and Cardenas et al. (2025) have found that lack of faculty knowledge about inclusive pedagogy is a key obstacle in STEM higher education as subject matter experts who are not trained in disability typically resort to traditional graph, diagram, and symbol representation, which are visually oriented. Another obstacle is the design of teaching and learning in the classroom. Although accessibility is a precondition for active participation (Lintangsari & Emaliana, 2020), bualar (2018) indicated that many educators are unaware of how to make their classroom conducive for blind students to be part of it. Writing this, noted that it is customary to have a sighted "assistant" observe and record the data for a blind student, thus preventing sustained STEM engagement and blind people's representation in STEM. Abstract concepts, such as cellular organisation, photosynthesis and atomic structure are particularly difficult to communicate without appropriate laboratories and instruments, such as a digital magnifier and braille measuring instruments, respectively, according to Qaisar et al (2024). Annie and Mubanga (2021) established that learners with visual impairments were routinely left out of demonstrations, not allowed to touch things, were kept relying on sighted learners and the lack of modification of the curriculum along with lack of staff training. Decreased active engagement - students who are blind or low vision were not able to work with the microscope at the same speed as students with sight (Koehler and Wild 2019). In mathematics, visually impaired students can be easily found to have problems comprehending symbols, equations and graphs, as materials of teaching are developed with diagrams and these diagrams are visible for their sighted peers, and therefore are not visible for the visually impaired learners (Akar & Övez, 2018; Emerson & Anderson, 2018). Yet another inhibiting factor for good pedagogy is the accessibility to assessment - Morina (2017) observed that whilst access has become more comprehensive in terms of reach, outreach and admissions, little attention has been paid to the accessibility of assessment, which is where progress in access is manifesting itself as an equitable outcome for the VIS learner. The absence of material accessible for screen readers is constantly mentioned as one of the major technological hurdles. The screen reader has been found to be essential to convert text to speech, but many educational resources, such as PDFs, websites and multimedia presentations, are not designed to be accessible and usable, according to Kisanga and Kisanga (2022), and Power (2024) added that PDFs are a commonly used but poorly suited format for sharing excerpts from textbooks unless they are specifically designed to be accessible. According to Dabi and Golga (2024), most websites tested are not accessible to screen reading software (such as JAWS and ZoomText), and Baguma and Wolters (2021) reported that many learning materials that have been uploaded to virtual learning environments based on Moodle are not accessible to screen reading software users and many PDF documents, PowerPoint presentations and multimedia resources are inaccessible to screen reading software users, which is an important barrier for students with visual impairment. In addition, Kelly and Smith (2021) also found that the video lectures featured in their study were not accessible with no audio description and that virtual laboratories in science are not screen-readable using screen readers, which pose a challenge to experiential learning .The provision of braille is patchy and limited. Both Bhardwaj and Kumar (2017) and Kumar and Nagar (2024) found that materials were not available – or not available in usable formats – in accessible media like Braille, audio, and large print, nor did there seem to be materials that provided the detailed explanations of the visual material or structured format necessary for effective use of screen-readers. Mustapha (2022) reported that refreshable Braille displays and digital platforms were both scarce in terms of access to them and limited in their capacity to represent mathematical expressions and that Braille literacy was not always a skill that many students have.Mathematical and scientific notation is a technical challenge that is unlike any other. The issues with MathML and LaTeX are intrinsic and hinder independent problem-solving, as mentioned by Maćkowski et al. (2018), yet as also pointed out by Ahmetovic et al. (2021), MathML and LaTeX are important to make mathematical texts usable for screen reader users. Screen readers like NVDA and JAWS offer navigation capabilities, but do not offer semantic understanding of mathematical structure, often rendering superscripts, fractions and matrices without maintaining spatial relationships that are crucial to understanding (Miesenberger et al., 2022).The effects of pedagogical and technological barriers to disadvantage are mediated by institutional support. Parveen et al. (2024) found that the examination system is not widely accessible in Pakistan Universities because of rigid formats and insufficient accommodations, and Mahmood et al. (2023) found that the majority of the Higher Education Institutions (HEIs) in Pakistan has not made their websites more accessible. Inappropriate pedagogic practices were also identified as a hindrance in students use of visual data representations, such as graph or chart, even when ATs were provided (Aftab and Ghaffar, 2025), further emphasising the interdependence between the provision of ATs and pedagogic competence that was identified throughout this review.The literature shows that students with visual disabilities who are enrolled in undergraduate science and quantitative reasoning courses are faced with two sets of barriers: pedagogical barriers arising from the lack of training of science instructors, the reliance on visually dependent instructional techniques, and the lack of accessible formats of assessment; and technological barriers arising from the incompatibility of digital materials with screen readers, the limited support for Braille, and the persistent inability to make mathematical notation accessible in a way that can be navigated. There have been a few studies that have examined some of these barriers in general STEM, but not much research examining these barriers in the compulsory General Education courses mandated by the HEC Undergraduate Policy (2023) that is the focus of the present study.

Research Methodology

A quantitative descriptive survey design was used to determine the pedagogical and technological accessibility barriers of undergraduate students with visual impairment in Natural Sciences and Quantitative Reasoning courses in terms of the HEC Undergraduate Policy 2023. This design allowed for the gathering of standardized data from a relatively large sample and for statistical comparisons to be made on the responses to various demographic variables. The study population consisted of the undergraduate students with visual impairments registered in public and private universities that provide these compulsory courses of General Education. The target group was chosen because they first-hand experienced the pedagogical and technological barriers to accessibility that they faced during the learning process of these courses. The sampling technique that was used was a multistage sampling. Purposive sampling was employed in selecting Universities that had students with visual impairment as undergraduate students and subsequently census sampling was used to include all the eligible students in the selected Universities. Such an approach was deemed to be appropriate given the relatively small number of undergraduate students who have a visual impairment and the ability to reach them via university disability support services and academic departments. The sample consisted of 122 visual impaired undergraduate students who filled out the questionnaire. They included individuals from diverse backgrounds in terms of gender, age, degree program, institution type, field of study, and degree of visual impairment, allowing for differences in perceived pedagogical and technological barriers to be explored.

Instrument Development

Data were gathered using a researcher-developed structured questionnaire that included questions related to pedagogical accessibility barriers as well as technological accessibility barriers and institutional support for undergraduate students with visual impairments in Natural Sciences and Quantitative Reasoning courses. The questionnaire was divided into 26 items measured by a 6-point Likert scale for obtaining mean scores and comparing responses to various demographic variables. To ensure that all the important dimensions of the study are represented, the content validity was ensured by developing the questionnaire from the available literature and by expert review. The internal consistency reliability was done by correlating the items of the instrument using Cronbach's alpha, and in this study, the total instrument has a Cronbach's alpha of 0.925, or excellent internal consistency.

Reliability Statistics

Cronbach’s Alpha	Number of Items
.925	26

Data Collection and Data Analysis

The questionnaires were given to undergraduate students who have a visual impairment from selected public and private universities. The participation was voluntary, the anonymous questionnaire was filled in with self-reported data about the pedagogical and technological accessibility barriers experienced in Natural Sciences and Quantitative Reasoning courses. Descriptive statistics such as frequencies, percentages, mean, and standard deviation were used to summarize the demographic data and study variables. Independent-samples t-tests and one-way analysis of variance (ANOVA) were used to analyze significant differences between perceived pedagogical and technological accessibility challenges based on gender, age, degree program, institution type, field of study, and level of visual impairment.

Demographic Analysis

Table 1: Frequency Distribution of Demographic Characteristics of Respondents

Category	Respondent	*Frequency*	*Percentage (%)*
Gender			
	Male	**66**	**54.1%**
	Female	**56**	**45%**
Age			
	16 to 19 years	35	28.7%
	20 to 23 years	68	55.7%
	24 to 27 years	16	13.1%
	Above 27 years	3	2.5%
Degree Program			
	B.Ed. (Hons) Special Education	40	32.2%
	Other BS programs	82	68.8%
Field of study			
	Humanities	39	32.2%
	Social science	77	63.1%
	Technological sciences	1	0.8%
	Interdisciplinary studies	3	2.5%
	legal studies	2	1.6%
Type Of Institution			
	Public	114	93.4%
	Private	8	6.6%
Type Of Visual Impairment			
	Low Vision	56	45.9%
	Blind	66	54.1%

Based on Table 1, the total number of undergraduate students with visual impairment that participated in the study was 122. Of these, 66 (54.1%) were male and 56 (45.9%) were female. The majority of participants, 68 (55.7%), were aged 20–23 years, followed by 35 (28.7%) aged 16–19 years, 16 (13.1%) aged 24–27 years, and only 3 (2.5%) above 27 years. In terms of degree programs, 82 (67.8%) participants were taking other BS and 40 (32.2%) were pursuing B.Ed. (Hons) special education. In terms of field of study, the students were mostly enrolled in Social Sciences (77, 63.1%), Humanities (39, 32.0%) and a few in Interdisciplinary Studies (3, 2.5%), Legal Studies (2, 1.6%) and Technological Sciences (1, 0.8%). Majority of the participants were studying in public sector universities (114, 93.4%) with only 8 (6.6%) studying in private sector universities. In terms of type of visual impairment, 66 (54.1%) were blind and 56 (45.9%) had low vision. The sample ages ranged from 20 to 23 years, most of whom are studying BS in public sector universities and the students from the Social Sciences and Humanities disciplines were the majority.Descriptive Statistics

Table 2. Descriptive Statistics of Pedagogical Challenges, Technological Barriers, and Administrative/Institutional Barriers

Statements	Mean	S.D.
Section 2: Pedagogical Challenges		
The teachers do not adjust their teaching methods to meet my needs.	3.647	1.610
Do not get enough support from teachers while studying these courses.	3.557	1.595
The explanations in class are not clear or easy to understand.	3.655	1.862
The explanations in class rely only on visuals (e.g., diagrams, graphs) and are not accessible in other ways.	5.008	1.566
Visual materials (e.g., diagrams, graphs, pictures) are not explained in accessible ways.	4.926	1.559
I face barriers in fully participating in class activities.	4.024	1.760
Assessment methods (assignments, quizzes exams) are not provided in accessible formats.	3.393	1.869
The pace of teaching in these courses makes it difficult for me to follow.	3.983	1.651
I often feel excluded during class activities because of inaccessible teaching methods.	4.155	1.715
Overall, I am not satisfied with the teaching and support in these courses.	3.934	1.784
Section 3: Technological barriers		
Teachers often share course materials (slides, notes) in image/PDF formats that are not readable with screen readers.	3.295	1.737
Course materials provided through photocopies or printed notes are not available in accessible formats.	3.172	1.751
Tables and data in these courses are not provided in accessible formats.	4.959	1.607
Scientific symbols and notations are not provided in accessible formats.	5.131	1.510
University library's digital resources are not accessible with screen readers.	4.803	1.358
Digital diagrams, graphs, and charts are not accessible with assistive technology.	5.049	1.238
Assistive technology (Braille printer, screen reader, magnifier) is not always available when I need it.	4.147	1.843
I have not received proper training in using assistive technology.	4.278	2.062
Technical support staff do not help quickly when I face problems.	4.377	1.544
Overall, technological barriers make it difficult for me to fully participate in these courses.	4.573	1.465
Section 4: *Administrative/Institutional barriers*		
University policies on accessibility in science and quantitative courses are not effectively implemented or monitored.	4.909	1.408
Teaching staff are not properly trained to support visually impaired students in laboratory or quantitative reasoning courses.	4.704	1.654
The examination system, including tests, assessments, and grading policies, is not adapted to meet the accessibility needs of visually impaired students.	4.311	1.814
My university does not provide sufficient financial and administrative resources (e.g., funding for assistive technology, accessible materials) to support visually impaired students.	4.500	1.544
Laboratory activities and requirements are not adapted to support the participation of visually impaired students.	5.172	1.290
I feel that institutional policies and administration do not make it easier for me to participate equally in academic activities.	4.532	1.575

The description of pedagogical challenges, technological barriers, and administration/institutional barriers for undergraduate students with visual impairments in Natural Sciences and Quantitative Reasoning courses (N = 122) are shown in Table 2. Pedagogical challenges that were noted included limited teacher support, lack of teacher adaptation of the teaching method, classroom explanations not easily understood, visual instructional materials not accessible, classroom participation hindrances, assessment methods not accessible, classroom instruction slow, and exclusion from classroom activities. Classroom explanations that used visual material only and no other materials or supports for that material received the highest mean score (M = 5.008, SD = 1.566), while the lowest mean score was for the inaccessible assessment methods (M = 3.393, SD = 1.869).

Technological barriers mentioned by students included inaccessible course materials, tables, scientific symbols and notations, digital resources in the library, diagrams, graphs and charts, limited access to assistive technologies, and delays in technical support and training in the use of assistive technologies. The scientific symbols and notations were found to have the highest mean score (M = 5.131, SD = 1.510), while the course materials that were presented through photocopies or printed notes received the lowest mean score (M = 3.172, SD = 1.751).As for administrative and institutional obstacles, students reported unproductive implementation of accessibility policies, a lack of training for teachers, unaccessible examination systems, insufficient financial and administrative support, limited accessibility of laboratory activities and institutional practices, that did not ensure equal academic participation. The examination system had the lowest mean score (M = 4.311, SD = 1.814) while laboratory activities and requirements had the highest mean score (M = 5.172, SD = 1.290). The results overall revealed that for undergraduate students who were visually impaired, there were significant pedagogical, technological, and administrative/institutional challenges accessing either Natural Sciences or Quantitative Reasoning courses.

Inferential Statistics

Table 3: Independent Samples t-Test Comparing Mean Scores of Pedagogical Challenges, Technological Barriers, and Administrative/Institutional Barriers Across Gender, Degree Program, Type of Institution, and Type of Visual Impairment

Factors	Variables	Groups	N	Mean	Sd	df	T	sig.
Gender	Pedagogical Challenges	Male	66	41.515	10.877	120	1.235	.219
		Female	56	38.839	13.060			
	Technological Barriers	Male	66	44.484	8.179	120	.882	.370
		Female	56	42.964	10.481			
	Administrative/ Institutional Barriers	Male	66	28.121	7.039	120	-.017	986
		Female	56	28.142	6.934			
Degree Program	Pedagogical Challenges	B.Ed. (Hons) Special Education	40	43.743	12.091	2.295	119	.024
		Other BS Programs	82	38.500	11.583			
	Technological Barriers	B.Ed. (Hons) Special Education	40	45.615	8.728	1.555	119	.123
		Other BS Programs	82	42.817	9.487			
	Administrative/ Institutional Barriers	B.Ed. (Hons) Special Education	40	30.410	7.099	2.547	119	.012
		Other BS Programs	82	27.024	6.707			
Type of Institution	Pedagogical Challenges	Public	114	40.701	12.047	1.454	120	.149
		Private	8	34.375	9.179			
	Technological Barriers	Public	114	43.973	9.283	.837	120	.404
		Private	8	41.125	9.716			
	Administrative/ Institutional Barriers	Public	114	28.438	6.752	1.860	120	.065
		Private	8	23.750	8.860			
Type Of VI	Pedagogical Challenges	Low Vision	56	37.357	10.786	-	120	.012
		Blind	66	42.772	12.404	2.550		

Technological Barriers	Low Vision	56	41.767	9.240	-2.246	120	.027
	Blind	66	45.500	9.066			
Administrative/ Institutional Barriers	Low Vision	56	27.660	6.870	-.686	120	.494
	Blind	66	28.530	7.067			

The results of the independent-samples t-test comparing the mean scores of pedagogical challenges, technological barriers, and administrative/institutional barriers, between the genders, between the degree program and between the types of institution and type of VI are presented in Table 3. The results showed that there was no statistically significant difference between male and female students in terms of pedagogical challenges ($t = 1.235$, $p = .219$), technological barriers ($t = .882$, $p = .370$) and administrative/institutional barriers ($t = -0.017$, $p = .986$). In the same way, there were no statistically significant differences between students from public and private institutions for pedagogical challenges ($t = 1.454$, $p = .149$), technological barriers ($t = .837$, $p = .404$) or administrative/institutional barriers ($t = 1.860$, $p = .065$); the mean scores were slightly higher for public institutions across all three areas. As far as the degree program is concerned, the students studying B.Ed. (Hons.) Students in Special Education had significantly greater pedagogical challenges ($t = 2.295$, $p = .024$) and administrative/institutional barriers ($t = 2.547$, $p = .012$) than students taking other BS programs. But no significant difference was found regarding the technological barriers ($t = 1.555$, $p = .123$). In addition, the study revealed significant differences between the mean scores of students with blindness and those with low vision in pedagogical challenges ($t = -2.550$, $p = .012$) and technological barriers ($t = -2.246$, $p = .027$) with the mean scores of students with blindness being higher. However, there was no significant difference between the two groups for administrative/institutional barriers ($t = -0.686$, $p = .494$). In summary, the results indicated significant differences in the selected barriers to accessibility depending on the degree program and type of visual impairment, but not in the type of pedagogical, technological or administrative/institutional barriers depending on the type of institution and gender.

Table 4: One-Way ANOVA Results for Pedagogical Challenges, Technological Barriers, and Administrative/Institutional Barriers by Age and Field of Study

Factors	***Variables***	**Source**	***Sum of Squares***	***Df***	***Mean Square***	***F***	***Sig***
Age							
	Pedagogical Challenges	Between groups	534.853	3	178.284	1.256	.293
		Within groups	16754.106	118	141.984		
	Total		17288.959	121			
	Technological Barriers	Between groups	184.154	3	61.385	.705	.551
		Within groups	10276.305	118	87.087		
	Total		10460.459	121			
	Administrative/ Institutional Barriers	Between groups	65.310	3	21.770	.443	.723
		Within groups	5800.592	118	49.158		
	Total		5865.902	121			
Field of study							
	Pedagogical Challenges	Between groups	71.194	4	17.798	.121	.975
		Within groups	17217.765	117	147.160		
	Total		17288.959	122			
	Technological Barriers	Between groups	196.324	4	49.081	.559	.639
		Within groups	10264.135	117	87.728		
	Total		10460.459	122			
	Administrative/ Institutional Barriers	Between groups	481.170	4	120.292	2.614	.039
		Within groups	5384.732	117	46.023		
	Total		5865.902	122			

The findings of the one-way ANOVA test are shown in Table 4 in order to compare pedagogical challenges, technological barriers, and administrative/institutional barriers between the age groups and fields of study. Comparing the different age groups, the results showed no significant differences in pedagogical challenges ($F = 1.256$, $p = .293$), technological barriers ($F = 0.705$, $p = .551$) or administrative/institutional barriers ($F = 0.443$, $p = .723$) indicating that the level of accessibility barriers experienced by students in different age groups was comparable. Likewise, there were no statistically significant differences across fields of study for pedagogical challenges ($F = 0.121$, $p = .975$) and technological barriers ($F = 0.559$, $p = .639$). Students' perceptions of administrative and institutional barriers, however, differed across fields of study ($F = 2.614$, $p = .039$), as there was a statistically significant difference between these two barriers across academic disciplines. Overall, the results indicate that age did not seem to be linked to accessibility barriers, while field of study was linked to accessibility barriers, but only those in the administrative/institutional category.

Discussion

The results from the present study suggest that undergraduate students with a visual impairment encountered a great number of pedagogical barriers when taking the Natural Sciences and Quantitative Reasoning courses. Participants especially said that classroom teaching was mainly used to present visual explanations with limited implementation of inclusive teaching practices. In the same vein, Hussain et al. (2022) identified that the visually impaired students at Pakistan's universities faced several accessibility challenges, such as low availability of Braille resources, screen reading software, audio books and other educational resources that would enable them to actively engage in university curricula and education. The study also found that lack of educational resources and accessibility provisions remained as a challenge to the academic experiences of visually impaired students, which confirmed the pedagogical barriers found in the present study. By another important finding, students had significant technological barriers, especially in the lack of access to scientific symbols, mathematical notations, diagrams, graphs and digital learning resources. The results of this study are in line with the findings of Reddy et al. (2021) who reported that students with visual impairment faced significant challenges in accessing mathematical and digital learning materials, due to limited provision and access to suitable assistive technologies. The study highlighted the importance of accessible digital tools and assistive technologies for enhancing higher education students' participation and learning outcomes, which align with the technological barriers identified in the current study. In addition, one of the most salient administrative and institutional hindrances to be found in the labs was practical learning experiences. The findings align with those of D'Agostino (2022) who noted that science instruction is heavily dependent on symbolic, spatial and visual information and that undergraduate chemistry teaching and laboratory environments are generally not accessible to blind and low vision students. The study also highlighted that the laboratory activities in science education are inaccessible for students with visual impairments and that the instructional adaptations are not sufficient to allow these students to participate in science education. The present study findings support the above findings and emphasize the importance of making lab activity and practical more accessible for universities. The study also revealed that, the students who pursue B.Ed. (Hons.) Students enrolled in Special Education programme reported significantly more pedagogical challenges and administrative/institutional barriers than compared to other undergraduate programmes. While no previous study has made a specific comparison across the different degree programmes, Firat (2021) also reported that there were significant pedagogical and institutional barriers faced by university students with visual impairments such as inaccessible learning materials, inadequate academic support, inadequate library resources, limited awareness of the faculty, and lack of disability support services. The results of this research corroborate the current study by showing that pedagogical and institutional challenges remain to have an impact on the educational experiences of students with visual impairments in higher education. The other important result was that students who were blind had significantly more pedagogical challenges and technological barriers than students with low vision. This is similar to what Odame et al. (2021) observed, which is that graduates with visual impairments faced difficulties in accessing learning materials, not having enough assistive technologies, limited academic support, and the institution's challenges while studying at university. The study also identified that these barriers limited the engagement of the students in academic activities and negatively impacted their learning experience which corroborates the current results. Last, the results showed a significant difference between administrative/institutional barriers in the various fields of study. This result is corroborated by Moriña and Orozco (2021), who found that disabled students had an unequal kind of education depending on the context of the university because the measures of institutional support, access, and teaching were executed in an inconsistent way in the different contexts. Their findings highlight the need to enhance institutional policies and to ensure that disability support is equally adequate in multiple academic disciplines, to ensure equitable access to higher education. The findings, overall, support that undergraduate students with visual impairments still face significant pedagogical, technological, and administrative/institutional barriers when taking Natural Sciences and Quantitative Reasoning courses. A number of measures must be taken to overcome these obstacles, including the use of inclusive teaching methods, the use of learning resources and technologies which are accessible to students with visual impairments, making improvements to the accessibility of laboratories, and the strengthening of institutional support systems for the equitable participation and academic success of students with visual impairments in higher education.

Conclusion

This paper reveals that undergraduate students with visual impairments who are taking Natural Sciences and Quantitative Reasoning courses often encounter significant pedagogical, technological, and administrative/institutional barriers, with a few instances of teacher assistance and institutional accommodation, however, they are used to the reliance on inaccessible visual instruction, un adapted laboratory activities, and inaccessible scientific symbols and digital resources. It was identified that students with a visual impairment had some access to the course content, however most of these students continued to experience limitations of following classroom instruction that relies on visual materials, and limited access to practical or assessment-oriented activities, indicating that these courses are not fully accessible to students with a visual impairment. The results also suggest that there is a significant variation in the perceptions of these barriers by degree program, type of visual impairment, and field of study and that experiences with accessibility are affected by overlapping individual and academic factors and vary across all students, but not by gender, institution type, or age. In sum, although formal policy frameworks like the HEC Undergraduate Policy 2023 are essential, the creation of accessible pedagogical practices, appropriate AT, and context-specific institutional implementation mechanisms are crucial toward ensuring the equitable academic participation of undergraduate students with visual impairments in higher education.

Recommendations

1. The pedagogical obstacle was visually oriented explanations, which should be accompanied by detailed explanations in words by instructors.
2. Institutions should implement accessible assessment methods (screen readable papers, oral exams, extended time) to address inaccessible assessment methods.
3. Universities need to dedicate resources to the development of assistive technologies which can faithfully display scientific and mathematical notation for students.
4. Digital materials (diagrams, graphs, charts, library resources) should be made accessible (tactile and screen-reader).
5. The procedures to be followed in the laboratory should be re-designed with the aid of tactile equipment, and trained assistants, so that visually impaired students can participate independently.
6. Dedicated disability support offices and accountability mechanisms should be established as part of accessibility policies, such as the HEC Undergraduate Policy 2023.

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