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Motivational factors for visually impaired college students in learning data analytics

Suliman Abdalla [1*], Amjad Alhaj [1], Elnazir Ramadan [2]

[1] Department of Sociology and Social Work, Sultan Qaboos University, Muscat, OMAN
[2] Department of Geography and Urban Sustainability, United Arab Emirates University, Al Ain, UAE

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Abstract
The aim of this study is to explore the key factors that motivate visually impaired college students to develop data analytics skills. Using a mixed-methods approach, the study integrates quantitative data from binary logistic regression analysis and qualitative insights from focus group discussions with undergraduate social science students. The quantitative findings reveal that the strongest motivators are the availability of adapted learning materials, teacher support and encouragement, and the perceived usefulness and relevance of statistics. In contrast, peer influence, gender, and type of impairment were not found to have significant impacts. The qualitative analysis underscores two primary barriers: technological and administrative challenges, as well as instructional and learning obstacles. These findings suggest that addressing these barriers and leveraging motivators can help create more inclusive educational programs. The study concludes with actionable recommendations for higher education institutions and instructors to better support visually impaired students in their pursuit of data analytics skills.

Keywords: data analytics, college students, visual impairment, motivational factors

INTRODUCTION

In today's data-driven landscape, leveraging data analytics has become a strategic necessity for organizations aiming to achieve sustainable competitive advantages (Colombari et al., 2023; Flores-Garcia et al., 2019; Provost & Fawcett, 2013). Globally, more organizations and businesses are recognizing the transformative power of data analytics, particularly in driving decision-making processes that enhance operational efficiency and productivity. This widespread recognition has spurred significant demand for expertise in areas such as data management, data visualization, statistical analysis, and proficiency in statistical programming languages (Ghasemaghaei, 2019; Janssen et al., 2017; Li et al., 2021). To meet this growing demand, educational institutions around the world have incorporated statistics and data analytics into their core curricula. This ensures that students develop the comprehensive statistical knowledge and data analytics skills required to thrive in today's fast-paced and dynamic work environments (Gould, 2010; Lu, 2022; Pan et al., 2018; Spence et al., 2011; Zhang et al., 2021; Zhao & Zhao, 2016).

Equipping university students with proficiency in data analytics presents significant challenges, particularly due to common obstacles such as statistics anxiety, low motivation, and diminished self-efficacy (Capshew, 2005; Finney & Schraw, 2003; Onwuegbuzie & Wilson, 2003; Valle et al., 2021; Wilson & Rosenthal, 1993; Zeidner, 1991; Zhang et al., 2021). These challenges are often more pronounced for students with visual impairments compared to their sighted peers (Godfrey & Loots, 2015; Marson et al., 2012; Stone et al., 2019). One primary reason is that statistics courses frequently rely on visual learning materials and graphical representations to explain complex concepts. For instance, topics such as probability distributions, hypothesis testing, correlation, and regression analysis depend heavily on images and graphs, which can be difficult for visually impaired students to access (Erhardt & Shuman, 2015; Marson, 2007; Unwin, 2000). Addressing these barriers requires a deliberate effort to

✉ sulabdalla@squ.edu.om **(*Correspondence)** ✉ amjadalhaj@squ.edu.om ✉ elnazirr@uaeu.ac.ae

Contribution to the literature

- Identification of key motivational factors, the study contributes by identifying specific motivational factors that drive visually impaired college students to learn data analytics skills.
- Insight into challenges faced, the study sheds light on the multifaceted challenges faced by visually impaired students in learning data analytics.
- Importance of empirical investigation in understanding the motivational dynamics of visually impaired students in data analytics education. Recommendations for higher education institutions and statistics teachers, the study emphasizes the importance of inclusivity in educational programs.

adapt instructional methods and materials to ensure inclusivity and accessibility for all learners.

It is crucial to emphasize that without appropriate adaptations to the learning environment, materials, and instructional strategies, visually impaired students face significant challenges in mastering statistics and data analytics. Insufficient adaptations can impede their ability to acquire statistical skills, foster negative attitudes toward the subject, and ultimately result in suboptimal learning outcomes. A fundamental aspect of supporting visually impaired students is enhancing their access to visual learning materials through compensatory strategies tailored to their specific needs. Various assistive tools and strategies have been developed to create a more inclusive and engaging learning environment that facilitates the acquisition of statistical knowledge and skills. For instance, Gibson and Darron (1999) highlighted the use of tactile instructional tools, such as cardboard and modeling clay, to teach concepts like the normal curve and regression line. Similarly, Vita and Kataoka (2014) demonstrated that tactile models can significantly aid visually impaired students in understanding complex topics such as probability and random walks. Marson et al. (2012) further emphasized the importance of instructor-created artifacts to support the learning of various statistical concepts. Additionally, numerous valuable resources offer access to assistive instructional materials specifically designed for teaching statistics to visually impaired students. For example, Inge Formenti from the American Printing House for the Blind provides a comprehensive range of teaching and learning products to meet these students' needs (Marson et al., 2012).

Erhardt and Shuman (2015) underscore the significant challenges involved in converting visual learning materials–such as numerals, tables, graphs, diagrams, mathematical equations, and formulas–into tactile and verbal formats. This process is inherently complex and poses substantial obstacles for both students and instructors. A notable challenge lies in the limited direct experience and skill set of many statistics instructors to effectively incorporate assistive instructional strategies into their teaching practices. It is essential to emphasize that statistics instructors bear an ethical responsibility to become familiar with a variety of assistive teaching tools and compensatory strategies crucial for delivering statistics courses to visually impaired students. Integrating these strategies can be relatively manageable in introductory-level courses focused on foundational concepts of descriptive and inferential statistics, where instructors may opt to forego the use of computer programming for calculations. However, in advanced statistics and data analytics courses, integrating accessible instructional techniques becomes more difficult due to the extensive reliance on complex mathematical notation and statistical software. Additionally, the process of converting visual learning materials into tactile and kinesthetic formats is often both costly and time-consuming, further complicating efforts to create an inclusive learning environment (Erhardt & Shuman, 2015; Gibson & Darron, 1999; Godfrey & Loots, 2015).

Statistics instructors beginning to teach classes that include visually impaired students need to consider several key questions to foster an inclusive learning environment. For instance, are all course materials accessible to visually impaired students? (accessibility of materials). Do students have the necessary technological tools to support their learning? (technology requirements). Is the classroom environment adapted to accommodate visually impaired students effectively? (classroom setup). What adjustments can be made to teaching methods to support these students? (alternative instructional methods). Are assessment practices both accessible and equitable? (assessment and evaluation). What collaborative measures can be taken with support services to enhance learning experiences? (collaboration and support). How will feedback from visually impaired students be collected and acted upon to improve their educational experience? (feedback and adaptability). Addressing these considerations enables statistics teachers to proactively meet the needs of visually impaired students and create a supportive learning environment. Additionally, understanding the challenges that visually impaired students face, such as barriers related to technology, administrative issues, and instructional limitations, is crucial for creating an inclusive classroom that promotes their learning and success.

In this context, the present study aims to explore the key factors that influence visually impaired students'

Table 1. The APS achieved by blind and partially sighted students

Statistical competencies	All		Blind		Partially sighted	
	APS	%	APS	%	APS	%
Understanding basic concepts of statistical methods	11.4	91.2	11.2	89.7	11.7	93.3
Explaining various types of variables and data	10.4	83.2	10.4	83.4	10.4	83.6
Describing methods of data collection and presentation	10.6	84.8	9.8	78.3	11.8	94.2
Explaining various types of sampling techniques	9.9	79.2	9.1	73.1	11.0	88.0
Running cross-tabulation analysis	9.0	72.0	8.5	68.0	9.7	77.3
Calculating and interpreting measures of central tendency	8.1	64.8	7.4	58.9	9.2	73.8
Calculating and interpreting measures of dispersion	7.2	57.6	6.6	52.6	8.2	65.8
Performing hypothesis testing	6.0	48.0	5.4	42.9	7.0	56.0

motivation to learn data analytics. To achieve this objective, data were collected through two rounds of interviews with visually impaired students: focus group discussions and individual interviews. The focus group discussions were designed to identify the primary challenges that visually impaired students face when learning statistics and data analytics. In contrast, the individual interviews sought to uncover specific factors that motivate these students to engage in learning statistics and data analytics. This dual approach allowed for a comprehensive understanding of both the obstacles and motivators affecting visually impaired students' learning experiences.

THE PRESENT STUDY

At Sultan Qaboos University, visually impaired students enrolled in various academic programs are expected to attain basic statistical and computational skills at a level equivalent to their sighted peers. To meet this academic standard, students must successfully complete at least one introductory statistics course as part of their curriculum. This study examines the teaching methods and learning outcomes in the social statistics course offered by the department of sociology and social work, as 80% of visually impaired undergraduate students are currently enrolled in the college of arts and social sciences. The course was initially designed to foster an inclusive classroom environment where visually impaired students could learn alongside their sighted peers, rather than in separate, specialized settings.

However, findings indicate that visually impaired students face significant challenges in achieving the same learning outcomes as their sighted counterparts due to the predominantly visual nature of statistical learning materials. Instructors often rely on verbal explanations to supplement equations, tables, graphs, and diagrams presented in slides, handouts, or notes. This teaching approach presents substantial challenges for students who are blind or have low vision, as it limits their ability to fully access and engage with the content (Jones et al., 2006). As a result, a decision was made to transition visually impaired students to specialized classrooms that provide tailored curricula and targeted instructional modifications to better meet their learning needs.

The primary aim of these specialized statistics classrooms is to reduce reliance on numerical, graphical, and symbolic representations in teaching statistical concepts and skills. In this customized instructional setting, certain highly visual content is minimized or excluded, such as complex equations, extensive numerical datasets, and graphical representations. For example, visually impaired students are not required to use equations to construct confidence intervals (CIs) for population parameters, display correlation and linear relationships through scatter plots, or calculate probabilities for specific values on a standard normal distribution. Additionally, although the course learning outcomes include software-specific competencies, such as the use of statistical package for social sciences (SPSS, version 23) for descriptive and inferential statistical analyses, this outcome has been omitted due to the unavailability of an adapted version of SPSS that is accessible to visually impaired students (Abdalla, 2021).

Evaluating the success of visually impaired students in meeting learning outcomes and acquiring essential statistical competencies is crucial. Two assessment measures are employed for this purpose. The first is the point score, which indicates the total number of points a student earns on all exam questions related to a particular competency. The second is the average point score (APS), calculated by summing all individual point scores for a given competency and dividing them by the number of students. The statistical data for these assessments were collected from the midterm and final exam scores of visually impaired students over two consecutive semesters. **Table 1** provides an overview of the maximum points (maximum score) for each statistical competency and the corresponding APS achieved by the students.

Overall, the results indicate that visually impaired students demonstrated significantly stronger performance on knowledge-based competencies (overall APS = 10.57) compared to their performance on analytical-based competencies (overall APS = 7.57). The mean difference between these two types of competencies was statistically significant ($t = 4.209$, $df = 6$, $p < .001$). This disparity can be attributed to the nature

Table 2. Participants' performance: mean (M) and standard deviation (SD)

Assessment method	Type of impairment		Gender	
	Blind	Partially sighted	Male	Female
	M (SD)	M (SD)	M (SD)	M (SD)
Discussion (maximum = 10)	9.4 (0.699)	9.9 (0.354)	9.7 (0.707)	9.6 (0.527)
Assignments (maximum = 30)	26.5 (1.269)	27.0 (1.309)	26.6 (1.333)	26.9 (1.269)
Mid-term exam (maximum = 20)	16.3 (0.160)	16.5 (0.926)	16.4 (1.236)	16.3 (0.866)
Final exam (maximum = 40)	32.2 (1.398)	32.5 (2.070)	31.8 (1.787)	32.9 (1.453)
Overall (maximum = 100)	85.4 (2.547)	85.9 (2.696)	84.4 (1.878)	86.8 (2.682)

of knowledge-based questions in statistics exams, which are primarily designed to assess students' theoretical understanding of core statistical topics and concepts. Such questions typically require students to provide verbal explanations and recall memorized information, making it easier to comprehend and answer concisely. In contrast, analytical-based questions necessitate a shift from rote knowledge to higher-level analytical and problem-solving skills, presenting greater challenges for students. These questions often involve complex reasoning and multi-step calculations, which require deeper cognitive engagement and extended time to complete.

These results suggest that visually impaired students may perform better on exams that primarily test memorized knowledge. However, relying solely on memorization is insufficient for fully acquiring the comprehensive skill set needed for statistical data analysis. Beyond understanding and recalling fundamental statistical concepts and methods, visually impaired students must also demonstrate proficiency in essential analytical skills and the practical application of their knowledge. This includes the ability to analyze linear relationships among variables, conduct various statistical hypothesis tests, and draw meaningful conclusions and inferences. Mastery of these analytical skills is crucial for translating theoretical understanding into effective practice in real-world data analysis scenarios.

While numerous research articles have examined the challenges faced by visually impaired students in learning statistics, most have emphasized the role of assistive technology adaptations. The contribution of this paper to the existing literature lies in its shift of focus to the specific factors that influence visually impaired students' motivation to learn statistics and data analytics. This study places greater emphasis on developing actionable strategies to enhance students' motivation, particularly in acquiring analytical and practical competencies, such as performing statistical computations and interpreting statistical outputs. By addressing these aspects, this paper aims to bridge the gap in current research and support more effective learning outcomes for visually impaired students.

METHODS

Participants

As previously mentioned, the current study involved two rounds of interviews: focus group discussions and individual interviews. A total of 64 visually impaired undergraduate students (36 females and 28 males) from Sultan Qaboos University in Oman were invited to participate. Of these participants, 48 were blind, and 16 had low vision. Selection criteria required participants to have completed at least one statistics course. **Table 2** presents descriptive statistics summarizing their performance in the statistics course, based on various assessment methods. The results indicated that, overall, female students performed slightly better than their male counterparts on the performance assessments. Additionally, students with low vision performed at a comparable level to their blind peers.

Data Collection Procedures

In the first round of interviews, a focus group discussion was conducted in July 2023 with 14 visually impaired students from the college of arts and social sciences. Among the participants, nine were blind, and five had low vision. A series of open-ended questions was designed to obtain an in-depth understanding of participants' perceptions of the challenges and difficulties involved in teaching statistics to visually impaired students. Discussions with the participants aimed to clarify and elaborate on all aspects of the identified issues and their resulting impacts. At the outset, participants were provided with an overview of the focus group's objectives and a set of predefined questions. Each statistical topic was introduced with a central question, followed by additional prompt questions to encourage further discussion and engagement. In the second round of data collection, individual interviews were conducted with 64 visually impaired students. These interviews included various close-ended questions and statements to collect participants' responses regarding the variables incorporated in the motivational model proposed in this study.

Data Analysis Methodology

Thematic data analysis

The qualitative data obtained from the focus group discussions were analyzed using Braun and Clarke's (2006) framework for thematic analysis. In the preparation phase, the first author thoroughly read and reviewed the focus group transcripts to become familiar with the data and gain an initial understanding of their content and meaning. An open-coding process was then conducted to organize the data systematically and meaningfully. During this stage, the transcript contents were divided into segments or meaning units based on words or sentences that conveyed similar content. Each unit was assigned a code that captured the essence of the text. The initial codes were reviewed and compared to identify similarities and differences, facilitating the grouping of related statements or words into sub-themes. These sub-themes were subsequently refined and organized into more abstract, high-level themes that encapsulated the statistical learning challenges faced by visually impaired students.

Binary Logistic Regression Analysis

Model specification

To explore the key factors predicting visually impaired students' motivation to learn statistical skills, a binary logistic regression (BLR) model was employed. BLR is a powerful predictive modeling technique particularly suited for situations where the dependent or response variable is dichotomous (Abdalla et al., 2024), meaning it can only take on two possible outcomes or categories, such as success-failure, yes-no, or presence-absence, typically coded as 0 and 1. The independent variables in this model can be either categorical or continuous. BLR is commonly used to model or predict the probability of a specific outcome based on the observed data from a set of predictors.

The parameters of the BLR model are estimated using the maximum likelihood (ML) approach, which maximizes the likelihood function to find the best-fitting model. This estimation is done by transforming the response variable (Y) into a logit link function, which represents the natural logarithm of the odds of the binary outcome. This transformation allows for more accurate prediction of Y-values from the sample data (Hilbe, 2015; Hosmer & Stanley, 2013; Lee, 2005). The general BLR model, consisting of a single response variable and k predictors, is expressed using the logistic function f(Y), which can be formulated, as follows:

$$f(Y) = Prob(particular\ outcome) = \frac{e^Y}{e^Y+1} = \frac{1}{1+e^{-Y}}, R_Y = \{0,1\}, \quad (1)$$

where Y is a linear combination function of the predictors and can be represented by the following logit transformation:

$$fY = logit(P) = ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots + \beta_k X_k, \quad (2)$$

where P is the predicted probability that the response variable $Y = 1$ (the probability of occurrence), given the values of the predictors $X_1, X_2, \ldots, X_k$. β_0, $\beta_1, \beta_2, \ldots, \beta_k$ are the ML estimates of the BLR coefficients. An estimated value of each (β_i) illustrates whether there is a positive (or negative) relationship between a particular predictor variable and the response variable for a particular category of that predictor compared to the reference category. Specifically, it can be interpreted as the average change in the log of the odds of the binary response variable associated with a one-unit increase in each predictor variable, with the other predictors held constant. For each estimated (β_i) coefficient in the BLR model, odds ratios (OR) are also estimated by taking the exponent of that coefficient ($OR = exp(\beta)$); it describes how much a particular outcome (the response variable) increases or decreases as a result of a one-unit increase in the corresponding predictor variable. In brief, OR greater than one indicate a positive relationship between the response variable and the predictor variable (the outcome of interest is more likely to occur), and OR less than one indicate a negative relationship (the outcome is less likely to occur). $\frac{P}{1-P}$ represents the preponderance ratio (OR), which is the ratio of the probability that a particular outcome occurs relative to the probability that the outcome does not occur.

Variables identification

In this study, the binary response variable (Y) is defined as "students' motivation to learn data analytics." To measure Y, a dichotomous question was developed, coded as 0 and 1, where 0 indicates a potential lack of motivation and 1 represents a high level of motivation to learn statistics. Ten explanatory variables were identified as predictors of students' motivation. These include seven variables measured using a Likert scale: teacher support and encouragement, peer influence, perceived usefulness and relevance of statistics, effectiveness of instructional strategies, perceived ease of use, and appropriate adaptation of learning materials. Each variable was assessed using three statements, rated on a 5-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). **Table 3** presents the specific statements used to measure each Likert scale variable. Additionally, the BLR model incorporated three nominal explanatory variables: gender, type of visual impairment (blind or low vision), and satisfaction with the academic program (satisfied or dissatisfied).

Table 3. Institutional difficulties and challenges associated with teaching statistics to visually impaired students

Difficulty type	Description	Associated resulting impact
1. Unavailability of appropriate assistive technology	Unavailability of statistical Braille learning material required to support learning statistics skills.	VI students are unable to perform any type of statistical data analysis.
		Graphical, tabular and symbolic content and materials cannot be provided in an accessible format.
	Unavailability of instructional statistical software (i.e., SPSS) adaptations to access the practical component of the course.	VI students are unable to use SPSS statistical software.
	Unavailability of screen reading software that is compatible with learning statistical skills.	VI students are unable to read the course handouts with a live reader.
2. Lack of administrative assistant skills	The administrative assistants in the college disability unit lack statistical knowledge.	Many VI students struggle to overcome the challenges of using SPSS statistical software applications in the lab room.
3. Lack of clear information and guidelines	The existing information and guidelines for delivering a statistics course do not fully meet all the necessary teaching and learning requirements.	Many VI students lack a clear understanding of the expectations set by their statistics course instructors.

Data analysis procedure

The parameters of the statistical learning motivational BLR model are estimated using the maximum likelihood estimation (MLE) method. Key outputs from the model include the OR with a 95% CI and the p-value for each regression coefficient (β_i) associated with each predictor (X_i) in the model. The estimated β_i coefficients indicate the contribution of each predictor to the probability value (P). To evaluate and validate the effectiveness of the fitted BLR model in describing the outcome variable, a range of statistical tests is employed. These include the Wald Chi-square test, the Omnibus tests of model coefficients, the Hosmer-Lemeshow test, and the Cox & Snell R square and Nagelkerke R square. The Wald Chi-square test, along with the associated p-values, determines the statistical significance of the individual regression coefficients assigned to each predictor, with the null hypothesis stating that a specific coefficient (β_i) equals zero. The Omnibus tests of model coefficients, accompanied by the chi-square goodness-of-fit test, assess the overall performance of the model. The Hosmer-Lemeshow test is used to evaluate the goodness-of-fit of the estimated BLR model, where an insignificant chi-square value suggests that the model fits the data adequately. Additionally, the Cox & Snell R square and Nagelkerke R square methods are employed to quantify the proportion of variation in statistical learning motivation explained by the model. All statistical analyses were conducted using the IBM SPSS, version 23.

RESULTS AND DISCUSSION

Results From the First-Round Interviews

At this stage of the interview process, a thematic analysis was conducted on the qualitative data collected from participants, focusing on the challenges they encounter while learning statistics and data analytics skills. The analysis identified two primary themes: technological and administrative challenges, and instructional and learning challenges.

Theme 1: Technological and Administrative Challenges

Focus group participants were first invited to share their experiences and perspectives on potential technological and administrative challenges associated with the delivery of statistics course. The thematic analysis of participants' feedback revealed three sub-themes:

(1) barriers to the use of assistive technology in statistics learning,

(2) limited access to administrative and technical support services, and

(3) a lack of clear accessibility and accommodation guidelines.

These sub-themes, along with their resulting impacts, are summarized in **Table 3**.

Barriers to the use of assistive technology in statistics learning

During the focus group, participants were invited to share their views and perceptions on the effectiveness of incorporating assistive technology devices and software into the statistics curriculum and instruction. The discussion revealed that nearly all participants regarded adequate access to assistive technologies as a crucial factor for enhancing students' ability to learn statistical analysis skills. This finding aligns with previous research emphasizing the significant role of assistive technology in supporting the learning of statistics and data analytics (Erhardt & Shuman, 2015; Gibson & Darron, 1999; Stone et al., 2019; Unwin, 2000). Participants highlighted the profound impact that assistive technologies can have on students' competence, engagement, confidence, and motivation to learn statistics. For instance, many participants expressed a strong preference for using statistical software packages such as SPSS, which provide additional learning opportunities for practicing statistical skills in comparison to their sighted peers. The majority of participants indicated that they would prefer to independently use SPSS for data analysis if an adapted version of the software were available and accessible to visually impaired students. In this context, several participants recommended that the university provide a computer screen reader program that enables visually impaired students to navigate the SPSS interface through either text-to-speech output or a refreshable Braille display.

Limited access to administrative and technical support services

Some focus group discussion questions aimed to assess the impact of administrative and technical support services on the delivery of statistics courses for visually impaired students. All participants expressed appreciation for the administrative support services provided by the students with disabilities support services unit, noting that these services significantly improved their access to statistical learning opportunities. Many participants highlighted the value of administrative support and guidance, particularly in facilitating approved exam accommodations and enhancing communication between students and instructors.

However, all participants raised concerns about the lack of technical support specific to statistical learning. There was a consensus that administrative assistants often lacked the necessary skills to effectively address technical issues encountered by visually impaired students in statistics courses. To address this gap, many participants suggested that administrative staff receive training to provide technical support tailored to statistics course delivery. Such support could include tasks like scanning and editing printed SPSS learning materials, as well as data entry and preparation in the SPSS data editor. The majority of participants emphasized that without these essential technical support services, acquiring skills in statistical data analysis would be considerably more challenging.

Lack of clear accessibility and accommodation guidelines

During the focus group, visually impaired students were asked to share their thoughts on the current mechanisms for providing guidelines and information related to statistical learning. All participants reported that they did not receive practical, written guidelines outlining how their needs could be accommodated to effectively learn statistical skills alongside their sighted peers. Specifically, participants highlighted the absence of learning assessment guidelines, a lack of procedural guidance on using assistive technology in statistics course, and unclear instructions for accessing course learning resources. These issues were frequently raised during the discussions, with many participants expressing frustration over the lack of structured guidelines and procedures, which exacerbated existing challenges in learning statistics. Consequently, several participants recommended the development of comprehensive written accessibility and accommodation guidelines. Such guidelines would serve as a valuable reference for visually impaired students, helping them navigate and overcome obstacles that may hinder their statistical learning.

Theme 2: Instructional and Learning Challenges

In the second part of the focus group discussions, visually impaired students were invited to share their opinions and perceptions regarding the instructional challenges they encountered while learning statistical skills. The thematic analysis identified five key sub-themes: reading and learning from the visual content of the course, understanding the instructor's verbal explanations of visual content, presenting datasets in graphical and tabular formats, performing various statistical computations and operations, and mastering the interpretation of statistical analysis results. These instructional challenges, along with their most significant sub-themes and associated impacts, are summarized in **Table 4**.

Incomplete understanding of the instructor's verbal descriptions of the visual content

One of the significant issues discussed by the focus group participants was their understanding of the visual content in the course, particularly when instructors used verbal descriptions to explain equations, tables, graphs, or diagrams displayed on slides, handouts, or notes. All participants reported experiencing substantial challenges and difficulties with the verbalization of visual learning content. Both blind and low-vision participants noted that comprehending lectures through auditory means alone was insufficient, especially when covering complex topics such as measures of dispersion, hypothesis testing, and correlation analysis. Participants consistently required an extended amount of time to fully process the information conveyed by the instructor through auditory explanations.

Additionally, the majority of participants reported heightened anxiety when listening to verbal explanations of visual content, such as the area under the normal curve, cross-tabulations, scatter plots, and various equational forms commonly used in statistical analysis. This type of statistical anxiety contributed to

Table 4. Instructional and learning difficulties associated with teaching statistics to visually impaired students

Learning activity	Activity description	Associated difficulty
1. Reading and learning from the visual content of the course	The course requires students to use graphs, charts, diagrams and tables as learning tools for representing a wide variety of datasets.	Many VI students struggle to achieve the expected learning outcomes when presented with information in graphical and tabular formats.
2. Understanding instructor's verbal descriptions of the visual content	The course instructor must provide students with clear and meaningful verbal descriptions of the visual content being presented in order to enhance their learning experience.	Many visual learning materials are difficult for VI students to fully understand when the instructor describes them.
3. Presenting datasets in graphical and tabular formats	The course learning outcomes emphasize the importance of graphical and tabular representation of data such as charts, graphs, tables and diagrams, in performing statistical analysis and drawing meaningful conclusions.	Many VI students struggle to create and present the graphics and tables needed for data analysis.
4. Perform various statistical computations and operations	The course requires students to perform a wide variety of statistical operations and calculations as learning tools for solving practical statistical problems.	VI students are unable to solve statistical problems that involve equations and mathematical expressions.
5. Mastering the skill of interpreting statistical analysis findings	Successful completion of the course requires students to demonstrate competency in drawing meaningful inferences and conclusions based on various descriptive and inferential statistical analyses.	VI students struggle to accurately interpret and draw reliable conclusions from statistical findings obtained through data analysis.

negative preconceived attitudes toward learning statistics, further complicating their learning experience.

Difficulties in performing statistical computations and operations

The focus group participants were then asked to reflect on their ability to perform basic statistical calculations, such as computing measures of central tendency and dispersion, calculating test statistics for hypothesis testing, and determining correlation coefficients, among other tasks. All participants confirmed that performing these types of statistical operations posed significant challenges. Many participants primarily attributed these difficulties to the heavy reliance on mathematical expressions and equations with complex constructs. Nearly all participants identified memorizing mathematical formulas and recalling statistical terms as the most difficult aspects of learning, which hindered their ability to effectively solve statistical problems. For instance, some participants mentioned that they frequently struggled with calculations involving fractions, percentages, squares, and square roots. Several participants emphasized that these challenges in performing statistical calculations had fostered a profound lack of self-confidence in their ability to succeed in statistics exams.

Barriers to accessing course learning materials

Focus group participants were invited to discuss their experiences and perspectives on accessing essential course learning materials and resources, including textbooks and classroom materials, in an appropriate and effective manner. A major challenge highlighted by all participants was their ability to study or read the required textbooks or learning materials provided by the course instructor. This issue was primarily attributed to the lack of availability of course materials in alternative adapted formats, such as Braille, audio, and digital text. Additionally, many participants expressed concerns about delays in gaining access to course materials in a timely manner. There was also a widespread consensus among participants that taking notes during statistics classes poses significant challenges for visually impaired students. This issue is particularly problematic given that the course content relies heavily on equations and various statistical symbols, as noted by several participants.

Challenges relating to students' learning assessment

Focus group participants were then invited to share their perspectives on the learning assessment practices implemented in the statistics course, to determine whether they had successfully achieved the intended learning outcomes. All participants confirmed that completing course assignments, classwork, and taking in-class quizzes and exams posed significant barriers. Notably, solving statistical problems in quizzes and exams was consistently identified as particularly challenging. Participants attributed this difficulty to the complex statistical terminology commonly used in these assessments. Additionally, it is important to highlight the prevalence of pre-test anxiety as an issue of particular concern. Discussions revealed that all participants experienced some degree of anxiety prior to taking statistics exams, which they indicated negatively

Table 5. Descriptive statistics for the independent variables

Nominal variables	Category	N	Percentage (%)
1. Gender	Male	28	43.8
	Female	36	56.2
2. Type of impairment	Blind	48	75.0
	Low vision	16	25.0
3. Program satisfaction	Satisfied	30	46.9
	Dissatisfied	34	53.1

Likert scale variables	Mean					SD
	Possible range	Value	%	Minimum	Maximum	
4. Teacher support and encouragement	(3-15)	7.66	51.0	3	14	2.993
5. Peer influence	(3-15)	7.33	48.9	3	15	3.152
6. Effectiveness of instructional strategies	(3-15)	7.89	52.6	3	15	3.665
7. Appropriate adaptation of learning materials	(3-15)	7.16	47.7	3	15	3.173
8. Perceived ease of use	(3-15)	8.22	54.8	4	15	2.560
9. Perceived usefulness and relevance of statistics	(3-15)	8.14	54.3	3	15	3.999

impacted their ability to perform well both before and during the exams.

Incomplete mastery of interpretation skills

Focus group participants were asked to share any difficulties they had encountered in interpreting statistical data analysis findings. There was consensus among the participants that reading and interpreting statistical results was one of the most anxiety-inducing learning activities. Many participants expressed difficulty in drawing meaningful conclusions from results related to complex statistical topics such as hypothesis testing, parameter estimation, and correlation analysis. The primary reason for these challenges was the interpretation process, which frequently involves highly technical terms such as probability distribution, null hypothesis, test statistics, statistical significance, and CIs, among others. Additionally, it was revealed that some participants struggled to comprehend the practical value and importance of statistical inferences in real-world contexts.

Regression Analysis Results

Descriptive analysis

As outlined in the methodological section, the BLR model in this study incorporates "students' motivation to learn data analytics" as the response variable, with two possible outcomes: 0 for students who are not motivated and 1 for those who are motivated to learn data analytics skills. Among the 64 visually impaired students, 37 (57.8%) were classified as lacking motivation, while 27 (42.2%) were classified as motivated to acquire statistics and data analytics skills. The model included nine explanatory variables: three nominal variables and six variables measured on a Likert scale. To include the Likert scale variables in the binary logistic model, a new composite variable was created for each independent variable by summing students' responses across all related items. These composite variables had a possible range from 3 to 15. **Table 5** provides key descriptive statistics for the independent variables. The results indicated that perceived ease of use, perceived usefulness and relevance of statistics, and the effectiveness of instructional strategies had the highest average values.

Regression analysis results

As previously mentioned, the interpretation of the BLR results is provided in terms of OR and their corresponding 95% CIs. The primary objective is to identify explanatory variables that significantly contribute to explaining the motivation of visually impaired students to learn data analytics skills. The estimation results are presented in **Table 6**. Overall, the findings indicate that six independent variables have statistically significant effects on motivating visually impaired students to learn data analytics. These variables include appropriate adaptation of learning materials, perceived usefulness and relevance of statistics, teacher support and encouragement, effectiveness of instructional strategies, perceived ease of use, and satisfaction with the academic program. Conversely, the results reveal that peer influence, gender, and type of impairment did not have statistically significant impacts on the motivation of visually impaired students to learn data analytics skills.

Among the predictors, appropriate adaptation of learning materials had the most significant impact, with an estimated OR of 3.347 (95% CI, 1.567-7.150). This finding suggests that for each incremental improvement in the adaptation of learning materials, the odds of transitioning from a non-motivated to a motivated state to learn data analytics skills are 3.347 times greater, assuming all other explanatory variables remain constant. Creating an accessible and engaging learning environment for visually impaired students in the realm of data analysis requires innovative approaches and thoughtful adaptations. Key strategies include

Table 6. BLR estimation results

Predictors	β	SE (β)	Wald χ^2	df	p-value	Exp (β)	95% CI for Exp (β)	
Gender	.277	.782	.125	1	.723	1.319	.285	6.110
Type of impairment	.115	.945	.015	1	.903	1.122	.176	7.152
Program satisfaction	-2.402	1.126	4.550	1	.033	.090	.010	.823
Teacher support and encouragement	.741	.351	4.466	1	.035	2.098	1.055	4.170
Peer influence	-.008	.209	.001	1	.970	.992	.658	1.496
Effectiveness of instructional strategies	-.938	.338	7.723	1	.005	.391	.202	.758
Adaptation of learning materials	1.208	.387	9.733	1	.002	3.347	1.567	7.150
Perceived ease of use	-1.472	.522	7.948	1	.005	.229	.082	.638
Perceived usefulness and relevance of statistics	.737	.256	8.280	1	.004	2.090	1.265	3.454
Test/model summary	Chi-square			df		p-value		
Omnibus tests of model coefficients	45.569			9		.000		
Hosmer and Lemeshow test	9.529			8		.300		
Model summary	Cox & Snell R square				Nagelkerke R square			
	.509				.679			

providing textbooks and lectures in accessible formats such as Braille, audio recordings, and documents compatible with screen readers. Additionally, using descriptive language to convey visual information is crucial for comprehension. Implementing these strategies fosters a supportive and stimulating learning environment that empowers visually impaired students to engage with and excel in the field of statistical data analysis. This result aligns with the findings of previous studies that highlight the significant influence of learning material adaptation on student motivation (Frank et al., 2020; Lourens & Swartz, 2016; Stone et al., 2019).

The results also revealed that teacher support was a significant factor in motivating visually impaired students to learn data analytics skills. The estimated OR (OR = 2.098, 95% CI, 1.055-4.170) indicates that teachers' support and encouragement made visually impaired students 2.098 times more likely to be motivated to learn data analytics, assuming all other independent variables remain constant. This highlights the pivotal role that teachers play in inspiring and motivating visually impaired students to engage with data analysis.

Effective teaching practices for visually impaired students include the use of real-world examples that align with their personal interests, demonstrating the relevance of data analysis to their passions and connecting it to their everyday experiences. Teachers can further boost motivation by recognizing and celebrating students' strengths in analytical thinking, tactile perception, and auditory skills. By tailoring instruction to meet individual needs, employing diverse learning strategies, and fostering a supportive learning environment, teachers can empower visually impaired students to develop confidence and excel in data analysis. The guidance and encouragement provided by teachers can open up new opportunities, ignite enthusiasm, and set the stage for a fulfilling journey in the field of data analytics.

The regression results also indicated that the perceived usefulness and relevance of statistics had a significant impact, with an estimated OR of 2.090 (95% CI, 1.265-3.454). This finding suggests that perceived usefulness and relevance of statistics were 2.090 times more likely to increase visually impaired students' motivation to learn data analytics skills, holding all other independent variables constant. Demonstrating the practical applications and real-world significance of statistics can greatly inspire visually impaired students to engage with data analysis. Instructors can motivate students by showcasing how data analysis can be applied to areas of personal interest, such as sports statistics or music analysis, and by involving students in data projects relevant to their local community. By highlighting the tangible impact and personal relevance of data analysis, educators can spark curiosity and foster a deeper motivation among visually impaired students to explore this empowering field. This finding aligns with previous studies suggesting that contextualizing statistical analysis within real-life problem-solving and decision-making scenarios can enhance the appreciation and perceived value of statistics and data analytics (Capshew, 2005; Carlson et al., 2011; Marson et al., 2012; Stone et al., 2019).

Other statistically significant predictors include the effectiveness of instructional strategies and perceived ease of use, with estimated OR of 0.391 (95% CI, 0.202-0.758) and 0.229 (95% CI, 0.082-0.638), respectively. Inspiring and motivating visually impaired students in data analysis depends on finding the right balance between effective instructional strategies and ease of use. This can be accomplished by breaking down complex statistical concepts into smaller, manageable components that can be learned and applied independently. Additionally, employing diverse representation methods–such as visual aids paired with descriptive explanations, audio descriptions, and tactile models–can enhance the learning experience and comprehension of statistics for visually impaired students. By integrating these instructional strategies with accessible, user-friendly tools and fostering a supportive learning environment, educators can create a positive and engaging atmosphere for visually impaired students in data analysis. This finding aligns with the conclusions drawn by Godfrey and Loots (2015) and Marson et al. (2012), who noted that one of the greatest challenges in teaching statistics to visually impaired students lies in adapting the visual learning materials typically used for sighted students.

Additionally, satisfaction with the academic program was found to have a statistically significant impact on visually impaired students' motivation to learn data analytics skills, with an OR of 0.090 (95% CI, 0.010-0.823). This result suggests that students who reported satisfaction with their academic program were 0.090 times more motivated to learn data analytics skills than those who were dissatisfied. It underscores the importance of academic program satisfaction as a motivating factor for visually impaired students in pursuing statistical data analysis. Enhancing student satisfaction can be achieved by promoting active learning and engagement through diverse teaching methods. These methods could include combining lectures with hands-on activities, collaborative projects, group discussions, and role-playing scenarios tailored to accommodate different learning styles and preferences. Creating a supportive and engaging learning environment can empower visually impaired students, fostering motivation and enthusiasm for exploring statistical data analysis. Ensuring student satisfaction contributes significantly to building a truly inclusive and impactful educational experience.

Assessment of the estimated model

The goodness of fit and predictive performance of the estimated BLR model were assessed using the Omnibus tests of model coefficients, the Hosmer-Lemeshow test, and the Nagelkerke pseudo R-square. The results of the Omnibus tests of model coefficients (Chi-square = 45.569, df = 9, p-value = 0.000) indicate that the full model, which includes all predictors, is significantly better than the null model containing only the intercept. This finding confirms that the estimated BLR model is statistically significant in explaining visually impaired students' motivation to learn statistics and data analytics skills.

Furthermore, the Hosmer-Lemeshow goodness-of-fit test yielded a p-value greater than 0.05 (Chi-square = 9.529, df = 8, p-value = 0.300), supporting the null hypothesis that there is no significant difference between the observed frequencies and the model-predicted frequencies of the response variable. This result suggests that the estimated BLR model provides an adequate fit to the data. Finally, the Nagelkerke pseudo R-square was used to evaluate the proportion of variation in the response variable explained by the explanatory variables. The results show that the explained variation in the response variable ranges from 50.9% (Cox & Snell R square) to 67.9% (Nagelkerke R-square), indicating that the model captures a substantial portion of the variance in visually impaired students' motivation to learn data analytics skills.

CONCLUSION AND IMPLICATIONS

This study examined the factors influencing visually impaired college students' motivation to learn data analytics, using a combination of qualitative data from focus groups and quantitative analysis through a BLR model. The qualitative findings revealed several key challenges that impede motivation, including technological and administrative barriers, difficulties accessing adapted learning materials, and navigating bureaucratic obstacles. Instructional and learning challenges were also prominent, characterized by a lack of effective instructional strategies, inaccessible course content, and insufficient support from instructors. Addressing these critical issues is essential for creating a more inclusive educational environment for visually impaired students in data analytics programs. By investing in accessible technologies, ensuring comprehensive support services, and implementing clear accessibility and accommodation guidelines, educational institutions can empower visually impaired students, enabling them to reach their full potential and excel in this rapidly evolving field.

Quantitative analysis using BLR revealed that the motivation of visually impaired students to learn data analytics is influenced by a combination of factors. These factors include the availability of appropriately adapted learning materials, the perceived value and relevance of data analytics skills, a supportive learning environment, personalized encouragement and support from instructors, effective teaching methods, ease of use, confidence in navigating data analytics tools and software, and a positive overall experience with the academic program. The study highlighted that the most significant predictors of motivation were the appropriate adaptation of learning materials, teacher support and encouragement, and the perceived usefulness and relevance of statistics. Notably, peer influence, gender, and type of impairment did not have a significant impact on motivation, suggesting that fostering an inclusive, accessible learning environment with effective instruction and relevant materials is more critical than focusing on individual characteristics. Overall, the findings underscore the importance of overcoming accessibility barriers, providing customized support, and showcasing the value of data analytics skills to inspire and motivate visually impaired students in this expanding field.

The findings of this study offer practical implications for higher education institutions and instructors of data analytics courses. By identifying the specific factors that drive visually impaired students' motivation to learn data analytics, decision-makers in higher education can implement targeted strategies to boost student engagement and enrich their learning experiences. Additionally, these insights can support statistics instructors, particularly those teaching visually impaired students for the first time, by providing a deeper understanding of the motivational drivers that can effectively foster students' learning of data analytics skills. This understanding can guide educators in creating inclusive and supportive teaching practices that empower visually impaired students to succeed in their studies.

At the institutional level, this study recommends that higher education institutions take proactive measures to create a supportive learning environment that facilitates the acquisition of data analytics skills for visually impaired students. Emphasis should be placed on integrating assistive technology that meets the specific needs of visually impaired students, enabling them to conduct various types of statistical data analysis effectively. Institutions should also ensure that accessible statistical software, such as adapted versions of SPSS, is available to students, providing them with the necessary tools to develop their data analytics skills. Additionally, screen reading software should be made readily accessible, as it plays a critical role in helping visually impaired students navigate course materials with the assistance of live readers or other supportive features.

Higher education institutions should also consider offering training programs for administrative staff responsible for coordinating services for students with visual impairments. These training programs should include instruction on the use of statistical software applications to better support students' learning needs. Furthermore, academic departments that offer statistics courses can leverage the findings of this study to develop comprehensive guidelines, providing detailed instructions and procedures for effectively teaching statistics to visually impaired students. This approach will contribute to creating a more inclusive academic environment that supports the success and engagement of all learners.

Additionally, the study provides several practical implications for teaching and learning. The findings offer valuable insights for data analytics instructors, deepening their understanding of the motivational factors that drive visually impaired students to engage with data analytics skills. Prospective statistics instructors can leverage these findings to identify the most effective combination of teaching strategies and instructional materials. For instance, the thematic analysis results can help instructors gain a comprehensive understanding of the technological, administrative, instructional, and learning challenges that visually impaired students face in statistics and data analytics courses. This knowledge can guide instructors in designing effective course management and delivery strategies, ultimately enhancing students' learning outcomes.

Based on the study's findings, it is recommended that statistics instructors acknowledge their ethical responsibility to become familiar with various assistive teaching tools and compensatory strategies essential for teaching statistics to blind and visually impaired students. Instructors should also recognize the importance of integrating these tools and strategies into their teaching practices to effectively support and engage visually impaired students in learning. By doing so, instructors can create an inclusive learning environment that fosters motivation, confidence, and academic success.

The study presented noteworthy findings and practical implications regarding the factors influencing visually impaired students' motivation to learn data analytics. However, some limitations should be acknowledged and addressed in future research. First, this study was limited to visually impaired students majoring in the social sciences, which may restrict the generalizability of the conclusions and implications. The data collected might not fully capture the diverse learning experiences of visually impaired students across other disciplines. Future research should consider including students with visual impairments from a range of academic fields to provide a more comprehensive and nuanced understanding of their learning experiences. Secondly, the BLR analysis was conducted using a relatively small sample size, which could impact the generalizability of the findings. As noted by Nemes et al. (2009), applying a logistic regression model with a large number of predictors to a small sample size can introduce a "small sample bias" in the MLE. Addressing this limitation in future studies by using larger sample sizes could improve the robustness and applicability of the results.

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