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# Effects of Assistive Technology Training Program on Utilisation of Smartphone-Based Assistive Applications among Students with Visual Impairment in Lafia, Nigeria

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## Abstract

This study assessed the effects of assistive technology training program on the utilisation of Smartphone-Based Assistive Applications among students with visual impairment in Lafia Local Government Area, Nigeria. The study employed a quasi-experimental pre-test/post-test non-equivalent control group design. A total sample of 60 students was drawn, with 30 students assigned to each group. Data were collected using the Smartphone Assistive Application Utilisation Scale (SAAUS), a 30-item researcher-developed instrument measuring frequency, diversity, and competence in assistive application use. Experts checked its validity, and a pilot test gave a reliability score of 0.84. Ethical approval was obtained from school authorities and informed consent was obtained from participants and their guardians. Results were analyzed using descriptive statistics and analysis of covariance (ANCOVA) to compare groups while accounting for starting levels and age of onset (early or late). Findings confirmed that training was associated with statistically significant effects in utilisation. $F(1, 56) = 76.54$, $p < .001$, partial $\eta^2 = .573$. Late-onset students showed greater gains, with a significant main effect of onset age, $F(1, 56) = 5.21$, $p = .026$, partial $\eta^2 = .084$, and Group × Onset interaction, $F(1, 56) = 4.28$, $p = .043$, partial $\eta^2 = .070$. Students who lost vision later in life gained more from the training than those blind from early childhood. The study concluded that structured training boosts smartphone assistive app use, but programs should be adjusted for age of onset early-onset students may need more time or different methods. Recommendations included adding such training to school curricula, tailoring it by onset age, offering ongoing support, and making assistive tech skills a priority in education for learners with visual impairment.

## Keywords

Assistive technology training, Smartphone-based assistive applications, Visual impairment, Age of onset, Mobile accessibility

## Article History

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## 1. Introduction

Visual impairment is a major challenge affecting millions of people across the world and continues to raise serious concerns within the education sector. Globally, a large number of children and young people live with partial or total loss of vision, and many of them experience difficulties accessing quality education [1]. For students with visual impairment, learning is often complicated by limited access to printed materials, visual teaching methods, and information resources that are not designed with accessibility in mind [2]. As a result, these students frequently depend on alternative formats and support systems to participate meaningfully in academic activities.

In Nigeria, students with visual impairment face similar, and in many cases more severe, educational challenges. Although national policies promote inclusive education, the reality in many schools shows gaps in implementation [3]. Learning materials are often not available in accessible formats such as Braille or audio, and teachers may lack adequate training in the use of assistive tools [4]. In addition, many schools do not have sufficient resources to support the specific learning needs of students with visual impairment. These challenges limit students' independence and restrict their ability to fully engage with schoolwork, especially in an increasingly digital learning environment [2].

Assistive Technology (AT) has been widely recognised as a practical means of reducing learning barriers and supporting students with visual impairment. AT refers to tools, devices, and systems that enable individuals with disabilities to perform tasks that would otherwise be difficult or impossible [5]. Early mastery of Smartphone-Based Assistive Applications prepares students for workplace independence, as technology competence is a documented predictor of successful employment outcomes for visually impaired youth [6]. For students with visual impairment, such technologies facilitate access to reading materials, support communication, enhance mobility, and promote active participation in classroom activities. AT plays a significant role in improving access to educational resources and promoting independent learning among students with visual impairment [7]. Evidence indicates that effective use of AT can lead to improved academic performance, increased self-confidence, and greater independence among learners with visual impairment [8]. Recent reviews highlight persistent gaps between AT availability and meaningful utilization in developing regions [9].

In recent years, smartphones have become one of the most important platforms for AT. Modern smartphones come with built-in accessibility features such as screen readers, voice commands, magnification tools, and audio feedback [7]. In addition, many Smartphone-Based Assistive Applications have been developed to support reading, note-taking, object recognition, navigation, and online learning. Compared to traditional assistive devices, smartphones are more affordable, portable, and widely available, making them especially relevant in developing countries like Nigeria [5]. Recent studies also show that Smartphone-Based Assistive Applications significantly enhance independence, digital accessibility, and participation among individuals with visual impairment when appropriate training is provided [10].

Recent developments in mobile learning technologies further demonstrate the potential of smartphone-based applications in inclusive education. Research has shown that mobile learning applications specifically designed for students with visual impairment can improve engagement, learning outcomes, and accessibility of instructional materials when combined with structured instructional support [11].

The widespread use of smartphones among young people suggests that they have strong potential to support students with visual impairment in their education. Many students already own smartphones or have access to them at home or in school. However, ownership of a smartphone does not automatically mean that it is being used effectively for learning. Evidence from previous studies indicates that many students with visual impairment use only basic phone functions and are not fully aware of or skilled in using assistive applications that could support their education [12]. This highlights a gap between access to technology and meaningful use of that technology.

In Nigeria, research on AT has highlighted critical gaps between device availability and meaningful utilization. While smartphones and screen readers are increasingly available in academic libraries, students with visual impairment often lack the training needed to use these tools effectively for information access and learning [13]. Even fewer studies have examined whether structured training programs can improve the way students with visual impairment use these applications over time. Most existing studies are descriptive in nature and do not clearly show whether training leads to improved and sustained utilisation of AT, especially at the local government level [4].

While descriptive studies in Nigeria have highlighted gaps in awareness, availability, and barriers to AT adoption among individuals with visual impairment [4], few have moved beyond surveys to examine the effects of structured training interventions on meaningful utilization of smartphone-based assistive applications. Existing research in the Nigerian and broader African contexts tends to be correlational or qualitative, documenting challenges such as inadequate teacher training, limited device access, and underutilization despite ownership [14]. But rarely employs quasi-experimental designs to establish intervention impacts or test moderators. In particular, there is a notable absence of studies investigating how age of onset of visual impairment (early/congenital versus late/adventitious) influences training outcomes, despite evidence suggesting that prior visual experience facilitates faster adaptation to touchscreen and non-visual interfaces [15]. At the local level, no documented evidence exists in Lafia more broadly on baseline utilization patterns of smartphone assistive applications among students with visual impairment, nor on whether targeted training programs can bridge the access-to-utilization gap in resource-constrained special education settings.

This methodological and contextual gap underscores the need for a controlled quasi-experimental study that evaluates training effects while accounting for individual differences such as age of onset.

In Lafia, there is little documented evidence on how students with visual impairment use Smartphone-Based Assistive Applications in their daily learning activities. It is unclear whether students receive formal training on how to use these applications or whether they rely on trial-and-error methods. Without proper guidance, students may struggle to use assistive applications effectively, which reduces the educational benefits that smartphones are expected to provide [8].

Evaluating the effects of a training program provides an opportunity to examine changes in utilisation patterns among students who receive the intervention compared to those who do not. By assessing students' level of utilisation before and after the training, it becomes possible to determine whether the program leads to measurable improvement. Comparing an experimental group that receives training with a control group that continues with routine instruction allows for a clearer understanding of the effectiveness of the intervention. Controlling for initial skill levels strengthens causal interpretation [7].

Therefore, this study focused on examining the effects of an AT training program on the utilisation of Smartphone-Based Assistive Applications among students with visual impairment in Lafia. The study addressed the following research questions: RQ1: To what extent do students with visual impairment utilise smartphone-based assistive applications before the training? RQ2: What is the level of utilisation after the training? RQ3: What is the difference in utilisation between students who received the training and those who did not? RQ4: Does age of onset of visual impairment influence utilisation outcomes?

The following null hypotheses were formulated in alignment with the ANCOVA model: $H_1$: There is no significant effect of group (experimental versus control) on post-test utilisation scores after controlling for pre-test scores $H_2$: There is no significant main effect of age of onset on post-test utilisation scores after controlling for pre-test scores. $H_3$: There is no significant interaction effect between group and age of onset on post-test utilisation scores after controlling for pre-test scores.

## 2. Conceptual Review

AT training program is defined by [16] as a structured set of learning activities designed to help individuals with disabilities acquire the practical knowledge, skills, and confidence needed to effectively use assistive devices and applications to support daily living, learning, and participation in society. Such training emphasizes hands-on practice and user-centered support to ensure that assistive technologies are meaningfully integrated into users' real-life contexts [17].

In the same vein, visual impairment is a term used to describe any degree of vision loss that cannot be corrected with glasses or contact lenses. According to the World Health Organization (WHO), visual impairment is defined as "a decrease in visual acuity to 20/70 or less in the better eye, with best possible correction, or a visual field of less than 20 degrees in the better eye" [18].

Similarly, Smartphone-Based Assistive Application is operationally defined as built-in or downloaded accessibility tools on a smartphone device that assist and is frequently used by a student with visual impairment to carry out variety of tasks, such as screen reading, OCR scanning, GPS navigation, or voice dictation, measured as the extent of day-to-day utilisation.

Age of Onset, operationally refers to the chronological age at which disability sets in, whether at birth, during childhood, or later in adulthood. It however, shapes how individuals learn adaptive skills and how they interact with assistive technologies.

In addition, Mobile accessibility for students with visual impairment refers to the process of independently and effective utilisation of smartphone or tablet by students with visual impairment to complete everyday academic tasks like reading course materials, submitting assignments, joining virtual classes, or navigating campus apps using the accessibility tools.

### 2.1 Theoretical Framework

This study is anchored on the Technology Acceptance Model (TAM) originally proposed by Davis (1989). TAM posits that an individual's behavioural intention to use a technology is primarily determined by two key beliefs: perceived usefulness (the degree to which a person believes that using the technology will enhance his or her performance) and perceived ease of use (the degree to which a person believes that using the technology will be free of effort) [19,20]. Although the core TAM constructs (perceived usefulness and perceived ease of use) were not directly measured in this study, the model serves as a valuable conceptual lens for understanding the utilisation of smartphone-based assistive applications. The AT training programme was specifically designed to target the central mechanisms proposed by TAM. Through structured hands-on demonstrations, guided practice, and skill-building activities, the training aimed to increase students' perceived ease of use by teaching practical gestures, commands, and navigation techniques for screen readers, magnification tools, and other accessibility features. Simultaneously, the training highlighted the practical benefits of these applications for academic tasks (reading materials, note-taking, navigation, and independent learning), thereby enhancing perceived usefulness. According to TAM, improvements in perceived usefulness and ease of use are expected to enhance behavioural intention and ultimately increase utilisation of assistive applications. Previous studies in AT and inclusive education have similarly applied TAM as a guiding framework even when only behavioural outcomes (utilisation) were measured, because training programmes naturally act on the model's core predictors [20].

### 2.2 Empirical Review

#### 2.2.1 AT and Access to Academic Content

Assistive technologies have been widely recognized as essential tools for improving access to information and learning materials for students with visual impairment. These technologies include screen readers, text-to-speech systems, navigation tools, and other accessibility features that enable visually impaired learners to interact with digital resources independently. Previous studies have shown that assistive technologies significantly enhance access to academic materials and facilitate participation in learning activities among students with visual impairment [7].

Despite the growing availability of smartphones and other digital devices, research indicates that many students with visual impairment use their devices only for basic functions and do not fully utilize assistive applications that could support their educational activities [21]. This situation reflects a gap between access to technology and meaningful use. Similar patterns have been documented in AT research, where lack of adequate training and insufficient support systems often lead to limited utilization or abandonment of assistive devices.

Recent technological developments have also expanded the possibilities of AT use among visually impaired individuals. Emerging innovations include artificial-intelligence-based object recognition systems, mobile navigation tools, and multimodal assistive interfaces that provide both audio and tactile feedback. These technologies are increasingly enabling visually impaired users to interact more independently with digital environments and access information more effectively [22,23]. The rapid advancement of such intelligent assistive technologies suggests that smartphones can function as powerful assistive tools capable of supporting both academic and daily activities.

#### 2.2.2 Training and Utilisation of Smartphone-Based Assistive Applications

Although assistive technologies offer substantial benefits, their effective use depends largely on users' knowledge and skills. Several studies have identified lack of training as one of the major barriers to the effective utilization of smartphone accessibility features among visually impaired individuals.

For instance, a study investigating smartphone screen reader usage among blind teenagers in rural Nepal revealed that although the participants owned smartphones, none had received formal training on how to operate screen readers or use accessibility features effectively [24]. The study further showed that the participants lacked knowledge of fundamental commands such as gesture navigation and text-selection functions. Similarly, another study examining global patterns of smartphone accessibility feature utilization among students with visual impairment identified inadequate training and limited awareness as the primary barriers to effective use of assistive technologies [17].

These findings indicate that ownership of smartphones alone does not guarantee meaningful use of assistive applications. Instead, structured training programmes are necessary to equip visually impaired learners with the skills required to utilize assistive technologies effectively for educational purposes.

#### 2.2.3 Age of Onset of Visual Impairment and Technology Adoption

Another factor that has been identified as influencing AT adoption is the age at which visual impairment sets in whether early onset or late onset. Research suggests that individuals with adventitious or acquired visual impairment often retain visual memory and spatial concepts developed before vision loss. These prior experiences can facilitate faster adaptation to touchscreen interfaces and digital technologies [25].

In contrast, individuals with congenital or early-onset blindness may require more structured instructional approaches when learning to use assistive technologies. Studies indicate that students with later-onset vision loss typically require less intensive training to achieve proficiency with assistive technologies, while those with early-onset blindness may benefit from scaffolded multisensory instruction that integrates tactile and auditory learning strategies [14]. These differences highlight the importance of designing training programmes that consider users' visual history and learning needs.

#### 2.2.4 Contextual Barriers in African Educational Settings

Beyond individual characteristics, institutional and environmental factors also influence the effective utilization of assistive technologies among students with visual impairment. Research conducted in African educational contexts has identified several barriers that limit the integration of assistive technologies in schools.

A qualitative study conducted at the Akropong School for the Blind in Ghana identified inadequate teacher training, limited availability of assistive software and hardware, unreliable electricity supply, and insufficient institutional support as major obstacles to effective AT use [13]. The study emphasized that awareness of assistive technologies alone is insufficient; sustainable access to functional devices, trained instructors, and maintenance support is necessary for meaningful technology utilization in educational settings.

Similarly, limited utilization of smartphone-based assistive technologies among students with visual impairment has been documented in Ghana, where factors such as inadequate training opportunities and lack of institutional support continue to constrain effective technology adoption [15]. These findings highlight the need for targeted interventions that address both individual and systemic barriers to AT use in developing country contexts.

#### 2.2.5 Real-World Evaluation of Smartphone Assistive Technologies

In addition to supporting educational activities, smartphone-based assistive technologies have over time demonstrated significant benefits in enhancing independent mobility and navigation among visually impaired individuals. For example, a field-based evaluation of the All Aboard smartphone application examined its effectiveness in assisting blind and visually impaired travelers to locate bus stops using real-time sign detection [22]. The study involved twenty-four legally blind participants navigating real urban environments in Boston. Findings revealed that the application significantly outperformed conventional GPS navigation tools such as Google Maps in accurately guiding users to bus stop locations. Importantly, the study also showed that participants combined the application with environmental cues such as auditory landmarks and tactile feedback to navigate effectively. This demonstrates that assistive technologies are often used in combination with users' adaptive strategies in real-world contexts.

### 2.3 Research Gap

The reviewed literature demonstrates that assistive technologies have considerable potential to enhance access to information and independence among individuals with visual impairment. However, several factors influence the effective utilization of these technologies, including the availability of training, users' awareness and competence, the age of onset of visual impairment, and institutional support systems. Although smartphone-based assistive applications are increasingly available, limited research has examined the impact of structured training programmes on their utilization among students with visual impairment particularly in developing countries. This gap provides the rationale for the present study.

## 3. Methodology

### 3.1 Research Design

The research design employed in this study is the quasi-experimental design (pre-test/post-test non-equivalent control group design) to investigate the impact of AT training program on utilisation of smartphone-based assistive applications among students with visual impairment. This research design was chosen because it applies to real-world settings, it allows causal inference by comparing baseline (pre-test) and outcome (post-test) measures, and also, it was not possible to randomly assign participants to groups within the school settings. Therefore, two intact groups of students were used: an experimental group, which received the AT training intervention, and a control group, which continued with regular instruction without the specialised training.

Both groups were assessed before the intervention (pre-test) and after the intervention (post-test) using the same utilisation measurement instrument. The design enabled the researcher to determine whether changes in utilisation scores were attributable to the training programme or not.

The design is represented as:

$O_1$ X $O_2$ (Experimental Group)

$O_1$ $O_2$ (Control Group)

Where:

X = AT training program

$O_2$ = Observation (utilisation measurement)

Due to the use of intact school-based groups (one school as experimental, the other as control), random assignment was not feasible. This non-equivalent control group design introduces potential selection bias, as systematic differences between schools could influence outcomes. To mitigate this, purposive selection ensured both groups were drawn from similar special schools in Lafia serving comparable student populations. Baseline comparability checks (Table 1) supported group equivalence on measured variables. However, unmeasured confounders cannot be fully ruled out, and findings should be interpreted with this limitation in mind."

**Table 1.** Baseline demographic characteristics and pre-test utilisation scores by group.

| Variable | Experimental Group (n = 30) | Control Group (n = 30) | Total (N = 60) | *p*-value |
|---|---|---|---|---|
| Age (years), *M* (SD) | 19.7 (2.8) | 19.9 (3.0) | 19.8 (2.9) | > .05 |
| Gender: Male, n (%) | 17 (56.7%) | 17 (56.7%) | 34 (56.7%) | > .05 |
| Severity: Blind, n (%) | 19 (63.3%) | 19 (63.3%) | 38 (63.3%) | > .05 |
| Age of Onset: Early-onset, n (%) | 21 (70.0%) | 21 (70.0%) | 42 (70.0%) | > .05 |
| Pre-test SAAUS Total Score, *M* (SD) | 28.45 (7.62) | 29.12 (6.94) | 28.79 (7.25) | > .05 |

Note: SAAUS: Smartphone Assistive Application Utilisation Scale

### 3.2 Study Area

The study was conducted in Lafia, located in Nasarawa State, Nigeria. Lafia serves as the administrative headquarters of the state and hosts several educational institutions, including schools that provide services for learners with visual impairment. The presence of students with visual impairment and the availability of smartphones among students made the location suitable for investigating the utilisation of Smartphone-Based Assistive Applications. These institutions serve a diverse population, including students with various forms of visual impairment who require Smartphone-Based Applications for independent living.

### 3.3 Population of the Study

The population for the study consisted of all students with visual impairment in Lafia, Nasarawa State, Nigeria. These students included both blind and low-vision learners who use smartphones for educational and personal communication purposes. The participants for this study consisted of students with visual impairment drawn from two special schools in Lafia. The sample comprised both male and female SSS 1 to SSS 3 students, within the age range of 15 to 25 years, representing upper primary and secondary school levels. All participants had access to smartphones capable of running assistive applications used in the training programme.

Characteristics of the Population: All 60 participants were senior secondary school (SSS 1-3) students with visual impairment enrolled in two special schools in Lafia, Nasarawa State, Nigeria. Participants ranged in age from 15 to 25 years (M = 19.8, SD = 2.9). The sample included 34 males (56.7%) and 26 females (43.3%). With regard to severity of visual impairment, 38 participants (63.3%) were classified as blind (total or near-total vision loss), and 22 (36.7%) had low vision (partial sight with best correction). Age of onset was dichotomized as early-onset (congenital or before age 5; n = 42, 70.0%) and late-onset (after age 5; n = 18, 30.0%). All participants reported owning or having regular access to a smartphone capable of running assistive applications (primarily Android devices with TalkBack or similar features), although prior formal training in assistive apps was minimal based on pre-test responses.

To establish baseline comparability between the experimental and control groups, demographic characteristics and pre-test SAAUS scores were compared (see Table 1). Independent samples t-tests and chi-square tests showed no statistically significant differences between the two groups on any demographic variable or pre-test utilisation scores (all $p > .05$). This supports reasonable baseline equivalence despite the use of non-randomly assigned intact school groups.

### 3.4 Sample and Sampling Techniques

Due to small population size, the study adopted Purposive sampling techniques. This approach was considered appropriate because the study required participants who were visually impaired and had access to smartphones capable of running assistive applications. However, the use of purposive sampling limits the generalisability of the findings because the sample does not fully represent all students with visual impairment. One school was adopted as experimental group while the other control group. No a priori power analysis was conducted, as the study was exploratory in a real-world, resource-limited educational setting with a naturally constrained population size. However, the observed large effect size for the main group effect (partial $\eta^2 = 0.573$) indicates that post-hoc statistical power for detecting this difference was very high (approaching 1.0 based on the obtained $F(1, 56) = 76.54$ and $\alpha = 0.05$), supporting the reliability of the primary finding despite the modest sample. The experimental group participated in the AT training programme, while the control group continued with regular learning activities.

### 3.5 Ethical Consideration

Ethical approval for this study was not required under the institutional guidelines governing non-invasive educational research at the Federal University of Lafia. However, formal administrative permission was obtained from the participating schools and the study adhered to established ethical standards for research involving human participants, including informed consent, voluntary participation, and confidentiality. All data were anonymized to protect participants' identities.

### 3.6 Instrument for Data Collection

The instrument that the researcher used to collect data is a researcher-designed instrument. The instrument enabled the researcher to collect detailed information from the respondent for the study on the effects of AT training programme on utilisation of Smartphone-Based Assistive Applications of students with visual impairment in Lafia, Nasarawa State. One instrument Smartphone Assistive Application Utilisation Scale (SAAUS) was developed by the researcher. The primary instrument used to collect data was the SAAUS, a 30-item researcher-developed questionnaire designed specifically for this study. The SAAUS measures the extent to which students with visual impairment utilize smartphone-based assistive applications in their daily learning and personal activities. The scale consists of three sub-dimensions: Frequency of use (10 items): Assesses how often participants engage with assistive features/apps (e.g., daily, weekly). Diversity of applications used (10 items): Evaluates the range/variety of different assistive apps or features employed. Competence in using assistive features (10 items): Measures perceived skill level and confidence in independent operation. All items are rated on a 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree). Higher scores indicate greater overall utilization. The total score is calculated by summing all 30 items (possible range: 30-150). Subscale scores can be computed separately if needed, but the present study analyzed the total utilization score for primary comparisons. Sample items from each sub-dimension include: Frequency: "How often do you use a screen reader (TalkBack or VoiceOver) to read text messages or documents?" (Rated 1-5). Diversity: "How many different smartphone assistive applications (object recognition, navigation, magnification) do you use in a typical week?" (Rated 1-5). Competence: "I can independently adjust magnification settings or voice commands without assistance." (Rated 1-5.)

It consisted of three sub-dimensions: frequency of use, diversity of applications used, and competence in using assistive features. The instrument comprised structured items rated on a Likert scale, with higher scores indicating greater utilisation of smartphone-based assistive applications. The instrument measured the extent to which students used Smartphone-Based Assistive Applications.

The SAAUS yields a total utilisation score (range: 30-150), with higher scores indicating greater frequency, diversity, and competence in assistive app use. Subscale scores (Frequency, Diversity, Competence; each 10-50) can be examined separately if needed, though the present analysis used the total score. Sample items are provided above.

### 3.7 Validity of the Instrument

Face and content validity were established through expert review by three specialists (one in Special Needs Education and two in Measurement and Evaluation). Experts evaluated item relevance, clarity, and coverage of the utilisation construct involving frequency, diversity, and competence. Suggested revisions were incorporated to improve alignment with the operational definition of smartphone-based assistive application utilisation. While exploratory factor analysis (EFA) was not conducted due to sample constraints, the three theoretically derived subscales provide initial support for dimensional structure, consistent with prior AT utilisation measures. In addition to expert validation, construct validity of the SAAUS was theoretically established by aligning items with three core dimensions of AT utilisation: frequency of use, diversity of applications, and operational competence. These dimensions are consistent with established conceptualizations of technology utilisation in AT literature, which emphasize not only access but also breadth and skill of use. Each item was mapped to one of these domains to ensure adequate construct representation.

Although EFA was not conducted due to the relatively small sample size, the internal consistency of the full scale ($\alpha$ = 0.84) and the theoretically grounded multidimensional structure provide preliminary support for the construct validity of the instrument. Future studies with larger samples are recommended to further establish the factor structure and dimensional stability of the SAAUS.

### 3.8 Reliability of the Instrument

Cronbach's alpha for the full 30-item SAAUS was 0.84, indicating good internal consistency. Following [26], this value suggests the items are sufficiently interrelated without excessive redundancy. Subscale alphas (if computed) should similarly exceed 0.70 for acceptability. This indicated that the instrument was internally consistent and suitable for the study.

### 3.9 Procedure for Data Collection

The study was conducted in three stages following ethical considerations all through the data collection process.

#### 3.9.1 Procedure for Pretest

Before the commencement of the intervention, a pretest was conducted for both the experimental and control groups. The purpose of the pretest was to establish baseline data on students' utilisation and exposure to smartphone-based assistive application. During the pretest, the SAAUS was used to observe students' baseline performance. All observations and ratings were conducted under standardized conditions to ensure consistency.

### 3.9.2 Procedure for Intervention

The experimental group received structured AT training programme on the use of Smartphone-Based Assistive Applications. The training programme lasted for 3 weeks and consisted of two sessions per week, with each session lasting approximately 90 minutes. Training covered accessibility features such as screen readers, voice commands, magnification tools, and navigation applications. The training sessions were conducted and involved guided demonstrations and hands-on practice for the experimental group. The control group continued with routine instruction, which did not include any structured training on smartphone-based assistive applications. Their learning activities were limited to regular classroom instruction without exposure to the intervention content.

### 3.9.3 Procedure for Posttest

At the end of the intervention, a posttest was conducted for both groups using the same instruments applied during the pretest. The instruments were administered with the assistance of the researchers to ensure that participants understood each item.

### 3.10 Method of Data Analysis

The collected data were analyzed using descriptive and inferential statistical tools. Mean, and standard deviation were used to summarize utilisation scores. To determine the effect of the training intervention while controlling for baseline differences, Analysis of Covariance (ANCOVA) was employed. The pre-test scores served as the covariate, while the post-test scores served as the dependent variable. The statistical software SPSS was used to perform the analysis, and statistical significance was determined at the 0.05 level of significance. Prior to conducting ANCOVA, key statistical assumptions were systematically evaluated. These included normality of residuals (assessed via skewness and kurtosis values), linearity between the covariate and dependent variable, homogeneity of variances (Levene's test), and homogeneity of regression slopes (interaction between covariate and grouping variable). All assumptions were satisfactorily met, indicating that the data were appropriate for ANCOVA analysis.

## 4. Results

Table 2 shows that students with visual impairment in the experimental group increased their mean utilisation score from 28.45 in the pre-test to 47.83 in the post-test after receiving the AT training. This substantial increase suggests that the intervention had a strong positive effect on Smartphone-Based Assistive Application utilisation. The findings of this study are consistent with recent research demonstrating that mobile-based assistive technologies can significantly enhance independence, learning engagement, and technology utilisation among visually impaired users when adequate training and support are provided [7,10].

**Table 2.** Pre-test and post-test mean utilisation scores of the experimental group.

| Test | N | M | SD | Std. Error | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| Pre-test | 30 | 28.45 | 7.62 | 1.39 | 0.14 | -0.91 |
| Post-test | 30 | 47.83 | 6.11 | 1.12 | -0.18 | -1.08 |

Sources: Computation using STATA.

Table 3 shows that students in the control group also recorded an improvement in mean utilisation from 29.12 to 34.67 under regular instruction. However, the magnitude of this improvement was considerably smaller than that observed in the experimental group.

**Table 3.** Pre-test and post-test mean utilisation scores of the control group.

| Test | N | M | SD | Std. Error | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| Pre-test | 30 | 29.12 | 6.94 | 1.27 | 0.11 | -0.88 |
| Post-test | 30 | 34.67 | 7.21 | 1.32 | 0.07 | -0.92 |

Sources: Computation using STATA.

Table 4 shows that the experimental group achieved a higher post-test mean utilisation score (47.83) than the control group (34.67). This indicates that the training intervention was more effective than routine instruction in improving utilisation of Smartphone-Based Assistive Applications.

**Table 4.** Post-test mean utilisation scores of experimental and control groups.

| Group | N | Post-test M | SD | Std. Error | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| Experimental | 30 | 47.83 | 6.11 | 1.12 | -0.18 | -1.08 |
| Control | 30 | 34.67 | 7.21 | 1.32 | 0.07 | -0.92 |

Sources: Computation using STATA.

ANCOVA was conducted to examine the effect of the AT training programme on post-test utilisation scores while controlling for pre-test differences and examining the moderating influence of age of onset. The results showed that group membership had a significant effect on post-test utilisation scores, $F(1, 56) = 76.54$, $p < .001$, partial $\eta^2 = .573$. This indicates that students who received the training achieved significantly higher utilisation scores than those in the control group. The pre-test covariate was not statistically significant, $F(1, 56) = 0.42$, $p = .519$, suggesting that baseline utilisation levels did not significantly influence post-test outcomes. A significant main effect of age of onset was observed, $F(1, 56) = 5.21$, $p = .026$, partial $\eta^2 = .084$, indicating that students with late-onset visual impairment tended to achieve higher utilisation scores than those with early-onset impairment. Furthermore, the interaction between group and age of onset was statistically significant, $F(1, 56) = 4.28$, $p = .043$, partial $\eta^2 = .070$, suggesting that the effectiveness of the training programme varied depending on the age at which visual impairment occurred, with students with late-onset visual impairment benefiting more from the intervention (Table 5).

**Table 5.** ANCOVA results for post-test utilisation scores.

| Source | Type III SS | Df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Pre-test (Covariate) | 19.61 | 1 | 19.61 | 0.42 | 0.519 | 0.007 |
| Group | 3546.21 | 1 | 3546.21 | 76.54 | 0.000 | 0.573 |
| Age of Onset | 241.88 | 1 | 241.88 | 5.21 | 0.026 | 0.084 |
| Group × Age of Onset | 198.76 | 1 | 198.76 | 4.28 | 0.043 | 0.070 |
| Error | 2449.11 | 56 | 43.73 | | | |
| Total | 40888.67 | 60 | | | | |

The adjusted mean difference between the experimental and control groups was substantial. On average, students in the experimental group scored approximately 13.16 points higher than those in the control group on the post-test utilisation measure, based on estimated marginal means. The 95% confidence intervals did not overlap substantially, indicating a robust group effect.

The effect size for the main effect of group (partial $\eta^2 = 0.573$) is considered large based on conventional benchmarks (small = 0.01, medium = 0.06, large = 0.14), indicating that the intervention accounted for a substantial proportion of variance in utilisation outcomes. Similarly, the interaction effect (partial $\eta^2 = 0.070$) represents a moderate effect, suggesting meaningful moderation by age of onset.

The estimated marginal means reveal a clear interaction pattern between group and age of onset. Students in the experimental group with late-onset visual impairment recorded the highest adjusted utilisation scores ($M = 50.60$, $SE = 1.20$), followed by those with early-onset impairment ($M = 44.90$, $SE = 1.25$). In contrast, the control group recorded lower adjusted means for both early-onset ($M = 33.20$, $SE = 1.30$) and late-onset students ($M = 36.10$, $SE = 1.28$). The differences between the experimental and control groups were more pronounced among late-onset students, supporting the presence of a moderating effect of age of onset (Table 6).

**Table 6.** Estimated marginal means of post-test utilisation scores by group and age of onset.

| Group | Age of Onset | Adjusted Mean | Std. Error | 95% CI Lower | 95% CI Upper |
|---|---|---|---|---|---|
| Experimental | Early | 44.90 | 1.25 | 42.40 | 47.40 |
| Experimental | Late | 50.60 | 1.20 | 48.20 | 53.00 |
| Control | Early | 33.20 | 1.30 | 30.60 | 35.80 |
| Control | Late | 36.10 | 1.28 | 33.50 | 38.70 |

## 5. Discussion of Findings

The findings of this study indicated that the AT training intervention had a significant positive effect on utilisation of Smartphone-Based Assistive Applications among students with visual impairment in Lafia. As shown in Table 2, the experimental group increased their mean utilisation score from 28.45 in the pre-test to 47.83 in the post-test, while the control group (Table 3) improved from 29.12 to 34.67 under routine instruction. The post-test comparison (Table 4) further confirms that students who received the training significantly outperformed their peers in the control group (47.83 versus 34.67), demonstrating the effectiveness of structured training in enhancing assistive application use. The increased utilisation of smartphone-based assistive applications observed in the experimental group can be explained through the TAM, suggests that users are more likely to adopt technologies when they perceive them as useful and easy to use [19].

The ANCOVA results demonstrate that the AT training programme significantly improved the utilisation of Smartphone-Based Assistive Applications among students with visual impairment. The large effect size (partial $\eta^2 = 0.573$) indicates that the intervention accounted for a substantial proportion of the variance in utilisation scores. In addition, age of onset significantly influenced utilisation outcomes. Students with late-onset visual impairment benefited more from the training programme than those with early-onset impairment. This may be attributed to prior visual experience and familiarity with touchscreen interfaces, which facilitate faster adaptation to smartphone-based assistive technologies. Comparison between the two groups confirmed that the experimental group had significantly higher post-test utilisation scores than the control group ($F = 76.54$, $p < 0.001$, partial eta squared = 0.573), and the non-significant pre-test covariate suggests that baseline utilisation did not influence these differences.

Importantly, age of onset emerged as a key determinant of utilisation outcomes. Students with late-onset visual impairment generally demonstrated higher gains in utilisation after the training compared to those with early-onset impairment. This suggests that prior visual experience and familiarity with smartphone interfaces may facilitate more rapid adoption of assistive applications. Conversely, early-onset students, who may have limited prior exposure to visual technology, appear to require more intensive or tailored training to achieve comparable proficiency. The interaction between group assignment and age of onset indicates that the effectiveness of the training intervention is moderated by the timing of vision loss.

These findings align with previous research emphasizing that training interventions improve AT competence [27,28], and that age of onset influences technology adoption trajectories among learners with visual impairment [17]. The large effect sizes observed in this study demonstrate that structured training, coupled with consideration of age of onset, can yield substantial improvements in assistive application utilisation, supporting independent learning and technological engagement among students with visual impairment.

The findings support the TAM, which suggests that users are more likely to adopt technology when they perceive it as useful and easy to use. The training programme likely enhanced students' perceived ease of use and perceived usefulness of Smartphone-Based Assistive Applications, thereby increasing their level of utilisation.

## 6. Conclusion

The study concluded that the AT training intervention significantly improved utilisation of Smartphone-Based Assistive Applications among students with visual impairment in Lafia Local Government. Students in the experimental group demonstrated considerably higher post-test utilisation scores than those in the control group, confirming the effectiveness of structured, hands-on training in enhancing the adoption and use of assistive technologies.

Crucially, the findings indicated that age of onset is an important determinant of utilisation outcomes. Students with late-onset visual impairment achieved higher gains in post-test utilisation compared to early-onset students, suggesting that prior visual experience and familiarity with technology facilitate faster adaptation. Conversely, students with early-onset impairment may require more intensive or differentiated training to achieve similar levels of competence. This underscores the need to tailor training interventions according to the age of onset to maximize the effectiveness of AT programs.

This study has several limitations. The relatively small sample (N=60), drawn purposively from only two special schools in Lafia, limits generalizability to broader Nigerian or international contexts. The short intervention duration (3 weeks) may not capture long-term retention of skills. Reliance on self-reported data via SAAUS introduces potential social desirability or recall bias. The quasi-experimental design with non-random school-based assignment precludes full causal attribution due to possible selection bias and unmeasured confounders. Future research should employ larger, multi-site samples, randomized designs where feasible, objective usage logs (e.g., app analytics), and longer follow-up periods.

## 7. Recommendations

The study recommends prioritizing the integration of structured AT training into the curriculum for students with visual impairment through government intervention, while encouraging teachers to adopt hands-on practice and practical application of smartphone-based applications. To optimize effectiveness, differentiated training strategies should be implemented based on the age of onset of visual impairment, providing students with early-onset conditions longer, stepwise, or multisensory training approaches, and those with late-onset impairment more intensive, technology-focused sessions. Furthermore, ongoing technical support and mentorship should be provided to reinforce the use of assistive applications and ensure consistent adoption across students with varying visual histories. Ultimately, policymakers and special needs educators are urged to prioritize AT literacy as a core component of educational programming for visually impaired learners.

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## Ethics Statement

Ethical approval for this study was not required under the institutional guidelines governing non-invasive educational research at the Federal University of Lafia. However, formal administrative permission was obtained from the participating schools. Informed consent was obtained from all participants and their guardians. The study adhered to ethical principles of voluntary participation, confidentiality, and data anonymization.

### Data Availability Statement

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

### Author Contributions

Yahaya Murotshak Komo: Conceptualization, Methodology, Investigation, Data Curation, Writing Original Draft, Writing Review & Editing.

Dungrit Peter Gelle: Validation, Formal Analysis,

Both authors read and approved the final manuscript.

### Conflict of Interest

The authors declare no conflicts of interest.

### Generative AI Statement

During the preparation of this manuscript, the authors used Grammarly / ChatGPT solely for language editing and proofreading. All content, analysis, and interpretations were authored and verified by the researchers. The authors take full responsibility for the content.

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