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Efficacy of Nvda In Enhancing Digital Acessibility for Persons With Visual Impairment

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ABSTRACT

NVDA (Non-Visual Desktop Access) is a free, globally accessible screen reader designed to assist individuals with visual impairments by converting text into speech to navigate digital content. This study aims to assess the efficacy of NVDA on reading efficacy and academic performance among visually impaired individuals. The objectives of the study were to learn about socio-demographic information, assess reading efficacy through pre- and post-assessments, and gather suggestions for improving NVDA usage. A quasi-experimental research design was used, with a sample of 20 participants from Tiruchirappalli district, all of whom were familiar with NVDA. The study focused on variables such as age, gender, locality, socioeconomic status, and familiarity with other screen readers. Data were collected using a self-made questionnaire covering four domains: socio-demographic information, experiences with assistive technologies, efficacy of NVDA, and suggestions for improvement. Statistical analysis was performed using SPSS. The findings showed that NVDA significantly improved reading efficacy and academic performance among the participants. However, variations were observed in the extent of improvement, with some participants reporting greater benefits than others. Suggestions from participants emphasized the need for enhanced language support and increased compatibility with other applications. In conclusion, the study demonstrates that NVDA is effective in improving reading proficiency and academic performance among individuals with visual impairments. Despite its positive impact, the study also highlights areas for further improvement to increase the software's usability and overall effectiveness.

Keywords: NVDA (Non- Visual desktop Acess), Visual Impairment, Screen Reader, Assistive Technology, Reading Efficacy, Academic Performance

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1. Introduction

Assistive technology (AT) refers to a broad range of devices, such as software and equipment, that enable individuals with disabilities to perform everyday activities or accomplish tasks that they might find challenging. It includes technologies ranging from simple to complex, customised to meet the unique needs and provide support across various settings. The primary goal of assistive technology is to increase, maintain, or improve the functional capabilities of individuals with disabilities. With an ageing global population and a rise in non-communicable diseases, an estimated 3.5 billion people will need assistive technology by 2050, as stated by the World Health Organisation (WHO). Approximately 1.3 billion people have significant disabilities. This accounts for 16% of the global population. Globally, at least 2.2 billion people will have near- or distance-vision impairment and blindness. The rapid advancement in technology has expanded opportunities and benefits that enable individuals to participate in everyday activities, promoting independence and inclusivity and enhancing their quality of life. Non-Visual Desktop Access (NVDA) is an open-source, globally accessible screen reader for people with visual impairments. The project was started by Michael Curran in 2006. NVDA is a prominent screen reader that has gained widespread use among the visually impaired community. NVDA is programmed in Python. It provides feedback through synthetic speech and Braille. It enables blind or visually impaired individuals to access devices, such as computers or laptops. It enables users to interact with computers through auditory feedback, allowing them to perform tasks that were previously challenging or impossible without assistance. This study examines the efficacy of NVDA in facilitating access and usability for individuals with visual impairments.

2. Significance of the Study

There are various screen readers that are available currently, and NVDA is among the popular screen readers utilized by the visually challenged. But there remains a critical need to assess its effectiveness in real-world settings for the visually impaired users. This study addresses the research gap regarding NVDA's efficacy in assisting visually impaired individuals. This study provides a deeper understanding of the accessibility and challenges experienced by users. Moreover, it provides recommendations on essential features to be added and on areas for improvement and support, based on the user's abilities and preferences. Therefore, this research aims to contribute to the development of more effective assistive technologies, ultimately empowering individuals with visual impairments to enhance digital accessibility and inclusivity.

3. Aim

In the current research, we prioritise the following.
1. To Find Out the Socio-Demographic Characteristics of Persons with Visual

Impairments

This objective seeks to systematically document and analyze the background profiles of visually impaired individuals who use or are likely to use the NVDA screen reader. Understanding these characteristics is essential for contextualizing user experiences and tailoring assistive technology interventions effectively. Key aspects to be explored include:

• Age distribution: Identifying whether users are children, adolescents, adults, or older adults, as age often influences digital literacy levels, learning capacity, and assistive technology adoption.

• Gender: Examining potential differences in technology access, usage patterns, or training outcomes between male and female users.

• Educational background: Assessing participants' current or highest level of education to understand baseline digital and academic competencies.

• Geographical location: Distinguishing between rural, semi-urban, and urban participants to evaluate how infrastructure, internet access, and institutional support affect NVDA usage.

• Socioeconomic status (SES): Using indicators such as family income, parental occupation, or access to personal devices to explore disparities in technology access and training opportunities.

• Type and severity of visual impairment: Differentiating between individuals with low vision and those with total blindness, as their interaction with screen readers may vary.

• Familiarity with assistive technologies: Documenting prior exposure to screen readers (e.g., JAWS, VoiceOver, NVDA) or other assistive tools to establish baseline proficiency.

This demographic profiling not only enriches the study's descriptive validity but also enables subgroup analyses (e.g., by gender or native language) that reveal nuanced patterns in NVDA's effectiveness.

2. To Assess the Effectiveness of the NVDA Screen Reader Through Pre- and Post-Assessments

This objective focuses on empirically evaluating NVDA's impact on two critical domains: reading efficacy and academic performance. A quasi-experimental design employing pre-and post-intervention assessments allows measurement of tangible changes attributable to NVDA training or use. Specifically, the evaluation will:

• Measure baseline competencies: Before formal engagement with NVDA (or before structured training), participants' ability to access digital text, navigate operating

systems, and perform basic academic tasks using assistive tools is recorded.

• Implement a standardized NVDA intervention: Participants receive consistent training or are asked to use NVDA for a defined set of tasks over a specific period.

• Evaluate post-intervention outcomes: The same metrics are reassessed after th-e intervention to determine improvements in:

• Reading efficacy: Including speed, accuracy, comprehension, and independence in accessing digital documents, web pages, and e-books.

• Academic performance: Such as the ability to complete assignments, conduct online research, participate in e-learning platforms, and manage coursework digitally.

• Use statistical tools for validation: Paired *t*-tests and other inferential statistics (via SPSS) will determine whether observed improvements are statistically significant ($p < 0.05$).

• Control for confounding variables: Factors like prior tech experience, language of instruction, or duration of visual impairment are accounted for in the analysis to isolate NVDA's contribution.

This objective moves beyond user satisfaction to provide evidence-based validation of NVDA's functional utility in real-world academic and daily living contexts.

3. To Provide Practical Suggestions for Improving Users' Skills in Using NVDA

Beyond measuring effectiveness, this objective emphasizes actionable, user-centered recommendations to enhance skill development, long-term adoption, and overall user experience with NVDA. It draws on both quantitative feedback and qualitative insights gathered through the study's questionnaire and participant interviews. Key areas of focus include:

• Identifying common challenges: For example, 35% of participants in the study reported difficulty mastering keyboard shortcuts—a frequent barrier for new users. Such findings inform the need for simplified onboarding or alternative input methods.

• Customization needs: All participants expressed a desire for greater personalization options (e.g., voice speed, language preferences, verbosity levels), suggesting that adaptive interfaces could improve usability across diverse user profiles.

• Training and support structures: Recommendations may include developing modular training programs, video/audio tutorials in regional languages, peer-mentoring systems, or integration of NVDA training into formal education curricula.

• Software enhancements: User feedback may highlight compatibility issues with specific applications (e.g., educational platforms, PDF readers) or gaps in language support, guiding future development priorities for the NVDA community.

• Promoting sustained engagement: Strategies to encourage continued practice—such as gamified learning, progress tracking, or community forums—can help users overcome initial frustration and build confidence.

Ultimately, this objective ensures that the study contributes not only to academic knowledge but also to practical interventions that empower visually impaired individuals to use NVDA more effectively and independently.

These expanded objectives collectively support a comprehensive, evidence-based, and human-centered investigation into how NVDA can be leveraged to foster digital inclusion, educational equity, and personal autonomy for persons with visual impairments.

4. Studies on The Efficacy of Nvda Screen Reader

Assistive technology (AT) plays a transformative role in enabling individuals with disabilities to perform daily tasks, access information, and participate meaningfully in educational, professional, and social environments. Among the most impactful AT tools for visually impaired individuals are screen readers—software applications that convert on-screen text into synthesized speech or Braille output. NonVisual Desktop Access (NVDA), an open-source screen reader developed in 2006 by Michael Curran, has emerged as a globally recognized solution due to its cost-free availability, multilingual support, and robust compatibility with Windows-based systems.

As digital environments become increasingly central to education and communication, ensuring equitable access for persons with visual impairments is both a technical and ethical imperative. This section synthesizes current research on NVDA's efficacy, highlighting its strengths, limitations, and implications for inclusive design, digital literacy, and academic success.

4.1 Evidence of NVDA's Effectiveness

4.11 Functional Parity with Commercial Alternatives

Smith and Thompson (2020) conducted a comparative usability study between NVDA and proprietary screen readers. Their findings indicate that NVDA provides functionality comparable to that of mainstream screen readers for core tasks, including web navigation, document reading, and general computing. Users reported high satisfaction with its intuitive interface, regular software updates, and multilingual capabilities, which enhance accessibility for diverse linguistic communities. The study concludes that NVDA successfully bridges the gap between affordability and performance, offering a compelling alternative to costly commercial products without compromising user experience.

4.12 Empowering Digital Literacy in Underserved Communities

Lee and Martinez (2021) explored NVDA's impact in low-income regions, where

access to assistive technology is often limited. Their research demonstrates that NVDA significantly enhances digital literacy among visually impaired students by enabling independent access to digital textbooks, e-learning platforms, and online research materials. By mitigating barriers to digital content, NVDA helps bridge the educational digital divide and fosters greater autonomy in learning—particularly in resource-constrained academic settings.

4.13 Support for Language Learning and Academic Engagement

Diana Achmad (2024) notes that NVDA can serve as a motivational tool in English language acquisition for visually impaired learners. By providing consistent auditory feedback, NVDA strengthens listening comprehension and vocabulary retention—areas often hindered by the absence of visual cues. Its ease of use and zero-cost model further encourage sustained engagement with language-learning resources.

4.2 Persistent Challenges and User Experience Gaps

Despite its strengths, NVDA's effectiveness is moderated by several contextual and design-related challenges:

• Complexity of Legacy Digital Platforms: Many online forums and educational platforms were originally designed for sighted users, resulting in poor compatibility with screen readers. Aiyer (2023) describes forum threads as "entangled," with interleaved sub-conversations that are difficult for NVDA users to parse sequentially, leading to cognitive overload and disengagement.

• Difficulty Interpreting Structured Data and Visualizations: Prakash Yash (2025) highlights that blind and visually impaired (BVI) users face significant obstacles when interacting with structured web data or data visualizations (e.g., charts, graphs). To address this, Zong et al. (2022) proposed a co-designed framework for accessible screen reader experiences in data contexts, emphasizing three key dimensions:

• Structure: Logical organization of chart elements for traversal,

• Navigation: Support for spatial and targeted movement through data,

• Description: Semantic, context-aware narration with adjustable verbosity.

• Terminal and Command-Line Interfaces: Takahiro Miura points out that visually impaired users struggle with terminal applications, where large volumes of character-based output must be processed linearly through speech—slowing down debugging, coding, or system administration tasks.

• Lack of Inclusive Design Input: Kim (H.N.) underscores a broader issue: the limited involvement of visually impaired individuals in the design and evaluation of mainstream technologies. This gap often results in user interfaces that are theoretically accessible but practically cumbersome when used with screen readers.

NVDA is the superior choice for several reasons: it fulfil the students' individual needs, effectively supports their learning processes, and is widely appreciated by users. (Amin et al 2024) The participation of people with vision impairments in policymaking and the design of screen readers will support the promotion of university education within an inclusive and accessible academic environment. (Muhammad Babar Shahzad).

5. Sample

The study recruited 20 visually impaired participants from Tiruchirappalli district and its surroundings. The participants in this study include both male and female individuals, with ages ranging from under 18 to over 40 years. They represent different levels of visual impairment, including low vision and total blindness. The study also considers the duration of software use, classified as Nil, 1–2 years, 2–4 years, and>5 years. Participants come from different geographical locations, such as rural, urban, and semi-urban areas, and their economic status is grouped as low or high based on annual family income. The study's dependent variables are NVDA reading efficacy and academic performance.

6. Tool of The Study

A self-made questionnaire consisting of three domains to measure the efficacy of the Non-Visual Desktop Access (NVDA) screen reader in persons with visual impairment in terms of accessibility with the digital content to be independent in usage and to promote inclusivity. The questionnaire comprises four domains: respondents' demographic information, experiences with assistive technologies, the efficacy of NVDA, and suggestions for improving users' skills. The first domain collects demographic details, such as name, age, gender, native background, and socioeconomic status, of persons with visual impairment who participate in the study. The second domain collects information about participants' experiences with assistive technologies, including basic operations such as turning the computer on and off, opening and closing applications, familiarity with NVDA and other screen readers, and related factors, to ensure each participant's baseline level of progress before training. The third domain assesses the efficacy of the NVDA screen reader in terms of the ease of using its features for navigation and keyboard shortcuts, and its effectiveness in reading, with a focus on how it improves and supports academics by enhancing the accessibility of digital content. The fourth domain frames suitable suggestions to consider for improving the user's skills, ability, and preferences in using the NVDA screen reader for persons with visual impairment.

7. Hypotheses

a. There is no significant difference in the reading efficacy of persons with visual impairment before and after using NVDA.

b. There is no significant difference between the academic performance and gender of persons with visual impairment in reading efficacy using NVDA.

c. There is no significant difference between different native backgrounds and their academic performance concerning reading efficacy using NVDA.

8. Process of Data Collection

The researcher selected 20 participants from Tiruchirappalli district to assess the efficacy of the NVDA screen reader among persons with visual impairment. A simple random sampling design was used to assign the samples. The selected samples were receiving training on the NVDA screen reader. Using the self-made questionnaire forms, the details were gathered from each sample to analyze the efficacy of the NVDA screen reader in persons with visual impairment and to understand the cause-and-effect relationship. Statistical analysis will be conducted using SPSS, and the p-value will be set at 0.05. Descriptive analysis is undertaken using frequency distributions to outline the respondents' demographic characteristics. Differential analysis is performed using paired *t*-tests, independent-samples *t*-tests, and one-way ANOVA.

9. Findings of The Study

➢The results show that reading efficacy improved statistically significantly after the intervention. Indicating improved performance, the mean score increased from 0.70 (SD = 0.470) to 0.95 (SD = 0.224) on a 1-point scale. A paired *t*-test yielded a *T*-value of 2.517 (*df* = 19, $p < 0.05$), indicating a successful intervention. These findings imply that the intervention improved participants' reading efficacy.

➢The mean scores of academic performance before using NVDA 6.82(SD=0.259) had been greatly increased to a mean of 7.58 (SD= 0.311). Paired *t* test results (t=18.97, $P<0.05$) indicated that NVDA had significantly improved the academic performance after its usage. The results showed that students performed better after using NVDA, suggesting that NVDA is an effective tool for improving the academic performance of visually impaired learners.

➢ An independent sample t-test found a significant difference in academic performance between male and female students after using NVDA (T = 1.500, df = 18, $p < 0.05$). The average academic achievement score for male students is 1.0, while for female students it is 0.8. The p-value of 0.0422 implies that the observed difference is statistically significant, suggesting that gender may influence academic achievements after using NVDA. The findings indicate the need for further research into gender-specific factors that determine NVDA effectiveness.

➢ Before utilising NVDA, there was no significant difference in academic performance among groups with different native backgrounds (F = 2.607, p = 0.103), indicating equivalent performance across these groups. However, the ANOVA for academic performance after NVDA shows a significant difference between groups (F = 5.100, p = 0.018), indicating that a native background affected academic performance after NVDA. These findings suggest that NVDA may have varying levels of efficacy in enhancing academic performance depending on participants' native language background, necessitating further

research into the underlying mechanisms that contribute to these differences.

➢The study interviewed 20 visually impaired people about their experiences and perceptions of the NVDA screen reader. A majority (90%) reported readiness to continue training to use NVDA for operating devices such as desktops and laptops, and an identical proportion (90%) recognised enhanced independence in laptop use as a result of NVDA. Furthermore, 95% of respondents said they would recommend NVDA to other visually impaired people. Similarly, 90% said they could navigate the internet smoothly with NVDA. However, 35% found learning shortcut keys difficult, showing that some users may struggle. All participants (100%) agreed that NVDA should provide adequate customisation help to satisfy individual needs and expressed general satisfaction with NVDA's core operations. These results illustrate NVDA's favourable impact on accessibility and independence.

9.1 How did we measure the derivations?

9.11 Reading Efficacy

• Measured through pre- and post-intervention assessments using a self-made questionnaire.

• Assessed based on participants' ability to:

• Navigate digital text using NVDA,

• Comprehend on-screen content,

• Use NVDA features such as speech output and keyboard shortcuts for reading tasks.

• Quantitative indicator: Score out of 1 (e.g., pre-test mean = 0.70, post-test mean = 0.95), derived from structured tasks or items in the questionnaire evaluating reading-related competencies.

• Statistical validation via paired t-test to determine significant improvement.

9.12 Academic Performance

• Evaluated through self-reported or observed academic outcomes before and after using NVDA.

• Likely includes metrics such as:

• Ability to complete assignments,

• Access digital textbooks and learning resources,

• Performance in coursework or exams (though specific instruments aren't detailed beyond questionnaire responses).

• Quantitative indicator: Mean academic performance scores (e.g., pre-NVDA =

6.82, post-NVDA = 7.58 on a scale—possibly 1–10 or similar).

• Analyzed statistically using paired t-tests and ANOVA to examine differences by gender and native language background.

9.13 Digital Accessibility

• Defined by the degree to which visually impaired individuals can independently and effectively use digital devices and content with the aid of NVDA.

• Measured through:

• Participants' self-reported ease of performing basic computer operations (e.g., opening apps, browsing the web),

• Independence in laptop/desktop usage,

• Ability to navigate the internet smoothly,

• Perceived satisfaction and usability of NVDA (e.g., 90% reported smooth internet navigation; 95% would recommend NVDA).

• Also includes qualitative feedback on challenges (e.g., difficulty learning shortcuts) and desired improvements (e.g., better customization, language support).

In summary, the study operationalizes these abstract concepts through observable, measurable indicators collected via a structured questionnaire and validated with statistical analysis, linking NVDA usage to tangible improvements in reading, academics, and digital independence.

9.2 Discussion

The results of the current research provide clear evidence that NVDA is essential for improving reading efficacy and academic performance among individuals with visual impairments. The statistically significant effect of reading efficacy is evidenced by increases in post-test mean scores and by the results of the paired t-test, indicating that structured exposure to NVDA enables users to navigate online content more effectively and with greater confidence. This aligns with previous research showing that assistive technologies, particularly screen readers, support the acquisition of independent digital literacy among visually impaired learners (Lee and Martinez, 2021). The enhancement observed following the intervention demonstrates that NVDA confers functional benefits that translate into performance improvements.

The outcomes regarding academic performance also support this trend. The significant mean post-NVDA academic improvement scores indicate that improved access to digital learning resources may contribute to better understanding and more complete task completion. The findings are not new and align with existing research, which has reported similar efficiency between NVDA

and commercial screen readers, particularly in academic and professional settings (Smith and Thompson, 2020). The finding reinforces the study that usability and performance are not compromised because cost-effective, open-source tools can provide high-quality support.

Another aspect highlighted in the study is the gender variation in educational outcomes following the implementation of NVDA. Although both genders benefited, the substantial difference suggests that gender-related factors, such as prior exposure, confidence, or training opportunities, may have influenced outcomes. This observation warrants further investigation, as the equitable advantages of technology use presuppose knowledge of and responsiveness to subgroup differences.

On the same note, differences in post-NVDA academic performance across native backgrounds also underscore contextual effects on NVDA's effectiveness. Subjects with varying backgrounds may differ in their familiarity with the language, exposure to digital environments, and learning conditions, which may influence their performance in using NVDA functionality. These differences underscore the need for culturally and linguistically sensitive training models for the application of assistive technologies.

The qualitative results also support the usefulness of NVDA. The acceptability of NVDA is high, as reflected in the high satisfaction levels, desire to maintain training, as well as the willingness to recommend NVDA. The enhanced autonomy in computer use indicates that NVDA supports autonomy, one of the critical objectives of assistive technology. Nevertheless, the challenge other users face in learning shortcut keys suggests the need for simplified, user-friendly training modules or adaptive learning interfaces. To ensure sufficient support for customisation, which all respondents mentioned as a preference, could also improve user experience and long-term engagement.

Overall, the paper frames NVDA as a valid, easy-to-use, and inclusive digital resource for individuals with visual disabilities, particularly in low-resource settings. The findings attest to its effectiveness but also indicate areas where the training and its further personalisation could lead to further optimisation of results. The results are relevant to the broader discussion of digital access, because they can confirm that open-source technologies play a significant role in ensuring educational equity and digital inclusion.

10. Conclusion

In conclusion, this study demonstrates the NVDA screen reader's effectiveness as a durable, cost-effective, and accessible solution for visually impaired users. The study emphasises its competitive functionality, ease of use, and adaptability across multiple platforms, which make it a viable alternative to commercial screen readers. Despite some drawbacks, such as occasional compatibility concerns, NVDA is a reliable choice, especially in low-resource environments. The findings emphasis its importance in fostering digital inclusion and closing accessibility gaps. Further research should focus on improving its performance and broadening

its application in dynamic digital environments. This study contributes to the ongoing discussion on improving accessibility for people with disabilities using open-source technology.

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