Journal of Namibian Studies, 34 S2(2023): 2226-2241 ISSN: 2197-5523 (online)

Assistive Computer Application Software, a Tool for Enhancing Mathematics Cognition

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Abstract

This study aims to investigate the acceptance of Job Access With Speech (J.A.W.S.) software as an assistive tool for enhancing mathematics education in Technical and Vocational Education and Training (T.V.E.T.) colleges, with a specific focus on students with visual impairments and educators. The research will explore the effects of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. in the teaching and learning of mathematics. The study will contribute to the existing literature by examining the factors influencing the acceptance of J.A.W.S. among students and educators in T.V.E.T. colleges, providing insights into the role of technology in inclusive mathematics education. The findings will inform educators and policymakers about the importance of integrating assistive technologies, such as J.A.W.S., to improve the academic performance and learning experience of students with visual impairments in mathematics education.

Keywords: Job Access With Speech, mathematics cognition, assistive computer application software, inclusivity

Introduction

Similar to the terminology used in various studies on assistive technology, the term "assistive computer application software" (A.C.A.S.) in this study refers to "any software program used to enhance the functional capabilities of any disabled person" [1, p. 1]. The primary objective of Job Access with Speech (J.A.W.S.) as an A.C.A.S. is to enable students with visual impairments (S.W.V.I.) to independently interact with computer applications using keyboard commands (shortcut keys) whereas receiving guidance through speech-based and non-speech (earcons) feedback [2]. J.A.W.S. software facilitates the interaction between S.W.V.I. and computing applications, promoting the development of computer skills, self-reliance, and independence [3]. However, despite the potential

benefits that J.A.W.S. offers to S.W.V.I. in their learning experience, certain factors continue to influence its acceptance, including the perceived ease of use and perceived usefulness of using such an A.C.A.S.

In the context of special education, perceived ease of use refers to users' perception of the effortlessness involved in using an A.C.A.S., with minimal cognitive effort required, particularly in teaching and learning environments where students face educational barriers [4]. On the other hand, perceived usefulness reflects the degree to which end-users associate the information system with enhanced job performance, thus determining its utility [5]. Self-efficacy, on the other hand, refers to an individual's belief in their capabilities to succeed in a specific situation or task [6].

However, despite the increasing scholarly attention on A.C.A.S. designed to enhance the educational experiences of students with visual impairments (S.W.V.I.), there remains a significant gap in research specifically focusing on the South African context [7]. This gap is particularly evident regarding the explicit usage of Job Access with Speech (J.A.W.S.) in the context of Technical and Vocational Education and Training (T.V.E.T.) mathematics education.

Research on the combined effects of perceived ease of use, perceived usefulness, and self-efficacy in relation to the adoption of J.A.W.S. as an A.C.A.S. in South Africa is still limited. Understanding the impact of perceived ease of use and perceived usefulness, along with individuals' self-efficacy in using the system, is crucial as these factors greatly influence the acceptance of A.C.A.S. among educators and S.W.V.I. [8].

This study is significant due to the growing body of literature outside of South Africa that highlights J.A.W.S. as a tool for facilitating digital information access for S.W.V.I. who prefer using screen readers [8, 9]. For instance, J.A.W.S. has been instrumental in enabling digital inclusion for S.W.V.I. in academic libraries across 14 universities in the UK and the USA [10]. Moreover, J.A.W.S. has been utilized by academics and professionals with visual impairments to engage in collaborative work, showcasing its potential benefits [11].

In another study, J.A.W.S. was found to be instrumental in enabling S.W.V.I. to access information in higher education institutions in Pakistan [12]. Similarly, the lack of availability of J.A.W.S. posed challenges for S.W.V.I. in higher education settings in Eswatini [13]. J.A.W.S. has also been used as a comparative tool for evaluating the task performance of screen reader prototypes [14], and its potential for reading foreign languages has been explored [15]. In the South African context, a study reviewing the provision of assistive technologies to students with various impairments in a higher education institution highlighted the inability of the institution's computer software to provide access to Mathematics for S.W.V.I. [16]. Another attempt to demonstrate inclusive teaching and learning practices in an online learning environment at a South African

institution revealed a lack of trainers' skills and knowledge in teaching S.W.V.I. [17].

Despite the growing need for research on J.A.W.S. usage in South Africa, there has been limited attention given to the examination of perceived ease of use, perceived usefulness, and self-efficacy as factors influencing the end-users' acceptance of J.A.W.S. Outside of South Africa, studies investigating the acceptance of digital products and services by individuals with visual impairments have recognized J.A.W.S. as a vital application for facilitating accessibility [18], [19], [20], [21]. These studies have consistently highlighted the challenges posed by incompatibility between screen readers and various application features, including J.A.W.S. Consequently, there is a need for further research to enhance the accessibility and compatibility of J.A.W.S. and other screen readers, ensuring the improved access and acceptance of these products and services for individuals with visual impairments. However, it is worth noting that existing acceptance studies focusing on perceived ease of use and perceived usefulness have limited relevance to the context of teaching and learning. Thus, it is essential to explore the implications of perceived ease of use, perceived usefulness, and users' computer self-efficacy specifically in the acceptance and seamless application of J.A.W.S., which serves as a fundamental requirement for the accessibility of digital applications, including those used in teaching and learning.

Despite the increasing use of assistive technologies (AT), commonly referred to as A.C.A.S. in the education of students facing barriers to learning, there has been a lack of attention towards self-efficacy as a central behavioral construct that contributes to the successful implementation of inclusive practices and the usage of A.C.A.S. in South African inclusive learning institutions [8], [23]. Surveys administered to teachers of S.W.V.I. revealed that although they expressed interest in utilizing AT, they felt the need for better preparation [23]. This finding aligns with an open- and closed-ended survey exploring teachers' perceptions of AT knowledge, training, and usefulness, which found a significant positive correlation between AT knowledge and perceived usefulness [8]. Therefore, it is crucial for educators of S.W.V.I. to be well-informed, skilled, and have high self-efficacy in specialized computer skills required to train their students in using A.C.A.S. like J.A.W.S. Other constructs related to self-efficacy include educators' A.C.A.S. knowledge, training, and basic mathematics literacy [8].

The current study aims to examine the effects of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. among T.V.E.T. college educators and S.W.V.I. in teaching and learning Mathematics. Mathematics education in higher learning institutions is less popular among S.W.V.I. due to early exclusion from mathematics, inaccurate advice, and inadequate support systems, often leading to discouragement from pursuing mathematics-based courses [25], [26]. A systematic review on trends and challenges in mathematics education for

the visually impaired highlighted various hardware and software technologies developed to cater to S.W.V.I.'s mathematics learning needs [27]. However, the review concluded that more work needs to be done by researchers and practitioners to provide effective solutions for S.W.V.I. in mathematics education. Given that J.A.W.S. is one of the software solutions for S.W.V.I., it is important to analyze the hypothetical impact of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. among T.V.E.T. educators and S.W.V.I., which forms the basis of the current research.

The primary aim of this study is to contribute to the discourse on promoting and supporting the inclusion and participation of S.W.V.I. in mathematics education, specifically using J.A.W.S. in T.V.E.T. colleges in South Africa. By investigating the perceived ease of use, perceived usefulness, and self-efficacy of J.A.W.S. among users in T.V.E.T. colleges, this study seeks to encourage further practical research and the development of technology acceptance theories in this context. Through these efforts, we can enhance the understanding and implementation of J.A.W.S. as an assistive tool, ultimately facilitating greater accessibility and participation for S.W.V.I. in mathematics education.

Research Objectives

Considering the discussions in the introduction, this research aims to investigate the impact of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. among T.V.E.T. educators and S.W.V.I.s in the context of teaching and learning Mathematics. The hypothesis posits that perceived ease of use, perceived usefulness, and self-efficacy play significant roles in influencing the acceptance of J.A.W.S. by T.V.E.T. educators and S.W.V.I.s in their Mathematics instruction. By exploring these factors, we can gain a better understanding of the dynamics surrounding the acceptance of J.A.W.S. and its integration into the teaching and learning processes.

Research Questions

Building upon the aforementioned objectives, this study seeks to address the following main research question: What is the impact of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. among T.V.E.T. educators and S.W.V.I.s in the context of teaching and learning Mathematics?

To provide a comprehensive understanding, the main research question is further divided into three specific sub-questions:

What is the influence of perceived ease of use on the acceptance of J.A.W.S. among T.V.E.T. educators and S.W.V.I.s in the teaching and learning of Mathematics?

How does the perceived usefulness affect the acceptance of J.A.W.S. among T.V.E.T. educators and S.W.V.I.s in the teaching and learning of Mathematics?

What is the role of self-efficacy in the acceptance of J.A.W.S. among T.V.E.T. educators and S.W.V.I.s in the teaching and learning of Mathematics?

By exploring these specific questions, this study aims to shed light on the effects, if any, of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. in the educational context of T.V.E.T. colleges, particularly in the field of Mathematics.

Methodology

To address the objectives outlined above, this study aims to explore the effects of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. among T.V.E.T. educators and S.W.V.I.s in the teaching and learning of Mathematics.

To gather relevant literature, an extensive search was conducted in various reputable journals such as the Journal on Multimodal User Interfaces, British Journal of Visual Impairment, Education and Information Technologies, Universal Access in the Information Society, Journal of Visual Impairment & Blindness, Journal of Computer Education, Teacher Education and Special Education, International Journal of STEM Education, Journal of Special Education Technology, and Google Scholar.

The literature review search employed the use of Boolean Operators (AND, OR), parentheses, wildcard character (*), and quotation marks to refine the search results. The search terms were derived from the research topic, including keywords such as Job Access With Speech Software (J.A.W.S.), students with visual impairments, visual impairment, students with low vision, Mathematics, Technical and Vocational Education and Training (T.V.E.T.), J.A.W.S. AND perceived usefulness, J.A.W.S. AND perceived ease of use, J.A.W.S. AND self-efficacy, assistive technology AND Mathematics AND blindness, assistive computer software AND Mathematics AND visual impairment, T.V.E.T. education AND Mathematics AND blindness, Technology Acceptance Model AND J.A.W.S. AND T.V.E.T. education, J.A.W.S. acceptance AND T.V.E.T. education, and STEM education AND T.V.E.T. AND visual impairments.

By conducting a comprehensive literature review encompassing these search terms, this study aims to provide valuable insights into the implications of perceived ease of use, perceived usefulness, and self-efficacy as determinants of T.V.E.T. educators' and S.W.V.I.s' acceptance of J.A.W.S. as an A.C.A.S. in the teaching and learning of Mathematics.

Criteria for Inclusion And Exclusion

Following an initial literature search across various journals, a purposive sampling approach was employed to select specific articles that were deemed relevant to the study. The focus was on recent publications from 2021 to 2022, meeting the following criteria: being peer-reviewed, published in English, discussing the use and acceptance of J.A.W.S. software in accessing Mathematics education in the T.V.E.T. sector, and involving students with visual impairments and/or educators/lecturers of students with visual impairments as participants.

However, due to the limited availability of published research specifically addressing the intended study, the search was expanded to include conference proceedings and literature published between 2006 and 2022. This broader search aimed to include publications related to the acceptance of digital services and products accessible through J.A.W.S. for S.W.V.I.s, as well as those discussing the inclusion of S.W.V.I. in mathematics education. In total, 52 articles were identified.

Upon reviewing the abstracts of these articles, 34 were retained. However, 9 publications that used vague terms such as "students with learning disabilities" (SLD) and "students with disabilities" (SD) without specifying the type of impairment were excluded. Additionally, 5 articles that focused on general STEM education for S.W.V.I. in primary and secondary settings were excluded, whereas those specifically addressing Mathematics and assistive technologies were retained, resulting in 18 publications.

After removing 4 duplicate articles and excluding 3 studies that utilized tactile devices as interventions for mathematics instruction and learning, a total of 8 publications remained. These 8 publications were thoroughly examined using an in-depth literature search guide, as depicted in Figure 1.

Figure 1. Flow chat of a literature review search strategy

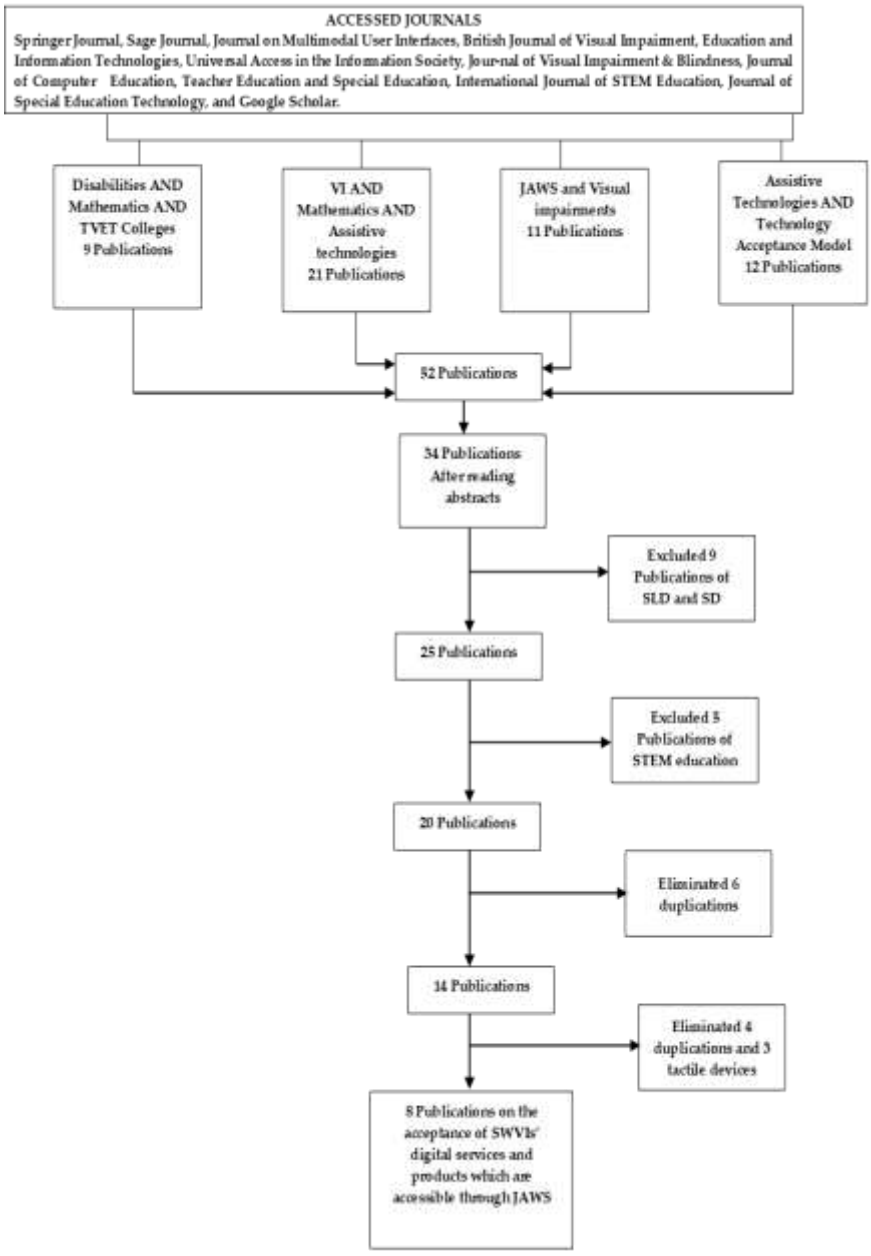

Table 1. Summary of the final 8 surveyed studies on S.W.V.I.s' Acceptance of J.A.W.S. as an Assistive Computer Application Software Technology.

Guiding Principles	Sources	Application And Influencing Factors Discovered	Participants And Country
Perceived ease of use	[21]	Web accessibility: Accessibility, vision impairment level	People with and without visual in the United Sates
Perceived usefulness	[21]	Web accessibility: Accessibility, vision impairment level	People with and without visual in the United Sates
Self-efficacy	[18]	Audio and music websites: Accessibility as well as its ease of use and usefulness, convenience	People with and without visual. The country was not specified
J.A.W.S.	[4]	Assistive technologies: facilitating condition, perceived ease of use, computer self-efficacy, result demonstrability, perceived usefulness	Special education teachers for the blind and the deaf in the United Sates.
Students with visual Impairments	[33]	Information Communication Technology: Perceived usefulness and perceived easiness	Persons with visual impairments In n Bangladesh
Educators of Students with visual Impairments	[19]	Website accessibility: Perceived convenience, perceived reliability, accessibility, vision impairment level	Students with visual impairments in Thailand.
Mathematics	[5]	Technologies: Positive attitudes, Self-efficacy, time, access	Special education teachers in the United Arab Emirates
T.V.E.T. colleges	[20]	Mobile applications: Performance expectance, attitude functionality, accessibility	People with visual impairments in USA, India, Australia, Africa, and Europe

Background

Over the past decade, there has been a limited focus on understanding educators' and students' perceptions of using A.C.A.S. for teaching and learning purposes in certain universities and schools [8], [28], [29]. The emphasis has been on exploring the general use of J.A.W.S. and other screen readers in teaching and learning for S.W.V.I., falling under the broader category of assistive technologies. However, some attempts have been made to investigate the factors influencing the acceptance of

A.C.A.S. [4], [5]. Unfortunately, these studies primarily focused on educators' acceptance, neglecting the perspectives of students. Educators who work with students facing learning barriers play a crucial role in introducing their students to various forms of knowledge about the world [4]. Therefore, imparting skills related to technology integration in the classroom is essential for special education educators [5]. However, educators' perceptions, attitudes, and self-efficacy regarding technology use significantly impact effective technology integration [30], [31]. As previously confirmed by the relationship between educators increased self-efficacy in assistive technology usage and perceived usefulness, effective AT integration can improve teaching and learning outcomes for students facing barriers [31]. However, according to the researcher, no studies have examined the factors influencing S.W.V.I.s' acceptance of J.A.W.S.

It is also worth noting that more than two decades ago, concerns were raised about the limited attention given to technology acceptance theories when it comes to systems used by users with visual impairments [32]. A similar concern was echoed in the work of [5], highlighting the scarcity of literature on the acceptance of assistive systems in special education guided by behavioral theories. Unfortunately, this scarcity of research persists to this day, resulting in a slow-paced growth of literature. Some studies, such as [33], have utilized the Technology Acceptance Model (TAM) to investigate the acceptance of information technology by individuals with visual impairments. Additionally, [5] explored factors impacting special education teachers' acceptance and actual use of technology. Other studies have focused on the use of the Unified Theory of Acceptance and Use of Technology (UTAUT) to examine website acceptance by individuals with visual impairments [18, [19], [21]. Despite these efforts, it is important to highlight that there is a notable gap in the literature concerning the combined effects of perceived ease of use, perceived usefulness, and self-efficacy on the acceptance of J.A.W.S. as an A.C.A.S. Therefore, the implications of perceived ease of use, perceived usefulness, and self-efficacy on T.V.E.T.s' acceptance of J.A.W.S. as an A.C.A.S. are demonstrated in Figure 2, highlighting the need for further investigation.

Figure 2. Implications of Perceived Ease of Use, Perceived Usefulness, And Self-Efficacy on T.V.E.T.s' Acceptance of J.A.W.S. as An A.C.A.S. adapted from The Acceptance Model of [34] and [35]

Perceived Ease of use of A.C.A.S.

The concept of perceived ease of use is defined in this research as "the degree to which a person believes that using a particular system would be free of effort" [34, p. 320]. As discussed earlier, screen readers such as J.A.W.S. play a crucial role in enabling individuals with visual impairments to access various applications and services. The application of two behavioral theories, T.A.M. and U.T.A.U.T., was deemed important for understanding the acceptance of such products among people with visual impairments. Measuring the ease of use of these products involved factors such as keypad navigation, accessing information through a screen reader, content navigation, reading graphical content, and executing commands with minimal cognitive effort.

Proficiency in the actions is equally important as the basics of J.A.W.S. navigation in developing mathematical literacy. For educators, teaching practical content to students with visual impairments can be challenging, often resulting in passive engagement due to their learning needs [38]. Conversely, students with visual impairments are expected to master a series of unfamiliar keyboard commands to actively participate in mathematics lessons [41].

T.V.E.T. colleges are still in the early stages of including students with visual impairments, and the use of J.A.W.S. in their classrooms is also relatively new. Furthermore, there is a lack of proficiency among educators and students with visual impairments when it comes to using A.C.A.S., primarily due to limited or no training on their usage. The assumption is that when mathematics students with visual impairments and educators in T.V.E.T. colleges find J.A.W.S. easy to use, their perception of its ease of use and intention to use it will increase. However, studies conducted by [8] and [23] did not employ any behavioral theories to explore educators' perceptions of adopting assistive technologies. Their findings regarding the relevance of prior computer proficiency or special education qualifications were contradictory. [8] found that knowledge and skills in using assistive technology predicted perceived ease of use, whereas [23] discovered that educators might possess the necessary technology and special education qualifications and computer skills, but this did not necessarily translate into readiness for technology acceptance.

In the realm of special education, two studies conducted in the United States utilized TAM to examine the determinants of educators' acceptance, including perceived ease of use, perceived usefulness, computer self-efficacy, and other constructs, regarding the adoption of assistive technologies [4], [5]. The findings from both studies indicated that perceived ease of use significantly influenced educators' computer self-efficacy, which in turn positively affected their behavioral intention to use the technology. [4] also connected self-efficacy to a demonstration factor, aligning with the findings of [8]. Consequently, there is a positive

correlation between perceived ease of use and self-efficacy, establishing perceived ease of use as a crucial determinant of special educators' utilization of assistive technologies. The existing evidence suggests that perceived ease of use significantly influences the acceptance of A.C.A.S.

Potential implication 1

In conclusion, the acceptance of J.A.W.S. as an A.C.A.S. for teaching and learning Mathematics in T.V.E.T. colleges is contingent upon the perception of educators and S.W.V.I.s that using J.A.W.S. would be effortless. The perceived ease of use is a significant factor influencing the acceptance of A.C.A.S., and it is important to consider other factors such as self-efficacy in order to gain a comprehensive understanding of J.A.W.S. adoption in T.V.E.T. colleges. This knowledge can be valuable for both researchers and practitioners in the field, as it sheds light on the factors that contribute to the successful integration of J.A.W.S. in T.V.E.T. education.

Perceived Usefulness of A.C.A.S.

In line with previous research [34], perceived usefulness plays a crucial role in users' acceptance of technology. In this study, perceived usefulness refers to the belief that using J.A.W.S. as an A.C.A.S. would improve S.W.V.I.s' academic performance, enhance their learning experience, and foster students' engagement in learning Mathematics. Additionally, educators using J.A.W.S. would gain a better understanding of their students' learning processes, allowing them to adapt their instruction and assessments to meet their students' specific needs in utilizing J.A.W.S. It has been suggested that perceived usefulness strongly influences users' attitudes and increases their intention to use a system [34]. Recent studies have also shown that perceived usefulness is a significant predictor of both perceived attitude and behavioral intention to use an assistive system [5]. Moreover, other research has indicated that whereas perceived usefulness is a dominant factor influencing the use of assistive systems in special education, factors such as demonstrability and self-efficacy also have a significant impact on perceived usefulness [4].

A. Potential implication 2

What could be deduced and possibly verified is that T.V.E.T. educators' and S.W.V.I.s' use of J.A.W.S. in teaching and learning Mathematics also depends significantly on the perceived usefulness. However, the usefulness of J.A.W.S. would only be significant provided a provision of demonstration or capacitation that will influence or heighten users' self-efficacy. Consequently, T.V.E.T. educators' and S.W.V.I.s' use of J.A.W.S. will be a function of perceived usefulness.

Self-Efficacy of A.C.A.S.

Self-efficacy, derived from the social cognitive theory [42], plays a significant role in this study. In the context of this research, self-efficacy refers to the belief that educators and S.W.V.I.s have in their ability to effectively use J.A.W.S. in teaching and learning Mathematics. It is crucial for educators and students with disabilities to feel confident in their capacity to utilize assistive technologies, as these technologies offer unique characteristics that can be fully utilized when an intuitive and user-friendly approach is established [4]. Research has indicated that computer self-efficacy has a strong motivating effect on users' completion of computer-related tasks [38]. In the field of special education, self-efficacy has been recognized as a critical construct in accepting A.C.A.S., including in inclusive classrooms [5]. Inclusive educators are tasked with incorporating A.C.A.S. to teach S.W.V.I., but it can be challenging for them to stay updated with the ever-evolving technology trends [38]. Therefore, providing educator training in computer applications has been emphasized [37].

Considering the implications of perceived ease of use, perceived usefulness, and self-efficacy in the acceptance of J.A.W.S. as an assistive computer application software, it is evident that self-efficacy mediates the relationships between perceived ease of use, perceived usefulness, and behavioral intention. However, due to the lack of concrete studies specifically focusing on T.V.E.T. educators' and S.W.V.I.s' self-efficacy in using J.A.W.S. for Mathematics education, it remains inconclusive how self-efficacy influences the acceptance of J.A.W.S. in teaching and learning Mathematics. Further research is needed to explore this relationship in the T.V.E.T. context.

Conclusion and Potential Contribution

In conclusion, this study emphasizes the importance of perceived ease of use, perceived usefulness, and self-efficacy in the acceptance of J.A.W.S. as an assistive computer application software for teaching and learning Mathematics in T.V.E.T. colleges. The findings suggest that educators' and S.W.V.I.s' perception of J.A.W.S. as an effortless tool and their belief in its usefulness greatly influence their acceptance and intention to use it.

The research contributes to the existing literature by highlighting the significance of self-efficacy in the context of J.A.W.S. acceptance. It underscores the crucial role that educators' and S.W.V.I.s' confidence in their ability to effectively utilize J.A.W.S. plays in their acceptance of the technology. The study emphasizes the need for comprehensive training and support for educators to enhance their computer self-efficacy and ensure the successful integration of J.A.W.S. in Mathematics education.

Furthermore, the study identifies a gap in the literature pertaining to the relationship between self-efficacy and J.A.W.S. acceptance in the T.V.E.T. context. This calls for further research to investigate how educators' and

S.W.V.I.'s, self-efficacy influences their acceptance and effective use of J.A.W.S. in Mathematics education within T.V.E.T colleges. Understanding this relationship will contribute to improving the adoption and implementation of J.A.W.S. as an A.C.A.S., ultimately enhancing teaching and learning outcomes for S.W.V.I.s in the field of Mathematics.

Overall, the study underscores the importance of considering the perceptions of ease of use, usefulness, and self-efficacy when examining the acceptance of J.A.W.S. as an A.C.A.S. By addressing these factors, educators, and S.W.V.I.s can effectively harness the potential of J.A.W.S. in enhancing teaching practices, improving academic performance, and fostering an inclusive learning environment in T.V.E.T. colleges.

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest.

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