International Journal of Innovative Research and Scientific Studies, 8(6) 2025, pages: 100-112

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Effectiveness of digital learning tools in upper secondary education: A data-driven sentiment analysis approach

Jose Lukose[1], Abayomi Agbeyangi[2*]

[1,2]*Walter Sisulu University, Buffalo City Campus, East London, South Africa.*

Corresponding author: Abayomi Agbeyangi (*Email: aagbeyangi@wsu.ac.za*)

Abstract

The integration of digital learning tools has transformed education by enhancing student engagement, accessibility, and instructional efficiency. However, their effectiveness in improving learning outcomes requires empirical validation, particularly in low-resource environments. This study evaluates the impact of tablets as digital learning tools on teaching and learning among upper secondary (Grade 12) learners in a high school in the Eastern Cape, South Africa. The study assesses the effectiveness of digital learning tools in enhancing engagement and academic performance. It also evaluates digital proficiency among teachers and learners while identifying key challenges and opportunities. A data-driven analytical approach was employed, collecting responses from 90 upper secondary learners and 10 teachers through structured Likert-scale questionnaires. Descriptive statistical measures were used to evaluate engagement, collaboration, and academic performance, while a rule-based sentiment scoring method was applied to classify perceptions as positive, neutral, or negative. The findings indicate that 78% of learners reported increased engagement, 84% noted improved collaboration, and a 79.49% relative increase in pass rates was observed. Sentiment scoring revealed average sentiment values of +0.55 for learners and +0.66 for teachers, reflecting overall positive perceptions. Key challenges identified included limited internet access, digital distractions, and increased teacher workload. The results confirm that digital learning tools enhance student engagement and academic performance but require better infrastructure, training, and structured policies for optimal adoption.

Keywords: Digital learning, ICT in education, Sentiment analysis, Technology-Assisted education.

DOI: 10.53894/ijirss.v8i6.9511
Funding: This study received no specific financial support.
History: Received: 30 June 2025 / **Revised:** 1 August 2025 / **Accepted:** 5 August 2025 / **Published:** 27 August 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Publisher: Innovative Research Publishing

1. Introduction

The integration of digital learning tools has revolutionized education by enhancing student engagement, accessibility, and instructional delivery [1, 2]. These tools, including tablets [3] laptops [4] e-learning platforms [5] reality-enhancing technologies [6] and interactive applications [7] offer personalized learning experiences that can improve comprehension and academic performance. In many developing regions, including South Africa's Eastern Cape, digital education is increasingly a solution to bridging learning gaps in under-resourced schools [8-10]. However, the extent to which these tools effectively enhance learning outcomes remains an area of ongoing research. These challenges include the inadequate readiness and resources of many South African higher education institutions to implement effective digital strategies, and teachers and learners' insufficient ICT training, which exacerbates existing inequalities, particularly those from rural areas [10].

Despite these challenges, the adoption of digital learning tools presents excellent opportunities for teachers and learners at various levels of educational systems. Some studies highlight learner participation and performance improvements [11-13] while others raise concerns over technical difficulties, distractions, and inadequate support for educators [10]. These mixed outcomes necessitate a deeper investigation into how digital learning tools influence upper secondary education (final year of high school), particularly in a low-resource environment.

This study aims to evaluate the effectiveness of digital learning tools in enhancing teaching and learning among upper secondary (Grade 12) learners in a high school in Eastern Cape, South Africa. Specifically, it examines the impact on student engagement and academic performance, assesses the digital proficiency of teachers and learners, and identifies the challenges and opportunities associated with their integration. The study employs descriptive analysis and a rule-based sentiment scoring method to provide both statistical and qualitative insights into the role of digital learning tools in upper secondary education. The main research question guiding this study is: "To what extent do digital learning tools improve student engagement, academic outcomes, and teaching effectiveness in upper secondary education?" The findings contribute to ongoing discussions on technology-enhanced learning in low-resource environments by understanding the opportunities and challenges associated with digital learning tools and providing evidence-based recommendations for policy improvements and infrastructure development. The insights gained are believed to be valuable for educators, policymakers, and researchers seeking to optimise digital learning strategies for improved educational outcomes.

The remaining part of the paper is structured as follows: Section 2 presents the literature review. Section 3 outlines the methodology. Section 4 presents the results and discussion. Section 5 concludes the paper and suggests future research directions.

2. Literature Review

The shift towards technology-assisted learning is particularly significant in secondary education [12]. where digital tools can facilitate engagement, collaboration, and improvements in academic performance. Several studies have addressed these areas, such as Adeyemo [10], who found that digital learning tools positively influence student motivation and knowledge retention by creating more engaging and flexible learning environments. Rafiq et al. [11] highlighted how technology enhances collaborative learning by enabling real-time interaction and resource sharing. Additionally, Alenezi [1] emphasized the role of data-driven insights in personalizing learning experiences, allowing educators to tailor instruction based on student progress. However, despite these benefits, challenges such as digital distractions, accessibility constraints, and varying levels of digital literacy among teachers and learners remain key concerns.[8].

2.1. The Role and Impact of Digital Learning Tools in Education

Digital learning tools have recently been recognized as transformative elements in traditional education, enhancing engagement, accessibility, and personalized learning experiences. Research indicates that technology-assisted learning improves student motivation, fosters collaboration, and provides instant access to a wealth of educational resources [12]. Digital tools such as tablets, online learning platforms, and interactive software enable students to learn at their own pace, engage with multimedia content, and develop essential digital literacy skills.

On the integration of digital tools and online learning platforms in higher education, Rafiq et al. [11] emphasized that digital learning tools play a crucial role in enhancing student engagement, providing personalized learning experiences, and improving academic performance in higher education. They examined the impact on learning outcomes among students in private universities in Lahore, Pakistan. They found that using technologies such as Learning Management Systems (LMS), collaborative platforms, and adaptive learning technologies enhances student engagement, motivation, and academic performance, contributing significantly to the educational landscape. Chisango et al. [8] examined how teachers perceive the use of technology in teaching and learning at rural secondary schools in the Eastern Cape of South Africa. The study highlighted that digital learning tools play a crucial role in education by providing flexible access to learning resources, enabling collaborative learning, and allowing teachers to employ diverse teaching methodologies that cater to various learner needs, ultimately enhancing educational outcomes. Similarly, on the use of how tablet computers can help preschool children learn to write letters, Patchan and Puranik [13] stated that digital learning tools, particularly tablet computers, play a significant role in education by providing immediate feedback and an enriched tactile experience, which can enhance preschool children's writing skills; however, the effectiveness of these tools varies, with intrinsic feedback being more beneficial than extrinsic feedback.

Addressing the relationship between the use of technology in education and student outcomes, Fernández-Gutiérrez et al. [14] employed an analysis of data from three rounds of PISA[1] (2009,2012, 2015) to assess the role of digital learning tools in education, revealing that while increased use of ICT does not positively impact student outcomes in maths and reading, it is associated with improved performance in science, indicating that the effectiveness of digital tools varies by subject and their specific applications in teaching. Pratama [15] investigated the role of digital learning tools, specifically mobile learning (m-learning), in enhancing education for secondary school students in Indonesia. Using a sample of 1,156 middle and high school students and employing an extended version of the Technology Acceptance Model (TAM) as the theoretical framework, the study investigates factors influencing m-learning acceptance while examining demographic variables such as sex, age, and location. The findings reveal that adopting mobile learning tools can lead to substantial improvements in educational engagement and performance, particularly when considering the unique characteristics of adolescents. Salmerón et al. [16] highlighted that digital learning tools, particularly in the context of comprehension-based Internet reading, enhance students' navigation efficiency and comprehension skills, as evidenced by a study of 558 adolescents from grades 7 to 10 who completed Internet reading tasks, revealing that proficiency in print reading and self-efficacy positively predict performance in these tasks. Similarly, in an earlier study on paper versus computer use, Porion et al. [17] asserted that digital learning tools, through comparative assessment using a controlled text structure and measurements of comprehension and memory among secondary school students, demonstrate that familiarity with computers can lead to equivalent or improved reading performance compared to traditional paper formats.

The effectiveness of digital tools in enhancing learning of mathematics and science subjects was examined by Hillmayr et al. [12]. The study demonstrated that using digital tools in secondary school mathematics and science classes not only enhances student learning outcomes but also positively affects learner participation. The implementation of interactive digital tools was associated with increased student motivation and engagement, leading to greater performance improvements. Specifically, intelligent tutoring systems and simulations contributed to these positive effects by facilitating a more engaging learning environment. Haleem et al. [2] indicated that integrating digital learning tools enhances learner participation by making education more engaging and interactive, allowing students to take a more active role in their learning process. This engagement is associated with improved performance, as technology-enabled methods like gamification, collaboration tools, and personalized learning paths help address individual learning gaps and motivate students, leading to a deeper understanding of the material and better academic outcomes.

Analysing the transformations in higher education towards digital learning, Alenezi [1] identified that digital learning tools, such as learning management systems and collaborative applications, play a critical role in enhancing pedagogical methods and student engagement, with the study utilising a qualitative analysis to demonstrate that effective integration of these tools leads to improved learning outcomes and greater accessibility in education. In the same way, Attard and Holmes [18] asserted that digital learning tools play a critical role in enhancing student engagement in mathematics education by employing a qualitative mixed-case study method, which revealed that exemplary teachers effectively used technology to foster positive pedagogical relationships and tailor learning experiences to individual student needs, ultimately leading to increased student interest and confidence in mathematics. Also, Buentello-Montoya et al. [6] examined the impact of virtual and augmented reality on teaching and learning mathematics. The study indicated that digital learning tools, specifically through augmented reality (AR) and virtual reality (VR), enhance mathematics education by facilitating better visualization and interaction with concepts, leading to improved student performance and increased motivation.

A digital formative assessment tool on student motivation in third-graders was explored by Faber et al. [19]. The study illustrated that digital learning tools, specifically a digital formative assessment tool called Snappet, significantly enhance educational processes by providing immediate feedback and adaptive assignments tailored to student learning needs. Utilizing a randomized experimental design involving 79 schools and 1,808 students, the study found that the implementation of Snappet positively affected both mathematics achievement and student motivation. Specifically, the findings indicated that students who engaged more intensely with the tool showed better academic performance, with higher effects observed in high-performing students. Similarly, Salmerón et al. [20] assessed the impact of tablets versus printed texts on reading comprehension among 182 upper primary school students and found that while low-skilled readers performed better with print, high-skilled readers were unaffected by the medium, indicating that digital learning tools may hinder comprehension for lower-skilled students, especially under time constraints. More so, Hammer et al. [21] investigated the role of digital learning tools, specifically tablets, in education by analyzing students' perceptions of instructional support before and after tablet introduction, revealing that students with lower motivation and self-concept perceive a more positive, supportive climate with tablets compared to traditional settings, which has implications for their motivation and learning outcomes. In the same vein, Chaibal and Chaiyakul [22] investigated the correlation between smartphone and tablet usage duration and child development using a cross-sectional study involving 85 community children, revealing a significant association between increased device usage and adverse effects on gross motor development, emphasising the need for careful monitoring by caregivers.

Despite the potential benefits, integrating digital learning tools in secondary education can face some challenges. A study by Salmerón et al. [20] highlighted that challenges in implementing digital learning tools include the risk of increased distraction among students, particularly those with lower reading comprehension skills, and the necessity for careful consideration of students' differences to optimize educational outcomes. In many low-resource environment schools, unstable internet connections and a lack of technical support make it difficult for teachers and students to utilize digital tools fully [10]. Furthermore, distractions from social media, gaming applications, and non-academic content pose significant challenges

[1] https://www.oecd.org/en/about/programmes/pisa.html

[22]. Research also highlights resistance to change among educators, who may lack confidence or adequate training to effectively integrate technology into their teaching practices [8]. These challenges underscore the need for structured policies, digital literacy programs, and ongoing teacher training to optimize the benefits of digital learning.

2.2. Machine Learning and Sentiment Analysis in Educational Research

Recent advancements in machine learning (ML) and natural language processing (NLP) have enabled researchers to analyze student and teacher feedback on digital learning more effectively. Sentiment analysis, a subfield of NLP, is increasingly used to evaluate perceptions and attitudes towards educational technologies [23]. Studies have demonstrated that ML models and rule-based sentiment scoring methods can be used to classify student sentiments, providing deeper insights into engagement levels, challenges, and overall user experience. According to Smith-Mutegi et al. [23] the emergence of artificial intelligence (AI) tools has increased public interest, transforming interactions with technology and promoting its usage. It encourages educators to implement insights in Science, Technology, Engineering, and Mathematics (STEM) education. Based on Twitter data analysis, the study applied machine learning models, specifically a random forest algorithm, to classify student sentiments regarding artificial intelligence in STEM education as positive, negative, or neutral. This approach allows researchers to move beyond traditional survey-based assessments by extracting meaningful patterns from open-ended responses. Deepanchakkaravarthy and Umarani [24] stated that rule-based sentiment scoring methods classify student sentiments by using predefined rules and sentiment lexicons, such as AFINN and SentiWordNet, to analyse feedback text. Similarly, Mekonen et al. [25] highlighting that rule-based sentiment scoring methods can classify student sentiments by using predefined sentiment lexicons and linguistic rules to assign polarity scores to words and their context. This approach, shown to be effective in the Kafi-noonoo language presented in the study, handles negations and modifiers to improve accuracy, making it suitable for analyzing student opinions even with limited data. Onan [26] investigated the performance of different learning methods and text representation schemes in sentiment analysis. The study employed machine learning and natural language processing techniques to analyze student and teacher feedback on digital learning, revealing that deep learning architectures, particularly long short-term memory networks (LSTM), significantly outperformed conventional supervised learning methods in sentiment classification accuracy. Similarly, Mujahid et al. [27] employed machine learning and natural language processing techniques, using TextBlob, VADER, and SentiWordNet for sentiment analysis on a dataset of 17,155 tweets, revealing both positive and negative sentiments regarding the effectiveness of online education during the COVID-19 pandemic.

The use of sentiment analysis has also been seen to expand in education due to the complexities of student language and feedback volume. According to Kastrati et al. [28] machine learning (ML) and natural language processing (NLP) significantly enhance the analysis of student and teacher feedback in digital learning environments, highlighting the rapid growth and application of deep learning techniques in this domain. The viewpoint supported by Escotet [29] sheds light on the bright future AI holds for higher education. The study indicated that Machine Learning (ML) and Natural Language Processing (NLP) have been utilized to analyze student and teacher feedback on digital learning, leading to enhanced insights into educational experiences and outcomes. Utilizing large volumes of text data from feedback forms, discussions, and evaluations, the study uncovers patterns and sentiments that offer critical insights into the effectiveness of digital learning environments. The outcomes reveal areas of strength and potential improvement in the educational process, facilitating the development of personalized learning experiences and informing instructional strategies tailored to the needs of both students and educators. Similarly, Javaid et al. [30] highlighted the significant outcomes of using ML and NLP in understanding the sentiment and themes present in the feedback, which ultimately aids educators in refining course content, enhancing teaching methods, and tailoring learning experiences to better meet the needs of students.

The studies in the literature suggest that while digital learning tools can enhance engagement and academic performance, their effectiveness is influenced by technological infrastructure, digital literacy, and institutional support. They also highlight the growing role of machine learning and sentiment analysis in evaluating digital education, offering more comprehensive insights into student and teacher experiences. However, there remains a gap in studies focusing on the specific challenges and opportunities of digital learning tools in South African schools, particularly in low-resource environments. This study addresses that gap by combining descriptive and sentiment analysis to assess the impact of digital learning tools, specifically tablets, in upper secondary education.

3. Materials and Methods

This study employed a mixed-methods research approach to assess the effectiveness of digital learning tools in upper secondary education. A combination of descriptive statistical analysis and rule-based sentiment scoring was used to evaluate the impact of digital tools on student engagement, academic performance, and teaching effectiveness.

The study involved a sample of 90 Grade 12 learners (N=90) and 10 teachers (N=10), randomly selected from a high school in Eastern Cape, South Africa. This sample size was sufficient to generate meaningful insights into the adoption and perceived effectiveness of digital learning tools, while capturing diverse perspectives from both students and educators. Data were collected through structured questionnaires comprising closed-ended Likert-scale items to assess engagement, digital proficiency, and academic performance, along with a few open-ended prompts to gather contextual feedback. Participation was voluntary, with informed consent obtained from all respondents. Ethical compliance was maintained by ensuring participant anonymity and using the data strictly for academic purposes.

Descriptive analysis was performed by calculating frequency distributions, percentages, and mean values to evaluate student engagement levels, teacher effectiveness, and observed academic improvements. To further understand perceptions of tablet-assisted learning, a rule-based sentiment scoring method was applied to the Likert-scale responses. Rather than using

open-text analysis or machine learning models, this approach involved mapping each Likert response to a fixed sentiment score: “Strongly Agree” = +1.0, “Agree” = +0.5, “Neutral” = 0.0, “Disagree” = –0.5, and “Strongly Disagree” = –1.0. Sentiment categories were classified as positive (score > 0.1), neutral (–0.1 ≤ score ≤ 0.1), and negative (score < –0.1). Average sentiment scores were computed separately for learners and teachers across 19 key statements. This scoring system enabled the quantification of attitudes toward digital learning tools and facilitated direct comparison between groups. The integration of descriptive statistics and rule-based sentiment scoring offered both empirical and interpretive insights into the effectiveness, usability, and limitations of digital tools in upper secondary education.

The Likert-scale responses in the questionnaire were used for rule-based sentiment scoring because they provide a structured and quantifiable way to measure participants' attitudes, enabling consistent sentiment classification and direct comparisons between learners and teachers. The research tasks were structured into two main components (see Figure 1): descriptive and rule-based sentiment scoring tasks.

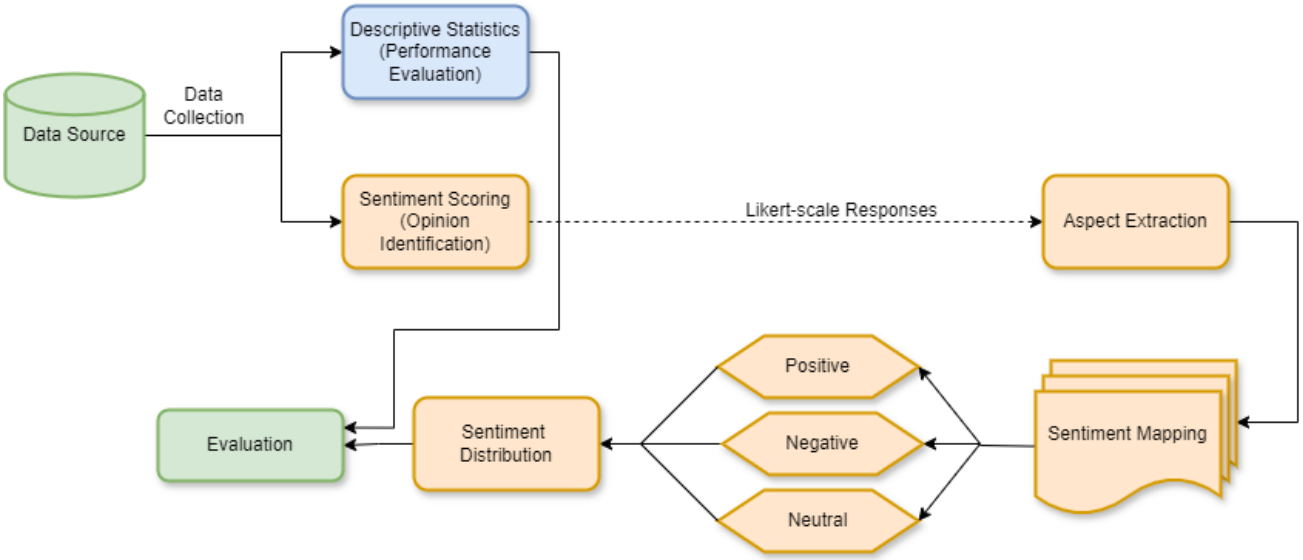

Figure 1.
Overview of Research Method.

3.1. Descriptive Analysis Task

Let X be the set of responses collected from learners and teachers, where each response x_i represents engagement level, collaboration, or performance improvement. The key measures include:

- Engagement Rate

$$ER = \frac{\sum_{i=1}^{N} E_i}{N} \quad (1)$$

where E_i is the engagement score reported by the respondent i, and N is the total number of respondents.

- Collaboration Score

$$CS = \frac{\sum_{i=1}^{N} C_i}{N} \quad (2)$$

where C_i represents the collaboration effectiveness rated by respondent i.

- Pass Rate Change

$$PR_{change} = \frac{PR_{after} - PR_{before}}{PR_{before}} \times 100 \quad (3)$$

where PR_{after} is the pass rate after digital tool integration and PR_{before} is the historical pass rate.

3.2. Sentiment Scoring Task

Let $S = \{s_1, s_2, \ldots, s_N\}$ represent the set of Likert-scale responses. Each response s_i is assigned a sentiment score $P(s_i)$ based on the following rule-based mapping:

$$P(s_i) = \begin{cases} +1.0 & if\ response\ is\ "Strongly\ Agree" \\ +0.5 & if\ responses\ is\ "Agree" \\ 0.0 & if\ response\ is\ \text{Neutral" or "}other" \\ -0.5 & if\ response\ is\ "Disagree" \\ -1.0 & if\ response\ is\ "Strongly\ Disagree \end{cases} \quad (4)$$

The proportion of sentiment categories in the dataset is computed as follows:

$$S_{positive} = \left(\frac{1}{N}\sum_{I=1}^{N} 1\,(P(s_i) > 0.1\right)\ x\ 100$$

$$S_{positive} = \left(\frac{1}{N}\sum_{I=1}^{N} 1\,(P(s_i) > 0.1\right) x\ 100$$

$$S_{positive} = \left(\frac{1}{N}\sum_{I=1}^{N} 1\,(P(s_i) > 0.1\right) x\ 100$$

where $1(\cdot)$ is the indicator function, which returns 1 if the condition is true, and 0 otherwise.

4. Results

4.1. Descriptive Results

The results of the descriptive statistics encompass the discussion on learners' and teachers' engagement, collaboration, and performance improvements.

4.1.1. Demographics of Participants

The study included 100 respondents (Table 1), consisting of 90 Grade 12 learners and 10 teachers from a high school in Eastern Cape, South Africa, the demographic profile of the participants provides insights into their gender, age, ethnicity, and home language, which are essential factors in understanding their experiences with digital learning tools. Among the learners, there was an equal gender distribution (50% male, 50% female), with the majority (90%) aged 16-20 years. All learners identified as Black African, with IsiXhosa as their primary home language (100%). Similarly, all teachers were Black African, with a slightly higher representation of female teachers (60%) compared to males (40%). The age distribution of teachers indicated that 50% were between 25 and 30 years old, while 30% were aged 41 to 50, and 20% were between 35 and 40 years old. No teachers were above the age of 50 years, which suggests that the teaching staff is relatively young, potentially influencing their adaptability to digital learning tools. The demographic profile provides context for understanding participants' familiarity with technology, as younger teachers and learners may be more comfortable adopting tablets, whereas older teachers might require additional training.

Table 1.
Demographic Profile of Participants.

Demographic Variable	Learners (N=90)	Teachers (N=10)
Gender	50% Male, 50% Female	40% Male, 60% Female
Age Distribution	90% (16-20), 7% (21-25), 2% (26-30), 1% (Above 30)	50% (25-30), 20% (35-40), 30% (41-50), 0% (Above 50)
Race	100% Black African	100% Black African
Home Language	100% IsiXhosa	-

4.1.2. Digital Proficiency and Preferred Online Platforms of Learners and Teachers

The study assessed the digital proficiency and preferred online platforms used by learners and teachers to determine their ability to effectively utilize tablet computers for learning and teaching. As expected, 96% of learners reported having experience with tablets, likely because they received them at the beginning of the academic year. Similarly, 100% of teachers had prior experience using tablets through personal ownership or institutional distribution. The proficiency levels varied, with 60% of learners rating their digital proficiency as moderate to high, while 40% struggled with tablet navigation and educational applications. Among teachers, 70% felt confident using tablets for instruction, whereas 30% required further training. These findings highlight the importance of structured digital literacy training programs to enhance the effective integration of digital tools.

The investigation on preferred online platforms used by learners and teachers. WhatsApp was the most preferred platform among learners (64%), followed by YouTube (27%) and Google (9%). This suggests that learners favor platforms that support instant communication and multimedia learning. Similarly, 60% of teachers preferred WhatsApp, with others opting for Google (20%) and specialized e-learning platforms such as 2U.com and Vodacom App. Learners also identified alternative online platforms that could be used for teaching and learning, with 49% favoring Zoom, 37% choosing Microsoft Teams, and 12% preferring YouTube. Among teachers, 40% suggested radio-based education, while others preferred Skype, Stack Overflow, webinars, and pre-installed tablet tutorials. These findings, as shown in Table 2, indicate that blended learning models combining different digital tools could enhance teaching and learning experiences.

The study also investigated the preferred online platforms used by learners and teachers. WhatsApp was the most preferred platform among learners (64%), followed by YouTube (27%) and Google (9%). This suggests that learners favor platforms that support instant communication and multimedia learning. Similarly, 60% of teachers preferred WhatsApp, with others opting for Google (20%) and specialized e-learning platforms such as 2U.com and Vodacom Fast Download. Learners also identified alternative online platforms that could be used for teaching and learning, with 49% favoring Zoom, 37% choosing Microsoft Teams, and 12% preferring YouTube. Among teachers, 40% suggested radio-based education, while others preferred Skype, Stack Overflow, webinars, and pre-installed tutorials on tablets. These findings indicate that blended learning models combining different digital tools could enhance teaching and learning experiences.

Table 2.
Digital Proficiency and Preferred Online Platforms for Learning and Teaching.

Category	% with Tablet Experience	% with High Proficiency	% Requiring Training	WhatsApp (%)	YouTube (%)	Google (%)	2U.com (%)	Vodacom App (%)
Learners	100	60	40	64	27	9	-	-
Teachers	100	70	30	60	-	20	10	10

4.1.3. Internet Accessibility and Tablet Usage for Learners and s

The availability of stable internet connectivity is crucial for effective tablet-assisted learning. The study found that all learners accessed the internet via mobile data or Wi-Fi, while teachers relied entirely on school-provided Wi-Fi for online activities, as shown in Table 3. Despite this accessibility, 10% of teachers believed that not all learners had adequate data access, suggesting disparities in connectivity outside the school environment.

On how frequently learners and teachers use tablets for educational activities, the findings revealed that 97% of learners used tablets to gather academic information. In comparison, 90% of teachers used them for lesson preparation. Additionally, 78% of learners confirmed receiving assessments via tablets, although a slight discrepancy was observed, as 100% of teachers reported using tablets for assessment purposes.

Table 3.
Internet Accessibility and Tablet Usage for Learners and Teachers

Activity	Learners (%)	Teachers (%)
Mobile Data & Wi-Fi	100	-
School Wi-Fi Only	-	100
Gathering academic information	97	90
Conducting assessments	78	100
Preparing lessons	-	90

4.1.4. Effectiveness of Tablet Use in Enhancing Teaching and Learning

To measure the impact of tablets on learning, respondents were asked about their experiences with collaborative learning, workload, and teacher talk time. Findings revealed that 54% (see Figure 2) of learners believed group work had improved, while 36% observed no change. However, 70% of teachers felt that group work had decreased, indicating a possible shift toward individualized learning approaches with digital tools. Regarding workload, 42% of learners felt their workload had increased, 39% believed it had decreased, and 19% observed no change. Among teachers, 50% reported an increased workload, while 40% believed it had decreased. This variation suggests that, while tablets facilitate faster access to information, they may also introduce additional responsibilities, such as managing digital resources and online assessments.

The impact of tablets on teacher talk time was also assessed. Sixty-four percent of learners felt that teacher talk time remained unchanged, while sixteen percent observed an increase and twenty percent noted a decrease. However, sixty percent of teachers reported increased talk time, indicating that digital tools may have led to more instructor-led discussions rather than student-driven learning.

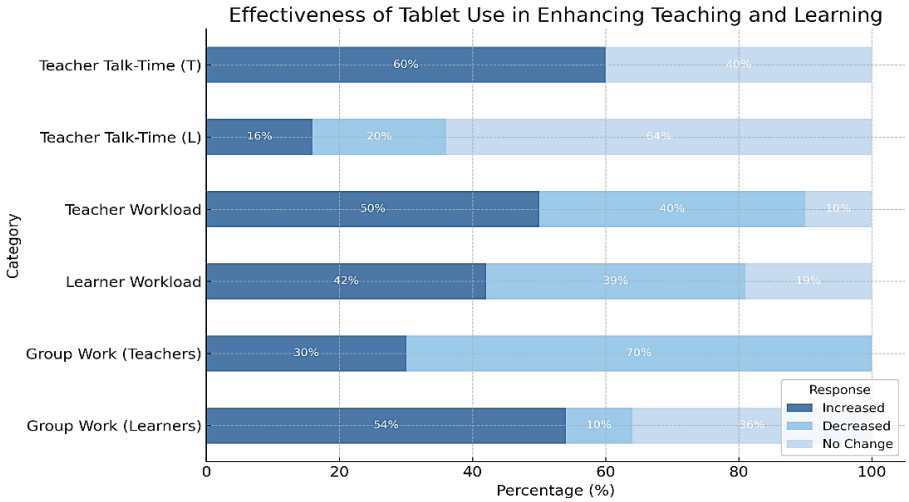

Figure 2.
Effectiveness of Tablet Use in Enhancing Teaching and Learning. Showing perceived changes in teaching and learning dimensions following tablet use, based on learner and teacher responses.

4.1.5. Learner Engagement and Motivation

Learners were highly engaged with digital tools, with 77% reporting increased participation in lessons and 79% stating that tablets enhanced their motivation to learn. Similarly, 75%, as shown in Table 4, agreed that tablets encouraged active

discussions, and 80% believed digital activities helped them grasp subject content better than traditional methods. Tablets also positively influenced homework completion, with over 60% of learners stating that they completed homework faster using digital devices. Additionally, 88% believed that tablets helped them concentrate more on tasks, further reinforcing the role of technology in improving focus and self-directed learning.

Table 4.
Learner Engagement and Motivation.

Engagement Aspect	Agree (%)	Strongly Agree (%)	No Opinion (%)
Increased participation	77	18	5
Motivation to learn	79	17	4
Homework completion	60	33	3
Increased concentration	88	5	7

4.1.6. Teachers' Perspectives on Tablet Integration

The majority of teachers viewed tablets as beneficial for lesson delivery. As depicted in Table 5, 100% of teachers agreed that tablets helped them complete their teaching programs on time, with 80% stating that digital tools improved their teaching ability. Furthermore, 90% of teachers agreed that tablets had changed their teaching methods, and 70% believed tablets enhanced lesson activities. However, 60% of teachers reported increased stress levels due to adapting to new technologies, highlighting the need for ongoing technical support and professional development programs. Despite this, 100% of teachers agreed that tablet exercises encouraged learners to participate in quizzes and interactive lessons, demonstrating their positive impact on classroom engagement.

Table 5.
Teachers' Perspectives on Tablet Integration.

Statement	Agree (%)	Strongly Agree (%)
Helped complete the syllabus on time	100	-
Improved teaching ability	80	20
Changed teaching approach	90	10
Enhanced lesson activities	70	30
Increased stress level	60	-
Continued use of the tablet	80	20

These findings indicate strong support for tablet integration in teaching and learning, with 98% of learners and all teachers recommending continued use of digital tools for future upper secondary learners. Additionally, 100% of teachers agreed that a new program should be developed to enhance the successful use of tablets in classrooms.

The final matric pass rate improvement reinforces the positive impact of digital tools, with pass rates rising from 23% in 2017 to 93% in 2024 [2], possibly due to the adoption of tablets. These insights suggest that while infrastructure, digital training, and internet access remain key challenges, the benefits of digital learning tools outweigh the limitations, making them valuable for enhancing education in low-resource environments.

4.1.7. Evaluation Measures

The study employed evaluation measures to quantify the impact of the learners and teachers on engagement, collaboration, and academic performance. The task Equations 1, 2 and 3 were used as key evaluation metrics:

- Learner Engagement Rate (ER)

  The engagement rate (ER), Equation 1, measures how actively learners participated in lessons using tablets. It is calculated as:

$$ER = \frac{\sum_{i=1}^{N} E_i}{N}$$

  With 78% of learners reporting increased engagement, the computed engagement rate is:

$$ER = \frac{(0.78 \times 90)}{90} = 0.78\ (78\%)$$

  This indicates that tablet-based learning significantly enhanced engagement, as most learners interacted with digital learning materials.

- Collaboration Score (CS)

  The collaboration score (CS) evaluates how tablets facilitate interaction between students and teachers. It is computed as:

$$CS = \frac{\sum_{i=1}^{N} C_i}{N}$$

  Since a total of 84% of learners and teachers reported improved collaboration, the calculated CS is:

[2] https://eceducation.gov.za/files/content/1736838972_Ssd9nyDI5B_2024-NSC-School-Performance-Report.pdf

$$CS = \frac{(0.84 \times 100)}{100} = 0.84\ (84\%)$$

This result suggests that digital tools enhanced student-teacher and peer collaboration, allowing for more interactive discussions and group work.

- Pass Rate Change (PR_{change})

To assess whether the introduction of tablets positively influenced academic performance, the pass rate change equation was used:

$$PR_{change} = \frac{PR_{after} - PR_{before}}{PR_{before}} \times 100$$

where:

i. PR_{before} = 39% (average pass rate before tablets (2017 – 23%, 2018 – 46%, 2019 – 48%))

ii. PR_{after} = 70% (average pass rate after tablet adoption (2020 – 54%, 2021 – 47%, 2022 – 67%, 2023 – 89%, 2024 – 93%)

$$PR_{change} = \frac{70 - 39}{39} \times 100 \approx 79.49\%$$

This result, as shown in Table 6, indicates an increase in pass rates, suggesting that tablet-assisted learning contributed to improved academic performance. However, other factors, such as teaching strategies and curriculum modifications, may have also affected this improvement.

Table 6.
Evaluation Results from Descriptive Task.

Metric	Computed Value (%)	Interpretation
Engagement Rate (ER)	78	High learner engagement with tablets.
Collaboration Score (CS)	84	Strong improvement in student-teacher and peer collaboration.
Pass Rate Change (PR_{change})	79.49	Significant improvement in matric pass rates after tablet adoption.

4.2. Sentiment Scoring Results

To gain deeper insights into the perceptions of learners and teachers regarding digital tool-assisted learning, a rule-based sentiment scoring was conducted on the Likert-scale responses (sample of scores shown in Table 7). The analysis categorized sentiments into positive, neutral, and negative to evaluate the user experience, challenges, and benefits of digital learning tools. As depicted in Figure 3 the analysis revealed an average student sentiment score of +0.55 and an average teacher sentiment score of +0.66, indicating an overall positive perception of tablet-assisted learning among both groups. However, teachers displayed slightly higher sentiment scores, suggesting that they found tablets more beneficial for instruction than learners did for studying. Both groups strongly agreed that tablets enhanced engagement, accessibility, and classroom efficiency. Teachers, in particular, expressed higher positive sentiments regarding student participation (+1.0), ease of teaching (+1.0), and access to digital resources (+1.0). Meanwhile, students found tablets helpful but had slightly lower enthusiasm, with responses clustering around moderately positive (+0.5 to +1.0) scores.

Table 7.
Sentiment Scoring Sample Data.

Statement	Learner Score	Teacher Score	Overall Score	Sentiment Category
Student involvement in teaching and learning has increased with tablets.	+0.5	+0.8	+0.65	Positive
The use of tablets is more distracting than helpful.	-0.5	-0.4	-0.45	Negative
My ability to teach has improved with tablets.	+1.0	+1.0	+1.0	Strongly Positive
Tablets have made my teaching job easier.	+0.6	+0.9	+0.75	Positive
The new program for the successful use of tablets should be modified.	+0.0	+0.1	+0.05	Neutral
My stress levels have increased due to tablet-based teaching.	-0.5	-0.6	-0.55	Negative

Despite the positive feedback, both groups had concerns regarding distractions and stress levels. The statement “Tablets are more distracting than helpful” received a negative sentiment score (-0.5) among students and teachers, indicating that off-task behavior and digital distractions remain challenging. Additionally, teachers reported stress related to digital lesson planning (-0.5), likely due to technical difficulties and adapting to new teaching methods. The neutral sentiment score (0.0) for modifying the tablet program suggests that students and teachers believe improvements are needed but do not strongly oppose the current implementation. This indicates that while tablet-assisted learning is effective, schools should refine their digital strategies to address usability issues and provide structured support.

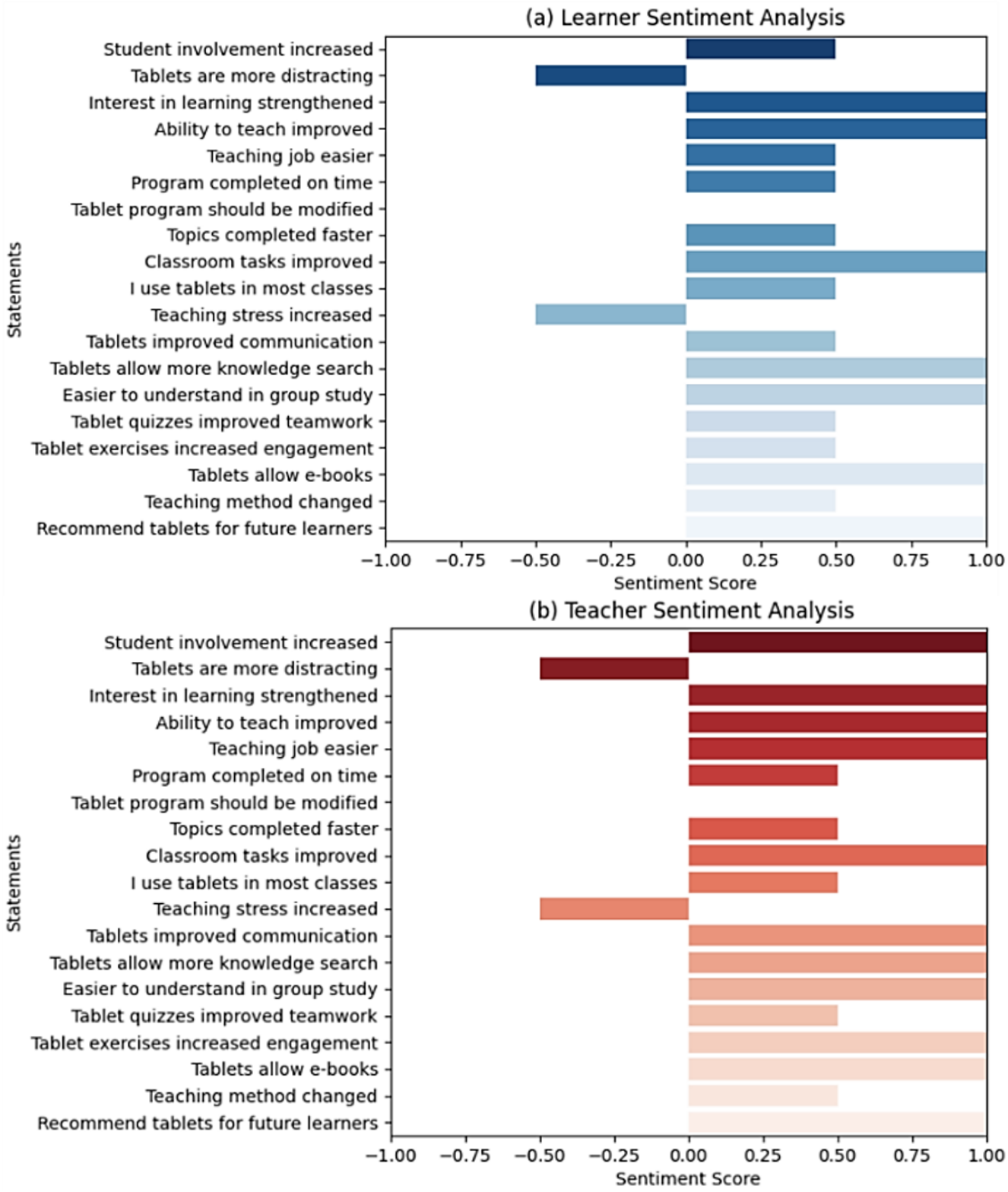

Figure 3.
Sentiment Scoring Distribution ((a) Learners, (b) Teacher).

4.3. Discussion

The findings from this study provide a comprehensive evaluation of tablet-assisted learning, highlighting its benefits, challenges, and overall effectiveness in enhancing teaching and learning. The results reveal that learners and teachers perceive tablet integration positively, with significant improvements in engagement, collaboration, and academic performance. However, challenges such as digital distractions, internet accessibility, and teacher workload stress remain key areas for improvement.

The engagement rate (ER) of 78% indicates that tablets effectively enhanced student participation in lessons, with most learners actively interacting with digital learning materials. This aligns with learners' positive sentiment score (+0.55), reinforcing their general approval of tablet-assisted learning. Similarly, the collaboration score (CS) of 84% highlights the

role of digital tools in fostering student-teacher and peer collaboration, making learning more interactive and dynamic. However, while learners embraced using tablets for academic tasks, teachers expressed concerns about the shift in classroom dynamics. About 70% of teachers observed decreased group work, indicating that tablet-based learning may have encouraged more individualized learning approaches rather than collaborative activities. This suggests the need for balanced instructional strategies that integrate both self-paced and group learning experiences to maintain engagement while leveraging the advantages of digital tools.

More so, teachers overwhelmingly supported using tablets, with 100% agreeing that digital tools helped them complete the syllabus on time and 80% acknowledging improved teaching ability. Additionally, the positive sentiment score (+0.66) among teachers suggests that they found tablets highly beneficial for lesson planning and content delivery. However, 50% of teachers reported an increased workload, likely due to the time and effort required to adapt lesson plans for digital instruction. The increased teacher talk time (60% reporting an increase) suggests that tablets may have shifted the instructional approach towards more teacher-led discussions rather than fully student-driven learning. Furthermore, 60% of teachers reported increased stress levels, reflecting the challenges of adapting to new digital teaching methods. This highlights the need for ongoing training programs, technical support, and workload management strategies to help teachers maximize the benefits of tablet-assisted instruction while minimizing stress.

A key finding of the study was the 79.49% increase in pass rates following tablet adoption, rising from an average of 39% before tablets to a 93% matric pass rate in 2024. While this improvement suggests a potential positive association between digital learning tools and academic outcomes, it is important to note that the result is descriptive and observational. The study did not include a control group, pre-post statistical testing, or adjustment for potential confounding factors. Therefore, this increase should not be interpreted as a direct causal effect of tablet use. Other contextual factors, such as changes in teaching strategies, curriculum reforms, or learner support initiatives, may have also contributed to the observed improvement. Nonetheless, the significant pass rate increase reinforces the effectiveness of digital learning interventions in low-resource educational environments.

Despite the benefits, both learners and teachers expressed concerns about digital distractions, with tablets receiving a negative sentiment score (-0.5) for promoting off-task behavior. Learners reported that they sometimes accessed non-educational content, reducing focus during lessons. Addressing this issue requires stronger content monitoring tools, structured lesson planning, and policies to ensure that tablets are primarily used for academic purposes. Additionally, internet access disparities remain a challenge, as 90% of teachers believed that not all learners had adequate data access, despite 100% of students reporting internet availability via mobile data or Wi-Fi. This suggests that while internet access exists, differences in affordability and reliability may limit some students' ability to engage with digital learning outside the school environment fully. Expanding affordable or subsidized internet options for students could help bridge this gap.

4.3.1. Results Comparison with Existing Studies

The findings of this study align with existing literature, highlighting the positive impact of digital learning tools on student engagement, collaboration, and academic performance. Similar to Hillmayr et al. [12] and Adeyemo [10], this study found that 78% of learners reported increased engagement, and a combined 84% of learners and teachers noted improved collaboration due to tablet-assisted learning. These results are consistent with previous research that emphasizes the role of technology-enhanced education in fostering interactive and flexible learning environments. Additionally, the 79.49% increase in matric pass rates following tablet adoption supports the results by Pratama [15] and Haleem et al. [2], that mobile learning and digital platforms significantly improve student motivation and academic success. However, while studies such as Attard and Holmes [18] and Buentello-Montoya et al. [6] suggest that digital learning tools enhance subject-specific understanding, Fernández-Gutiérrez et al. [14] caution that the impact of ICT on student performance varies across subjects. This study does not isolate subject-specific improvements, suggesting that further research is needed to determine whether tablet-assisted learning is more effective for certain disciplines.

Despite these benefits, the challenges identified in this study also align with existing literature. Similar to Salmerón et al. [20] and Chaibal and Chaiyakul [22], this study found that digital distractions remain a significant concern, with sentiment scoring analysis revealing a negative score (-0.5) regarding off-task behavior. Additionally, as noted by Chisango et al. [8], internet access disparities continue to hinder the full implementation of digital learning, with 10% of teachers believing that not all students have reliable data access outside of school. Furthermore, the study's findings on teacher workload stress and the need for structured digital literacy programs are consistent with Alenezi [1], who emphasized the importance of professional development to ensure effective technology integration. The sentiment scoring results, which revealed an average score of +0.55 for learners and +0.66 for teachers, further support Kastrati et al. [28] and Javaid et al. [30] that rule-based sentiment scoring provides deeper insights into user perceptions of digital education. These comparisons indicate that tablet-assisted learning holds significant potential for enhancing secondary education, but its effectiveness depends on infrastructure, digital literacy, and structured implementation strategies.

4.3.2. Recommendations and Future Directions

The findings of this study highlight the significant benefits and challenges associated with digital tool-assisted learning. To maximize the effectiveness of digital learning tools, several key recommendations are proposed to enhance student engagement, improve teaching efficiency, and address the limitations identified in this study, as follows:

- Enhance Digital Literacy and Teacher Training - While teachers showed positive sentiment (+0.66) toward tablets, 30% required further training to effectively integrate digital tools into teaching. Schools should implement continuous

digital literacy programs, focusing on online lesson planning, digital assessment techniques, and troubleshooting technical issues. Training should be tailored to different proficiency levels, and peer mentoring programs or teacher-led workshops can further improve digital competence.

- Improve Collaborative Learning and Minimize Distractions - The study revealed a decline in group work, with 70% of teachers reporting reduced collaboration due to more individualized learning with tablets. Schools should adopt blended learning strategies, integrating virtual discussions, group assignments, and digital collaboration tools like Google Classroom and Microsoft Teams. Additionally, digital distractions were a concern, with a negative sentiment score (-0.5) related to off-task behaviour. Schools should implement digital usage policies, such as limiting non-educational apps during school hours, using content monitoring tools, and promoting structured digital lesson plans to keep students focused.
- Expand Internet Accessibility and Refine Tablet Learning Programs - While 100% of students accessed the Internet via mobile data or Wi-Fi, 10% of teachers believed not all learners had reliable data outside school. Schools should partner with internet providers to offer affordable student data plans or provide offline access to essential learning resources. Additionally, learners and teachers had a neutral sentiment (0.0) regarding modifying tablet programs, indicating room for improvement. Schools should conduct periodic assessments, gather user feedback to refine digital learning strategies, and introduce adaptive learning platforms that personalize instruction based on learner progress.

4.4.3. Study limitations

This study provides valuable insights into digital tool-assisted learning; however, some limitations should be acknowledged. Firstly, it focuses on a single high school in the Eastern Cape, South Africa, with a sample size of 100 respondents; the findings may not be fully generalisable to other schools with different socio-economic and technological conditions. Secondly, the research covered only one academic year; it did not assess long-term learning outcomes or retention rates. Additionally, the analysis relied primarily on descriptive statistics with sentiment scoring insights without incorporating inferential statistical methods such as confidence intervals or hypothesis testing. Consequently, observed improvements (e.g., in pass rates or engagement levels) should be interpreted as indicative trends rather than statistically significant effects. Furthermore, the use of self-reported questionnaire data may introduce response bias, with some participants potentially providing socially desirable answers rather than objective assessments. Finally, while the study observed a 79.49% improvement in matric pass rates, this result cannot be conclusively attributed to tablet use alone, as other factors such as teaching strategies, curriculum changes, or student support initiatives may also have played a role.

5. Conclusions

This study highlights the positive impact of digital tool-assisted learning on student engagement, collaboration, and academic performance, with strong approval from both learners and teachers. The 78% engagement rate and 84% collaboration score reflect the effectiveness of digital tools in enhancing participation and interaction. The calculated 79.49% improvement in matric pass rates suggests that the digital tool contributed to better learning outcomes. However, challenges such as teacher workload stress, digital distractions, and internet accessibility constraints must be addressed to maximize the effectiveness of digital learning initiatives.

Overall, the study underscores the transformative potential of digital tools in education, particularly in low-resource environments, while emphasizing the need for continuous evaluation and refinement of digital learning programs to ensure equitable and effective technology integration in schools. In future research, integrating system logs, usage analytics, and classroom observations will be considered to verify self-reported insights.

References

[1] M. Alenezi, "Digital learning and digital institution in higher education," *Education Sciences,* vol. 13, no. 1, p. 88, 2023. https://doi.org/10.3390/educsci13010088

[2] A. Haleem, M. Javaid, M. A. Qadri, and R. Suman, "Understanding the role of digital technologies in education: A review," *Sustainable Operations and Computers,* vol. 3, pp. 275-285, 2022. https://doi.org/10.1016/j.susoc.2022.05.004

[3] A. F. Helm and J. M. McDermott, "Impact of tablet use on young children's inhibitory control and error monitoring," *Journal of Experimental Child Psychology,* vol. 222, p. 105446, 2022. https://doi.org/10.1016/j.jecp.2022.105446

[4] C. Hall, M. Lundin, and K. Sibbmark, "A laptop for every child? The impact of technology on human capital formation," *Labour Economics,* vol. 69, p. 101957, 2021. https://doi.org/10.1016/j.labeco.2020.101957

[5] C. S. Santiago Jr, M. P. Leah Ulanday, Z. R. Jane Centeno, M. D. Cristina Bayla, and J. S. Callanta, "Flexible learning adaptabilities in the new normal: e-learning resources, digital meeting platforms, online learning systems and learning engagement," *Asian Journal of Distance Education,* vol. 16, no. 2, p. 38, 2021.

[6] D. A. Buentello-Montoya, M. Lomelí-Plascencia, and L. Medina-Herrera, "The role of reality enhancing technologies in teaching and learning of mathematics," *Computers & Electrical Engineering,* vol. 94, p. 107287, 2021. https://doi.org/10.1016/j.compeleceng.2021.107287

[7] F. Tuma, "The use of educational technology for interactive teaching in lectures," *Annals of Medicine and Surgery,* vol. 62, pp. 231-235, 2021. https://doi.org/10.1016/j.amsu.2021.01.051

[8] G. Chisango, N. Marongwe, N. Mtsi, and T. E. Matyedi, "Teachers' perceptions of adopting information and communication technologies in teaching and learning at rural secondary schools in eastern cape, South Africa," *Africa Education Review,* vol. 17, no. 2, pp. 1-19, 2020. https://doi.org/10.1080/18146627.2018.1491317

[9] K. Aruleba and N. Jere, "Exploring digital transforming challenges in rural areas of South Africa through a systematic review of empirical studies," *Scientific African,* vol. 16, p. e01190, 2022. https://doi.org/10.1016/j.sciaf.2022.e01190

[10] K. S. Adeyemo, "The status of digital innovation and data security in South African higher education," *South African Journal of Higher Education*, vol. 37, no. 2, pp. 26-39, 2023.
[11] S. Rafiq, S. Iqbal, and A. Afzal, "The impact of digital tools and online learning platforms on higher education learning outcomes," *Al-Mahdi Research Journal*, vol. 5, no. 4, pp. 359-369, 2024.
[12] D. Hillmayr, L. Ziernwald, F. Reinhold, S. I. Hofer, and K. M. Reiss, "The potential of digital tools to enhance mathematics and science learning in secondary schools: A context-specific meta-analysis," *Computers & Education*, vol. 153, p. 103897, 2020. https://doi.org/10.1016/j.compedu.2020.103897
[13] M. M. Patchan and C. S. Puranik, "Using tablet computers to teach preschool children to write letters: Exploring the impact of extrinsic and intrinsic feedback," *Computers & Education*, vol. 102, pp. 128-137, 2016. https://doi.org/10.1016/j.compedu.2016.07.007
[14] M. Fernández-Gutiérrez, G. Gimenez, and J. Calero, "Is the use of ICT in education leading to higher student outcomes? Analysis from the Spanish Autonomous Communities," *Computers & Education*, vol. 157, p. 103969, 2020. https://doi.org/10.1016/j.compedu.2020.103969
[15] A. R. Pratama, "Fun first, useful later: Mobile learning acceptance among secondary school students in Indonesia," *Education and Information Technologies*, vol. 26, no. 2, pp. 1737-1753, 2021. https://doi.org/10.1007/s10639-020-10334-w
[16] L. Salmerón, A. García, and E. Vidal-Abarca, "The development of adolescents' comprehension-based Internet reading activities," *Learning and Individual Differences*, vol. 61, pp. 31-39, 2018. https://doi.org/10.1016/j.lindif.2017.11.006
[17] A. Porion, X. Aparicio, O. Megalakaki, A. Robert, and T. Baccino, "The impact of paper-based versus computerized presentation on text comprehension and memorization," *Computers in Human Behavior*, vol. 54, pp. 569-576, 2016. https://doi.org/10.1016/j.chb.2015.08.002
[18] C. Attard and K. Holmes, "It gives you that sense of hope': An exploration of technology use to mediate student engagement with mathematics," *Heliyon*, vol. 6, no. 1, p. e02945, 2020. https://doi.org/10.1016/j.heliyon.2019.e02945
[19] J. M. Faber, H. Luyten, and A. J. Visscher, "The effects of a digital formative assessment tool on mathematics achievement and student motivation: Results of a randomized experiment," *Computers & Education*, vol. 106, pp. 83-96, 2017. https://doi.org/10.1016/j.compedu.2016.12.001
[20] L. Salmerón, P. Delgado, C. Vargas, and L. Gil, "Tablets for all? Testing the screen inferiority effect with upper primary school students," *Learning and Individual Differences*, vol. 86, p. 101975, 2021. https://doi.org/10.1016/j.lindif.2021.101975
[21] M. Hammer, R. Göllner, K. Scheiter, B. Fauth, and K. Stürmer, "For whom do tablets make a difference? Examining student profiles and perceptions of instruction with tablets," *Computers & Education*, vol. 166, p. 104147, 2021. https://doi.org/10.1016/j.compedu.2021.104147
[22] S. Chaibal and S. Chaiyakul, "The association between smartphone and tablet usage and children development," *Acta Psychologica*, vol. 228, p. 103646, 2022. https://doi.org/10.1016/j.actpsy.2022.103646
[23] D. Smith-Mutegi, Y. Mamo, J. Kim, H. Crompton, and M. McConnell, "Perceptions of STEM education and artificial intelligence: A Twitter (X) sentiment analysis," *International Journal of STEM Education*, vol. 12, no. 1, p. 9, 2025. https://doi.org/10.1186/s40594-025-00527-5
[24] K. Deepanchakkaravarthy and S. Umarani, "Enhancing educational outcomes through natural language processing using sentiment analysis to understand course feedback," in *Proceedings of the 2024 13th International Conference on System Modeling and Advancement in Research Trends*, pp. 643–648, 2024. https://doi.org/10.1109/SMART63812.2024.10882554.
[25] M. Z. Mekonen *et al.*, "An opinionated sentiment analysis using a rule-based method," *Bulletin of Electrical Engineering and Informatics*, vol. 14, no. 1, pp. 726-732, 2025. https://doi.org/10.11591/eei.v14i1.8568
[26] A. Onan, "Sentiment analysis on massive open online course evaluations: A text mining and deep learning approach," *Computer Applications in Engineering Education*, vol. 29, no. 3, pp. 572-589, 2021. https://doi.org/10.1002/cae.22253
[27] M. Mujahid *et al.*, "Sentiment analysis and topic modeling on tweets about online education during COVID-19," *Applied Sciences*, vol. 11, no. 18, p. 8438, 2021. https://doi.org/10.3390/app11188438
[28] Z. Kastrati, F. Dalipi, A. S. Imran, K. Pireva Nuci, and M. A. Wani, "Sentiment analysis of students' feedback with NLP and deep learning: A systematic mapping study," *Applied Sciences*, vol. 11, no. 9, p. 3986, 2021. https://doi.org/10.3390/app11093986
[29] M. Á. Escotet, "The optimistic future of Artificial Intelligence in higher education," *Prospects*, vol. 54, no. 3, pp. 531-540, 2024. https://doi.org/10.1007/s11125-023-09642-z
[30] M. Javaid, A. Haleem, R. P. Singh, S. Khan, and I. H. Khan, "Unlocking the opportunities through ChatGPT Tool towards ameliorating the education system," *BenchCouncil Transactions on Benchmarks, Standards and Evaluations*, vol. 3, no. 2, p. 100115, 2023. https://doi.org/10.1016/j.tbench.2023.100115