International Journal of Learning, Teaching and Educational Research
Vol. 25, No. 1, pp. 872-901, January 2026
https://doi.org/10.26803/ijlter.25.1.40
Received Oct 22, 2025; Revised Dec 10, 2025; Accepted Jan 15, 2026

Barriers and Enablers in the Adoption of Homework Intelligent Tutoring Systems among University Students in Disadvantaged South African Areas

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Abstract. Homework Intelligent Tutoring Systems (HITSs) are artificial intelligence-based tools that provide personalized learning support, yet their use in disadvantaged South African communities remains limited. This exploratory study examined the barriers and success factors that influence the adoption of HITSs among university students from underserved areas. Guided by Van Dijk's Digital Access Theory and the Unified Theory of Acceptance and Use of Technology, the study used a descriptive quantitative design. Data were collected through an online questionnaire using convenience and snowball sampling with a final sample of 37 participants. Descriptive and correlational analyses were performed in Excel. The findings show that the main barriers to HITSs adoption are infrastructure constraints, especially unreliable electricity, unstable internet access, and high data costs. Despite these challenges, students reported strong performance expectancy, effort expectancy, and intention to use the tools, suggesting that acceptance is influenced more by access limitations than by user attitudes. Privacy concerns were moderate, indicating limited awareness of data risks. The study extends both theoretical models by showing how access constraints shape technology acceptance in disadvantaged contexts. Practical recommendations include offline access, reduced data requirements, and multilingual support. The results are exploratory due to the small sample size and provide a foundation for future research.

Keywords: Artificial Intelligence; Digital Divide; Educational technology adoption; Homework Intelligent Tutoring Systems; ICT

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1. Introduction

Artificial Intelligence (AI) has transformed educational technology, with Homework Intelligent Tutoring Systems (HITSs) emerging as powerful tools that deliver personalized instruction and adaptive feedback to support student learning (Canuja et al., 2024; Lin et al., 2023). These AI-enabled systems address critical educational challenges by providing instant remediation and maintaining student engagement when students are struggling with difficult material (Sasikala & Ravichandran, 2024).

Despite their potential to improve educational quality and access in resource-constrained settings (Ntsobi & Mwale, 2024), HITSs implementation in disadvantaged South African communities face significant barriers. While South Africa recognizes the transformative potential of AI in education (Funda & Mbangeleli, 2024), the gap between AI's promise and its actual adoption remains substantial. No African country ranks among the top nations benefiting from AI and Intelligent Tutoring Systems (ITSs) (Buliva, 2019), despite over 60% of Sub-Saharan Africa's population being under 25, a demographic that could benefit significantly from AI-enabled learning tools (Buliva, 2019).

In today's globalized education landscape, higher education institutions (HEIs) are relying heavily on educational technology to improve teaching and learning (Feng et al., 2025). However, universities in richer countries are able to adopt advanced educational technologies, whereas those in resource-constrained contexts face older infrastructure and limited technical support, which weakens the impact of technology-enhanced learning initiatives (Feng et al., 2025). This disparity reflects broader implementation challenges in disadvantaged areas where barriers, including inadequate infrastructure, unstable connectivity, unreliable electricity, limited device access, high data costs, and limited digital literacy, hinder adoption (Mustafa et al., 2024).

As the pace and scale of technological change rapidly increase, it is essential to ensure that these advancements are harnessed effectively and do not deepen existing inequalities or introduce new ones, particularly in the South African context (Hart, 2023). While existing literature documents infrastructure barriers in African education broadly (Hart, 2023; Mustafa et al., 2024), no studies have systematically examined how these barriers interact with technology acceptance factors to influence HITS adoption among university students from disadvantaged backgrounds. To address this gap, this study examined the challenges and critical success factors affecting the effective implementation of HITSs in disadvantaged areas of South Africa, with a focus on four main research questions (RQs):

- What are the key barriers and critical success factors for implementing HITSs in disadvantaged communities in South Africa? (RQ1)
- How do socio-economic factors, such as poverty and lack of digital literacy skills, influence the effectiveness of HITSs in disadvantaged areas of South Africa? (RQ2)
- How do concerns about data privacy, security, and ethics affect adoption and trust when using HITSs? (RQ3)

- How can existing HITSs be adapted to address the specific needs of learners in disadvantaged areas of South Africa? (RQ4)

The Unified Theory of Acceptance and Use of Technology (UTAUT) and Van Dijk's Digital Access Model were used to ground this study. The UTAUT highlights four key factors that influence behavior: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC) (Chisango & Marongwe, 2021). It "*provides a basic conceptual framework by combining models that explain the individual acceptance of IT*" (Ayaz & Yanartas, 2020, p. 2). While the UTAUT is a widely used framework for examining how people adopt technology in education, particularly within higher education settings (Xue et al., 2024), it does not provide sufficient information on users' access to and use of information and communication technology (ICT). In contrast, Van Dijk's model explores and provides an understanding of the complexities of access to ICT (Kennedy & Cronjé, 2023). These frameworks complement each other by addressing different dimensions of technology implementation.

This study offers both theoretical and practical contributions. Theoretically, it extends UTAUT and Van Dijk's Digital Access Theory by examining their applicability to AI-enabled educational tools within disadvantaged South African communities. Integrating both frameworks provides a comprehensive understanding of how material access barriers interact with technology acceptance factors to influence HITS adoption. Practically, the research informs strategies for designing educational technologies adapted to resource-constrained settings, making them more effective, inclusive, and sustainable. The findings provide valuable insights for policymakers, developers and educators seeking to bridge the digital divide and improve educational outcomes in disadvantaged communities.

2. Literature Review

The digital divide refers to the gap between individuals with technology access and the skills to use it and those who do not have access (Miah, 2023). According to Chomunorwa et al. (2022), educational technology fosters an education system that promotes equal access to education. However, not all learners have equal access to technology (Miah, 2023). In South Africa, the digital divide exists between schools in affluent suburbs and poorly resourced schools in underserved communities (Chisango & Marongwe, 2021). HITSs play a key role in education as they improve engagement, personalization, and collaboration for both students and teachers (Nyathi & Joseph, 2024). However, despite their benefits, the implementation of HITSs faces significant challenges related to the digital divide, including socioeconomic, infrastructural, and pedagogical barriers that impact both students and teachers in disadvantaged communities. These barriers hinder equitable access to educational technologies.

2.1 Theoretical Frameworks

This study employed an integrated theoretical approach combining the UTAUT and Van Dijk's Digital Access Model. This study operationalized three UTAUT constructs (PE, EE, and SI) directly through questionnaire items, while FC was examined indirectly through Van Dijk's material access barriers, recognizing that infrastructure deficits in disadvantaged contexts represent the most critical facilitating conditions for technology adoption. Van Dijk's model addresses the structural digital divide through motivational access, material access, skills access, and usage access (Hart, 2023; Kennedy, 2023). This study used both frameworks by measuring material, skills, and usage access barriers (Van Dijk) alongside UTAUT's PE, EE, SI, and Behavioral Intention (BI). This integrated approach allowed the identification of whether implementation challenges stem primarily from access barriers or acceptance factors, informing targeted intervention strategies for resource-constrained educational settings.

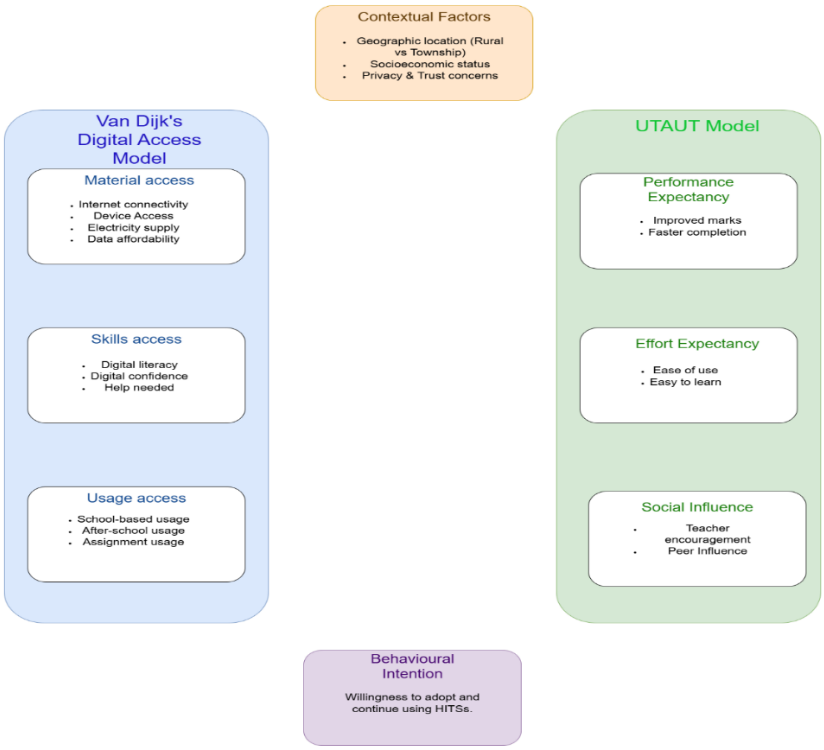


Figure 1: Integrated Conceptual Framework for HITS Implementation

Figure 1 integrates Van Dijk's Digital Access Model and the UTAUT framework to explain HITS adoption in disadvantaged South African communities. The integrated framework examined PE, EE, and SI from UTAUT, while FC was conceptualized through Van Dijk's material access dimension (internet, electricity, devices, and data affordability), recognizing that infrastructure represents the primary enabling or constraining condition in resource-limited contexts. Material, skills, and usage access barriers interact with PE, EE, and SI to determine BI to use HITS.

Infrastructure deficits are consistently identified as a barrier across studies (Ahiaku et al., 2025; Chisango & Marongwe, 2021). These barriers include digital devices and secondary technology tools such as electricity and internet connectivity (Chisango & Marongwe, 2021; Duma et al., 2021). According to Van Dijk's Digital Access Theory, material access to ICT means having the right devices, infrastructure, and resources available so that people can use it properly and efficiently (Kennedy & Cronjé, 2023). Material access is a key foundation for building digital skills and being able to use HITS. Prior research on technology access has primarily focused on students' physical access to devices, and mainly on testing and using tools that measure access in learning (Habibi et al., 2023). Yet, existing research has not examined whether high BI (UTAUT) persists despite material access deficits. Therefore, while material access is consistently recognized as foundational (Peters et al., 2022; Crompton et al., 2021), its relationship to student acceptance intentions remains unexplored.

Beyond material access, digital literacy represents a critical skill dimension of Van Dijk's framework. Lack of digital literacy in rural and township communities remains a significant contributor to the digital divide in South African education (Chumunorwa et al., 2022; Hart, 2023). Researchers highlight that teachers and students in disadvantaged communities often have difficulty understanding and using educational technologies, due to the lack of digital literacy skills (Hart, 2023; Chisango & Marongwe, 2021). Van Dijk's skills access to ICT in education is vital for building digital literacy, developing 21st-century skills, accessing learning resources, and improving the overall learning experience (Kennedy & Cronjé, 2023).

While most recent studies explore a broader set of questions about accessing and using information technologies and examine a wider range of influencing factors (Vassilakopoulou & Hustad, 2023), a clear gap still exists between simply having access to ICT and actually using it effectively (Bucea et al., 2020). Within the UTAUT framework, digital literacy has been shown to have a positive relationship with PE and EE. (Aavakare & Nikou, 2020; Jang et al., 2021). However, no study has examined whether students in these contexts perceive HITSs as easy to use (EE) despite limited digital literacy skills.

These infrastructure and skills barriers are further compounded by socio-economic challenges such as high levels of poverty and unemployment faced by disadvantaged communities (Chomunorwa et al., 2022; Gasa, 2024), creating interconnected challenges that reinforce digital exclusion. Researchers posit that the lack of financial resources is a factor that hinders the implementation of HITSs in disadvantaged communities (Chumunorwa & Mugobo, 2023; Hart, 2023). Students from low-income households may lack access to computers, the internet, or even electricity at home, which makes it challenging for them to engage with educational technologies (Sammu & Johnson, 2024). Furthermore, schools in disadvantaged communities often do not have the budget to implement educational technologies such as HITSs (Sammu & Johnson, 2024).

Within UTAUT, PE and EE capture users' beliefs about technology's benefits and ease of use (Bayag & Madimbe, 2024). Research confirms that both students and teachers are more inclined to adopt educational technology when they perceive it will benefit them and improve efficiency (Chomunorwa & Mugobo, 2023; Hart, 2023). However, these studies measure beliefs independently without examining how they interact with actual access barriers documented by Van Dijk's framework. Teacher beliefs represent a critical dimension of SI in UTAUT.

Teachers are instrumental to technology implementation success (Chomunorwa et al., 2022), with their attitudes, often shaped by inadequate training, directly influencing student adoption (Chisango & Marongwe, 2021; Hart, 2023). Yet existing research has not examined whether students maintain high BI to use HITS despite limited teacher support—a gap this study addressed by measuring both constructs. Research suggests that culturally adapted and offline-capable HITS features may address implementation challenges (Castillo et al., 2022; Chumunorwa & Magubo, 2023; Sammu & Johnson, 2024).

However, this research remains conceptual; no studies have empirically tested whether these adaptations actually improve acceptance factors (PE and EE) or adoption intentions among students in disadvantaged South African contexts. This study addressed this gap by examining which specific features students prioritize and how these relate to their acceptance intentions. There are several challenges with the implementation of AI-enabled technologies, including a lack of transparency, reliability issues, and ethical concerns (Aladi, 2024). Privacy and security concerns are inevitable when implementing AI-based technologies such as HITSs (Rana et al., 2024; Zhenyuan, 2022; Jiang et al., 2022). Trust is important during the adoption of AI-based educational technology, as students have strong privacy concerns about how educational technologies handle and use their data (Zhenyuan, 2022; Jiang et al., 2022).

Studies indicate that students are most worried about the data handling practices of the educational systems; their second biggest concern is the control of the information being collected (Zhenyuan, 2022). However, there is limited research examining how these privacy and ethical concerns specifically impact HITSs' adoption in the South African disadvantaged community context, highlighting a gap this study aimed to address.

3. Methodology

This study adopted a descriptive, quantitative research design informed by a positivist paradigm. A descriptive design collects organized information to accurately depict circumstances (Mohd et al., 2022), while a quantitative approach enables the measurement of numerical data using statistical analysis (Pandey et al., 2023). The positivist paradigm treats implementation barriers as phenomena that can be studied scientifically through observation and data (Ugwu et al., 2021). This combination allowed the researchers to analyze the characteristics and relationships of HITSs’ implementation in disadvantaged South African communities through the theoretical lens of Van Dijk’s Digital Access Model and the UTAUT, thereby quantifying barriers and success factors affecting adoption.

Furthermore, the study employed survey research as a research strategy. Survey research is a quantitative research strategy in which participants from a sample group are requested to answer questions, through surveys, questionnaires, or polls (Ghanad, 2023). This approach allowed for the distribution of questionnaires as a data collection method to students from disadvantaged communities in order to gather their experiences, challenges, and perceptions of using HITSs.

3.1 Sampling

The target population for this study comprised university students from disadvantaged areas who had used HITSs. Participants had to be currently enrolled for an undergraduate degree at any South African HEI. The study employed convenience and snowball sampling. Convenience sampling selects respondents based on accessibility (Golzar et al., 2022). The researchers shared the link to the questionnaire with their contacts via WhatsApp, requesting them to forward it to their contacts who had used HITSs. This process, known as snowball sampling, was followed to increase the number of respondents, resulting in a sample size of 37.

The sample of 37 participants reduced the study's statistical power and generalizability. The relatively small sample size was a result of the strict inclusion criteria, limited population accessibility, and the limited timeframe available to conduct the research. To mitigate this limitation, the study adopted an exploratory approach with findings interpreted as suggestive rather than conclusive.

3.2 Data Collection Instrument and Analysis

Data were collected using an online questionnaire administered via Google Forms (see Appendix 1). The questionnaire consisted of six sections: Section 1 contained three screening questions to determine the eligibility of the respondent to continue with the questionnaire. These included: prior HITSs use, from a disadvantaged area, and HEI enrolment. Respondents not meeting all criteria were excluded. Section 2 was based on Van Dijk's Digital Access Theory and contained nine Likert-scale questions measuring material, skills, and usage access. Section 3 was based on UTAUT factors. It included eight Likert-scale questions measuring PE, EE, SI, and BI. Sections 4, 5, and 6 included open-ended and multiple-choice questions regarding challenges, privacy concerns, and suggested adaptations.

Content validity was ensured by grounding questionnaire items in established theoretical constructs. Section 2 items were based on Van Dijk's Digital Access Model (material, skills, and usage access) and Section 3 items operationalized UTAUT constructs (PE, EE, SI, and BI) using validated instruments. Each Likert-scale item measured a specific construct, ensuring alignment with the research questions and theoretical framework.

Initially, the authors intended to use SPSS, but due to licensing issues at the institution and time constraints of the project, SPSS licensing could not be obtained in time. Therefore, Excel was employed for data analysis, enabling calculation of descriptive statistics (means, standard deviations, frequencies, and percentages), and Pearson correlation coefficients with significance testing ($p<0.05$).

Given the exploratory nature of the study and the research questions focusing on identifying barriers, success factors, and relationships between access variables and acceptance factors, descriptive and correlational analyses were deemed appropriate and sufficient. Descriptive statistics addressed RQ1 (key barriers and success factors), RQ3 (privacy concerns), and RQ4 (feature adaptations) by quantifying the prevalence and severity of various challenges. Correlation analysis addressed RQ2 (socioeconomic influences) by examining relationships between material access, digital literacy, and technology acceptance constructs. The small sample size (n=37) and exploratory nature of the study made more complex inferential analyses inappropriate at this stage.

3.3 Reliability of the Data Collection Instrument

The reliability of a research instrument refers to its consistency, meaning it produces similar results when applied multiple times under the same conditions (Ranganathan et al., 2024). Upon the completion of data collection, internal consistency of the 22-Likert scale items was assessed using Cronbach's alpha. Cronbach's alpha values range between 0 and 1, where higher values indicate that the items consistently measure the same variable or dimension and demonstrate greater reliability. Conversely, a low value (close to 0) suggests that some or all items do not assess the same construct, meaning the questionnaire lacks reliability or internal consistency (Bujang et al., 2024).

Table 1: Cronbach's alpha values for the study (N=37)

Reliability statistics	
#Questions	22
Sum of the variances	27.911
Variance of total scores	135.978
Cronbach's alpha	0.833

As shown in Table 1, the Cronbach's Alpha value of 0.833 indicates significant reliability and suggests that the study could be replicated.

3.4 Ethical Considerations

Throughout this research, the researchers had the responsibility of respecting the rights and interests of their participants, their audience, their academic community, and society at large (Mirza et al., 2023). Approval was obtained from relevant stakeholders before commencing data collection and securing permission to conduct the research with the target population. The researchers obtained ethical clearance from the University of Johannesburg (Ethical Clearance Code: 2025AIS034) and secured participants' informed consent through an online form before administering the questionnaire.

Taking part in the questionnaire was optional. The questionnaire was anonymous, and the respondents were assured that their responses would remain private and anonymous. No personally identifiable information was collected. Computer-based questionnaire records were accessed by the researchers only, using access privileges and passwords. Electronic data will be securely stored for a minimum of five years in password-protected files accessible only to the researchers, in accordance with the University of Johannesburg's research data management policies. After this period, data will be permanently deleted.

4. Results

The findings of the study provide valuable insights into the challenges and success factors of HITSs in disadvantaged areas of South Africa. A total of 83 questionnaire responses were received, but only 37 met the inclusion criteria, which were:

- Participants had used HITSs before.
- Participants were enrolled at an HEI.
- Participants came from a rural area or township.

Consequently, 46 responses had to be excluded from the analysis process due to incomplete sections or failing to meet the criteria as presented above, which prevented them from proceeding with the remainder of the questionnaire. Thus, all 37 respondents who completed the questionnaire had used HITSs before, were currently registered at a HEI in South Africa, and were from a disadvantaged area, as these were the prerequisites for participation.

This section begins by outlining the respondents' demographic characteristics through frequency analysis. The demographics are presented based on the type of residential area (Figure 2).

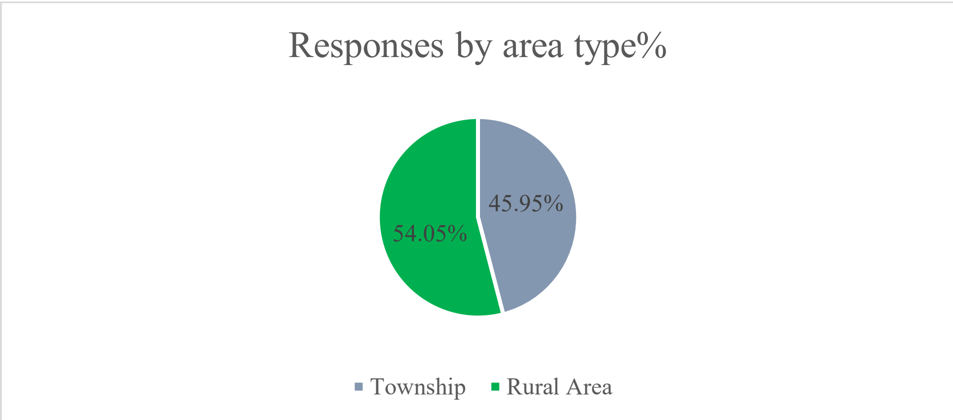


Figure 2: Residential Demographics Distribution

As shown in Figure 2, more than half, 54.05% (20), of the respondents were from rural areas, and 45.95% (17) were from townships.

The subsequent sections present the findings, which are organized thematically according to the theoretical constructs from Van Dijk's Digital Access Model (material access, skills, and usage access) and the UTAUT (PE, EE, SI, and BI). The questionnaire contained items grouped by the theoretical constructs. All constructs in the questionnaire had item statements that were rated on a five-point Likert scale ranging from 1 – strongly disagree to 5 – strongly agree, with 3 – neutral.

4.1 Material Access

Material access assessed whether students had sufficient technology infrastructure and whether they could afford the costs associated with HITSs. Table 2 presents the mean and standard deviation results of this construct.

Table 2: Material access (N=37)

Material Access	**N**	**Mean (M)**	**Standard Deviation (SD)**
I had stable internet access to access HITSs	37	3.62	1.11
I had access to reliable electricity supply to use HITSs	37	3.35	1.16
I had regular access to computers, smartphones tablets to access HITSs.	37	3.84	0.83
I could afford to buy data to access HITSs	37	2.89	1.125

Material access scores reveal a critical pattern validating Van Dijk's multidimensional access framework. While device access was adequate (M=3.84, SD=0.83), data affordability emerged as the primary barrier (M=2.89, SD=1.125), with nearly half the sample unable to sustain connectivity despite owning devices. The variability in internet (SD=1.11) and electricity access (SD=1.16) suggests infrastructure inequality even within disadvantaged communities. These findings confirm that device ownership alone is insufficient for digital inclusion; the ongoing costs and infrastructure reliability determine actual usage capacity.

As depicted in Figure 3 below, more than half of the respondents (51.35%) indicated that unreliable electricity was the biggest challenge, followed by high data costs (48.65%).

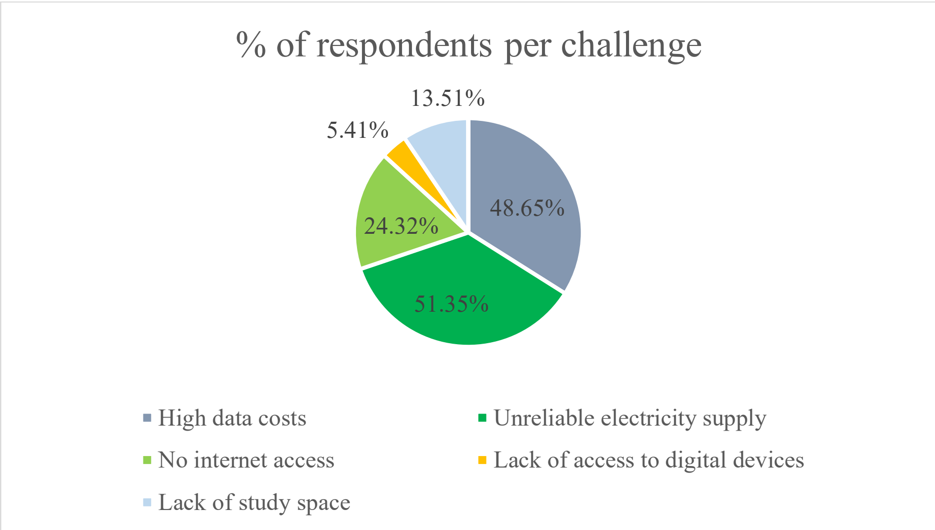


Figure 3: Challenges Faced by Respondents When Using HITSs

4.1.1 Residential disparities

Figure 4 reveals residential disparities in HITSs usage challenges between rural areas and townships.

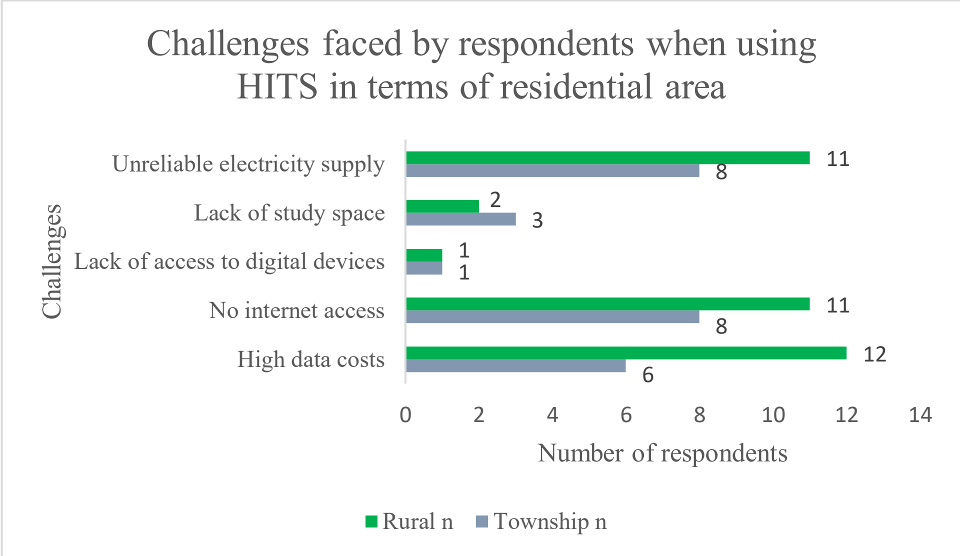


Figure 4: Challenges Faced by Respondents When Using HITSs in Terms of Residential area

Rural respondents reported higher rates of no internet access (n=11) compared to township respondents (n=8), indicating that connectivity challenges affect both areas but are more severe in rural areas. High data costs affect rural areas more (n=12) compared to townships (n=6). Unreliable electricity supply was the most common challenge across both areas, but it is more pronounced in rural areas (n=11) than in townships (n=8). These residential disparities confirm that infrastructure barriers are more severe in rural contexts.

4.2 Skills Access and Usage Access

Skills access (Table 3) assessed whether respondents had sufficient ICT skills to engage with HITSs efficiently, while usage access (Table 4) determined whether they had ICT infrastructure at home or the institution to use HITSs.

Table 3: Skills access (N=37)

Skills access	N	Mean (M)	Standard Deviation (SD)
I was confident with using digital tools for learning	37	3,84	1,04
I needed help when I used HITSs for the first time	37	3,08	1,30
I was confident in my digital skills to use HITSs effectively	37	3,70	1,20

Skills access demonstrated moderate digital confidence (M=3.84, SD=1.04) with notable variability, indicating disparities in digital literacy. Initial support requirements (M=3.08, SD=1.30) varied substantially, reflecting varied prior technology exposure. Usage access patterns revealed stronger after-school engagement (M=3.84, SD=1.12) than school-based usage (M=3.0, SD=1.39), suggesting personal device reliance compensates for inadequate institutional infrastructure.

Table 4: Usage access (N=37)

Usage access	**N**	**Mean (M)**	**Standard Deviation (SD)**
I used HITSs during school hours	37	3	1,39
I used HITSs after school hours	37	3,84	1,12
I used HITSs regularly to complete my assignments	37	3,65	1,06

For usage access, school-based HITS usage was limited (M=3.0, SD=1.39), with high variability suggesting access differs across institutions. In contrast, after-school usage was strong (M=3.84, SD=1.12), indicating consistent personal use patterns. Regular assignment use was moderately high (M=3.65, SD=1.06), demonstrating academic integration of HITSs with generally consistent patterns across respondents.

4.3 Pearson Correlation Analysis

The Pearson correlation results between material access, SI, and skills variables are summarized in Table 5. The Pearson correlation analysis in Table 5 reveals significant positive relationships among HITSs material access variables.

Table 5: Pearson correlation analysis (N=37)

Variable 1	Variable 2	Correlation(r)	Sample size(n)	t-stat	degrees of freedom (t)	p-value	Significance
Internet access	Device access	0.71	37	5.96	35	<0.01	**
Electricity	Device access	0.58	37	4.19	35	<0.01	**
Device access	Data affordability	0.54	37	3.83	35	<0.01	**
Internet access	Electricity	0.75	37	6.72	35	<0.01	**
Digital confidence	Internet access	0.54	37	3.84	35	<0.01	**
Digital confidence	Device access	0.45	37	2.97	35	<0.01	**
Peer motivation	Help needed	0.54	37	3.75	35	<0.01	**
Peer motivation	Teacher motivation	0.37	37	2.35	35	<0.05	*
Easy learning	Digital confidence	0.37	37	2.38	35	<0.05	*

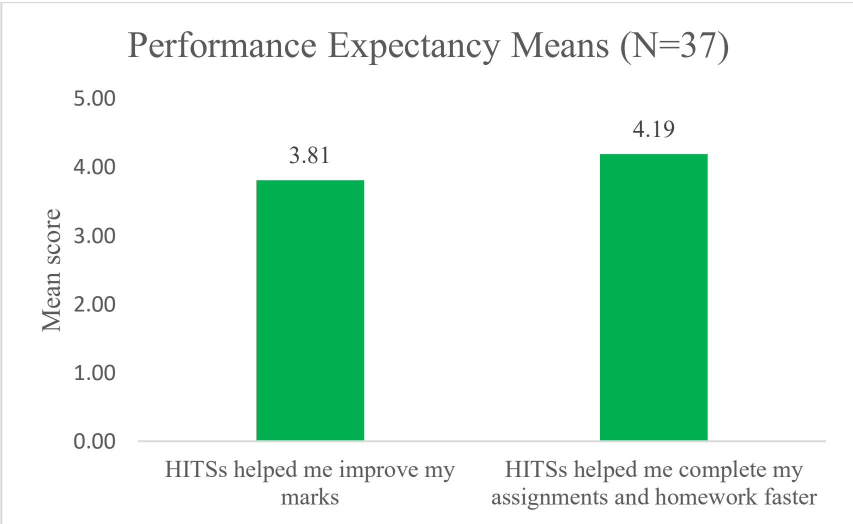
*Note: * $p < 0.05$; ** $p < 0.01$*

Material access variables showed statistically significant correlations: internet and device access *($r = 0.71$, $p < 0.01$)*, electricity and device access *($r = 0.58$, $p < 0.01$)*, and device and data affordability *($r = 0.54$, $p < 0.01$)*, indicating that students lacking one resource tend to lack multiple others. Digital confidence showed statistically significant positive correlations with both internet access *($r = 0.54$, $p < 0.01$)* and device access *($r = 0.45$, $p < 0.01$)*, both representing large and medium-to-large effects, respectively. These findings indicate that students with better access to digital resources tended to have higher confidence in their digital skills.

Social influence variables also demonstrated significant relationships. Peer motivation and help needed showed a large positive correlation *($r = 0.54$, $p < 0.01$)* revealing that students who needed more help when first using HITSs were more likely to be influenced by peer motivation. Peer motivation and teacher motivation demonstrated a medium positive correlation *($r = 0.37$, $p < 0.05$)*, suggesting that social influence from peers and teachers tended to occur together. Easy learning and digital confidence showed a medium positive correlation *($r = 0.37$, $p < 0.05$)*, indicating that respondents who found HITSs easy to learn also tended to have higher digital confidence.

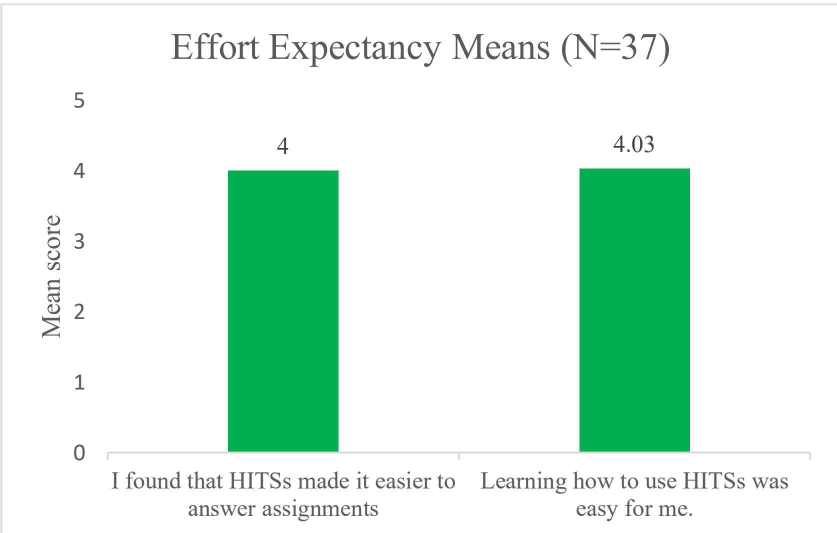
4.4 UTAUT Constructs

UTAUT items revealed consistently high technology acceptance despite documented access barriers. Performance Expectancy items demonstrated strong beliefs about HITS benefits: students agreed HITS improved their marks (M=3.81, SD=0.91) and enabled faster assignment completion (M=4.19, SD=0.94), as shown in Figure 5. Effort Expectancy items showed high usability perceptions: students found HITS made assignments easier (M=4.0, SD=0.82) and was easy to learn (M=4.03, SD=1.01), illustrated in Figure 6. Behavioral Intention was high (M=4.0, SD=0.97), shown in Figure 7.



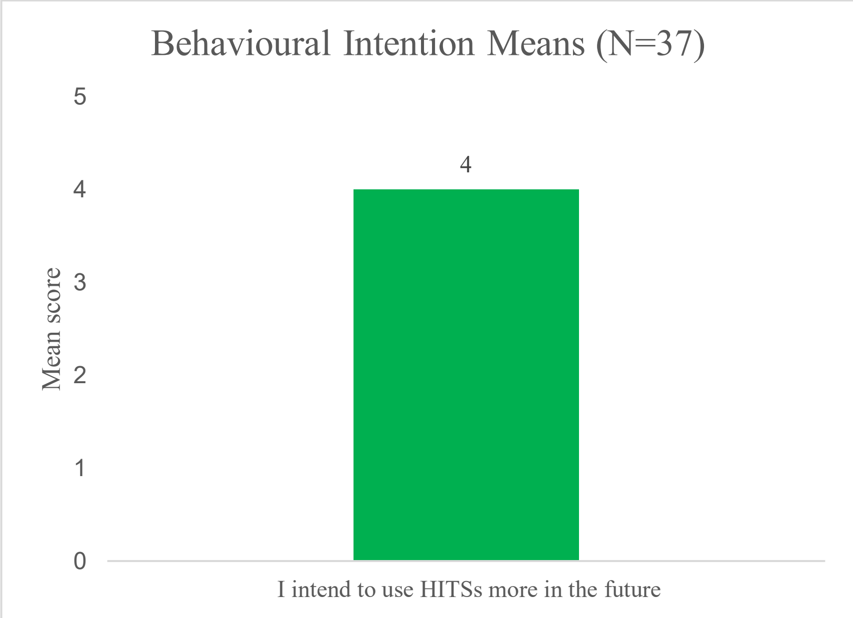
Note: Standard deviations are 0.91 (improved marks) and 0.94 (faster completion)

Figure 5: Performance Expectancy Means (N=37)



Note: Standard deviations are 0.82 (easier assignments) and 1.01 (easy to learn)

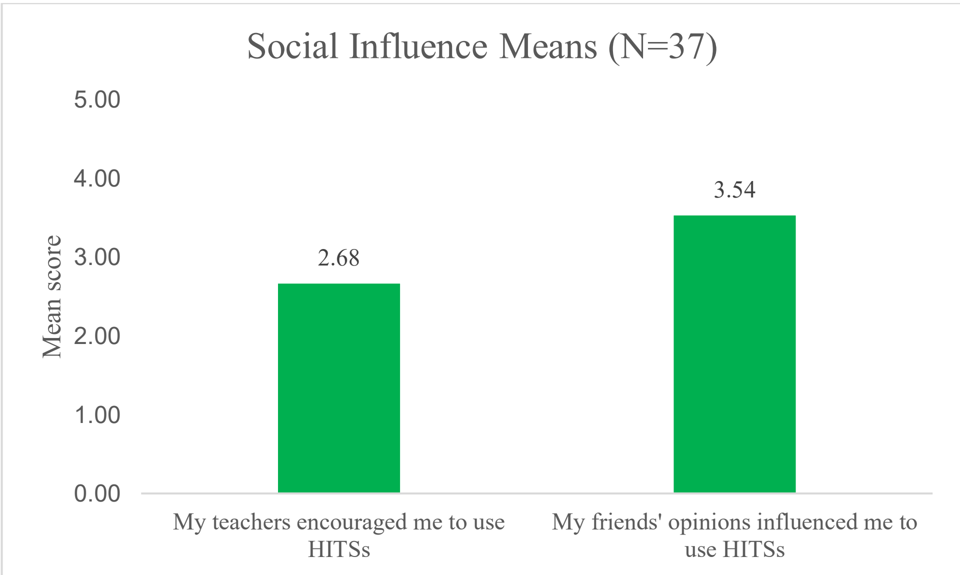
Figure 6: Effort Expectancy Means (N=37)



Note: Standard deviation is 0.97

Figure 7: Behavioral Intention Means (N=37)

However, SI (Figure 8) presented a contrasting pattern. Teacher encouragement remained insufficient (M=2.68, SD=1.49), while peer influence was moderately positive (M=3.54, SD=1.14). The 0.86-point gap between peer and teacher support suggests that technology adoption in disadvantaged contexts operates through informal peer networks rather than formal institutional channels, a deviation from UTAUT's typical application in well-resourced settings, where institutional support features prominently.



Note: Standard deviations are 1.49 (teacher encouragement and 1.14 (peer influence)

Figure 8: Social Influence Means (N=37)

Despite consistently high scores across Performance Expectancy items (M=3.81-4.19, Figure 5), Effort Expectancy items (M=4.0-4.03, Figure 6), and Behavioral Intention (M=4.0, Figure 7), teacher encouragement remained low (M=2.68, Figure 8). This pattern challenges traditional UTAUT assumptions: students maintain strong acceptance beliefs despite insufficient institutional support, suggesting that Social Influence from teachers may be less critical in disadvantaged contexts where peer networks compensate for institutional gaps. The disconnect between high acceptance across all UTAUT items and documented material access barriers (Section 4.1) indicates that adoption obstacles are structural rather than attitudinal. Strong latent demand exists, awaiting infrastructure enablement rather than motivational interventions.

4.5 Privacy, Trust, and Safety

Privacy, trust, and safety concerns assessed how users felt about data safety when using HITSs as shown in Table 6.

Table 6: Privacy, trust, and safety concerns (N=37)

Privacy, trust and safety concerns	N	Mean (M)	Standard Deviation (SD)
I was confident my personal information was safe when using HITSs	37	3,54	1,07
I worried about who saw my data when using HITSs	37	2,78	1,27
I avoided using HITSs because I didn't trust the tool	37	2,32	1,27

Respondents reported moderate confidence in personal information safety (M=3.54, SD=1.07), indicating mixed trust levels in data protection. Concerns about data visibility were limited (M=2.78, SD=1.27), though the high standard deviation showed substantial variability—some respondents worried significantly while others did not. Trust issues did not prevent HITS use (M=2.32, SD=1.27), suggesting that, despite concerns, students continued engaging with the technology.

4.6 Feature Improvements

In Table 7 participants were asked to select which features would improve their experience with HITSs through multiple-choice checkboxes.

Table 7: Feature improvements

Feature improvements		
Feature option	**Frequency**	**% of respondents**
Offline access capability	22	59,46
Data free usage	21	56,76
Support for various South African Languages	8	21,62
Interactive tutorials	6	16,22
User friendly interface	9	24,32

Offline access capability was the most requested feature (n=22, 59.46%), followed closely by data-free usage (n=21, 56.76%). Support for various South African languages was selected by 21.62% of respondents, indicating language barriers for non-English speakers. Nine respondents (24.32%) requested user-friendly interface improvements, suggesting usability challenges with current platforms. Interactive tutorials were requested by fewer respondents (n=6, 16.22%), indicating limited demand for additional learning support features.

5. Discussion

This study's theoretical contribution aligns with emerging global frameworks for technology-enhanced learning in developing contexts. The Smart Education Framework emphasizes intelligent learning environments supported by adequate infrastructure, qualified teachers, and appropriate pedagogical approaches (Demir, 2021; Yang, 2025). The findings empirically validate this framework's applicability to South Africa by demonstrating that all three components—infrastructure (material access), teacher support (social influence), and pedagogical effectiveness (performance expectancy)—significantly influence HITS adoption. The Digital Learning Ecology framework similarly emphasizes the interconnectedness of learners, resources, and context (Nguyen et al., 2023). The integrated UTAUT-Van Dijk model operationalizes this ecological perspective by showing how contextual factors moderate relationships between access barriers and acceptance factors.

5.1 Infrastructure Barriers as Primary Challenges

From a Van Dijk theoretical perspective, the findings illustrate how material access barriers create the foundation of digital exclusion. While students reported good access to digital devices and stable internet connections, they struggled with data affordability (M=2.89) and reliable electricity (M=3.35). High data costs are linked to income inequalities affecting users' ability to afford connectivity (Pillay & Struweg, 2023), particularly in underserved communities. This represents a critical gap in Van Dijk's "material access" dimension, where device ownership proves insufficient without ongoing financial resources to maintain connectivity (Chomunorwa & Mugobo, 2023; Hart, 2023).

Furthermore, frequent power outages due to South Africa's loadshedding crisis disrupt internet connectivity, especially in rural areas (Mbaleki et al., 2023; Olatoye & Fru, 2024). Strong positive correlations between internet access, device access, electricity, and digital confidence ($r=0.71$, $r=0.45$, $r=0.54$; all $p<0.01$) confirmed that students lacking one resource tend to lack multiple others, demonstrating the interconnected nature of Van Dijk's access dimensions. These socioeconomic constraints prevent equal HITS access (Şen Ersoy, 2023).

Residential disparities revealed that rural communities face more severe infrastructure challenges than townships, though both remain disadvantaged compared to urban areas. This geographic stratification aligns with Van Dijk's emphasis on how structural inequalities shape material access patterns. Importantly, identified barriers stem from systemic factors rooted in structures and policies rather than individual student circumstances or motivation. Addressing these requires coordinated action: internet providers offering subsidized data bundles and policymakers lowering taxes on internet service providers (Zongozzi & Ngubane, 2025).

5.2 Skills and Digital Literacy Disparities

Van Dijk's theoretical proposition that material access alone is insufficient for digital inclusion was validated by findings showing skill variations among disadvantaged students. While most students reported adequate digital literacy, disparities existed—some were highly equipped with digital skills and confidence, others had minimal competencies. The digital capability divide denotes disparities in skills needed to effectively use information technology, stemming from socioeconomic status and family backgrounds (Faloye & Ajayi, 2022). Positive correlations between digital confidence and material access variables (r=0.54 with internet access, r=0.45 with device access) empirically demonstrate how material deprivation constrains skills development, creating a reinforcing cycle of digital exclusion that impedes student advancement and deepens educational gaps (Jibrin et al., 2024; Şen Ersoy, 2023).

5.3 Strong Student Acceptance Despite Barriers

A critical UTAUT finding emerged: despite material access deficits documented through Van Dijk's framework, students maintained strong beliefs about HITS benefits (PE M=4.0). PE is the strongest predictor of BI in UTAUT (Hart, 2023). High BI (M=4.0) revealed students' willingness to continue using HITS regardless of infrastructure barriers. This disconnects between intention and material access conditions challenges traditional UTAUT applications. While UTAUT typically assumes that FC (institutional support, infrastructure) moderates the intention-behavior relationship (Wibowo, 2023), our findings suggest that in disadvantaged contexts, strong intentions persist despite absent infrastructure, creating latent adoption potential that can be activated once access barriers are addressed.

However, insufficient teacher support (M=2.68) represents a critical gap in UTAUT's SI construct. Teacher and peer perspectives play key roles in HITS adoption, helping overcome existing barriers (Hart, 2023). The moderate positive correlation between peer and teacher motivation (r=0.37, $p<0.05$) suggests social influence operates through multiple channels, with peers partially compensating for limited teacher support.

5.4 Privacy, Trust, and Ethical Concerns

Students expressed low concern about data safety, privacy, and trust in HITS platforms, contrasting with research emphasizing high privacy concerns (Binitie et al., 2025). However, this finding warrants critical examination through an AI ethics lens. Educational technologies gather a lot of student data, from personal details and activity patterns to broader anonymized behavior trends (Schlosser et al., 2022). Students from disadvantaged backgrounds are most at risk when privacy and security are treated as optional in a contingent sociotechnical system. When systems are designed without making privacy a core priority from the start, it creates fairness and justice issues because the people with the least resources end up being harmed the most (Wagman et al., 2023).

This may reflect limited awareness of security risks among South African students. Privacy concerns may be less salient when immediate practical barriers (connectivity and affordability) dominate experiences. This highlights the privacy dilemma that arises when convenience is prioritized and examines how this tension plays out as teachers and universities rely more on technology (Robertson & Muirhead, 2019). Students struggling with foundational material barriers may prioritize immediate utility over abstract privacy risks. Gaps in technological infrastructure make data management even harder for disadvantaged students who do not have dependable digital systems. These issues highlight the need for a strong governance framework to maintain data quality (Medeiros et al., 2025).

Research confirms that privacy concerns do not necessarily prevent educational technology use (Jiang et al., 2022; Rana et al., 2024), suggesting privacy considerations, while ethically important, may not function as primary adoption barriers in resource-constrained contexts where access challenges overshadow data governance concerns. Without proactive governance, HITS implementation risks inadvertently exploiting disadvantaged students through extractive data practices masked as educational innovation.

5.5 Feature Priorities and Implications for Developing Countries

Over half of the students requested offline access capability, confirming data affordability challenges. Additionally, 21.62% needed multilingual support, indicating language barriers for non-English speakers. These feature priorities reflect broader lessons for adapting AI-enabled educational technologies to developing contexts. HITS design must prioritize accessibility over sophisticated features, aligning with development studies emphasizing technologies designed for actual conditions rather than idealized scenarios (Castillo et al., 2022; Mustafa et al., 2024). However, low privacy salience does not justify minimizing data protection; rather, it underscores heightened ethical responsibilities for policymakers and HITS developers to protect vulnerable populations.

For developing countries facing similar infrastructure constraints, successful HITS implementation requires: (1) offline-first architecture synchronizing data when connectivity is available, (2) culturally and linguistically adapted content reflecting local educational contexts, (3) low-bandwidth optimization, and (4) simplified user interfaces accommodating varying digital literacy levels. Educational institutions, application developers, and course developers must overcome cultural and language obstacles by adapting content to local contexts (Şen Ersoy, 2023). User-friendliness requests highlight the critical importance of Van Dijk's "skills access" dimension—even with material access, lack of digital competencies prevents effective usage, necessitating digital literacy initiatives.

6. Conclusion

This study examined challenges and success factors of implementing HITSs in disadvantaged South African areas. The findings reveal that infrastructure barriers, particularly unreliable electricity and high data costs, constitute primary hindrances to adoption. Despite these systemic challenges, students demonstrated high BI, EE, and PE, indicating that barriers are infrastructure-related rather than user-related. Insufficient teacher support revealed critical institutional gaps, while significant digital skills variation showed disparities within disadvantaged communities. The study offers theoretical and practical contributions. The integrated UTAUT-Van Dijk framework demonstrates that high technology acceptance can coexist with severe material access barriers in resource-constrained contexts. The findings inform strategies for designing contextually appropriate HITS that prioritize offline functionality, multilingual support, and simplified interfaces for disadvantaged communities.

Limitations include the focus on university students rather than high school learners or out-of-school youth, a small sample size (n=37) limiting generalizability, and a limited geographic scope. Future research should include diverse student populations, employ mixed-methods approaches combining quantitative and qualitative data, conduct comparative studies across African countries to identify context-specific versus generalizable barriers, and implement longitudinal designs tracking adoption patterns over time.

The study's findings carry significant policy and theoretical implications. Policymakers must prioritize investments in digital infrastructure, affordable connectivity solutions, and teacher professional development as prerequisites for equitable educational technology access. Theoretically, this study extends understanding of technology adoption by demonstrating that structural access barriers and user acceptance operate as distinct dimensions; high acceptance alone cannot overcome material deprivation. These insights inform educational technology implementation across developing countries facing similar infrastructure constraints.

7. Conflict of Interest

The authors declare no conflict of interest. No funding or external support was received.

8. Acknowledgment

No AI tools were used in the preparation of this manuscript.

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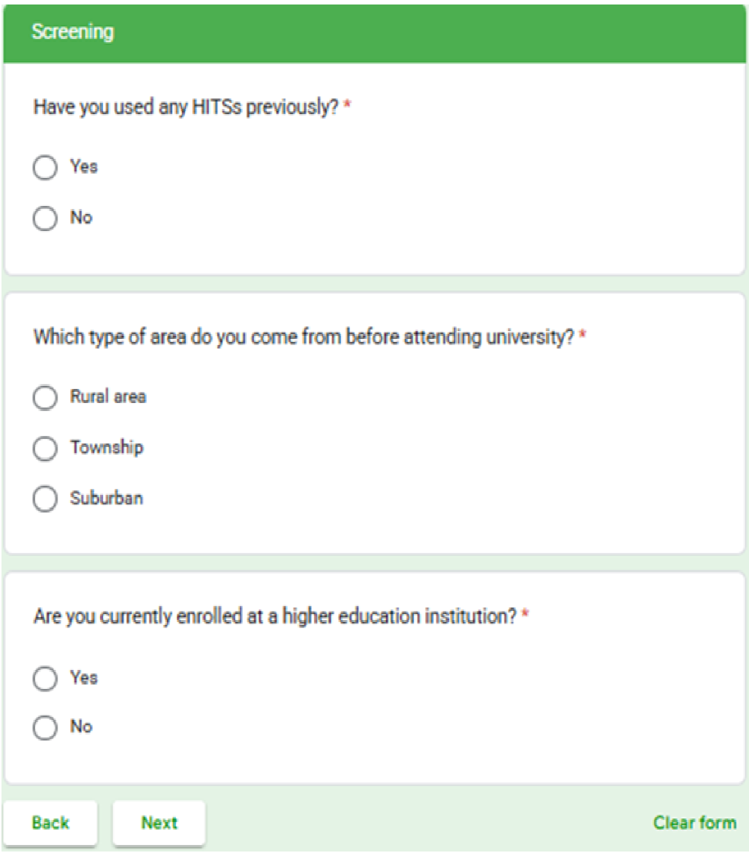
Appendix 1: Questionnaire


Screening

Have you used any HITSs previously? *

- Yes
- No

Which type of area do you come from before attending university? *

- Rural area
- Township
- Suburban

Are you currently enrolled at a higher education institution? *

- Yes
- No

Back Next Clear form

Digital Access

Material access *

Please choose the correct number for each of the statements below based on the criteria as listed:

Strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5

	1	2	3	4	5
I had stable internet access to access HITSs	○	○	○	○	○
I had access to reliable electricity supply to use HITSs	○	○	○	○	○
I had regular access to computers, smartphones tablets to access HITSs.	○	○	○	○	○
I could afford to buy data to access HITSs	○	○	○	○	○

Skills access *

Please choose the correct number for each of the statements below based on the criteria as listed:

Strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5

	1	2	3	4	5
I was confident with using digital tools for learning	○	○	○	○	○
I needed help when I used HITSs for the first time	○	○	○	○	○
I was confident in my digital skills to use HITSs effectively	○	○	○	○	○

Usage access *

Please choose the correct number for each of the statements below based on the criteria as listed:

Strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5

	1	2	3	4	5
I used HITSs during school hours	○	○	○	○	○
I used HITSs after school hours	○	○	○	○	○
I used HITSs regularly to complete my assignments	○	○	○	○	○

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UTAUT

Performance Expectancy (PE) *

Please choose the correct number for each of the statements below based on the criteria as listed:

Strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5

	1	2	3	4	5
HITSs helped me improve my marks	○	○	○	○	○
HITSs helped me complete my assignments and homework faster	○	○	○	○	○

Behavioural Intention (BI) *

Please choose the correct number for each of the statements below based on the criteria as listed:

Strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5

	1	2	3	4	5
I intend to use HITSs more in the future	○	○	○	○	○

Back Next Clear form

Barriers of implementing HITSs in disadvantaged areas

What challenges did you face when using HITSs. Select all that apply *

- [ ] High data costs
- [ ] No internet access
- [ ] Lack of access to digital devices
- [ ] Lack of study space
- [ ] Unreliable electricity supply
- [ ] Other: ______

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Privacy, trust and safety

Privacy, trust and safety concerns *

	1	2	3	4	5
I was confident my personal information was safe when using HITSs	◉	○	○	○	○
I worried about who saw my data when using HITSs	○	○	○	○	○
I avoided using HITSs because I didn't trust the tool	○	○	○	○	○

What would have increased your trust in HITSs? *

Your answer ______

Back Next Clear form

Adaptation strategies

Which features would have improved your experience with HITSs? *

- [x] Offline access capability
- [ ] Support for various South African Languages
- [ ] Data free usage
- [ ] Interactive tutorials
- [ ] User friendly interface

What did you wish HITSs had that they didn't offer? *

offline access

Did HITSs support your learning needs? *

- ○ Yes
- ○ No
- ○ Partially

Would you have preferred the content to be in your home language? *

- ○ Yes
- ○ No

Effort Expectancy (EE) *

Please choose the correct number for each of the statements below based on the criteria as listed:

Strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5

	1	2	3	4	5
I found that HITSs made it easier to answer assignments	○	○	○	○	○
Learning how to use HITSs was easy for me.	○	○	○	○	○

Social Influence (SI) *

Please choose the correct number for each of the statements below based on the criteria as listed:

Strongly disagree=1, disagree=2, neutral=3, agree=4, strongly agree=5

	1	2	3	4	5
My teachers encouraged me to use HITSs	○	○	○	○	○
My friends' opinions influenced me to use HITSs	○	○	○	○	○