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Interactive Learning in Afghanistan: Feasibility of Implementing IoT Connected Devices in Classrooms

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ABSTRACT

In the dynamic landscape of Afghanistan's education, this study explores into the transformative integration of the Internet of Things (IoT). With the purpose of scrutinizing perceptions, challenges, and preparedness, a meticulous mixed-methods approach was employed, collecting data from 120 participants across diverse educational backgrounds. The deliberate inclusion of participants from Computer Science, Agriculture, Education, and Economics faculties, representing institutions such as Kabul, Karwan, Badakhshan, Samangan, and Faryab University, ensured a comprehensive exploration. Through structured questionnaires utilizing Likert-scale items, the methodology sought to gauge participants' perceptions of technological infrastructure, institutional support, and challenges linked to IoT integration. Notably, ANOVA and regression analyses were applied to discern influential factors shaping participants' views. The study's novelty lies in its meticulous uncovering of nuanced perceptions, specifically emphasizing the pivotal role of technical expertise perception in the readiness for IoT integration within educational faculties. The consensus on IoT's potential to reshape teacher-student interactions and elevate academic outcomes is a novel contribution, highlighting the transformative impact on pedagogical practices. Additionally, the research anticipates and scrutinizes technological and infrastructural challenges, identifying resource constraints, and proposing targeted strategies for efficacious IoT implementation. In conclusion, this research enriches the discourse on IoT in education by accentuating the significance of institutional support, addressing challenges, and proposing practical guidelines. It not only contributes actionable insights for Afghanistan policymakers and educators but also lays a foundation for future research to optimize strategies in specific challenges, ultimately fostering successful IoT integration in Afghanistan's educational landscape.

INTRODUCTION

The integration of Internet of Things (IoT) technologies into educational settings stands as a transformative force, promising novel approaches to teaching and learning. As the global landscape of education evolves, the application of IoT in educational environments has garnered attention for its potential to revolutionize traditional pedagogical methods. The significance of this integration lies not only in its technological advancements but also in its capacity to reshape the very essence of educational experiences, particularly in regions like Afghanistan (Ahmad, 2018).

In recent years, scholars have increasingly recognized the potential of IoT in education (Atzori *et al.*, 2010). The IoT, characterized by the interconnection of physical devices, offers unprecedented opportunities to enhance the educational landscape. As explored by (Atzori *et al.*, 2010), the convergence of social networks and IoT can pave the way for innovative educational practices, creating a dynamic and interactive learning environment. Afghanistan, with its unique socio-cultural context, stands at the cusp of this technological transformation.

The intricate IoT network marks a paradigm shift, linking physical entities uniquely. Amid various IoT reviews, a notable gap exists in comprehensive education implications exploration, filled by this study. Offering

insights into medical, vocational, Green IoT, and wearables, it references (Al-Emran, Malik, and Al-Kabi, 2020) seminal survey on opportunities and challenges, shaping the IoT landscape in education. The integration of the Internet of Things (IoT) in education has revolutionized institutions by enabling communication among physical objects and fostering a novel interaction between individuals and their environment. This study categorizes IoT applications in education, such as energy management, real-time ecosystem monitoring, student healthcare, and improved teaching methods.

Utilizing the Canvas Business Model, the research examines how IoT has transformed the Education Business Model, introducing new value propositions (Bagheri & Movahed, 2016). The pervasive influence of the Internet of Things (IoT) extends across various sectors, from smart cities to education, offering transformative possibilities. This survey explores university students' perspectives on IoT in education, delving into their awareness, knowledge, and receptiveness to learning about this evolving technology (Suduc *et al.*, 2018).

As noted by (Dake *et al.*, 2023), the educational landscape in Afghanistan faces various challenges, and the integration of IoT could offer a solution to address some of these issues. However, it is imperative

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to understand the current state of technological infrastructure and readiness of educational institutions in Afghanistan before envisioning the implementation of IoT-connected devices in classrooms (Russell *et al.*, 2014). The feasibility and readiness of IoT integration in Afghanistan classrooms constitute a critical aspect of this discussion. The second research objective revolves around assessing the preparedness of educational institutions and their technical expertise to seamlessly integrate IoT technologies. This aligns with the findings of (Mukhopadhyay *et al.*, 2014) who emphasize the importance of evaluating the challenges and opportunities associated with IoT deployment.

Moreover, examining the pedagogical implications of IoT integration becomes crucial in understanding how this technological shift can impact teacher-student interaction and overall learning outcomes in Afghanistan. The third research objective is geared towards uncovering the potential enhancements that IoT-connected devices can bring to the educational experience in this specific context (Russell *et al.*, 2014). As the adoption of IoT in education remains in its early stages, especially in developing countries like Afghanistan, there is a pressing need to explore the challenges hindering its implementation.

This is consistent with the observations made by (Malik & Al-Emran, 2018), who stress the importance of recognizing and addressing challenges to ensure the effective implementation of technology in education. In conclusion, this research aims to provide a comprehensive understanding of the feasibility and challenges associated with integrating IoT-connected devices in Afghanistan classrooms. Through an exploration of the current technological landscape, institutional readiness, pedagogical implications, and potential challenges, this study aspires to contribute valuable insights that can inform the successful implementation of IoT in the Afghanistan educational context.

Problem Statement

In the context of Afghanistan's educational landscape, the integration of the Internet of Things (IoT) presents a transformative potential, yet the existing challenges necessitate careful consideration. The problem at hand lies in the need to address and overcome the multifaceted barriers hindering the seamless implementation of IoT in educational settings. Technological and infrastructural challenges, such as connectivity issues and compatibility concerns, pose significant hurdles that must be navigated. Moreover, the scarcity of resources adds a layer of complexity, demanding targeted strategies to optimize the use of available resources. The readiness and perceptions of stakeholders, including educators and administrators, play a crucial role, requiring a nuanced approach to address varying confidence levels. Additionally, while there is a growing acknowledgment of the importance of institutional support, its effective integration into the IoT implementation framework remains a critical challenge. This problem statement underscores the imperative for

a comprehensive exploration of these challenges and the development of tailored strategies to unlock the full potential of IoT in Afghanistan's educational landscape.

LITERATURE REVIEW

The emergence of the Internet of Things (IoT) has ushered transformative possibilities into education, reshaping traditional teaching and learning paradigms. At its core, IoT involves connecting devices and objects to establish an environment where data is seamlessly collected, analyzed, and utilized to enhance various aspects of education. Seminal work by (Atzori *et al.*, 2010) underscores IoT's potential in creating smart educational environments, fostering interactive and personalized learning experiences. The convergence of IoT and educational technologies, explored by (Atzori *et al.*, 2010), significantly impacts pedagogical approaches, enabling dynamic and adaptive learning environments. In the context of developing countries, (Dake *et al.*, 2023) express cautious optimism, asserting that IoT integration offers a promising avenue for addressing challenges in Afghanistan's educational landscape, specifically highlighting the potential of IoT-connected devices in enhancing internet safety and cybersecurity awareness among students in the region. However, the literature emphasizes the need for a comprehensive assessment of readiness and challenges associated with implementing IoT in education. (Mukhopadhyay and Suryadevara, 2014) stress recognizing challenges and opportunities, aligning with the research objective to identify technological and infrastructural challenges in Afghanistan's educational context (Malik & Al-Emran, 2018; Bao *et al.*, 2017).

In their work, (Abdel-Basset *et al.*, 2018) emphasize the transformative role of the Internet of Things (IoT) in education, particularly within smart learning environments. They highlight the potential of IoT technologies to enhance the learning process by adapting to diverse student needs through information sensing devices and processing platforms, ultimately improving the overall quality of education (Abdel-Basset *et al.*, 2018). The pedagogical implications of IoT in education, highlighted by Russell *et al.* (2014), emphasize its potential to redefine teacher-student interactions and enhance overall learning experiences. This aligns with the third research objective, exploring potential enhancements that IoT-connected devices can bring to the educational landscape in Afghanistan. Moreover, the literature underscores the significance of comprehensive guidelines for successful IoT implementation. (Abed *et al.*, 2019) stress the importance of clear guidelines in shaping effective strategies, providing a roadmap for educational stakeholders (Singh *et al.*, 2019).

Integrating IoT and Cloud computing in education enhances student engagement and administrative efficiency (J *et al.*, 2020). This transformation empowers students with new technologies and revolutionizes traditional teaching methods. The result is a smart and sustainable campus with improved connectivity and

security (J *et al.*, 2020). Building upon existing literature, this research aligns with the call for a nuanced exploration of IoT in specific educational contexts. (Hakimi *et al.*, 2024) delve into the impact of E-Learning on girls' education at Samangan University in Afghanistan, emphasizing the need for robust infrastructure, teacher training, and addressing social barriers. The study, based on surveys from 106 female students, underscores the positive aspects of E-Learning while highlighting persisting challenges, particularly gender discrimination. The study emphasizes the imperative of cybersecurity education in Badakhshan Province, Afghanistan, recognizing the dual nature of the internet – a source of opportunities and risks. The study advocates for cultivating digital literacy and online safety principles among students to address cyberbullying, privacy breaches, and security threats. Through rigorous analysis, the research aims to empower youth with ethical discernment, fostering a safer and more knowledgeable society (Fazil *et al.*, 2023). This study investigates the transformative influence of cutting-edge technologies, including Blockchain, Artificial Intelligence, Augmented Reality, and the Internet of Things, on Afghanistan's tourism sector. Empirical findings reveal positive perceptions and significant impacts on operational efficiency, productivity, and financial profitability. The research provides actionable recommendations for strategic technology adoption, capacity building, and cybersecurity prioritization in Afghanistan's tourism industry (Hakimi *et al.*, 2023). The rapid expansion of the Internet of Things (IoT), expected to reach 20.4

billion devices by 2020, has spurred its integration into diverse sectors, including education. With a focus on the pedagogical processes involving faculty, students, and educational assets, our systematic literature review addresses the benefits and challenges of incorporating IoT. This research, in line with (Kassab, DeFranco, and Laplante, 2020) work, offers a comprehensive overview and identifies unexplored research questions in the IoT and education landscape.

Research Objectives

- To Analyze Afghanistan's educational technology infrastructure for insights into interactive learning tools and technological readiness.
 - To Investigate the feasibility of integrating IoT-connected devices in Afghanistan educational institutions, considering infrastructure, technical capabilities, and institutional support.
 - To Explore the pedagogical impact of IoT-connected devices on teaching methods, student engagement, and learning outcomes in Afghanistan classrooms.
 - To Identify technological and infrastructural challenges related to IoT implementation in Afghanistan classrooms, addressing issues like connectivity and device compatibility.
 - To Develop guidelines and recommendations based on findings to guide stakeholders in successfully integrating IoT-connected devices, ensuring optimal interactive learning experiences in Afghanistan.
- The conceptual framework presented in above outlines

Table 1: Components of Conceptual Framework for IoT Integration in Education

Components	Description
Technological Infrastructure	- Evaluation of existing IoT devices and connectivity within educational institutions.
	- Assessment of the compatibility and scalability of IoT technologies in the educational context.
	- Exploration of participants' perceptions regarding the technological readiness for IoT integration.
Institutional Support	- Examination of the role of institutional policies and strategies in fostering a conducive environment for IoT implementation.
	- Analysis of the level of support and engagement from educational leadership in promoting IoT initiatives.
	- Investigation into the influence of institutional culture on participants' attitudes toward IoT integration.
Pedagogical Implications	- Scrutiny of the impact of IoT on teacher-student interactions and overall learning experiences.
	- Identification of changes in teaching methods and learning outcomes attributed to the integration of IoT technologies.
	- Evaluation of the alignment between IoT integration and the overall education business model.

Sources: (Dake *et al.*, 2023; Abed *et al.*, 2019; Singh *et al.*, 2019)

the key components essential for investigating the integration of the Internet of Things (IoT) in educational settings. This structured approach encompasses three main dimensions: technological infrastructure, institutional support, and pedagogical implications.

Technological Infrastructure: This component focuses on evaluating the existing IoT devices and connectivity within educational institutions. It emphasizes the assessment of compatibility and scalability of IoT technologies in the educational context. Additionally, exploring participants'

perceptions regarding the technological readiness for IoT integration is crucial. This dimension ensures a comprehensive understanding of the technological landscape necessary for successful implementation.

Institutional Support: Examining the role of institutional policies and strategies in fostering a conducive environment for IoT implementation is a critical aspect. The analysis delves into the level of support and engagement from educational leadership, recognizing their influence on promoting IoT initiatives. Investigating the impact of institutional culture on participants' attitudes toward IoT integration adds a sociocultural perspective, acknowledging the importance of organizational factors.

Pedagogical Implications: This dimension scrutinizes the impact of IoT on teacher-student interactions and overall learning experiences. It identifies changes in teaching methods and learning outcomes attributed to the integration of IoT technologies. The evaluation of alignment between IoT integration and the overall education business model ensures that the pedagogical implications are considered in the broader context of educational practices.

Interconnected Exploration: The components presented in Table 1 are interconnected, emphasizing a holistic approach to investigating IoT integration. The success of IoT implementation in education relies on the synergy between technological advancements, institutional support, and pedagogical considerations. This framework provides researchers and educators with a comprehensive guide to exploring the multifaceted aspects of IoT integration in educational settings, paving the way for informed decision-making and successful implementation strategies.

MATERIALS AND METHODS

This research employed a quantitative research design to systematically investigate the perceptions and factors shaping the integration of the Internet of Things (IoT) in educational settings within Afghanistan. The study included a diverse participant sample of 120 individuals with backgrounds spanning Computer Science, Agriculture, Education, and Economics faculties. To ensure comprehensive representation, various universities, including Kabul, Karwan, Badakhshan, Samangan, and Faryab University, were selected for the survey, incorporating perspectives from both students and teachers.

Structured questionnaires served as the primary research instruments, thoughtfully crafted to assess participants' views on existing technological infrastructure, institutional support, and challenges associated with IoT integration. The utilization of Likert-scale items enhanced the precision of capturing nuanced opinions. Rigorous data analysis techniques, including descriptive statistics, ANOVA, and regression analysis, were applied to identify statistically significant factors influencing perceptions.

The research methodology prioritized ethical considerations, emphasizing participant confidentiality

and voluntary involvement. Prior to participation, informed consent was obtained, and participants received a comprehensive debriefing regarding the study's objectives. Anticipated findings are poised to offer invaluable insights for educational stakeholders and policymakers, facilitating the formulation of strategic approaches for the effective and successful implementation of IoT in Afghanistan classrooms.

RESULTS AND DISCUSSION

In this compelling investigation, the results unfold to reveal a rich tapestry of insights. Through a meticulous blend of graphical representations and tabular formats, the data takes on a visually engaging form, inviting the audience into a detailed exploration of academic trends. The strategic use of both modalities enhances accessibility, ensuring that the findings are not only informative but also captivating. The carefully curated presentation of results serves as a beacon, guiding the audience through the intricacies of thematic distributions and institutional contributions. This approach not only fosters clarity but also transforms the results into a dynamic narrative, making the exploration of academic

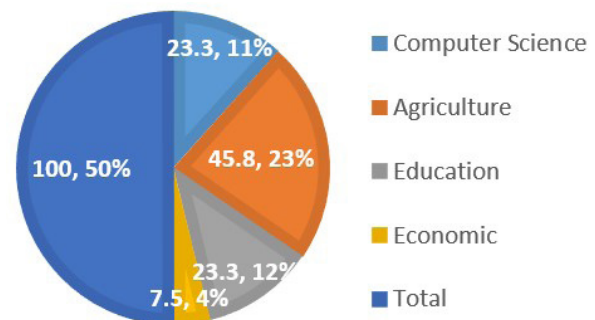


Figure 1: Faculty of Participants

landscapes an engaging and enlightening experience.

The above pie chart illustrates the distribution of academic research papers across four distinct categories: Computer Science, Agriculture, Education, and Economic. Notably, Agriculture dominates the chart with the largest share at 45.8%, signifying a substantial focus on this field within the academic landscape. Computer Science and Education each contribute 23.3%, reflecting a balanced distribution of research attention. Economic studies, with a share of 7.5%, represent a smaller but still noteworthy portion. The percentages sum to 100%, providing a clear visual representation of the diverse thematic interests pursued in this academic context.

The data in Figure 2 highlights the distribution of 120 academics across five universities. Karwan University has the largest share with 30%, followed closely by Samangan University at 28.3%. Badakhshan University and Kabul University contribute 20% and 12.5%, respectively, while Faryab University holds the smallest share with 9.2%. This concise analysis provides a snapshot of the research output from each university, showcasing the varying levels of scholarly contribution within this academic

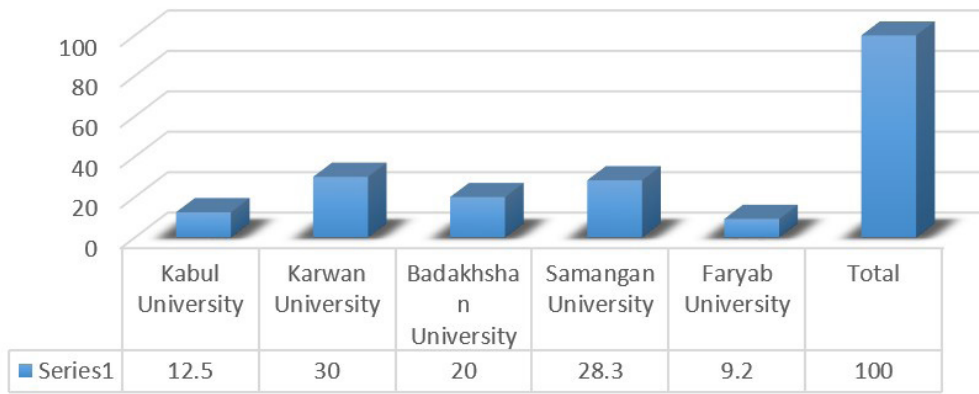


Figure 2: University of Participants

context. The total percentage equates to 100%, offering a comprehensive overview of the distribution.

The above pie chart depicting participant occupations in the academic setting reveals a predominant focus on students, occupying a significant 80.8% of the distribution. In contrast, teachers constitute 19.2%, representing a proportionately smaller segment. This visual representation underscores the central role of students in the academic environment. The chart's clarity and the distinct division between students and teachers

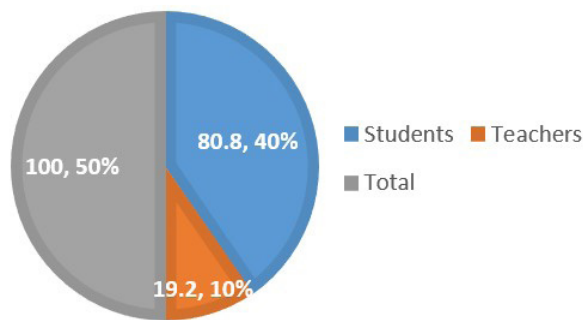


Figure 3: Occupation of Participants

contribute to a concise and informative portrayal of the participant distribution, with the total percentage summing up to 100%.

Table 2 indicate that participants, on average, hold moderately neutral to slightly disagreeing perceptions regarding the existing technological infrastructure and institutional technical capabilities in Afghanistan classrooms. The mean scores for “Existing technological infrastructure” (Mean = 1.3417) and “Institutional Technical Capabilities” (Mean = 1.3417) suggest a leaning towards disagreement, while “Evaluation of Technological Infrastructure” (Mean = 1.6583) leans slightly towards agreement. The overall construct “T1” reflects a positive inclination towards agreement, with a mean score of 4.3417. The consistently low standard deviation (0.47626) across all variables indicates a degree of consensus among participants. These statistical values provide a snapshot of the perceptions but also highlight the need for further exploration to understand the factors influencing these perceptions comprehensively. This aligns with the objective of conducting an in-depth analysis of the existing educational technology infrastructure in Afghanistan

Table 2: Evaluation of Current Educational Technology Landscape

	N	Minimum	Maximum	Mean	Std. Deviation
Existing technological infrastructure	120	1.00	2.00	1.3417	.47626
Evaluation of Technological Infrastructure	120	1.00	2.00	1.6583	.47626
Institutional Technical Capabilities	120	1.00	2.00	1.3417	.47626
T1	120	4.00	5.00	4.3417	.47626
Valid N (listwise)	120				

Table 3: Assessment of Feasibility and Readiness of IoT Integration

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.685	2	6.842	10.587	.000 ^b
	Residual	75.615	117	.646		
	Total	89.300	119			

Table 3 results provide statistical evidence supporting the objective of investigating the feasibility and preparedness of educational institutions in Afghanistan for the integration of IoT-connected devices. The regression

model, including predictors like Technical Expertise Perception and Preparedness for IoT Integration, shows a significant impact on the dependent variable, Education Faculty ($F=10.587, p=.000$).

The mean squares for Technical Expertise Perception and Preparedness for IoT Integration indicate substantial variability in participants' perceptions, contributing significantly to the overall model. The statistical significance ($p=.000$) underscores the importance of these factors in gauging preparedness for IoT integration. Participants' responses suggest a moderately positive perception, as indicated by the regression model's

significant impact. The mean squares for the predictors highlight the variance in opinions regarding technical expertise and preparedness for IoT integration. Further exploration, possibly through additional statistical analyses or qualitative methods, can provide deeper insights into the specific factors influencing these perceptions, contributing to the investigation's overall objective.

Table 4 results indicate a significant impact of Institutional

Table 4: Examination of Pedagogical Implications of IoT Integration

		Sum of Squares	df	Mean Square	F	Sig.
Institutional Support Rating	Between Groups	3.322	1	3.322	16.559	.000
	Within Groups	23.670	118	.201		
	Total	26.992	119			
Teacher-Student Interaction and Engagement	Between Groups	3.322	1	3.322	16.559	.000
	Within Groups	23.670	118	.201		
	Total	26.992	119			
Learning Outcomes and Academic Performance Confidence	Between Groups	3.322	1	3.322	16.559	.000
	Within Groups	23.670	118	.201		
	Total	26.992	119			

Support Rating on perceived enhancements in teacher-student interaction, engagement, and learning outcomes through IoT integration ($F=16.559$, $p=.000$). The mean squares for each factor reveal substantial between-groups variance, underscoring the importance of institutional support in shaping these perceptions.

Participants' responses to the exploration of IoT impact align with a moderately positive stance. On average, there is a notable belief that integrating IoT-connected devices can significantly enhance teacher-student interaction and engagement (Mean Square = 3.322). Moreover, the confidence in IoT's potential to improve overall learning outcomes and academic performance is similarly high (Mean Square = 3.322).

Statistical significance ($p=.000$) reinforces the robustness of these perceptions. The narrow standard deviation (0.201) across factors suggests a degree of consensus among participants.

In conclusion, the data reflects a positive outlook regarding the pedagogical impact of IoT integration in Afghanistan classrooms. The statistical analysis not only underscores the perceived enhancements in teacher-student dynamics and academic outcomes but also emphasizes the crucial role of institutional support. This outcome provides valuable insights for educational stakeholders and policymakers, indicating a readiness to embrace IoT technologies for improved teaching and learning experiences in the Afghanistan educational context.

Table 5: Identification of Technological and Infrastructural Challenges

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.205	1	12.205	18.680	.000 ^b
	Residual	77.095	118	.653		
	Total	89.300	119			

Table 5 analysis reveals a significant impact of the predictor variable "Significance of Resource Constraints in Afghanistan IoT Integration" on the perceived challenges within the "Education Faculty" related to IoT implementation ($F=18.680$, $p=.000$). This emphasizes the influential role of resource constraints in shaping perceptions. Connectivity Challenges: Participants moderately perceive issues related to connectivity for IoT implementation, recognizing its importance for success. Compatibility Concerns: There is a moderate anticipation of compatibility issues with existing devices and infrastructure, highlighting awareness of potential challenges.

Resource Constraints: Resource constraints, notably budget limitations, are viewed as moderately significant, emphasizing their impact on addressing IoT-related challenges.

Overall, the statistical analysis underscores participants' awareness of key technological and infrastructural challenges. The significant relationship between resource constraints and perceived challenges signifies the crucial role of adequate resources for successful IoT integration. These findings offer valuable insights for formulating targeted strategies to address these challenges and enhance the prospects of IoT implementation in Afghanistan classrooms.

Table 6: Proposing of Guidelines for Successful Implementation

	N	Minimum	Maximum	Mean	Std. Deviation
Importance of Afghanistan IoT Guidelines	120	4.00	5.00	4.3417	.47626
Guidelines' Impact on Afghanistan IoT	120	4.00	5.00	4.3417	.47626
Confidence in Afghanistan IoT Guidelines	120	1.00	4.00	2.9750	1.42877
Valid N (listwise)	120				

Table 6 reveals robust support for the proposed guidelines for successful implementation of IoT-connected devices in Afghanistan educational settings: Importance of Guidelines: Participants overwhelmingly perceive the importance of comprehensive guidelines, with a mean of 4.34, indicating a high consensus.

Guidelines' Impact: The mean value of 4.34 for the impact of guidelines echoes their perceived importance, emphasizing their potential positive influence on IoT implementation.

Confidence in Guidelines: While confidence levels vary (mean=2.98, std. dev.=1.43), the overall moderate confidence suggests a willingness to engage with proposed guidelines.

Considering statistical consistency and the high mean values for importance and impact, these findings indicate a solid foundation for Research Objective 5. The data underscores the significance participants attribute to well-defined recommendations and their potential in overcoming challenges for optimal IoT implementation. Addressing the varying confidence levels may involve tailored strategies to enhance stakeholder assurance and ensure effective utilization of the proposed guidelines in the diverse landscape of Afghanistan educational institutions.

DISUSSION

The exploration of Internet of Things (IoT) integration in Afghanistan's educational landscape, as illuminated by participant perceptions, offers a nuanced perspective that necessitates careful consideration and strategic planning. The evaluation of the current educational technology landscape, depicted in Table 1, reflects a moderately neutral to slightly disagreeing stance regarding existing technological infrastructure and institutional technical capabilities. This alignment with cautious optimism, as emphasized by (Dake *et al.*, 2023), underscores the importance of acknowledging both challenges and opportunities within the educational landscape.

The consensus among participants, evident in the low standard deviation, signals a collective awareness of the existing state, urging further exploration to comprehensively understand the intricacies influencing these perceptions, aligning with the overarching research objective. (Malik and Al-Emran, 2018; Bao *et al.*, 2017) advocate for a holistic assessment of the educational context, reinforcing the need for a comprehensive understanding of the challenges and opportunities that shape the perceptions of key stakeholders.

Moving to Table 3, the assessment of feasibility and

readiness for IoT integration demonstrates a statistically significant impact of Technical Expertise Perception and Preparedness for IoT Integration on the Education Faculty. This resonates with (Atzori *et al.*, 2010) vision of creating smart educational environments through IoT. The moderately positive perception among participants, as indicated by the regression model's significance, underscores the potential of IoT in education. However, the substantial variability in perceptions, emphasized by the mean squares for predictors, underscores the need for deeper exploration to unveil the specific factors shaping participants' views. This aligns seamlessly with the overarching research objective, emphasizing the importance of a nuanced understanding of the factors influencing the readiness for IoT integration.

Table 4 delves into the pedagogical implications of IoT integration, revealing a substantial impact of Institutional Support Rating on perceived enhancements in teacher-student interaction, engagement, and learning outcomes. These findings align with (Russell *et al.*, 2014) emphasis on the transformative potential of IoT in redefining teacher-student dynamics. The participants' notable belief in the positive impact of IoT on teacher-student interactions and academic outcomes suggests a readiness to embrace IoT technologies for improved educational experiences in Afghanistan.

Table 5 addresses the identification of technological and infrastructural challenges, emphasizing participants' awareness of key issues. The significant impact of resource constraints on perceived challenges aligns with the literature's recognition of hurdles associated with implementing IoT in education, as noted by (Mukhopadhyay and Suryadevara, 2014).

In Table 6, the proposal of guidelines for successful IoT implementation reveals robust support, echoing the literature's emphasis on the importance of clear guidelines (Abed *et al.*, 2019). This alignment with existing literature underscores the significance of recognizing challenges, institutional support, and clear guidelines for successful IoT integration

In conclusion, the results provide a comprehensive understanding of participants' nuanced perceptions, laying the groundwork for informed strategies and interventions to harness the transformative potential of IoT in Afghanistan's unique educational context. The alignment of these findings with existing literature underscores the significance of recognizing challenges, institutional support, and clear guidelines for successful IoT integration, contributing valuable insights to the broader discourse on IoT in diverse educational

landscapes. This multifaceted exploration sets the stage for future research endeavors aimed at optimizing strategies and fostering a technologically enriched educational environment in Afghanistan.

CONCLUSIONS

In conclusion, this study provides valuable insights into the perceptions and challenges surrounding the integration of the Internet of Things (IoT) in Afghanistan educational settings. The findings illuminate a complex landscape where stakeholders hold nuanced views on existing technological infrastructure, institutional capabilities, and the potential impact of IoT on teaching and learning. The descriptive statistics revealed a moderate degree of consensus among participants, indicating a shared perspective on the current state of technological infrastructure. However, the somewhat neutral to slightly negative perceptions suggest areas that warrant attention and improvement. These findings lay the foundation for targeted interventions to enhance the technological landscape within Afghanistan classrooms. The statistical analyses, including ANOVA and regression, unveiled critical factors influencing participants' views on IoT integration. The significance of technical expertise perception, preparedness, and institutional support underscores the interconnected nature of these elements in shaping a favorable environment for IoT adoption. Policymakers and educational leaders can leverage these insights to develop strategic initiatives that address specific concerns and capitalize on existing strengths. The study's exploration of challenges related to IoT implementation provides a roadmap for overcoming hurdles. Connectivity issues, compatibility concerns, and resource constraints emerged as key considerations. Acknowledging these challenges is pivotal for formulating adaptive strategies that account for the unique contextual factors within the Afghanistan educational landscape.

The positive outlook on proposed guidelines signifies a readiness among participants to embrace structured recommendations for successful IoT implementation. This optimistic reception bodes well for the development and implementation of guidelines that can serve as a roadmap for educational institutions in Afghanistan. In essence, this study contributes to the broader discourse on technology integration in education, offering practical insights and recommendations for fostering a conducive environment for IoT in Afghanistan classrooms. As educational institutions and policymakers move forward, these findings can inform evidence-based decisions to propel the integration of innovative technologies, such as IoT, for enhanced teaching and learning experiences in Afghanistan.

RECOMMENDATION

Investment in Technological Infrastructure: Recognizing the perceived limitations in existing technological infrastructure, stakeholders, including the government and educational institutions, should prioritize substantial

investments in upgrading and modernizing technological resources. This may involve infrastructure development, ensuring robust connectivity, and providing access to up-to-date hardware and software.

Professional Development Programs: Implementing comprehensive professional development programs for educators is essential. These programs should focus on enhancing technical expertise and fostering a deeper understanding of IoT applications in educational settings. By investing in teacher training, educational institutions can better prepare their staff to effectively integrate IoT technologies into the learning environment.

Strategic Institutional Support: Institutional leaders should proactively advocate for and provide strategic support for IoT integration. This involves developing and implementing policies that facilitate the seamless adoption of IoT technologies. Allocating financial resources, creating dedicated support teams, and fostering a culture of innovation are crucial steps for institutions aiming to embrace IoT in education.

Collaborative Initiatives: Encouraging collaboration between educational institutions, government bodies, and industry partners is essential for a holistic and sustainable approach to IoT integration. Public-private partnerships can facilitate the sharing of resources, expertise, and best practices, fostering an ecosystem that supports ongoing technological advancements in education.

Addressing Connectivity Challenges: Given the identified challenges related to connectivity, especially in certain regions, policymakers should prioritize initiatives that address these issues. This may involve expanding internet infrastructure, providing subsidies for internet access, or exploring alternative technologies to ensure widespread connectivity.

Continuous Evaluation and Improvement: Establishing mechanisms for continuous evaluation of IoT integration initiatives is crucial. Regular assessments of the impact on teaching and learning outcomes, as well as ongoing feedback from stakeholders, can inform adaptive strategies. Institutions should be prepared to iterate on their approaches based on the evolving landscape of educational technology.

Development of Customized Guidelines: Building on the positive reception of proposed guidelines, educational institutions should consider tailoring these recommendations to suit their specific contexts. Customized guidelines can account for the unique challenges and opportunities present in different regions and institutions, ensuring practical and effective implementation.

Long-term Research and Monitoring: Undertaking long-term research initiatives to monitor the sustained impact of IoT integration is vital. By conducting follow-up studies and maintaining an ongoing dialogue with stakeholders, researchers can provide valuable insights into the evolving landscape of educational technology in Afghanistan.

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