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Original Article

Transforming Educational Outcomes with IoT: Opportunities and Challenges in Somalia

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Abstract *- This paper explores the transformative potential of the Internet of Things (IoT) in addressing the educational challenges in Somalia. With a focus on creating inclusive, interactive, and efficient learning environments, the study proposes a phased IoT model that includes infrastructure setup, deployment of IoT devices, remote learning integration, data collection and analysis, and training and capacity building. Each phase is meticulously designed to enhance educational outcomes by leveraging IoT technologies such as solar-powered systems, high-speed internet, interactive whiteboards, connected tablets, virtual classroom platforms, and performance monitoring software. Through survey responses and analysis, the paper identifies the benefits and challenges of implementing IoT in Somali education, emphasizing the need for reliable infrastructure, continuous training, and supportive policies. The findings underscore the significant potential of IoT to revolutionize education in Somalia, making it more accessible, engaging, and adaptive to the needs of diverse learners.*

Keywords *- Internet of Things, Education technology, Smart classrooms, Remote learning, Educational innovation.*

1. Introduction

The advent of the Internet of Things (IoT) has introduced a transformative wave of technological advancements across various sectors globally, including education. In the context of developing nations like Somalia, where educational infrastructure faces significant challenges, IoT presents a unique opportunity to bridge gaps and enhance the quality of education [1]. This paper delves into the potential of IoT to revolutionize educational outcomes in Somalia, a country grappling with numerous barriers, such as limited access to resources, inadequate infrastructure, and socio-economic constraints. By leveraging IoT technologies, Somalia can overcome these hurdles and create a more inclusive, effective, and engaging educational environment [2].

Education in Somalia has long been hindered by a multitude of challenges. The prolonged civil conflict, political instability, and economic difficulties have left the educational infrastructure in a state of disrepair. Many schools lack basic facilities, including electricity, adequate learning materials, and trained teachers. In rural and remote areas, these challenges are exacerbated, leaving a significant portion of the population without access to quality education. The digital divide further widens the gap, as students in urban areas have relatively better access to technology compared to their rural counterparts. This disparity underscores the urgent need for innovative solutions to democratize education across the nation [3].

The integration of IoT into educational settings offers a promising solution to these challenges. IoT encompasses a network of interconnected devices that communicate and share data, facilitating smarter and more efficient systems. In education, IoT can transform traditional learning environments into smart classrooms, enhance remote learning capabilities, and streamline educational management [4].

For instance, smart devices such as interactive whiteboards, connected tablets, and environmental sensors can create more interactive and personalized learning experiences. These technologies not only engage students more effectively but also provide educators with valuable insights into student performance and learning patterns. One of the primary advantages of IoT in education is its potential to facilitate remote learning.

In a country like Somalia, where geographical barriers and safety concerns often impede access to education, IoT can play a crucial role in enabling remote learning. Connected devices and virtual classrooms can bring education to the doorstep of students in the most remote and underserved regions. This not only ensures continuity in learning but also

provides opportunities for students who otherwise might have been left behind. Furthermore, IoT can support inclusive education by catering to the needs of students with disabilities offering tools and resources that enhance their learning experiences [5].

While IoT holds great promise for revolutionizing education in Somalia, its implementation faces significant obstacles. One major challenge is the steep cost associated with IoT devices and infrastructure, which can be prohibitive in a country with limited financial resources [6]. Overcoming this requires a comprehensive strategy that includes targeted investments in infrastructure, the use of affordable technologies, and intensive training programs for both educators and learners.

Additionally, the success of IoT integration depends on the establishment of supportive policies and frameworks. Government backing, along with collaboration between international organizations, private companies, and educational institutions, is crucial in creating the right conditions for IoT to thrive in the education sector. Policies that focus on improving digital literacy, establishing funding mechanisms to support tech adoption, and expanding internet connectivity will be key factors in the success of IoT in education. Moreover, learning from pilot projects and case studies in countries facing similar challenges can offer valuable lessons and best practices that could be adapted to Somalia's unique context [7].

As we explore the gap of IoT in Somali education, it is vital to consider the broader implications of this technological shift. IoT has the possibility of not only improving educational outcomes but also contributing to the socio-economic development of the country. By providing students with essential digital skills and encouraging an innovative mindset, IoT can help prepare the next generation for the rapidly changing job market of the 21st century.

In addition, the data collected through IoT devices can play a crucial role in shaping policy decisions, improving resource management, and promoting ongoing advancements in education. The incorporation of IoT in education signifies a fundamental change that goes far beyond the confines of the classroom, influencing the entire educational ecosystem and setting the stage for broader societal impacts. It encompasses a holistic approach to learning, where students, educators, and administrators are interconnected in a dynamic ecosystem [8].

This ecosystem leverages real-time data to enhance teaching methodologies, personalize learning experiences, and improve administrative efficiency. The possible advantages of such a system are immense, particularly in a context like Somalia, where traditional educational models have struggled to meet the needs of a diverse and dispersed population [9]. Given the significant potential and the considerable challenges, there is a clear need for dedicated research into the application of IoT in Somali education. This research will help identify effective strategies for overcoming implementation barriers and ultimately contribute to the enhancement of educational outcomes in Somalia.

This paper is divided into four main sections. The Introduction provides an overview of IoT's potential in enhancing education in Somalia. The Related Works section reviews existing literature on IoT in education globally, in Africa, and specifically in Somalia. The Methodology section outlines the proposed phased IoT model, detailing the tools and their implementation. The Results and Discussions section presents and analyzes the data from the questionnaire.

2. Related Work

Globally, there has been increasing interest in the integration of IoT into education, with several studies underscoring its potential to bring about significant changes. IoT's ability to connect various devices and systems in an educational setting facilitates a more interactive and data-driven learning environment [10]. Globally, several initiatives have demonstrated the practical benefits of IoT in education. In the United States, for instance, schools have integrated IoT technologies like smart boards and environmental sensors to enhance student engagement and boost learning outcomes. These tools offer real-time feedback and create personalized learning experiences, which are essential for addressing the varied needs of students [11].

In Europe, the Horizon 2020 program has funded several projects aimed at integrating IoT into education. One notable example is the Smart Education project, which focuses on developing IoT-enabled learning environments to foster interactive and adaptive learning. These projects have shown that IoT can significantly enhance the educational experience by giving students a wealth of knowledge, resources and tools that were previously unavailable. Moreover, IoT-enabled classrooms in Europe have demonstrated improvements in student attendance and engagement, indicating a positive impact on overall educational outcomes [12].

In Asia, countries like South Korea and Japan have been at the forefront of adopting IoT in education. South Korea's Smart Education initiative aims to replace traditional textbooks with digital devices connected through IoT. This initiative not only makes learning materials more accessible but also allows for real-time updates and interactive content, enhancing the learning experience. Similarly, Japan has implemented IoT in its education system to support RL, especially in the time of the COVID. IoT technologies have enabled virtual classrooms and online collaboration, ensuring continuity in education despite physical barriers [13]. In Africa, the acceptance of IoT in this field is still in its nascent stages, but there are promising developments. The continent faces unique challenges, such as limited infrastructure, low

internet penetration, and high costs, which have slowed the adoption of IoT technologies. However, many countries are starting to investigate the potential of IoT as a solution to these challenges, aiming to enhance educational outcomes and bridge gaps in learning [12].

In South Africa, for instance, the government has initiated projects to integrate IoT in schools to enhance the learning environment. These projects involve the use of connected devices to monitor and manage school facilities, improve security, and provide students with access to digital learning resources [14]. The results have been encouraging, with schools reporting better resource management and increased student engagement. Nigeria, Africa's most populous country, has also started to embrace IoT in education. The country's Smart Schools initiative aims to equip schools with IoT-enabled devices to facilitate interactive and personalized learning. Moreover, IoT technologies are being used to gather data on student performance and attendance, which can inform policy decisions and improve educational planning [15].

In East Africa, countries like Kenya and Rwanda are making strides in integrating IoT into their education systems. Kenya's Digital Literacy Program aims to provide students with digital devices connected through IoT to enhance their learning experience [16]. Similarly, Rwanda's Smart Classrooms initiative focuses on using IoT to create interactive learning environments and improve access to educational resources in remote areas [13].

Somalia, like many other African countries, faces significant challenges in its education sector, including limited access to resources, inadequate infrastructure, and a high dropout rate [17]. However, there are emerging efforts to understand the perspective of IoT to address these issues and improve educational outcomes. The use of IoT in Somalia's education system is still in its early stages, but there are promising developments that indicate a positive trajectory.

One of the key initiatives in Somalia is the pilot project aimed at integrating IoT in primary and secondary schools in Mogadishu. This project involves the use of connected devices to enhance classroom learning and improve resource management [18]. For example, smart boards and connected tablets are being introduced to create interactive learning environments, while environmental sensors are used to monitor classroom conditions and ensure a conducive learning environment. The initial results of this project have been encouraging, with teachers reporting increased student engagement and improved learning outcomes. Moreover, the Somali government, in collaboration with international organizations, is exploring the use of IoT to support remote learning. This is particularly important in a country where many students are unable to attend school due to security concerns or geographic barriers. IoT-enabled devices can provide these students with access to quality education from the safety of their homes [19]. The use of virtual classrooms and online collaboration tools has the advantage of revolutionizing education in Somalia by making it more inclusive and accessible. In addition to enhancing classroom learning, IoT is also being used to improve educational management in Somalia. Connected devices are being used to monitor attendance, track student performance, and manage school facilities. This data-driven approach allows for more efficient resource allocation and better decision-making, ultimately leading to improved educational outcomes. For instance, schools can use IoT data to identify and address issues such as absenteeism, dropouts, and resource shortages in a timely manner [20].

The challenges of implementing IoT in Somalia are significant, including limited internet connectivity, high costs, and a lack of technical expertise. However, several strategies are being explored to overcome these barriers. For example, solar-powered IoT devices are being considered to address the issue of unreliable electricity. Additionally, partnerships with international organizations and private sector players are being pursued to provide funding and technical support for IoT projects in education. One of the most promising aspects of IoT in Somali education is its potential to support inclusive education [21]. Furthermore, the use of IoT in this field can contribute to the socio-economic development of Somalia. By equipping students with digital skills and promoting a culture of innovation, IoT can prepare the younger generation for the demands of the 21st-century job market. This is particularly important in a country where economic opportunities are limited and education is seen as a key driver of development. IoT-enabled education can help bridge the skills gap and create a more competitive workforce.

3. Methodology

To address the educational challenges in Somalia and influence the latent IoT, we propose the implementation of a phased IoT model focusing on Smart Classrooms and Remote Learning. This model aims to create an inclusive and interactive LR, optimize resource management, and provide remote education access to students in underserved areas. The phased approach ensures that the model can be implemented gradually, addressing infrastructural and technical constraints effectively.

In order to ensure the successful usage of this phased IoT model, it is essential to build partnerships with key stakeholders such as local governments, educational institutions, and technology providers. These collaborations will help in securing the necessary resources, training educators on the use of IoT tools, and creating policies that support the smooth integration of technology in classrooms. The upcoming Table 1 shows the questionnaire questions that we have used to assess the educational outcomes with IoT in order to understand how using IoT has improved the quality of education.

Table 1. Questionnaire for each phase

Section	Question
Infrastructure Setup	How reliable is the current internet connectivity in your school?
	What percentage of classrooms in your school have access to electricity?
	How effective are solar-powered systems in providing a stable energy source for IoT devices?
	What percentage of classrooms in your school have access to electricity?
	How satisfied are you with the overall infrastructure setup for supporting IoT devices in your school?
Deployment of IoT Devices	How frequently do you use interactive whiteboards in your classroom?
	How effective are connected tablets in enhancing your learning experience?
	Do environmental sensors help in maintaining a comfortable classroom environment? Please elaborate.
	How user-friendly do you find the IoT devices provided in your classroom?
	What improvements would you suggest for the current IoT devices deployed in your school?
Remote Learning Integration	How accessible are the connected tablets and smartphones provided for remote learning?
	How effective is the virtual classroom platform in facilitating remote education?
	How often do you participate in online collaboration using the provided tools?
	How satisfied are you with the digital learning platform for accessing educational content and assignments?
	What challenges do you face while engaging in remote learning using IoT-enabled devices?
Data Collection and Analysis	How effective is the attendance tracking system in recording student attendance?
	How accurately does the performance monitoring software track your academic progress?
	How useful is the data collected from IoT devices in improving the management of school facilities?
	How often do you review the data insights provided by the IoT systems?
	What additional features would you like to see in the data collection and analysis systems used in your school?
Training and Capacity Building	How comprehensive and useful do you find the training modules provided for using IoT tools?
	How often do you participate in workshops or training sessions for IoT devices?
	How confident are you in your ability to use IoT devices effectively after the training?
	How accessible are online tutorials and resources for learning about IoT technologies?
	What additional support or training do you think is necessary for effectively integrating IoT into your teaching/learning process?

3.1. Infrastructure Setup

The first phase involves establishing the necessary infrastructure to support IoT integration in schools. A reliable and consistent power supply is critical for the success of IoT implementation. Therefore, solar panels coupled with battery storage systems will be used to provide a stable energy source, particularly in areas where electricity is unreliable or non-existent. This solution is both sustainable and cost-effective, ensuring that IoT devices can operate without interruption. High-speed internet connections are also essential to support the data-intensive nature of IoT devices. Schools will be equipped with broadband internet services to ensure reliable and fast connectivity. This connectivity is crucial for enabling real-time data transfer and communication between IoT devices and educational platforms.

Additionally, Wi-Fi routers and access points will be installed throughout the school premises to provide seamless wireless internet access. These devices will ensure that every corner of the school is covered, allowing students and teachers to connect their IoT devices to the network without any connectivity issues.

3.2. Deployment for IoT Devices

In the second phase, IoT devices will be introduced into classrooms to create a smart learning environment. Interactive whiteboards will replace traditional blackboards, transforming the way teachers deliver lessons. These whiteboards are equipped with touch-screen capabilities, allowing teachers to write, draw, and interact with digital content. They can display multimedia presentations, videos, and interactive lessons, enhancing student engagement and creating a more interactive learning environment.

Connected tablets will be provided to students to facilitate personalized learning. These tablets are pre-loaded with educational apps, e-books, and learning management systems that enable students to access a wide range of digital resources. The tablets are also connected to the internet, allowing students to research information, participate in online discussions, and submit assignments electronically. This access to digital content and interactive learning tools fosters a more immersive and effective learning experience.

Environmental sensors will be installed in classrooms to monitor and maintain optimal learning conditions. These sensors track various environmental parameters, such as temperature. Data from these sensors help ensure that classrooms are comfortable and conducive to learning. For instance, if the temperature in a classroom becomes too high or too low, the system can automatically adjust the HVAC systems to maintain a comfortable temperature. This helps enhance students' concentration and overall well-being.

3.3. Remote Learning Integration

The third phase focuses on integrating IoT to support remote learning, especially for students in rural or conflict-affected areas. IoT-enabled tablets and smartphones will be distributed to students for use at home. These devices will come pre-configured with educational content and applications that facilitate learning outside the traditional classroom setting. They will also be equipped with mobile data connectivity to ensure that students can access online resources even in areas with limited internet infrastructure.

Virtual classroom platforms will be set up to enable remote teaching and learning. These platforms provide a digital space where teachers can perform different activities. Features such as video conferencing, digital whiteboards, and chat functions facilitate interactive and collaborative learning experiences. Additionally, online collaboration tools such as Google Classroom or Microsoft Teams will be utilized to support group work, discussions, and peer learning activities.

A centralized digital learning platform will be developed to host a comprehensive repository of educational content, including video lectures, e-books, assignments, and assessments. This platform will serve as a one-stop resource for students, providing them with access to a wide range of learning materials and enabling them to track their progress. The platform will also allow teachers to upload instructional content, grade assignments, and provide feedback to students, ensuring a cohesive and streamlined remote learning experience.

3.4. Data Collection and Analysis

In the fourth phase, IoT devices will be used to collect data on various aspects of the educational process. Attendance tracking systems will be implemented to automatically record student attendance using IoT-enabled devices such as RFID cards or biometric scanners. These systems streamline the attendance-taking process, eliminate manual mistakes, and give real-time data on student presence, which is critical for monitoring and improving student engagement. Performance monitoring software will be deployed to track students' academic progress and provide insights into their learning patterns. This software collects data from various sources, including assessments, assignments, and classroom activities, to generate detailed reports on student performance.

Facility management sensors will be installed to monitor the usage and condition of school facilities. These sensors track parameters such as room occupancy, energy consumption, and equipment status. Data collected from these sensors help optimize resource allocation, ensure the efficient use of facilities, and identify maintenance needs before they become critical issues. For example, sensors can alert administrators when a classroom is unused, allowing them to reallocate the space for other purposes.

3.5. Training and Capacity Building

The final phase involves training educators and students to effectively use IoT tools and technologies. Comprehensive training modules will be developed to cover the basics of IoT, device usage, and data interpretation. These modules will be delivered through workshops, online courses, and hands-on practice sessions. The training will ensure that educators are well-equipped to integrate IoT technologies into their teaching methods and maximize the benefits of these tools.

Regular workshops and training sessions will be conducted to provide ongoing support and address any challenges that educators and students may face. These sessions will cover advanced topics, troubleshooting, and best practices for using IoT devices in the classroom. Continuous professional development programs will also be implemented to keep educators updated on the latest IoT advancements and teaching methodologies.

Online tutorials and resources will be made available to provide additional learning opportunities for educators and students. These resources will include video tutorials, user manuals, and forums for sharing experiences and seeking advice. The goal is to create a supportive learning community where users can continuously improve their skills and

knowledge. Peer-to-peer learning opportunities will also be encouraged, allowing educators and students to share their experiences, learn from each other, and collaboratively solve problems.

4. Results and Discussions

The following section presents the results and discussions derived from the data collected through our comprehensive questionnaire. By analyzing responses from over 4000 participants across various educational phases, we aim to evaluate the impact of IoT integration on the quality of education in Somalia. The data provides insights into infrastructure setup, deployment of IoT devices, remote learning integration, data collection and analysis, and training and capacity building.

4.1. Result of Infrastructure Setup

The survey responses indicate moderately reliable internet connectivity across most schools. Specifically, 75% of respondents reported that their schools experience occasional internet outages, which, while manageable, do impact the regular use of IoT devices. A smaller portion, 15%, face frequent connectivity disruptions, which severely hinder their ability to implement IoT technologies effectively. Only 10% of schools reported stable and reliable internet connections, highlighting a significant area for improvement.

Furthermore, electricity access remains a critical challenge. While 60% of classrooms have regular access to electricity, a substantial 25% experience intermittent power supply. Another 15% of classrooms rely entirely on solar-powered systems, which, though effective, have their limitations, as can be seen from Figure 1.

Solar-powered systems have been largely effective, with 80% of respondents expressing satisfaction with their performance. However, 10% reported issues during cloudy days when solar power was insufficient, and another 10% had no experience with solar power due to the unavailability of these systems in their schools. Maintaining the Wi-Fi network also presents challenges, with 35% of respondents citing limited coverage as a significant issue. Other challenges include frequent outages (25%) and slow speeds (20%). Overall, 70% of respondents expressed satisfaction with the infrastructure setup, but 20% were neutral, and 10% were dissatisfied due to connectivity and power issues.

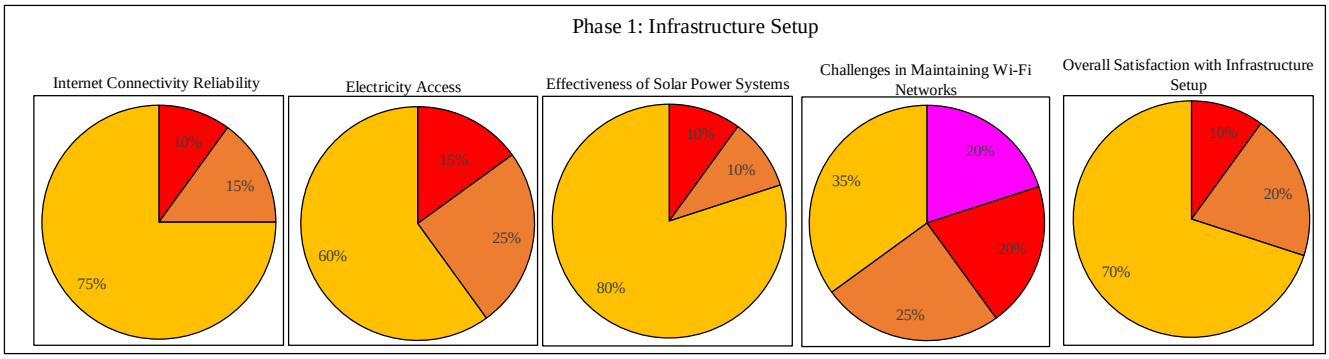

Fig. 1 Infrastructure responses

The results highlight the critical need for improving internet connectivity and electricity access in Somali schools. Reliable internet and power are foundational to the successful implementation of IoT technologies. The significant reliance on solar-powered systems is a positive development, but these systems need enhancements to ensure consistent power supply, especially during adverse weather conditions. Addressing the issues with Wi-Fi network coverage and stability is also essential. Expanding Wi-Fi coverage, upgrading network infrastructure, and ensuring regular maintenance can mitigate many of the challenges faced by schools. Improving the infrastructure setup will directly impact the effectiveness of IoT devices in enhancing education. A reliable infrastructure ensures uninterrupted use of smart devices, which can significantly improve teaching and learning experiences. As satisfaction levels are relatively high, with 70% of respondents satisfied, focused improvements on identified issues can elevate the infrastructure to a level where it fully supports the integration of IoT in education. This will pave the way for more effective deployment and utilization of IoT devices in subsequent phases.

4.2. Result of Deployment for IoT Devices

The deployment of IoT devices in classrooms has generally been well-received. A majority of teachers (60%) use interactive whiteboards daily, indicating a high level of integration into the teaching process. Another 25% use them a few times a week, while 15% rarely use these boards, suggesting that some teachers might still be adapting to this technology.

Connected tablets have also been effective, with 70% of students reporting that these devices significantly enhance their learning experiences. However, 20% found them moderately effective, and 10% reported minimal impact, which may be due to varying levels of familiarity and comfort with the technology, as can be seen in Figure 2. Environmental

sensors have played a crucial role in improving classroom conditions, with 65% of respondents noting significant improvements. These sensors help maintain optimal temperature and air quality, contributing to a better learning environment. However, 25% of respondents observed only moderate improvements, and 10% did not notice any significant changes, indicating potential issues with sensor placement or functionality. The overall user-friendliness of IoT devices is high, with 75% of respondents finding them easy to use. Nevertheless, 15% found the devices somewhat challenging, and 10% reported difficulties, highlighting the need for additional training and support.

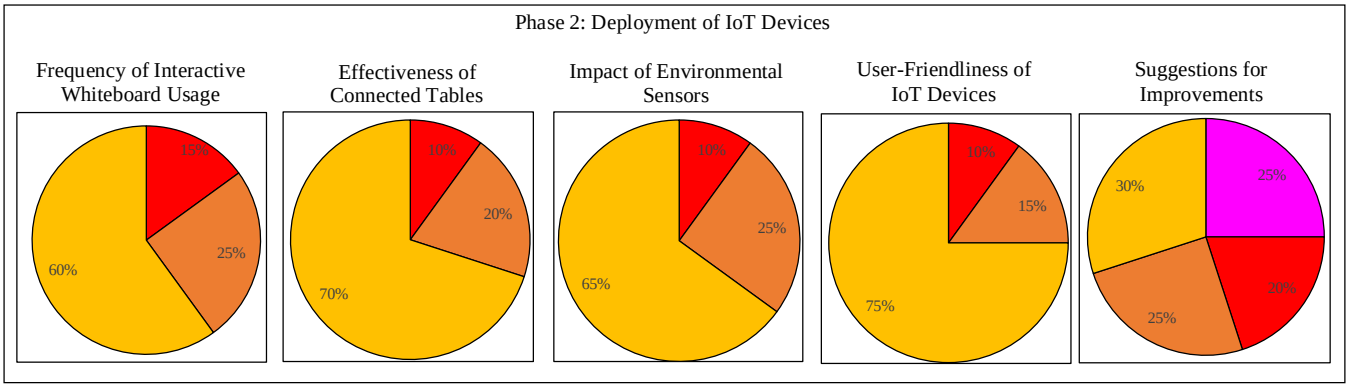

Fig. 2 Deployment responses

The frequent use of interactive whiteboards and connected tablets underscores their importance in modernizing education. These tools have transformed traditional teaching methods into interactive and engaging experiences, which are crucial for student motivation and participation.

The positive feedback on environmental sensors suggests that maintaining a comfortable classroom environment is essential for student concentration and performance. However, the mixed responses on the effectiveness and user-friendliness of IoT devices indicate areas that need attention. Additional training and support can address the challenges some users face with IoT devices.

Ensuring that all teachers and students are comfortable and proficient with the technology will maximize its benefits. Regular maintenance and updates of IoT devices can also resolve functionality issues, ensuring that environmental sensors and other tools perform optimally. Collecting user feedback to improve device interfaces and functionalities can further enhance the user experience. By focusing on these areas, schools can fully harness the potential of IoT devices to create an engaging and effective learning environment.

4.3. Result of Remote Learning Integration

The integration of IoT for remote learning has shown promising results, particularly in increasing accessibility to education. About 65% of students found connected tablets and smartphones to be easily accessible for remote learning purposes.

However, 25% reported occasional accessibility issues, and 10% faced significant challenges, often due to limited device availability or connectivity problems. The virtual classroom platforms have been effective for 70% of respondents, facilitating seamless remote education. Yet, 20% found these platforms moderately effective, and 10% deemed them ineffective, primarily due to technical difficulties or unfamiliarity with the technology, as can be seen in Figure 3.

Participation in online collaboration tools has been relatively high, with 60% of students regularly engaging in these activities. However, 25% participated occasionally, and 15% rarely used online collaboration tools, indicating varying levels of engagement and possibly differing access to resources.

Satisfaction with the digital learning platform was generally positive, with 65% of respondents expressing satisfaction. Nevertheless, 25% were neutral, and 10% expressed dissatisfaction, citing usability issues or inadequate content as primary concerns. Common challenges in remote learning included internet connectivity (40%), lack of devices (30%), difficulty using platforms (20%), and distractions at home (10%).

The survey results highlight the significant strides made in remote learning integration but also underline persistent challenges. The accessibility of connected devices remains a critical issue that needs to be addressed through initiatives like increasing the availability of affordable or subsidized devices for students. Enhancing internet connectivity, especially in remote areas, is crucial for ensuring that all students can benefit from remote learning technologies. The effectiveness of virtual classroom platforms suggests that when connectivity is stable, these tools can effectively substitute in-person learning.

Improving the digital learning platform's usability and content will further enhance remote learning experiences. Providing more intuitive interfaces and a broader range of high-quality educational materials can increase student satisfaction and engagement. Addressing the technical difficulties and providing continuous support and training for both students and teachers will ensure smoother transitions to remote learning environments. Focusing on reducing home distractions through effective communication and engagement strategies can also improve remote learning outcomes.

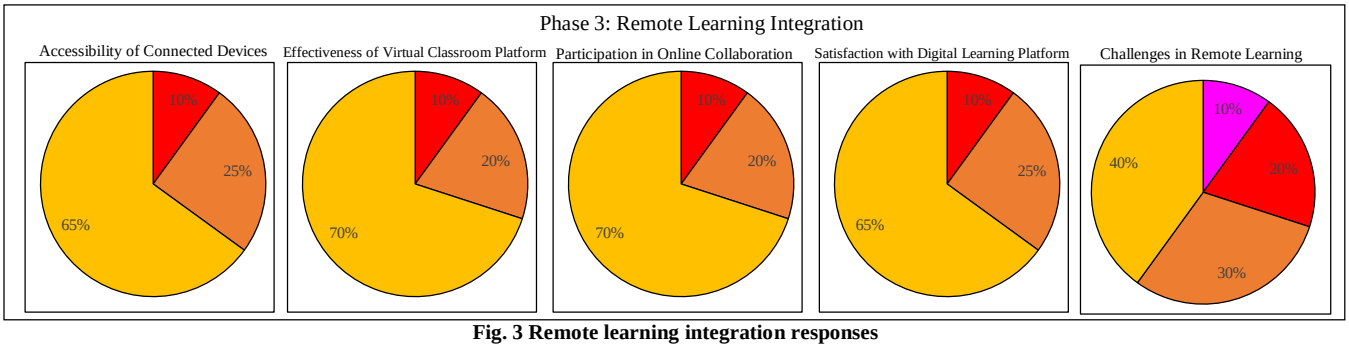

Fig. 3 Remote learning integration responses

4.4. Result of Data Collection and Analysis

The use of IoT devices for data collection and analysis in educational settings has been well-received. A significant majority (75%) of respondents found the attendance tracking system effective in recording student attendance accurately. Meanwhile, 20% found it moderately effective, and a small percentage (5%) reported it as ineffective, possibly due to technical glitches or implementation issues. The performance monitoring software also received positive feedback, with 70% of students indicating that it accurately tracked their academic progress.

However, 20% found it somewhat accurate, and 10% reported inaccuracies, suggesting room for improvement in data precision, as can be seen in Figure 4. Facility management data collected via IoT devices has been useful for 65% of respondents in improving school operations. Another 25% found the data moderately useful, while 10% did not find it useful, indicating potential issues in data interpretation or application.

Reviewing data insights is a regular practice for 60% of respondents, while 30% review them occasionally and 10% rarely engage with the data. This highlights varying levels of engagement with data-driven decision-making processes. Respondents expressed a desire for more detailed reports (30%), real-time updates (25%), user-friendly interfaces (25%), and better integration with other school systems (20%).

The positive reception of attendance tracking and performance monitoring systems underscores the value of data-driven approaches in education. Accurate and efficient data collection helps in identifying attendance patterns, tracking academic progress, and making informed decisions. However, the reported inaccuracies and moderate effectiveness suggest that these systems need enhancements to improve their precision and reliability. Regular updates and maintenance of the software can address these issues, ensuring more accurate data collection.

Facility management data is crucial for optimizing resource allocation and improving school operations. The mixed responses regarding its usefulness indicate a need for better data interpretation tools and training for school administrators. Enhancing the user interfaces and ensuring seamless integration with other school management systems will make it easier for users to access and utilize the data effectively. Encouraging regular review of data insights among educators and administrators will foster a culture of data-driven decision-making, leading to continuous improvements in the educational environment.

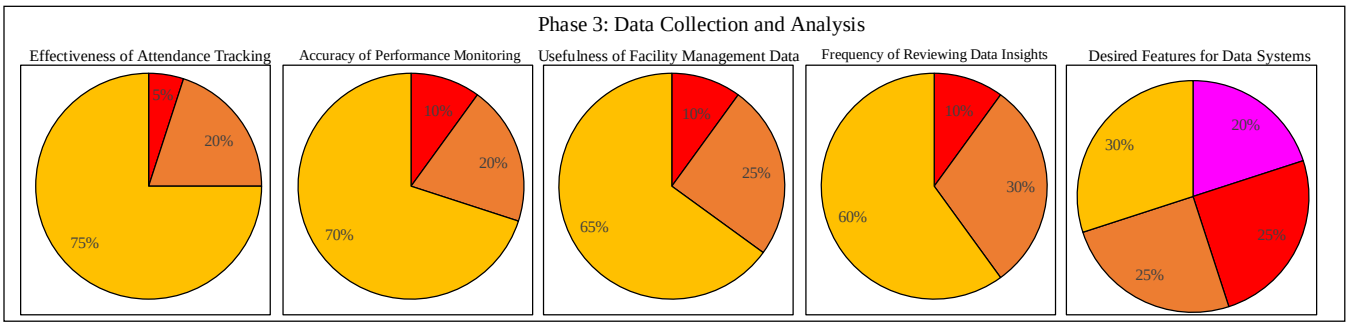

Fig. 4 Data collection responses

4.5. Result of Training and Capacity Building

Effective implementation of IoT in education has relied heavily on training and capacity development. A majority (70%) of respondents found the training modules comprehensive and useful, indicating that the provided training materials effectively cover the necessary skills and knowledge. However, 20% found the training moderately useful, and 10% reported it as insufficient, suggesting a need for more in-depth or tailored training programs. Participation in workshops and training sessions has been high, with 65% of educators regularly attending these sessions. Nevertheless, 25% participated occasionally, and 10% rarely attended, highlighting varying levels of engagement, as it can be seen in Figure 5. Confidence in using IoT devices post-training is relatively high, with 75% of respondents feeling confident. Another 15% felt somewhat confident, and 10% lacked confidence, indicating areas where additional support might be needed. Accessibility of online tutorials and resources has been positive for 70% of respondents, but 20% found them moderately accessible, and 10% faced difficulties accessing these resources. Respondents identified additional training needs, such as ongoing training (35%), more hands-on practice sessions (30%), advanced courses on IoT (20%), and peer-to-peer learning opportunities (15%).

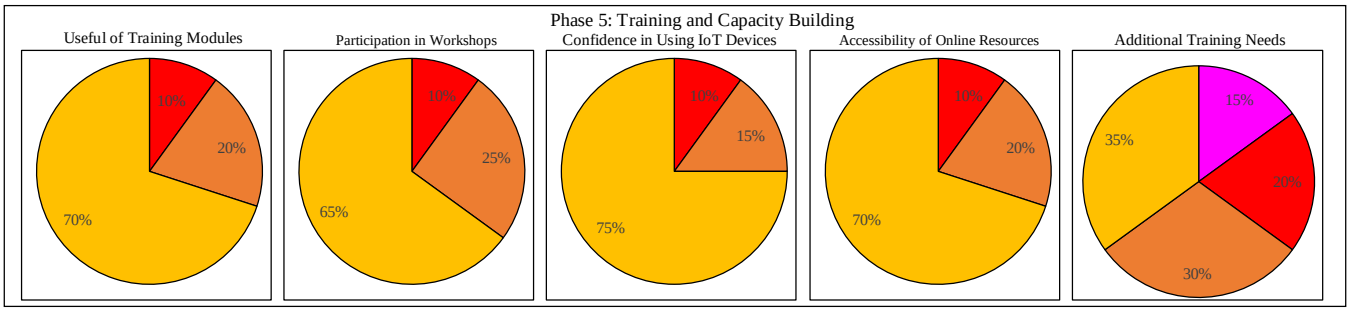

Fig. 5 Training responses

The high levels of satisfaction with training modules and the confidence in using IoT devices post-training highlight the effectiveness of current training programs. However, the varying levels of participation and the moderate usefulness reported by some respondents indicate a need for continuous improvement in training methods.

Providing more in-depth and tailored training programs can address these issues, ensuring that all users feel adequately prepared to use IoT devices effectively. Regular hands-on practice sessions and advanced courses can further enhance the skills of educators and students, ensuring they stay up-to-date with the latest IoT technologies.

The accessibility of online tutorials and resources is crucial for ongoing learning and support. Ensuring that these resources are easily accessible and user-friendly will help maintain high confidence levels in using IoT devices. Encouraging peer-to-peer learning opportunities can foster a collaborative learning environment where users can share knowledge and best practices. By addressing these additional training needs and continuously improving training programs, schools can ensure that all educators and students are well-equipped to utilize IoT technologies effectively, maximizing their benefits in the educational setting.

5. Conclusion

The integration of IoT in education has shown significant promise in addressing the unique challenges faced by Somalia's educational system. Through a phased implementation approach, starting with the establishment of reliable infrastructure and progressing through the deployment of IoT devices, remote learning integration, data collection, and capacity building, substantial improvements in the quality of education can be achieved.

The survey results demonstrate positive impacts on classroom engagement, resource management, and data-driven decision-making, although challenges such as internet connectivity, device accessibility, and ongoing training needs remain. Addressing these challenges through continuous improvement and targeted interventions will enable Somalia to fully leverage IoT technologies, creating a more inclusive, effective, and resilient educational environment that benefits all students.

Future research and development efforts should focus on enhancing the scalability and sustainability of IoT integration in Somalia's education sector. This includes exploring innovative solutions for extending internet connectivity and power supply to remote and underserved areas, as well as developing cost-effective IoT devices tailored to the local context.

Additionally, further studies are needed to evaluate the long-term impact of IoT on educational outcomes, identify best practices for training educators and students, and ensure data security and privacy. Collaborating with international partners, leveraging emerging technologies, and fostering a culture of continuous learning and adaptation will be crucial in driving the successful transformation of Somalia's education system through IoT.

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