Empowering Science Teachers: Leveraging Communication Skills to Enhance Primary Science Learning through Digital Platforms

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Abstract

The research explores the role of digital technologies in empowering teachers by enhancing their communication skills with students by focusing on teachers' and students' interaction using digital platforms. Researchers collected qualitative data via semi-structured interviews from 43 science teachers using a convenient sampling technique to address this objective. Interview results show that digital technology platforms such as Zoom and Google Classroom offer significant opportunities for effective *communication, allowing teachers to respond promptly* to their students via chat or video. Additionally, findings also highlighted that digital tools like as simulations and augmented reality simplify complex scientific concepts in raising deeper engagement. Further study results also highlighted that schools should have proper continuous professional development for teachers to improve their digital communication skills and provide training on utilizing online educational tools effectively. The study results also emphasized that integrating innovative teaching strategies like online forums and interactive activities can improve student engagement. Further study results are anticipated that provide immediate feedback, creating a more efficient learning environment. It is essential to address infrastructure challenges, such as the availability of modern technology and reliable internet, to ensure effective use of digital tools. Finally, the study stresses the need for a balance between digital and face-to-face interactions to maintain personal connections between teachers and students. Based on the above results, it is suggested that schools should increase digital technologies platforms to increase teachers' communication with their students, which could increase the students' learning through encouraging an 2 ALI AHMAD AL-BARAKAT, SARAH BADER ALOTAIBI, JAWAHER SAUD ALRASHOOD, ROMMEL MAHMOUD ALALI, KHALED M. AL-SAUD AND NAHLA ABBAS HILMI IBRAHIM invironment that improves student academic lack of digital communication proficiency (Balalle, 2024). interactive environment that improves student academic performance.

Keywords: Digital Technology, Primary Science Learning, Communication Skills, Digital Platforms.

Introduction

The shift to digital education has been accelerated by global crises such as the COVID-19 pandemic, which forced educational institutions to adopt remote learning strategies (Ting et al., 2020). This sudden transition highlighted the crucial role of digital communication skills in maintaining student engagement and academic continuity (Mustapha et al., 2021). This is the reason, digital technology integration in education has transformed teaching and learning around the world (Cramarenco et al., 2023). Due to the advancement of digital platforms, instructors these days are utilizing various technology tools that are enhancing the communication and collaboration with the industry (Williamson et al., 2020). It also increases the teacher's effectiveness to increase the students' interactive learnings, which increase the students' engagement in the science education (Sá and Serpa, 2020). In this perspective, science teachers had to rapidly transition to online teaching, which is not often addressed without adequate preparation or training in digital communication tools (Jonassen et al., 2008). The effectiveness of digital platforms in raising teacher-student interaction has been widely debated to increase student engagement, assessment methods, and the quality of virtual interactions (Kärkkäinen and Vincent-Lancrin, 2013). Through examining the role of digital technology in empowering the teachers of sciences, this research aimed to provide valuable insights into enhancing teacher-student communication in the digital era.

As digital technologies increase communication with students, they increase student engagement (Balalle, 2024; Margaryan et al., 2011). Therefore, in the education settings, the science field also gets benefits from digital platforms through facilitating simulations, virtual laboratories, and realtime interaction between teachers and students (Margaryan et al., 2011). However, despite these advancements, many teachers struggle to fully leverage digital tools to improve their communication skills and interaction with students (Sayaf et al., 2021). Effective communication in the digital age requires not only technological proficiency but also the ability to engage students meaningfully in online discussions, provide feedback, and encourage participation through virtual platforms (Nkomo et al., 2021). In this regard, advancement in technology has revolutionized education, but its full prospective remains unexploited due to teachers'

Addressing this issue is crucial for optimizing digital teaching and learning experiences.

Along with same lines, teacher extended their instruction to increase student interactive learning through using digital platforms beyond traditional classroom instructions (Aldhaen, 2024). Historically, in the digital platform, video conferencing tools, a learning management system (LMS), and online discussion forums have redefined teacher-student interactions, which are making them more flexible and accessible (Balalle, 2024). Importantly, science requires such of digital platform to increase the communication strategies to explain complex scientific concepts effectively in virtual settings (Li et al., 2024). The effectiveness of these digital communications depends on factors such as teachers' digital literacy, adaptability to new technologies, and ability to create engaging online learning experiences (Aldhaen, 2024). Literature cited that despite the availability of digital resources, many science teachers face challenges in adapting to digital teaching methods due to a lack of training, limited institutional support, and resistance to change (Nilsson, 2024). Such types of challenges delayed the digital technology utilization in minimizing the teacher's communication with the students, which is affecting the overall teaching and learning experience (Kareem et al., 2022; Nilsson, 2024). As digital technology provided significant opportunities for increasing teachers' and students' interactions, the barriers to adoption, such as inadequate training and institutional resistance, must be addressed to maximize its benefits.

It has been highlighted that digital technology studies have been widely discussed in the extant literature, but still, there remains a significant gap in research focusing on its role in enhancing communication skills among science teachers. For instance, Nilsson (2024) and Wallace et al. (2023) studies highlighted that digital platform increases interactive learning, which provides access to students to the vast educational resources, which facilitates them to increase their learning experiences. Nevertheless, the majority of the extant studies have been primarily focused on the students' perspectives, while ignoring the challenges that are being faced by teachers in the adaptation of digital communication (Rizk and Hillier, 2022; Wallace et al., 2023). On the other hand, some of the studies also highlighted the role of digital literacy for the educator, which ignored how digital technology specifically enhances science teachers' communication skills (Blundell, 2021; Rizk and Hillier, 2022; Wekerle et al., 2022). Additionally, extant literature also focused on the general benefits of digital learning rather than addressing

the practical difficulties teachers encounter in raising effective communication in virtual settings (Althubyani, 2024; Dhillon and Murray, 2021; Wekerle et al., 2022). The lack of empirical studies examining teacher-student interactions through digital platforms creates a gap in understanding the role of technology in empowering educators, particularly in the field of science education. Addressing this gap, it is important for developing strategies to enhance teachers' digital communication skills, which can empower science teachers to utilize digital technology effectively, thereby enhancing their communication skills and overall teaching effectiveness. Therefore, this study aimed to examine the role of digital technology in empowering science teachers by enhancing their communication skills, particularly focusing on teacher-student interactions through digital platforms.

Current research results are important because findings contribute to growing research on digital education, and how digital technology science allows teachers to increase their communication ability. By focusing on the teacher-student interaction, the study provides valuable insight into handling practical challenges that are facing teachers in a digital learning environment and provides recommendations for optimizing communication strategies through digital platforms. The study findings can also be beneficial for teachers, decision makers, and educational institutions who will support teachers to improve digital teaching practice and for technological progress. In addition, the study results also highlighted the importance of professional development in equipping science teachers with the skills required to effectively navigate digital communication, which will ultimately improve science education in the digital age. Further study is divided into four chapters, the second chapter was a literature review where the main empirical studies were discussed. The third chapter was the research methodology, where the research design and research approach were discussed. Chapter four was relevant to data analysis and results, where the main themes of the study were found and then were interpreted. The last chapter was relevant to studying the discussion and implications based on the study results.

Literature Review

In the current dynamic environment, digital technologies have changed the structure of institutions because it has transformed the lives of people from traditional movements to digitalization (Jain et al., 2021). Digital technology alone has singlehandedly altered how we teach and learn at all levels, from kindergartens to primary schools (Pozo et al., 2021). For many educational institutions, technology

adoption has become a growing focus in enhancing the capabilities of teachers (Mustapha et al., 2021). Effective communication is one of the critical skills that underpin the practitioners' ability to engage successfully in educational processes (Haleem et al., 2022). To enhance the learning and teaching process, teachers must be encouraged to adopt contemporary digital technologies and modern educational tools (Haleem et al., 2022), which entails more than just enabling digital competencies. There must be an appreciation of how these technologies can serve the educational goals being pursued, especially in the pedagogy of science (Pozo et al., 2021). Teaching within the field of science encompasses cultivating accessible innovative approaches in teaching that allow students to grasp sophisticated scientific ideas (Al-Salman and Haider, 2021). The use of digital platforms equips the teacher with the appropriate tools and methods, such as videos, interactive apps, and presentations, that make these topics simpler and easier to grasp and increase student interest and understanding of the material (Al-Salman and Haider, 2021; Haleem et al., 2022).

Keeping in view previous discussion, digital technology integration in education has been explored extensively through various theoretical lines, which emphasize its role in increasing teacher-student communication. It has been emphasized that technology, education, and material knowledge are necessary for effective teaching in the digital environment (Pinto and Leite, 2020). They also explained that science teachers should develop technical knowledge with educational strategies to facilitate meaningful learning in digital classes. Undoubtedly, effective communication in the virtual learning environment is closely linked to teachers' ability to integrate digital tools into a directive design, which allows interactive, studentcentered learning experiences. Other studies also stated that science teachers who have strong digital efficiency are better equipped to promote attractive discussions, provide timely reactions, and create interactive learning opportunities through digital platforms (Abdullayeva and Maxmudova, 2024; Getenet, Haeusler, et al., 2024). Moreover, another study also emphasized the valuable insights into the role of digital technology in enhancing teacher-student communication (Getenet, Haeusler, et al., 2024). Their study results posited that students are engaged in the learning system when their needs for autonomy, competence, and relatedness are met. Digital platforms provide opportunities for science teachers to create personalized and interactive learning experiences, which increases a sense of autonomy among students. Moreover, digital communication tools such as discussion forums, real-time feedback, and virtual simulations enable students to develop a deeper understanding

of scientific concepts, which increases the sense of competence (Awidi and Paynter, 2024). Teachers who leverage digital tools effectively can raise a sense of relatedness by maintaining open lines of communication, encouraging collaboration, and providing timely support to students (Kiryakova and Kozhuharova, 2024). Thus, based on these studies, digital technology is important because it enables science teachers to raise interactive, student-centered learning experiences, enhance engagement, and create a dynamic educational environment that strengthens teacher-student communication.

Getenet, Haeusler, et al. (2024) empirically further highlighted that digital learning platforms increase students' learning through improving the communication channels with the teachers, like discussion boards and automated feedback systems. Their study results also emphasized that digital tools always facilitate a more dynamic and interactive learning environment. In the same vein, Hinostroza et al. (2024) also found that students who engaged in collaborative digital activities showed a deeper understanding of the skills and scientific concepts to solve better problems. The study also emphasized that teachers who were trained in digital communication strategies were more successful in promoting meaningful conversation with the students. On the other hand, Getenet, Cantle, et al. (2024) examined the impact of digital tools on teacher-student communication was analyzed across multiple educational institutions. Their results showed that teachers who actively used digital communication tools, such as video conferencing, online discussion forums, and real-time feedback systems, reported higher levels of student engagement and satisfaction. Their research concluded that digital technology plays a crucial role in bridging communication gaps between teachers and students, particularly in the context of science education, where complex concepts require interactive and visual explanations.

Similarly, the study of Agyei et al. (2024) discovered digital simulation efficiency in increasing teacher-student communication in mathematics classes, where teachers at the secondary school had studied. Their study results showed that students who were engaged with digital simulation were more likely to ask questions, seek clarification, and participate in the discussion than those in traditional class settings. The study results also emphasized the importance of digital units in creating interactive and inquiry-based learning experiences, which are crucial for effective science education. The findings from the study have been continued with the study of Survani et al. (2024), which highlights the role of digital technology such as Twitter, Facebook, and educational blogs in increasing students' conversation. Their research findings revealed that students who were associated with their teachers through social media experienced high levels of inspiration and academic

achievements. The study also highlighted that teachers who maintained an active online attendance were more successful in addressing the students' questions and providing timely response, which increase the results of general learning. The previous study results was supported by Parveen and Ramzan (2024), who studied the effectiveness of digital technology in increasing teacher-student communication. They found that the students who interacted with their teachers through mobile applications demonstrated more ideological understanding and improved educational results. Researchers, based on their findings, emphasized that the mobile learning application provides a flexible and available communication channel that allows teachers to join students beyond traditional class settings.

Fälth and Selenius (2024) further conducted a study on the importance of various digital technologies like pre-recorded video lectures, online guizzes, and interactive discussion boards in influencing student engagement in increasing the communication between the teachers and students. They found that students who accessed digital learning materials before attending class were more prepared, engaged, and proactive in discussions. Teachers who effectively utilized digital platforms reported improved classroom interactions and higher levels of student participation. Authors also suggested that digital technology enhances teacher-student communication by providing multiple avenues for interaction, feedback, and engagement. Further study of Sailer et al. (2021) also highlighted the role of digital discussion forums in raising teacher-student communication. They found that students who actively participated in online discussion forums demonstrated higher levels of critical thinking and engagement. Finally, Poultsakis et al. (2021) study of examined the effectiveness of digital technology in improving teacher-student communication. Their study result found that science teachers who incorporated digital storytelling techniques were able to explain complex scientific concepts more effectively, leading to improved student comprehension and participation in discussions.

Based on the above findings, it is highlighted that digital technology increases the teacher's students' communications, particularly in science education. Through leveraging digital technology, science teachers can create more interactive and student-centered learning environments, which can improve the communication and learning experience of students. These findings highlighted that current research is needed to explore best practices for integrating digital communication tools into science education and addressing potential challenges faced by teachers in digital learning environments. Therefore, current research explores the role of digital technologies in empowering teachers by enhancing their communication skills with students by focusing on teachers' and students' interaction using digital platforms.

Method

Research Design

This study was largely targeted towards understanding the influence of digital technology on communication skills, specifically focusing on teacher-student interactions. The researcher chose the qualitative method for the reason that it is useful for collecting in-depth information about diverse aspects of a single issue (Bryman, 2017). Consequently, this study used a qualitative approach and gathered data through semi-structured interviews among the respondents within their actual classroom.

Subjects of the study

The sample of the study was composed of 43 science teachers from different schools in Al-Ahsa region, Saudi Arabia. The sample was conveniently selected based on the availability and willingness of the subjects to cooperate. Teachers were picked based on their willingness to take part in the research and were contacted directly to tell them what the study intends to achieve and why their participation is important. This approach to sampling helps the educator researchers because it takes less time and is more convenient as it captures the readiness of the teachers to enhance the educational process and the enthusiasm of the teachers towards the study.

To guarantee that participants varied in their educational practices in science teaching, candidates were recruited from multiple schools in Al Ahsa area. The purpose of this distribution was to offer a general depiction of the educational potential in the region, along with how teachers utilize modern technologies while teaching scientific disciplines. In this regard, ensuring diversity among participants in terms of professional background and teaching experience was important, as it would help acquire useful and complex information surrounding the phenomenon of integrating technology into science education.

Data Collection Instruments

The main component of this research was to collect data through semi-structured interviews that sought to know how science teachers employed digital technology to improve communication with their students. Moreover, these interviews sought to understand the role of other digital tools like Google Classroom and Zoom in facilitating teacherstudent interaction as well as communication, understanding, and exchange of information during the learning process. To begin with, the interview guide had four questions. However, the guide was thoroughly scrutinized by a panel of experts in science education, measurement and evaluation and digital technology before clearing the data collection, where the experts managed to give feedback on how this could be done much better. Through the incorporation of experts' suggestions, the guide was improved to include five questions. This step was important for the interview instrument to ensure validity by ensuring the interview questions comprehensively covered all research objectives.

In order to maintain accurate data findings from the investigation, the researchers practiced a 'test-retest' tactic whereby moderation interviews were conducted with separate teachers who were nonparticipants of the study sample. They did this with 7 teachers at a 3-week distance, with 2 participants for each of the interview sessions. The results were computed from all the interviews through Cohen's Kappa, which determines the rate of agreement between two variables. These results were expected and fair, as the participants were for the most part in reasonable agreement and as such there were no issues. The rate of acceptance was in reality very high, standing at an impressive 95%, suggesting that the instrument was effective on both occasions.

For the purpose of capturing the precise responses from the concerned participants, along with ensuring comprehensive and coherent data to be collected, all the interviews were conducted aided with audio recording devices and thus aimed at protecting the overall findings from being flawed. This way, there was no significant data that was missed in the course of the interviews enabling clearer detailing of insights during analysis.

A specialized team conducted the data collection, making sure that all ethical procedures were followed. Consent was acquired from all parties involved before data collection began to ensure that participants comprehended the purpose of the study as well as the confidentiality of their involvement. All data was stored in flash drives that were password protected such that only the researchers could access them. Further, in order to enhance confidentiality of the participants, no one was referred to by name and all other forms of identifying data were omitted during the research. There were strict measures put in place to ensure that no participant privacy was breached, which was above the required ethical principles and academic research standards.

Data Analysis

The analysis of the data was done through thematic analysis employing the steps of the Grounded Theory technique. The interviews were transcribed and organized into sets. The material was also critically and reflectively read paying attention to each word, phrase, and sentence. This exercise resulted in the emergence of several codes which were subsequently scrutinized and sorted. Afterward, all the assigned codes were

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given useful themes, and the relations and patterns between them were examined. Finally, a general overview of the core and minor themes was developed based on the patterns that arose throughout the investigation. They were chosen based on their frequencies and percentages, which in turn enabled them to pull out relevant information concerning how digital mediums and communication tools can assist in making science lessons more interactive and engaging, particularly in the cases of online and hybrid teaching. Based on the data analysis, the following themes were created.

Theme 1: Empowering Science Teachers to Use Technology in Teaching

The results of the interviews with 41 out of 43 (95.34%) respondents revealed that the majority of the teachers indicated that technology has become an integral component of science pedagogy. These results show that participants during the research reported that the use of tools such as simulations and augmented reality enables students to learn difficult scientific concepts more easily, which makes the entire experience engaging, and improves understanding.

Many of the participants reported that students are able to comprehend the material positively when it is offered through narration or when the students are actively engaging with it. One of them said: "*Interactions with students through simulations help them see chemical reactions happening virtually which gives them a better understanding of concepts than traditional classrooms.*"

On the other hand, even after agreeing on the positive aspects, some participants pointed out that there will be difficulties in using them effectively. Several participants pointed out that the lack of modern technological provision remains a major problem that may affect the daily use of these resources. Some respondents also added that the technological infrastructure in some schools is not sufficient to cope with the basic demands of today's education. One respondent commented,

"Even when there are available modern technological tools, certain schools are still short of devices, unfortunately or have very low-quality internet, which prevents these tools from being useful to students."

From the above observations, it can be concluded that sustained guidance and efficient education for respondents is necessary. By ensuring that there is sufficient technological infrastructure in schools, we can guarantee that all students will be able to use these tools, which will enhance the learning experience. Meeting these challenges can greatly improve the use of technology in education for science.

Theme 2: Developing Effective Communication Skills with Students through Digital Platforms

In the second theme, 90.69% of participants regard

the use of Google Classroom and Zoom as effective tools for increasing engagement with students. According to the respondents, students' queries can be efficiently addressed through these platforms since the feedback can be delivered instantly, along with the comments on the assignments. As one respondent noted:

"Digital platforms have made it easier to communicate with students because I can respond to their questions at times that suit them, which significantly improves their understanding of the content,". A different respondent observed, "In e-learning platforms, I am able to provide instant responses to assessments and projects helping students enhance their performance."

With respect to interpersonal communication among learners, the respondents pointed out that more interactions are noted through these platforms compared to the traditional face-to-face classroom environment. Students are more able to articulate their thoughts and participate in discussions related to some scientific issues. One of the respondents stated:

"Debates these days on such platforms facilitate greater levels of critical thinking by allowing students to voice their opinions with more authority."

Nevertheless, some respondents of the study offered arguments about the constraints that digital platforms offer. They argued that students may lack personal contact with their instructors which can hamper the overall communication quality. This was due to fact that students might not know how to utilize these tools proficiently. One of the respondents puts it this way:

"Although these platforms have great advantages, there is a portion of the students who do not interact fully because they have problems with technology or have low skills in using it."

Theme 3: Implementing Innovative Teaching Strategies Online

In the third theme, it was found that 88.37% of respondents agreed to the importance of innovative teaching strategies, such as the use of educational games and augmented reality that actively assist students in engagement with scientific content. Several respondents also pointed out that Kahoot and Quizlet as interactive tools help grab students' attention and motivate them to take part in scientific activities. One respondent stated,

'Interactivity in the classroom is a much-needed component that every child requires to engage with the concept they have been taught. Interactive gaming applications give them the chance to apply the concepts they've learned in a non-traditional setting which significantly enhances their understanding.'

Additionally, many respondents accentuated that

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augmented reality and simulation assist them in explaining the difficulties of scientific concepts in simpler ways that are visually appealing. One respondent associated with this aspect has said, '

In explaining cellular processes or studying the solar system, augmenting reality has tremendous positive impact on students understanding of this phenomenon.'

Nonetheless, with a number of respondents highlighting the great advantages of these novel techniques, some respondents in the focus groups remarked that implementing these strategies does require an efficient amount of skill, in terms of technology knowledge, and hardware infrastructure. One respondent stated,

'Applying these strategies requires high technical knowledge and advanced electronic devices which may not be available in every school.'

The above theme's overall results highlighted that diverse pedagogical methods are able to enhance the educational framework in the most positive way and these instructors should be provided with continuous support and training to make sure that these methods are used successfully.

Theme 4: Motivating Student Participation and Interaction through Digital Platforms

Fourth theme results show that 83.72% of respondents stated that digital tools significantly participated in engaging students. In particular, most respondents pointed out that the learners' participation in lessons and scientific work is higher when these are offered as online presentations. One respondent observed that,

"Students participate more in discussions through digital platforms, where they can ask questions and discuss

ideas in a more open way than in traditional classrooms." Another respondent contended that, "Students have greater potential to partake in the material online through interactive activities, and their willingness to learn is significantly higher."

On the other hand, other respondents pointed out that although online interactions have their benefits, they do not seem to be as effective as face-to-face interactions in traditional classrooms. For instance, they pointed out that some students prefer direct contact with the instructor or fellow students. A teacher commented,

"There are opportunities for interaction on digital platforms. However, some students have issues engaging with the content on the platform, particularly if there is no face-to-face communication with the instructor."

Results of Theme 5: Effective Student Assessment through Digital Tools

The fifth theme results shown that 81.39% of the targeted participants accept the incorporation of digital tools into the assessment procedure. Respondents noted that digital assessments provide accurate and timely tools for evaluating student performance and offering immediate feedback on assignments. One participant claimed that

"in the case of electronic exams, I am able to evaluate student performance with speed, and provide efficient feedback, in which their academic progress gets enhanced."

Several respondents however expressed that most students' abilities in areas such as criticism or oral expressions can easily be overlooked in digital tests.

Theme	Strengths	Challenges Identified
Empowering Science	 95.34% of respondents agreed that technology enhances science pedagogy. 	 Limited access to modern
Teachers to Use	• Tools like simulations and augmented reality help students grasp	technological tools.
Technology in	complex concepts more effectively.	• Poor technological infrastructure
Teaching	Narration and interactive tools improve engagement.	in some schools.
Developing Effective	• 90.69% of respondents found Google Classroom and Zoom	• Look of nonconal contact with
Communication	effective for student engagement.	• Lack of personal contact with
Skills with Students	• Digital platforms provide instant feedback and encourage student	 Some students struggle with technology or have low digital skills
through Digital	interaction.	
Platforms	Online discussions raises critical thinking.	teenhology of have low digital skins.
Implementing	• 88.37% of respondents supported using educational games and	Requires high technical
	augmented reality.	knowledge.
Strategies Online	 Kahoot and Quizlet enhance student engagement. 	 Advanced devices may not be
Strategies Offinie	Augmented reality simplifies complex scientific concepts.	available in all schools.
Motivating Student	• 83.72% of respondents stated that digital tools increase student	• Some students prefer face-to-face
Participation and	engagement.	interactions.
Interaction through	 Online presentations and interactive activities encourage participation. 	• Lack of direct communication with
Digital Platforms	Digital platforms create open discussion spaces.	instructors may reduce engagement.
Effective Student Assessment through	 81.39% of respondents supported digital assessments for their accuracy and efficiency. Digital tools provide timely feedback on student performance 	 Some student skills, like oral
		expression and independent
		problem-solving, may be
	- Dignar tools provide timery recuback on student performance.	overlooked in digital assessments.

Table 1: Themes Results

Source: Author's Illustration.

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assessment gives accurate results however not all aspects of students' skills such as oral the solving problems independently are factored," commented one respondent.

Going from these notes, it is evident that the hassle caused by digital assessment is solved without fail and also the accuracy level of measuring a student's performance has increased significantly. Although there are challenges with computerized assessments, instructors need to start developing other means of measuring skills that do not lend themselves easily to metabolic testing systems. The above themes are summarized in the Table 1 below,

Discussion of the Results

The research explores the role of digital technologies in empowering teachers by enhancing their communication skills with students by focusing on teachers' and students' interaction using digital platforms. Through semi-structured interviews with 43 science teachers, the research used a qualitative approach to explore how these communication skills influence the learning process and student understanding of scientific concepts. The study found the five main themes, where overall results showed that most schools have had the increased use of technology in their instruction. In the first theme, respondents' results showed that the majority of the teachers indicated that technology has become an integral component of science pedagogy. The findings highlighted that technology integration in science education positively impacts to student learning, especially through tools such as simulations and augmented reality (AR). These results align with previous studies where shown that these technologies facilitate a deeper understanding of complex scientific concepts by offering interactive and immersive learning experiences (Dede et al., 2000; Pellas et al., 2021). Further empirical studies have also shown that students' comprehension improves when they actively engage with the material through technological tools, which aligns with constructivist theories of learning (Bizami et al., 2023; Freitas and Neumann, 2009). On the other hand, along with the benefits, various challenges also persisted in using technologies has found in the context of infrastructure and accessibility. Teachers noted that the lack of modern technological provisions, coupled with inadequate devices and poor internet connectivity, hinders the effective use of these tools in some schools (Baxter and Hainey, 2024). This discrepancy in resources emphasized the need for systemic support and investment to ensure that all students can benefit equally from technological advancements in education. Based on the findings, it is suggested that educators integrate digital tools to enhance student engagement while also providing traditional methods to support students who

The second theme of the study was regarding the communication skills developed on digital platforms. The findings revealed that teachers regard Google Classroom and Zoom as helpful for communicating with students. This finding matches with several recent studies that show the growing usefulness of digital platforms for communication between teachers and students (Klippel et al., 2019). Study findings and empirical findings support the view that teachers' use of digital platforms correlates with their increasing reliance on digital tools that allow them to communicate in a more effective and timely manner. Furthermore, findings also indicated that these platforms allow teachers to respond to questions raised by students at their own time, which improves the quality of educational Interaction. Along with the benefits of digital platforms to increase communications, it has also been found that some concerns from a few of the instructors regarding the level of interaction with students over the platforms, based on their presumption that remote teaching lacks classroom interaction. This supports the findings of Duraku and Hoxha (2020), who stated that faceto-face communication with students in a classroom setting is equally beneficial to student's interpersonal relations and academic performance. Hence, based on these findings, it is obvious that the integration of the two extremes, namely, digital education and personal education in the classroom is a potential improvement to the effectiveness of the instructional objectives.

In the third theme, it was found that most of the respondents agreed with the importance of innovative teaching strategies, such as the use of educational games and augmented reality that actively assist students in engaging with scientific content. These findings underlined the value of using tools such as educational games and augmented reality in raising student engagement with scientific content. The result is in line with the previous study of Dewanto et al. (2024), where they found that the use of educational games motivated students to learn more science, and the use of augmented reality frameworks made the scientific concepts easily understandable and appealing. They also highlighted that educational games also raise students' actual involvement in the learning of scientific concepts, which is an important aspect in their comprehension. Along with the benefits of using educational games or augmented reality to increase the students' engagement, it has also been noted that the integration of these pedagogical techniques poses a challenge because of their sophisticated requirements in technology. This aligns with the works of researchers (Farazouli et al., 2024), who pointed out that the implementation of educational games as a learning technique requires various adequate technical

skills training. Therefore, based on the above findings, it is argued that to resolve the disparities of using digital technologies, there should be a fast pace of technological advancement, and the ability of the teachers to use these resources effectively is dependent on the implementation of training sessions.

Fourth theme results show that the majority of the respondents stated that digital tools significantly participated in engaging students. These findings highlighted that increase in student attentiveness during lessons and other educational activities when students were assigned lessons using these digital platforms. This finding agrees with other research (Alieto et al., 2024; İbi'li' et al., 2024), which highlighted the benefits of using these platforms in promoting students' collaborative work as well as motivating them to engage in scientific work. Along with the benefits of increasing engagement of the students, it has also been found that learners were able to articulate their views and engage with issues more deeply through these platforms. This shift is because, unlike conventional education, these digital platforms can provide a more flexible and interactive environment that encourages students to voice their ideas without the apprehension of being immediately judged by their teacher. It was cautioned that this interaction is less effective on students who prefer faceto-face interaction with the teacher. This is in line with the study of Nakao et al. (2025), which states that some students cannot adapt to the digital learning environment. Based on the findings, it is suggested that educators integrate digital tools to enhance student engagement and collaborative learning while also accommodating students who prefer face-to-face interactions to ensure inclusivity.

The fifth and last theme results show that teachers considered digital assessments to be an effective method for testing and giving feedback to students. The result is similar to the study of Viberg et al. (2024) where they pointed out that digital assessments improve the precision of the evaluation conducted and alleviate human error, which the teachers of this study seem to have corroborated. Despite the benefits, some of the respondents also asserted that digital assessments may not adequately capture the full range of skills a student possesses, including their analytical or oral proficiency. The study finding is consistent with numerous other studies (Kizilcec et al., 2024; Klingbeil et al., 2024), which show that comprehensive assessment should be undertaken using more than one approach to capture all the learner's skills. An observation that stems from the above literature is that while digital assessments can certainly aid in refining the evaluation process, they ought to be supplemented with other means of evaluation to capture areas of student skills that are difficult to measure using technology. Based on the findings, it is suggested that digital assessments should be complemented with alternative evaluation methods to capture a comprehensive range of student skills, including analytical and oral proficiencies.

Implications and Recommendations

The findings from this study have important practical implications for science education, particularly in the digital technology integration, improving communication skills to enhance students' learning. From a practical point of view, the results emphasize the technique, such as simulation and improved reality, which is being helped to elaborate on students' understanding of scientific concepts, providing an attractive and interactive learning experience. However, teachers should face challenges related to infrastructure and access, as the lack of technical regulations in some schools has contributed to uneven access to these resources. In addition, the use of digital platforms such as Google Classrooms and Zoom has contributed to increased communication, so that teachers can provide timely feedback and support, thus improving students' understanding and commitment. Integration of innovative teaching strategies such as educational games and promoted reality has helped to increase students' involvement, but it requires sufficient teacher education to ensure effective implementation. In addition, the use of digital devices should be supplemented with traditional face to face interactions, which can only struggle with a digital teaching environment. Finally, while digital assessment has helped to improve the assessment of the assessment, they should be supplemented with alternative assessment methods to capture a wide range of students, including analytical and oral profanity. Therefore, a balanced approach that combines digital and traditional methods together with continuous business growth and improvement in infrastructure will help to strengthen teachers to maximize technology capacity in science education.

According to these, recommendations could be made that aim to improve the ability of teachers to work with technology more effectively. First, educational institutions must provide adequate technological facilities that enable teachers to keep up with the increasing pace of digital education. Second, educational policies should center on ensuring that teachers continuously improve their skills through professional training programs designed to enable them to utilize technology in teaching more efficiently. These programs should also combine new practices with traditional teaching methods to enhance the learning experience and achieve better outcomes. It is equally important to analyze the effect of technology on education as an industry comprehensively, which includes not only increases in students' grades, but also their engagement and involvement in educational activities. Therefore, in any 10 ALI AHMAD AL-BARAKAT, SARAH BADER ALOTAIBI, JAWAHER SAUD ALRASHOOD, ROMMEL MAHMOUD ALALI, KHALED M. AL-SAUD AND NAHLA ABBAS HILMI IBRAHIM further research work, technological progress in this sphere should be noted, especially as it relates to numerous and sophisticated technology-enabled learning environments.

Conclusions, Limitations, and Future Research Directions

The research explores the role of digital technologies for empowering teachers through enhancing their communication skills with students by focusing on teachers' and students' interaction using digital platforms. The important outcomes from the analysis of the results is that integrating technology into the science curriculum at the elementary level is a requirement and not a choice. The use of technology, such as digital simulations or augmented reality, can break down sophisticated topics in science and allow students to learn more interactively and realistically. The success of these technologies in education, however, depends on the presence of adequate infrastructure with modern devices, dependable internet, and consistent maintenance and training for educators. Moreover, it is equally important to strike an appropriate balance in the employment of modern aids versus personal touch in teaching, which is crucial and beneficial for students' overall academic performance and understanding of the subject. Regarding improving communication via digital platforms, the study observed that these platforms had greatly aided in the interaction between teachers and students owing to flexible communication and immediate feedback. Some teachers, on the other hand. We were dissatisfied with the absence of direct personal contact with students. This brings out the importance of having a balance between digital teaching and conventional methods to make the learning process more effective. Moreover, the study showed that creative modern approaches like educational games and augmented reality are useful in getting children to participate in learning scientific content and increasing the motivation for learning. On the other hand, these approaches require sophisticated technical knowledge from the teachers for successful implementation.

As for the limitations, a few requirements regarding the scope and generalizability of the findings of this study need to be pointed out. The first stems from the fact that the research approached interviewed a selected few teachers only, which certainly does not portray the full scope of experiences of all science teachers in the use of technology in teaching. This could have been achieved with a much larger and more diverse sample. Relating to future research directions, to further aid in educational technology studies, there is an urgent need for longitudinal studies assessing the outcomes of instructional technology on student performance, their cognitive skills, and engagement levels in virtual classrooms. Second, as was

themselves have very narrow diffusion, and did not probe the larger context of teachers' actual teaching practice and pedagogy. This research could also concentrate on the impact of new technologies on the development of effective novel teaching approaches and on the fostering of critical thinking and collaboration among learners. Further studies might seek to understand the balance between teaching style, curricular requirements, and the use of technology. The last limitation of this study is that the age and social status of learners were not taken into consideration in terms of experiences with digital learning tools, even though these are vital aspects that should be included in further research. Lastly, this work should focus on the ways of blending digital pedagogy with conventional teaching techniques to formulate effective and lasting educational results that aid in the advancement of the educational system as a whole.

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