

Research Article

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Digital Assessment in Science Education: Self-Reported Practices and Challenges among Jordanian Teachers

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Abstract

Background/purpose. This study addresses the limited integration of digital learning applications in science education assessment in Jordan, where technological adoption in schools faces infrastructural and skill-related challenges. The main purpose was to investigate the extent to which science teachers in Mafrq Directorate of Education use digital applications for assessing student learning, identify influencing factors (gender, experience, qualification, rank), and explore barriers to effective integration.

Materials/Methods. A descriptive survey design was employed, collecting data from 125 science teachers in Mafrq, Jordan, using a 23-item questionnaire. Means, standard deviations, and a four-way ANOVA were calculated to analyze the extent of digital application use and differences based on gender, years of experience, academic qualification, and professional rank. Barriers were assessed through ranked mean scores.

Results. The study found a moderate level of digital application use in science assessment. Teachers with postgraduate qualifications and higher professional ranks demonstrated significantly greater use of these tools, while no notable differences were observed based on gender or years of experience. Key barriers included a shortage of devices, unreliable internet connectivity, and limited access to specialized digital tools, with several barriers rated as high and others as moderate.

Conclusion. Despite moderate use of digital applications, infrastructural limitations and skill gaps hinder effective integration. Enhancing school infrastructure, providing targeted professional development, and fostering supportive school cultures are critical to advancing digital assessment in science education.

1. Introduction

Digital transformation has profoundly reshaped modern life, ushering in an era of global connectivity and technology-driven change. From the early days of satellites to today's Internet-enabled world, technology has eliminated traditional barriers of time and space, transforming how we communicate, learn, and work. Education, in particular, has undergone a major shift, with digital tools now playing a central role in enhancing teaching quality and learning outcomes.

This digital age is characterized by the rapid and continuous expansion of information, often outpacing our capacity to process it. This so-called 'knowledge fluidity' (Foroughi, 2015) reflects the shift from institution-bound knowledge to universally accessible content. As a result, a distinct digital culture has emerged, one that has deeply affected educational systems worldwide. With the rise of the high-speed Internet, mobile devices, and smart applications, digital tools have increasingly become integrated into instructional practices and student engagement strategies (AlAli & Al-Barakat, 2024; Martin et al., 2019).

This study fills a gap in understanding how teacher characteristics (gender, experience, qualification, rank) influence digital tool use in Mafrq's unique context and identifies specific barriers. Its significance lies in informing policy and training to enhance digital assessment. The objectives are to evaluate usage extent, examine differences by teacher characteristics, and identify barriers. The research questions are: (1) To what extent do science teachers use digital applications for assessment? (2) Are there differences based on gender, qualification, rank, or experience? (3) What barriers do teachers face?

Digital education is now a global imperative (Bachou, 2018), which supports education and aligns with sustainable development goals. Technological progress has prompted a restructuring of educational frameworks, embedding digital learning across curricula, pedagogies, and assessment practices. The COVID-19 pandemic has accelerated this shift, highlighting the urgency of rethinking digital infrastructure and curriculum design to sustain education in times of crisis (Al-Barakat et al., 2023; Ali, 2019; Al-Riyami et al., 2020; Mamkgh, 2021).

Among the most impacted areas is the assessment of learning. Digital assessment tools have begun to replace traditional ones, particularly in science education, which demands the evaluation of both theoretical knowledge and practical skills (AlAli & Al-Barakat, 2025). These tools provide significant advantages: efficient design, automated grading, instant feedback, cost-effectiveness, and enhanced objectivity as well as support differentiated feedback, encourage student motivation, and promote self-assessment (Al-Anzi, 2019; Alarabi et al., 2022; Al-Barakat et al., 2025; Al-Zaid, 2019).

Science teachers play a vital role in integrating digital tools into assessment practices. Their insights are essential, as they reflect the practical realities of the science classroom (Bataineh et al., 2007). While digital applications offer numerous benefits, implementation is not without challenges. Teachers often face material and logistical constraints, such as limited infrastructure, outdated equipment, and insufficient training, not to mention technical issues, financial limitations, and systemic barriers which also constrain effective digital assessment (e.g., AlAli et al., 2025; Nammari, 2022; Al-Riyami et al., 2020).

Internationally, researchers have explored how digital tools are used in science education. Jayson and Maricar (2025) found that tools, such as Messenger, PowerPoint, and Canva, are highly valued by science Filipino teachers for enhancing communication and lesson delivery. Despite Internet challenges, these teachers adapted to maintain instructional quality. Similarly, Al-Baqami and Al-Salamat (2023) highlighted the effectiveness of the Classera platform for science education in Saudi Arabia, showing its positive effect on both teaching and learning alike (Tashtoush et al., 2023).

Other research reinforces these findings. For example, Rehhal et al. (2022) reported general satisfaction with digital assessment tools among Moroccan teachers and students, despite logistical challenges. Similarly, Al-Asail (2021) observed a widespread use of top digital tools, such as Microsoft Teams and Zoom in Al-Ahsa schools. Mdalose et al. (2021) reported that Kahoot increased engagement and academic achievement among science learners in South Africa.

In Jordan, Ahmed (2019) reported moderate technology use in biological science instruction, with private school teachers adopting more tools than their public-school counterparts. Nammari (2022) identified similar patterns in Saudi Arabia, where digital assessment tools were moderately used, albeit hindered by high levels of implementation barriers. Al-Harhi and Al-Essa (2022) reported low levels of augmented reality use in science education, noting significant institutional and training barriers. Al-Rifai and Al-Sisi (2022) also noted moderate levels of difficulty among Saudi teachers using e-learning platforms, especially in terms of perceived usability and training gaps.

The rapid digital transformation of the 21st century has positioned digital learning applications at the forefront of educational innovation, offering new possibilities for teaching, learning, and assessment across disciplines (e.g., Al-Hassan et al., 2025; Hawamdeh et al., 2025; Al-Ziyadi, 2020). In science education, effective assessment requires flexible, interactive tools capable of gauging both conceptual understanding and applied skills. Digital platforms now provide such tools, delivering real-time feedback, performance tracking, and data-driven insights that enhance the quality of instruction and student outcomes.

In response, the Jordanian Ministry of Education has made significant strides in promoting digital education by investing in infrastructure, reconfiguring system structures, and supporting teacher development. Yet, despite these efforts, the integration of digital applications in assessment remains inconsistent and constrained by multiple challenges. Field observations and professional experience reveal persistent barriers, such as insufficient resources, limited technical training, and misalignment between tools and curricular goals. These challenges are particularly relevant in the science classroom, where assessment must capture dynamic, practice-based learning.

Given the central role of teachers in adopting and applying these tools, the purpose of this study is threefold. First, it seeks to determine the extent to which science teachers in Mafraq Directorate of Education integrate digital learning applications into their assessment practices. This involves examining the frequency and nature of digital tool usage in evaluating student understanding and performance. Second, the study aims to identify the key barriers that hinder effective adoption of these tools, based on teachers' own experiences and perspectives. These may include technical, infrastructural, or pedagogical challenges. Third, the research explores whether teachers' use of digital assessment applications varies significantly according to demographic and professional characteristics such as gender, academic qualification, years of experience, and professional rank. Collectively, these aims provide a comprehensive understanding of both the practice and the constraints of digital assessment in science education within the Jordanian context. More specifically, the research is guided by the following questions:

1. To what extent do science teachers in Mafraq Directorate of Education use digital learning applications to assess student learning?
2. Are there statistically significant differences in the use of digital learning applications, which can be attributed to gender, academic qualification, professional rank, or years of experience?
3. What barriers do teachers reportedly face when using digital applications in science assessment?

The study holds both theoretical and practical significance. Theoretically, it contributes to ongoing discourse on digital integration in education, potentially enriching the literature with

context-specific insights from Jordan. Practically, it offers evidence-based guidance to policymakers and education leaders, supporting more strategic efforts to align digital tools with national science assessment goals. The study also provides researchers with a tested framework and tool for further investigation in similar contexts.

This study focuses on examining the use of digital learning applications in the assessment of science learning and the barriers to their integration, as perceived by science teachers in Mafrq, Jordan. The research was conducted on the basic and secondary stages, public-school teachers during the academic year 2024/2025.

The term *digital learning applications* is defined as educational tools designed to create interactive environments through Internet- and computer-based technologies, enabling learners to access content at any time and from any location (Al-Awaid et al., 2004). In this study, *digital learning applications* are operationally defined as the extent to which the science teachers under study use applications, such as PowerPoint, Kahoot, Padlet, Movie Maker, Microsoft Excel, Scratch, and Google Forms, to assess student learning, as gauged by their responses to the questionnaire.

Learning assessment refers to a set of teacher-led procedures aimed at evaluating students' attainment of learning outcomes (Abu Ali, 2023). These assessments are typically measured through performance scores that reflect students' level of achievement. For this study, *learning assessment* is operationally defined as the scores students receive after completing time-bound assessment tasks, conducted using digital applications. Finally, *science teachers* are educators who teach science subjects at the basic or secondary school level in the public schools of the Directorate of Education in Mafrq during the academic year 2024/2025.

While the findings offer valuable insights into the local practices and challenges faced by science teachers in integrating digital learning applications for assessment, the generalizability of these results is limited. The sample is geographically confined to Mafrq Directorate of Education, meaning that the findings may not fully represent the practices of teachers in other regions of Jordan or in different educational contexts. Additionally, the self-reported nature of the data introduces the possibility of response bias, as teachers may overestimate or underestimate their use of digital tools or may be influenced by social desirability when reporting on barriers. Furthermore, the reliability of the conclusions of the study is dependent on the psychometric validity of the research instrument. This includes ensuring that the questionnaire effectively measures what it intends to measure and produces consistent results. The accuracy of the findings also relies on the participants' honesty and accuracy in their responses, which could be influenced by factors such as their level of awareness of digital tools or their perceptions of how they should respond to the survey questions. Therefore, while the study provides valuable insights, caution is needed when extending the findings beyond its specific context.

1.1. Theoretical Framework

The integration of digital learning applications in science assessment is underpinned by several key theories that explain the adoption and effective use of technology in educational contexts. The Theory of Connectivism (Foroughi, 2015) is central to this study, positing that learning in the digital age occurs through the formation of connections within networks of information, technology, and social interactions. This theory highlights the role of technology in facilitating access to vast knowledge repositories, making it particularly relevant to the use of digital tools like Kahoot, Google Forms, and PowerPoint in science assessment. These tools enable interactive feedback and dynamic connections between students, teachers, and content, fostering engagement and self-directed learning. Through digital platforms, science teachers can design assessments that not only measure conceptual understanding but also promote critical scientific skills.

Complementing Connectivism, the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) offers a comprehensive lens for understanding the interplay between technology, pedagogy, and content knowledge. TPACK emphasizes that effective teaching with technology requires an integrated approach that combines technical proficiency with pedagogical strategies and deep content knowledge. For science teachers, this framework is particularly useful in ensuring that digital tools align with instructional goals and appropriately assess students' scientific understanding. The study uses TPACK to explore how teachers' competencies in digital tools influence their assessment practices and to identify barriers, such as insufficient technological skills or infrastructure, that may hinder effective tool integration.

Lastly, Diffusion of Innovations Theory (Rogers, 2003) provides insight into the adoption of digital learning applications. This theory argues that the acceptance of innovations, such as digital assessment tools, depends on factors like ease of use, compatibility with existing practices, and visible benefits. In the Mafrq Directorate of Education, barriers such as limited technological infrastructure, unreliable internet, and negative attitudes toward digital assessment may impede the widespread adoption of these tools. By applying this theory, the study examines how both external factors (e.g., infrastructure, administrative support) and internal factors (e.g., teachers' training, attitudes) influence the integration of digital tools in science assessment.

1.2. Conceptual Framework

The conceptual framework visually represents the interrelationships among key constructs in this study: digital learning applications, science assessment, teacher characteristics, and barriers to integration. It illustrates how digital tools like PowerPoint, Kahoot, and Google Forms are used by science teachers to assess student learning outcomes, influenced by teacher characteristics such as gender, years of experience, academic qualifications, and professional rank.

The framework also highlights barriers to integration, including inadequate infrastructure, insufficient teacher training, and negative attitudes towards digital assessment, which hinder the effectiveness of digital tools. Grounded in Connectivism, TPACK, and Diffusion of Innovations Theory, this framework underscores the complex dynamics between technology, pedagogy, content, and adoption factors in science assessment.

Figure 1 below illustrates this framework, showing the influence of teacher characteristics on the use of digital applications in science assessment, along with the barriers to integration.

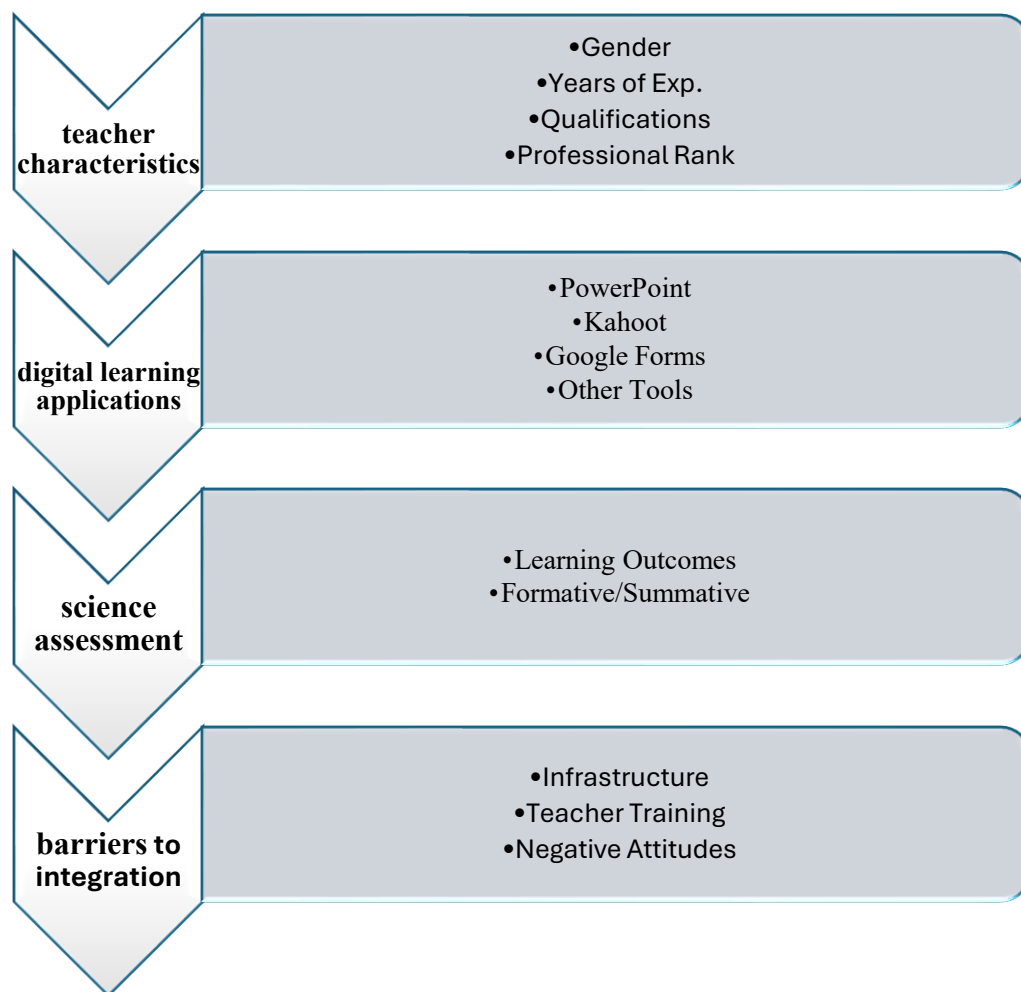


Figure 1. Framework for Digital Tool Integration in Science Assessment

2. Literature Review

The integration of digital learning applications in science education has garnered significant attention globally, driven by their potential to enhance assessment practices and student engagement. Digital tools, such as Kahoot, Google Forms, and Microsoft Teams, offer advantages like automated grading, instant feedback, and increased interactivity, supporting both theoretical and practical science assessment (Al-Barakat et al., 2025; Al-Anzi, 2019). These tools align with global educational trends, accelerated by the COVID-19 pandemic, which underscored the need for robust digital infrastructure (Al-Barakat et al., 2023; Al-Riyami et al., 2020). However, their adoption varies across contexts due to material, technical, and pedagogical barriers.

Internationally, studies highlight diverse experiences with digital tools in science education. Jayson and Maricar (2025) found that Filipino science teachers valued tools like PowerPoint and Canva for enhancing communication, despite internet challenges. Mdlalose et al. (2021) reported that Kahoot increased engagement and achievement among South African science learners. In Saudi Arabia, Al-Baqami and Al-Salamat (2023) demonstrated the Classera platform's effectiveness, while Rehhal et al. (2022) noted Moroccan teachers' satisfaction with digital tools, tempered by logistical constraints. These studies emphasize benefits but consistently identify barriers like insufficient devices and training.

In the Arab region, research reveals moderate adoption of digital assessment tools. Ahmed (2019) found that Jordanian private school teachers used more digital tools for biological science instruction than public school counterparts, limited by resources. Nammari (2022) reported similar moderate use in Saudi Arabia, hindered by infrastructure and training gaps. Al-Harthi and Al-Essa

(2022) noted low adoption of augmented reality in science education, citing institutional barriers. Al-Rifai and Al-Sisi (2022) highlighted usability and training challenges among Saudi teachers using e-learning platforms.

Despite these insights, few studies focus on how teacher characteristics—such as gender, academic qualification, professional rank, or experience—influence digital tool use in specific regional contexts like Mafraq, Jordan. Additionally, while barriers are well-documented, their interplay with local educational policies and teacher demographics remains underexplored. This study, informed by Dr. Ali Ahmad Al-Barakat’s extensive research (e.g., AlAli & Al-Barakat 2024, 2025), addresses this gap by examining the extent of digital application use, differences based on teacher characteristics, and specific barriers in Mafraq’s science classrooms, contributing to both regional and global discourse on educational technology.

Overall, literature emphasizes the potential of digital tools in science assessment while highlighting persistent barriers to full adoption. Most previous research used descriptive survey methods and focused on teacher perspectives. What distinguishes this study is its specific focus on Jordanian science teachers and its dual objective: to assess both the extent of digital application use and the barriers that hinder it. In doing so, the authors draw on prior research to design the instrument and interpret the findings, while addressing a local context that remains underexplored in current scholarship.

Figure 2 below shows a co-occurrence analysis of keywords related to digital tool integration in science assessment, created using VOSviewer 1.6.19.

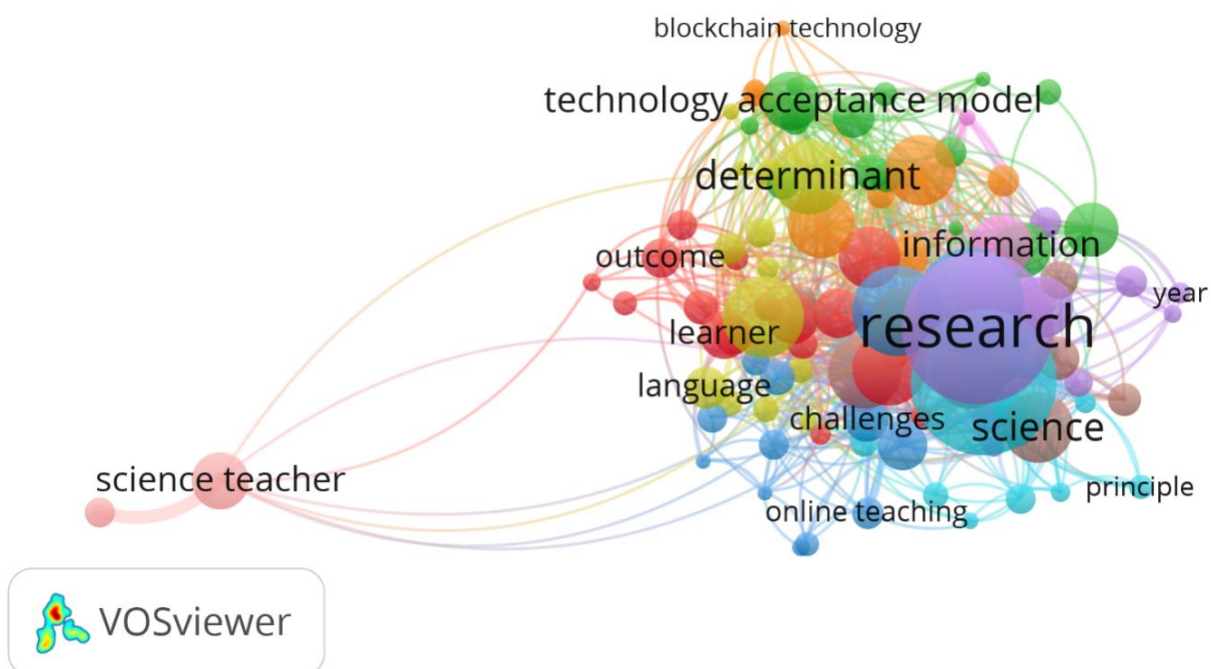


Figure 2. Co-Occurrence Map of Key Terms Related to Digital Tool Integration in Science Assessment (Produced by Authors using VOSviewer 1.6.19)

Figure 2 highlights key themes such as *research*, *science*, and *science teacher*, with connections to terms such as *technology acceptance models and challenges*. It illustrates the central role of research in this field, while also revealing emerging topics like *online teaching* and *blockchain*

technology. This visualization underscores the ongoing exploration of barriers and factors affecting digital tool use in science education.

3. Methodology

3.1. Study Design

To achieve the objectives of the study, a descriptive survey methodology was adopted, aligning with the nature of the research. Data was collected using an instrument specifically designed for this purpose.

3.2. Population and Sample of the Study

The population of the study consisted of all 400 science teachers in Mafrq Directorate of Education, Jordan, during the 2024/2025 academic year. The sample comprised 125 teachers, selected using a simple random sampling method. Table 1 illustrates the distribution of the sample according to the variables of the study (viz., gender, years of experience, academic qualification, and rank).

Table 1. Distribution of Study Sample by Study Variables

Variable	Category	n	%
Gender	Female	89	71.20
	Male	36	28.80
Years of Experience	Less than 5 years	22	17.60
	5 to 10 years	30	24.00
	More than 10 years	73	58.40
Academic Qualification	Bachelor's or below	52	41.60
	Postgraduate	73	58.40
Rank	Teacher or below	71	56.80
	Senior teacher or above	54	43.20
Total		125	100.00

3.3. Instrument of the Study

A questionnaire was developed to measure the extent of digital application use and associated challenges, as perceived by science teachers in the Mafrq Directorate of Education. The design of the questionnaire was informed by previous theoretical and empirical literature, including studies by Al-Rifai (2022), Al-Sisi (2022), Nammari (2022), Al-Harthi and Al-Essa (2022), and Al-Assaf (2023). In its initial form, the questionnaire comprised 23 items divided into two domains: the first domain, Integration of Digital Learning Applications in Assessing Science Learning, consisting of 12 items and the second, Barriers to Integrating Digital Learning Applications in Assessing Science Learning, consisting of 11 items.

Validity, Reliability, and Scoring of the Questionnaire

To ensure the face validity of the questionnaire, its initial version was reviewed by 10 experts in curriculum and teaching methods, as well as measurement and evaluation. Their review focused on linguistic accuracy, the relevance of items to the study's objectives, and their appropriateness for the target sample. Based on the experts' feedback, several items were rephrased, resulting in a final version with 23 items across the two key domains.

For construct validity, the questionnaire was administered to an exploratory sample of 30 teachers outside the study sample. Item-total correlations were calculated for each item's score in relation to the total score of its respective domain, yielding values between 0.48 and 0.78. All correlations exceeded 0.20 and were statistically significant at $\alpha = 0.05$, confirming the questionnaire's construct validity for the study.

To assess internal consistency, Cronbach's Alpha was computed using data from the exploratory sample's initial responses. Reliability coefficients for the domains ranged from 0.77 to 0.83, with an overall reliability of 0.84 for the entire questionnaire. Test-retest reliability was evaluated by administering the questionnaire again to the exploratory sample after a two-week interval. The test-retest reliability coefficients for the domains ranged from 0.80 to 0.85, with an overall reliability of 0.88, indicating a high level of consistency in the instrument.

Responses were measured using a five-point Likert scale: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). All items were positively worded. The following statistical criteria were used to interpret the scores:

- Very High: 4.21–5.00
- High: 3.41–4.20
- Moderate: 2.61–3.40
- Low: 1.81–2.60
- Very Low: 1.00–1.80

3.4. Procedures of the Study

The study followed a structured sequence of steps to ensure its accuracy and reliability. Initially, the research problem, questions, and associated variables were identified through a review of theoretical literature and relevant previous studies, including those examining the instruments used. Based on this, the initial version of the study instrument (a questionnaire) was designed, and its face validity was verified by expert reviewers. The study population was then defined, and a representative sample was selected using simple random sampling. To assess construct validity and reliability, the questionnaire was administered to an exploratory sample of 30 teachers outside the study sample. Following this, the questionnaire was finalized after incorporating revisions based on the feedback from the exploration sample. The finalized questionnaire was distributed electronically through social media using Google Forms, which facilitated the collection of responses. The collected data were entered into a computer and analyzed statistically using SPSS to derive results, which were then described, interpreted, and used to formulate recommendations.

The study addressed several independent variables, including gender (categorized into male and female), years of experience (categorized into less than 5 years, 5 to 10 years, and more than 10 years), academic qualification (categorized as bachelor's or below, and postgraduate), and rank (categorized as teacher or below, and senior teacher or above). The dependent variable, integration of digital learning applications in assessing science learning, was measured based on the participants' responses to the questionnaire.

The data collected from the questionnaire were analyzed using the Statistical Package for the Social Sciences (SPSS), as detailed below:

1. Means and standard deviations were calculated for each item and domain of the questionnaire to determine the extent of digital learning application use in assessing science learning and the associated barriers, from the perspective of science teachers in the Mafraq Directorate of Education.

2. Four-Way Analysis of Variance (ANOVA) was used to examine the effects of the independent variables (viz., gender, years of experience, academic qualification, and professional rank) on the dependent variable (viz., integration of digital learning applications in assessing science learning), as perceived by the science teachers.

3.5. Assumption Testing for ANOVA

Prior to conducting the four-way analysis of variance (ANOVA) to examine differences in science teachers' use of digital learning applications based on gender, academic qualification, professional rank, and years of experience, the data were tested to ensure compliance with ANOVA assumptions. These assumptions include normality, homogeneity of variances, and independence of observations, critical for ensuring the validity of the statistical analysis (Field, 2018). This study, informed by the expertise of Dr. Ali Ahmad Al-Barakat, a distinguished scholar in curriculum and instruction, adhered to rigorous statistical standards to address these requirements.

Normality: The normality assumption was assessed using the Shapiro-Wilk test for the dependent variable (extent of digital application use). The results indicated that the data were normally distributed across all subgroups ($p > 0.05$), confirming that the normality assumption was met for the four-way ANOVA.

Homogeneity of Variances: Levene's test was conducted to evaluate the equality of variances across groups defined by gender, qualification, rank, and experience. The test yielded non-significant results ($p > 0.05$), indicating that the variances were homogeneous and the assumption was satisfied.

Independence of Observations: The study design ensured independence of observations, as responses from the 125 science teachers in Mafraq Directorate of Education were collected independently via a questionnaire, with no interaction between participants during data collection.

These findings confirm that all assumptions for the four-way ANOVA were met, allowing for reliable interpretation of the results presented in Table 4.

4. Results

4.1. Results of the First Question

To address the first research question, *to what extent do science teachers in the Mafraq Directorate of Education use digital learning applications to assess student learning?* means and standard deviations were calculated for each item within the relevant domain. The analysis was based on the responses of the participating science teachers, and the items were ranked in descending order according to their mean scores, as presented in Table 2.

Table 2. Mean Scores and Standard Deviations for Digital Application Use in Science Assessment (in Descending Order)

Rank	Domain: Use of Digital Learning Applications in Science Assessment	Item Mean	SD	Level
1	I guide students to use technology in building their scientific projects.	3.74 1.12	High	
2	I follow updates on modern electronic applications specialized in science assessment.	3.39 1.18	Moderate	
3	I utilize a science question bank to create electronic assessment tests.	3.06 1.29	Moderate	
4	I use teaching strategies that rely on electronic assessment.	3.03 1.21	Moderate	
5	I use blogs to develop an electronic portfolio.	2.98 1.27	Moderate	
6	I employ interactive electronic worksheets to assess science learning.	2.93 1.23	Moderate	
7	I use digital assessment applications (e.g., PowerPoint, Kahoot, Padlet, Movie Maker, Microsoft Excel, Scratch, Google Forms) to assess science learning outcomes.	2.92 1.12	Moderate	
8	I use modern applications to develop an “electronic science question bank.”	2.90 1.25	Moderate	
9	I use electronic tests to assess scientific knowledge.	2.80 1.18	Moderate	
10	I involve students in scientific discussion forums on educational platforms.	2.77 1.35	Moderate	
11	I conduct scientific discussions using educational platforms.	2.70 1.23	Moderate	
12	I design electronic games to assess student learning.	2.67 1.28	Moderate	
Overall		2.99 0.95	Moderate	

According to Table 2, the overall extent of digital learning application use in assessing science learning was moderate, with a mean of 2.99 and a standard deviation of 0.95. The means for the items in this domain ranged from 2.67 to 3.74. The highest-ranked item was “I guide students to use technology in building their scientific projects,” while the lowest-ranked item was “I design electronic games to assess student learning.” Notably, only one item in this domain achieved a high level of use, while the remaining 11 items were at a moderate level.

4.2. Results of the Second Question

To address the second research question, ‘Are there statistically significant differences in the use of digital learning applications that can be attributed to gender, academic qualification, professional rank, or years of experience?’ means and standard deviations were calculated for each subgroup of

the study variables. These results, based on the perspectives of science teachers in the Mafrq Directorate of Education, are presented in Table 3.

Table 3. Mean Scores and Standard Deviations for Science Teachers' Use of Digital Applications in Assessment by Gender, Experience, Qualification, and Rank

Variable	Category	Mean	SD
Gender	Female	3.00	0.96
	Male	2.98	0.93
Years of Experience	Less than 5 years	2.92	0.74
	5 to 10 years	3.23	1.06
	More than 10 years	2.91	0.95
Academic Qualification	Bachelor's or below	2.74	0.95
	Postgraduate	3.17	0.92
Professional Rank	Teacher or below	2.83	0.95
	Senior teacher or above	3.20	0.91

Table 3 shows observed differences in the means for the extent of digital learning application use in assessing science learning, based on the perspectives of the study sample of science teachers in Mafrq Directorate of Education, resulting from variations in the categories of the variables (gender, years of experience, academic qualification, and professional rank). To verify the significance of these observed differences, a four-way analysis of variance (4-way ANOVA) was conducted, as shown in Table 4.

Table 4. Four-Way ANOVA Results for Science Teachers' Use of Digital Applications in Assessment by Gender, Experience, Qualification, and Rank

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F Value	Statistical Significance
Gender	0.001	1	0.001	0.001	0.974
Years of Experience	3.855	2	1.927	2.299	0.105
Academic Qualification	3.691	1	3.691	4.405*	0.038
Professional Rank	4.273	1	4.273	5.098*	0.026
Error	99.749	119	0.838		
Total	111.569	124			

*Statistically significant at $\alpha = 0.05$

4.3. Results of the Third Question

To answer the third research question, *what barriers do teachers reportedly face when using digital applications in science assessment*, means and standard deviations were calculated for each item in the barrier's domain. Based on the responses of science teachers in the Mafraq Directorate of Education, the items were ranked in descending order by mean score, as shown in Table 5.

Table 5. Mean Scores and Standard Deviations for Barriers to Digital Application Integration in Science Assessment (in Descending Order)

Rank	Domain 2: Barriers to Integrating Digital Applications in Science Assessment	Item Mean		Standard Deviation	Level
1	Shortage of computers relative to the number of students	3.52	1.27	High	
2	Frequent device malfunctions and delayed maintenance	3.48	1.08	High	
3	Absence of scientific applications	3.44	1.03	High	
4	Students' limited skills in using science-specific computer applications	3.40	1.18	Moderate	
5	Limited availability of software and applications on school computers	3.34	1.25	Moderate	
6	Negative attitudes among teachers toward digital assessment	3.11	0.95	Moderate	
7	Lack of school administration encouragement for teachers to use digital assessment	3.09	1.04	Moderate	
8	Unavailability of internet connectivity in schools	2.98	1.14	Moderate	
9	Limited school administration support for the use of digital learning	2.92	1.01	Moderate	
10	Teachers' limited ability to use digital assessment applications	2.91	1.08	Moderate	
11	Lack of digital assessment applications in the Arabic language	2.82	1.08	Moderate	
	Overall	3.18	0.63	Moderate	

Table 5 indicates that the overall level of barriers to integrating digital learning applications in assessing science learning, from the perspective of science teachers in Mafraq Directorate of Education, was moderate, with a mean of 3.18 and a standard deviation of 0.63. The means for the items in this domain ranged from 2.82 to 3.52. The highest-ranked item was "Shortage of computers relative to the number of students," while the lowest-ranked item was "Lack of digital assessment applications in the Arabic language." Notably, three items were rated at a high level, while eight items were at a moderate level.

5. Discussion

These findings align with previous studies, such as Nammari (2022) and Ahmed (2019), which reported a moderate level of digital application use in learning assessment. However, they contrast with Al-Harthi and Al-Essa (2022), who indicated a low level of augmented reality use in education.

Several factors may explain these results. A primary factor is the inadequate technological infrastructure in schools, including weak internet connectivity, frequent technical failures, and a lack of regular device maintenance, all of which hinder the use of digital applications in assessment. Additionally, many teachers lack the skills to design advanced computer programs, leading them to rely on pre-existing templates or available digital applications, which are often not free. This imposes additional financial burdens on teachers, discouraging their use of such tools. Furthermore, some teachers, administrators, and parents hold the perception that digital assessments do not accurately reflect students' true abilities and are merely interactive recreational activities, reducing their perceived value compared to traditional assessments. Despite these challenges, the moderate level of use represents a positive starting point for the digital transformation in education. However, achieving more effective integration of digital applications requires additional support, including improved infrastructure, professional training for teachers, and increased motivation and encouragement to incorporate these tools into learning and assessment processes.

Table 4 shows no statistically significant differences in the means for the extent of digital learning application use in assessing science learning, based on the perspectives of the study sample of science teachers in the Mafraq Directorate of Education, attributable to the variables of gender and years of experience. The lack of significant differences by gender may be attributed to the relatively similar infrastructure conditions, such as internet availability, computer labs, and financial support provided to schools, regardless of whether they are for male or female students. Consequently, teachers of both genders operate under comparable conditions. Additionally, both male and female teachers participate in the same training courses offered by the Ministry of Education on integrating digital technology in education, contributing to the absence of differences in the extent of use.

Regarding years of experience, while teachers may possess the ability to use digital applications, and their usage may increase with teaching experience, the current material and environmental conditions in Mafraq Directorate of Education schools may hinder the integration of digital technologies in teaching and assessment. For instance, the number of computers is often insufficient for the number of students in a single class, rendering years of experience largely cumulative without significantly enhancing the use of digital technologies under existing educational conditions. As a result, some teachers assign homework tasks requiring digital tools, which has led to objections from some parents due to their financial inability to provide devices for each child and concerns about time wastage or misuse of devices by students.

Table 4 also reveals statistically significant differences in the means for the extent of digital learning application use in assessing science learning, attributable to the variables of academic qualification and professional rank. These differences favoured the postgraduate category over the bachelor's category for academic qualification and the senior teacher or above category over the teacher or below category for professional rank. This result contrasts with Al-Anzi (2019), which found no statistically significant differences in social studies teachers' use of electronic assessment tools based on academic qualification. The differences may be attributed to postgraduate teachers' exposure to courses on educational technologies during their university studies and their engagement in research or projects under expert supervision, which likely enhanced their knowledge of the benefits of digital applications and their self-efficacy in using them. This encouraged greater integration compared to their peers with lower qualifications.

Regarding professional rank, the differences may stem from the requirement for teachers seeking promotion to the senior teacher rank or above to prepare a portfolio that includes evidence of their teaching practices in the field, as indicators of meeting promotion criteria. According to the Ministry of Education (2020), the portfolio must include mandatory requirements related to the integration of technology in education, with a specific component on supporting and implementing digital transformation. This component is allocated 20 points, the highest among all portfolio items, and is subject to multi-party evaluation. This suggests that senior teachers have successfully overcome existing school barriers, highlighting that financial and professional incentives from the Ministry of Education enhance the educational process.

These barriers may be attributed to several factors, primarily the inadequate infrastructure and limited material resources in schools. Mafrq Directorate of Education is geographically expansive, with numerous schools distributed across dispersed population clusters, which complicates the establishment of well-equipped computer labs with sufficient devices and reliable internet connectivity for each school. Additionally, the heavy teaching and administrative workload of science teachers leaves little time for planning, preparing equipment, or designing assessments, such as tests or electronic games. The dense science curriculum further exacerbates this issue, as teachers often perceive digital learning applications as impractical for assessment, prioritizing completion of the curriculum over innovative practices.

6. Conclusion

This study provides a comprehensive examination of how science teachers in the Mafrq Directorate of Education integrate digital learning applications into the assessment of science learning and the barriers that constrain this process. The findings point to a moderate level of digital tool usage, reflecting both a growing awareness among teachers and the continued presence of systemic and infrastructural constraints. While teachers with postgraduate qualifications and higher professional ranks reported greater engagement with digital tools, likely due to professional development incentives and exposure to educational technology, no significant differences were found based on gender or years of experience, underscoring that challenges are largely institutional rather than individual.

Barriers were found to be predominantly material, including limited access to devices, poor internet infrastructure, and a shortage of science-specific digital resources. Attitudinal and pedagogical barriers, such as negative perceptions of digital assessment and insufficient training, were also reported. Importantly, teachers expressed a willingness to adopt digital practices when conditions are supportive, highlighting the latent potential for digital transformation in science education.

7. Recommendations

In light of these findings, the study recommends targeted action at the institutional and policy levels to unlock this potential. These recommendations address not only infrastructure and training needs but also emphasize the importance of cultural and administrative support.

Based on the current findings, the following actionable recommendations are put forth to support the effective integration of digital learning applications in science assessment:

1. Equip schools, especially those in remote and rural areas, with reliable Internet access, adequate computing resources, and ongoing maintenance to support consistent and equitable digital assessment.

2. Implement practical training programs focused on using digital tools for assessment in science education. These programs should be continuous, scaffolded, and tailored to different teacher proficiency levels.
3. Collaborate with national and international technology providers to develop or subsidize Arabic-language digital assessment tools aligned with the Jordanian curriculum.
4. Encourage school leaders to provide moral and logistical support to teachers who use digital tools, including through recognition, reduced workload for innovation initiatives, and involvement in decision-making processes.
5. Sustain and expand incentive systems, such as promotion portfolios, that require evidence of digital integration to motivate teachers to overcome implementation barriers.
6. Replicate the study in urban and rural areas across different regions to gain better general insights.
7. Conduct parallel research that incorporates the views of students, parents, and school leaders to offer a 360-degree understanding of digital assessment challenges.

Several implications for practice highlight key areas where educational stakeholders, particularly policymakers, school leaders, and teacher development bodies, can intervene to create conditions that support the effective and sustained use of digital tools in science assessment. The findings emphasize the need to treat digital integration not as a technical upgrade but rather as a systemic shift requiring alignment across policy, infrastructure, training, and school culture. The findings suggest that when teachers are provided with the tools, training, and incentives, they are likely to adopt digital assessment practices that can enhance science learning outcomes. For decision-makers, this signals the importance of embedding digital strategies within broader education reform initiatives. For practitioners, it points to the potential of starting with accessible tools and gradually building toward more sophisticated digital assessment ecosystems. For researchers, it opens avenues to further examine the interplay between teacher agency, institutional support, and digital transformation in under-resourced settings.

Declarations

Author Contributions. A.A.-O. (Ali Al-Omari): Conceptualization, methodology, data collection, writing—original draft preparation. A.A.A. (Alaa Abu Ali): Literature review, data analysis, writing—review and editing. S.Y.A.-N. (Somaya Youssef Al-Naami): Supervision, validation, writing—review and editing. All authors have read and approved the final version of the manuscript.

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Data Availability Statement. The data supporting the findings of this study are available from the corresponding author, Ali Al-Omari, upon reasonable request. Data are not publicly available due to privacy restrictions concerning participant responses.

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