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Digital Competence of Teachers and the Factors Affecting Their Competence Level: A Nationwide Mixed-Methods Study

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Abstract: Digital transformation opens up multiple opportunities for educators to achieve the continuity of learning through life, aligning with UNESCO's fourth goal of sustainable development, and to prepare them for the digital age. Effective integration of technology goes beyond using it for its own sake; it involves using it to deepen students' learning experiences. Digital transformation raises key questions about teachers' digital competence. Building on the DigCompEdu framework, the current study aims to uncover the level of digital competence of science teachers and their perceptions towards it as well as to identify the factors influencing this competence. The study adopted a mixed-methods approach utilizing a sequential explanatory design. This design involved a questionnaire which was administered to a sample of 611 science teachers, while a semi-structured interview was applied to 13 teachers. The results indicate that the teachers' level of digital competence was medium (58.4%). The study also revealed that the teachers had high-level positive perceptions towards the use of digital technologies (78%). Furthermore, the results indicate that perceived usefulness and subjective norms directly influence digital competence. This study also identifies the benefits of digital technologies and the challenges that teachers encounter in implementing them in the educational environment. The benefits focus on enhancing students' motivation and assessing their learning experiences, communicating with the educational community, and the continuousness of e-learning. The challenges, however, include the acceptance of technology by the educational community; cognitive and skill-related challenges faced by teachers; administrative and teaching burdens; limited access to digital technologies and tools; and challenges related to student behaviors. As a result, a set of recommendations and implications are proposed for educational policymakers, curriculum and professional development program designers, researchers, and educational practitioners.

Keywords: digital transformation; digital competence; digital technologies; DigCompEdu; sustainable digital skills



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1. Introduction

Recently, our perception of the world have undergone a fundamental shift towards various transformations including the adoption of sustainability as a lifestyle. Such a transformation conforms to the global use of digital technologies in promoting creative approaches that tackle challenges and achieve sustainability in ecological, economic, social, and educational aspects [1,2]. Digital technologies are particularly important in facing global challenges and crises. Therefore, it is essential to adopt digital solutions across various fields to cultivate the potential of digitization in overcoming these challenges and crises.

In the field of education, digital transformation has created learning opportunities for both teachers and learners, with such opportunities being well-suited to the demands and challenges of the digital age [3]. Educational curricula have also developed to be more interactive and attractive, and the teaching practices of teachers have improved in a way that has reflected positively on learners' performance [4,5].

Science curricula, with their applied topics, relate closely to technology. This relation has prompted several initiatives for science education reform such as the Next Generation Science Standards (NGSS) [6] and the Science, Technology, Engineering, and Mathematics (STEM) approach within which technology is an essential component. Some initiatives have even established a set of standards for including digital technology in science education and enhancing teachers' digital competence [7]. The significance of digital technologies lies in their ability to offer interactive and immersive learning environments that facilitate remote learning and support flexible, adaptive learning whereby a teacher endeavors to create technology-based teaching methods that enable the comprehension of complex and abstract scientific concepts [8].

Modern technologies and their educational applications facilitate relaying scientific knowledge to students through investigation and experimentation [9]; they increase students' effective participation in the educational process and develop their creative and critical thinking skills, self-efficacy, and self-regulation [10,11]; they enhance learning aptitude [12], motivation [13], computer skills [14], and online interactions [15,16]; they offer students access to various information sources compared to the limitedness of traditional teaching; and they equitably provide students with the continuity of learning through life. Such benefits of modern technologies in education represent an integral part of the education sustainable development goal (SDG4) [17]. Given these benefits, a number of digital applications and tools that can be utilized in science teaching have emerged, such as immersive virtual platforms, interactive modeling, and simulation software [18–20].

Such digital applications and tools require teachers to possess a certain level of digital competence. This competence is a key skill of the 21st-century teacher as well as one of the eight major competencies of the European Union [21] and serves as a cornerstone in education development. For teachers, possessing digital competence is vital to increase the incorporation of technologies into their teaching practices, which ultimately leads to sustainable educational development [22]. Digital competence transcends the mainstream concept of a teacher's basic knowledge of technology and computer programs towards a comprehensive concept that encompasses the knowledge, skills, and attitudes related to digital, moral, and legal factors [23]. It also covers information management, creating digital content, and employing digital systems and classes enhanced with digital tools to achieve the effective integration of technology [24]. Even though there has been considerable attention paid to the concept of digital competence and the importance of its integrative uses in educational practices [25], there is not a unified, comprehensive definition of this concept [26]. The lack of such a definition is a result of digital competence being a wide concept related to various fields, in addition to its complexity and sensitivity in social and cultural contexts [27–29].

However, there have been attempts to define digital competence from several aspects [23]. For example, Ferrari [30] offered a definition that is based on three main domains: knowledge, affective, and skills. It was defined as the skills, knowledge, values, and abilities necessary for using technology with high proficiency in carrying out tasks such as problem solving as well as creating and sharing content. Ilomäki et al. [29] defined digital competence from a comprehensive perspective in which technological fields and scientific knowledge intersect with the technological skills that an individual needs in order to effectively learn and interact in a digital knowledge community. More comprehensively, the European Council's definition of digital competence centers on the optimal use of technology in education in a safe and responsible manner that fosters learning, work, and participation in society [31].

1.1. Conceptual Frameworks of Digital Competence and Literature Review

It is important that digital competence relies on conceptual frameworks, models, and standards that include several competence fields through which teachers' level can be evaluated [32] and their professional development needs can be determined. Therefore, a number of progressive frameworks and models on teachers' digital competence have been

developed globally [12] such as the technological, pedagogical, and content knowledge (TPACK) framework [33]; the ISTE standards of the International Society for Technology in Education for enhancing teachers' use of technology [34]; and the UNESCO ICT Competency Framework, which identifies 18 competencies in information and communications technology distributed over six aspects [35].

Despite the popularity of some digital competence models, the European Framework for the Digital Competence of Educators (DigCompEdu) was built as a European-Union-wide framework that was later used globally. This framework focuses on measuring educators' digital competence; identifying their strengths and weaknesses; as well as determining the professional and training needs for the integrative use of technology in educational processes [36,37]. The framework consists of twenty-two digital competences organized into six areas, as shown in Figure 1. The first is the professional engagement area, which centers on using digital technologies for institutional communication and professional cooperation. The second is the digital resources area which is related to creating, modifying, and sharing digital sources and resources. The third area is teaching and learning, which covers the implementing and management of digital technologies in teaching practices and self-learning. The fourth area is assessment, which includes using digital tools in implementing various assessment strategies while developing and improving the assessment process. Empowering learners is the fifth area, which focuses on learners' accessibility to digital technology in order to satisfy their various needs and desires as well as to ensure their effective participation in the educational process. Finally, facilitating learners' digital competence is the sixth area, which refers to enabling learners to innovatively and effectively use digital technologies for communication, information technology, and problem solving [36].

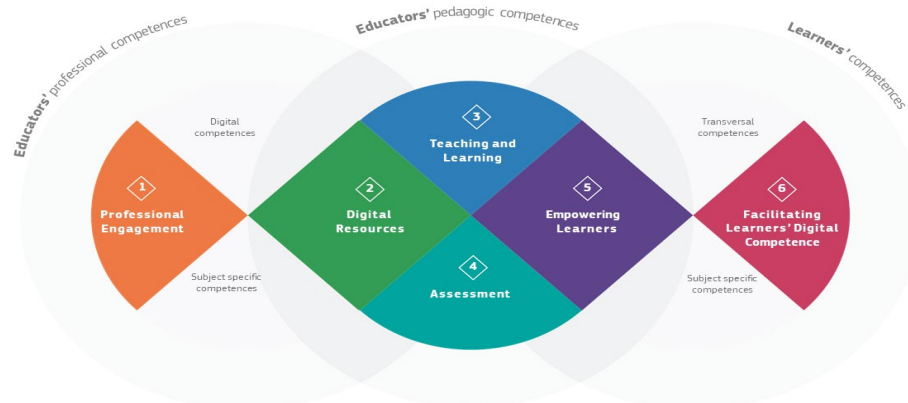


Figure 1. DigCompEdu framework and its areas [36].

Due to the importance of teachers having sustainable digital skills that promote the development of societies [38,39], the growing significance of teachers' digital competence, and the DigCompEdu's prominent presence in the digital skills landscape, numerous studies have utilized this framework, among others, to assess teachers' digital competence. These studies have also examined the utilization of technology in science classrooms and investigated teachers' perspectives and challenges and the factors influencing the effective implementation of digital technologies.

In science teaching, the accessibility of digital technologies has been particularly emphasized. This availability of technology enables students to access current scientific information, thereby enhancing their learning experiences [40]. The beneficial outcomes that digital technologies achieve for students encourage teachers to use them. Science teachers are motivated to integrate technology into their classrooms, especially when this integration is supported and when they are given the chance to reflect on their teaching practices [41]. Studies have reported examples of successful use of the internet to promote inquiry-based science classrooms [42].

Mukminin et al. [43] used path analysis to examine the factors that influence science teachers' integration of digital resources in education in some Indonesian rural areas. It was revealed that attitude played the most significant role in predicting teachers' use of digital technologies, while self-efficacy was found to be insignificant. Other factors such as knowledge, skills, and facilitating conditions were not found to be significant in teachers' integration of digital technologies. The intention to use such technologies was reported to be the only influential factor.

Using the DigCompEdu framework, Vieira et al. [44] examined the digital competence of 20,935 science teachers in Portugal. The findings revealed that teachers specializing in biology and geology achieved higher scores in digital proficiency in comparison to their counterparts in other subjects. Additionally, physics and chemistry teachers reflected higher levels of digital competence than teachers of mathematics and natural sciences. It was also revealed that there were significantly positive correlations among all competence areas across the STEM subjects.

Alshahrani [45] used a descriptive method to examine the digital skills required to use the Madrasati platform in Saudi Arabia from the point of view of middle-school science teachers. The study also attempted to ascertain whether there were statistically significant differences attributed to the educational qualification and years of experience variables. It was revealed that teachers indicated a high level of agreement that digital skills were necessary to use the platform. It was also revealed that the educational qualification and years of experience variables had no statistically significant impact on teachers' responses.

The presence of cognitive and performance aspects of digital-age skills among science teachers was examined in another descriptive study [46]. The study attempted to identify if the years of experience, the level taught, and gender variables had a significant impact on the presence of digital-age skills among science teachers. It was reported that the years of experience variable significantly influenced the presence of the cognitive aspect of digital-age skills among science teachers, in favor of teachers who had less than ten years of experience, while it had no significant impact on the performance aspect. As for the level taught, it had a significant impact on both the cognitive and performance aspects of digital-age skills, favoring secondary school teachers. There was no significant impact, however, for gender on the presence of cognitive and performance aspects of digital age skills among science teachers.

A descriptive approach was used by AlSaree et al. [16] to investigate the digital skills that middle-school science teachers in Saudi Arabia needed as well as to measure the level at which they possessed these skills. The findings showed that the teachers possessed these skills at a moderate level. It was also revealed that the effective use of the internet was the skill with the highest rating, followed by the skills of using email and virtual classroom management.

Alzahrani [47] conducted a study to examine the extent to which high school science teachers utilize technology, specifically Microsoft 365 on the Madrasati platform, according to their own perspectives. Through the distribution of a questionnaire to 135 female science teachers, the findings indicated a high level of technology usage among them. Furthermore, the study revealed that there were no statistically significant differences among the participants regarding their level of education, years of experience, and participation in professional development training programs.

In another study on high school science teachers, Aal Ziad [48] conducted a study aiming to investigate their utilization of technology, specifically augmented reality. The study involved one hundred teachers and nine supervisors in Saudi Arabia. The findings indicated that, from the teachers' perspectives, there was a high level of technology usage, whereas the supervisors perceived it to be moderate. Additionally, the study concluded that there were statistically significant differences among the participants in relation to their level of education. Notably, there were also significant differences based on years of experience, favoring older teachers.

Muammar et al. [49] investigated the digital competence of fifty-one faculty members at UAE universities and found that the majority of participants rated themselves as digitally competent in all six areas of the framework. In another study, Pérez-Calderón [50] applied the DigCompEdu to 109 teachers in Spain. The study revealed that the teachers' digital competence ranged from medium to high. The study also revealed that the level of digital competence was affected by the gender, age, and years of experience variables, favoring males, younger teachers, and teachers with fewer years of experience, respectively. In an attempt to understand the factors related to teachers' digital competence, Lucas et al. [51] applied the DigCompEdu to a sample of 1071 elementary and secondary school teachers in Portugal and found that the level of teachers' digital competence varied based on the gender variable, favoring males, and on the age variable, favoring younger teachers. The study also showed that personal factors such as age, gender, experience, and self-confidence in using technology and social media were more indicative of teachers' digital competence than contextual factors such as infrastructure and accessibility to technology. Based on cross-sectional studies, Çebi and Reisoğlu [52] applied a questionnaire to 518 pre-service teachers in Turkey. Their digital competence level was revealed to be medium while there were statistically significant differences based on the gender variable in favor of males and on the specialty variable in favor of computer and educational technology specialties.

In Saudi Arabia, Al Khateeb [53] attempted to measure the digital competence of a sample of 110 teachers of English using a questionnaire based on the European Digital Competence Framework for Citizens (DigComp). The study indicated a low level of participant digital competence where the majority of the participants were classified as "simple" in all areas, revealing a level that was incompatible with the skills of 21st-century teachers. Using the TPACK Model, Al-Abdullatif [54] revealed that the level of digital competence of 113 pre-service teachers was very low, while [55] indicated that pre-service teachers possessed a higher level of technological knowledge than that of content and pedagogical knowledge. The study also found a correlation between the teachers' TPACK level and the gender, age, and teaching experience variables.

As for teachers' perceptions of using digital technologies, Alnofaie [56] explored the perceptions of digital technology use of English foreign language teachers and university students in Saudi Arabia. Although the results pointed out that the participants lacked an understanding of their utilization of digital technologies and the pedagogical strategies, they held a positive perception towards usefulness and ease of use of digital technologies. The findings showed that PowerPoint, email, and virtual learning environments were the most frequently used digital technologies for the purpose of presenting content, conducting assessments, resources sharing, and communication.

Using the qualitative method, Alsultan [57] conducted a study on science teachers to investigate their perceptions towards the integration of digital game-based learning in their instructional practices. The results indicated that teachers perceive that integrating digital game-based learning into science education in Saudi Arabia can enhance their students' cognitive and affective learning outcomes. Furthermore, the science teachers mentioned some logistical barriers that hinder the integration of digital technologies in their practices such as the availability of educational games that can be adopted in the context of Saudi.

Alblaihed [58] utilized the TPACK model to conduct a study to explore the perceptions of Saudi primary pre-service science and mathematics teachers towards the integration of digital technologies into their classrooms and practices. The finding revealed that integrating technologies is important and plays a crucial role in the teaching and learning process. Furthermore, participants who used technology in their teaching practices believed that students' performance was improved.

Although information and computer technologies have been emphasized in modern education, the incorporation of these technologies still faces hesitance on the part of many teachers [59]. The literature indicates that science teachers infrequently and inconsistently integrate digital technologies into their teaching practices [60,61]. In addition, Cope and Kalantzis [62] argued that the integration of technologies in teaching practices does not

guarantee enhanced learning outcomes. This argument emphasized that teachers' possession of the knowledge and experience in digital technologies does not automatically guarantee their successful integration into teaching practices [63]. It is important that technology is utilized within the context of meaningful science and not solely for the sake of using technology itself [60].

1.2. The Factors Influencing Digital Competence

Teachers' use of digital technologies depends mainly on their acceptance of such technologies and their ability to integrate them into their teaching practices [8]. In the Technology Acceptance Model (TAM), illustrated in Figure 2, Davis [64] provides a number of factors influencing teachers' acceptance and use of technology. Building on the TAM model, several studies have focused on the factors that influence teachers' acceptance of digital technology. Of these factors, teachers' perceptions towards technology and its uses in the educational environment serve as motivating factors for technology-related activities [65]; affect teachers' behavior [66]; and predict technology integration in their classes [67]. Of these perceptions, there were the perceived usefulness [68–72]; the type of digital tools, their number, and ease of use [51,71–73]; subjective norms [69–71]; teachers' self-confidence and competence [3,73]; their openness to modern technologies [51]; and professional factors related to professional development in digital technology [3]. These factors indirectly affect the actual use of technology through affecting the behavioral intention factor, which directly affects the actual use of technology.

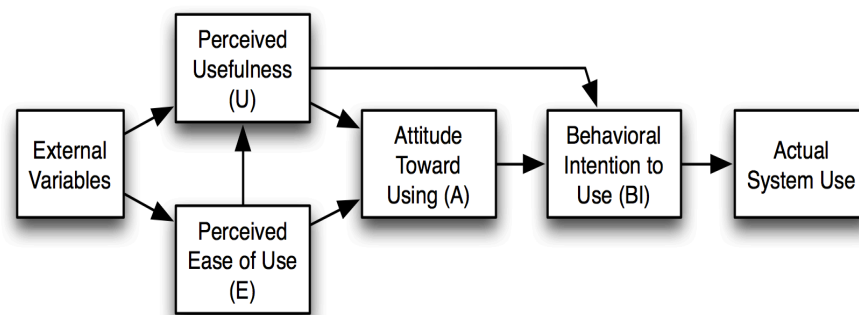


Figure 2. Technology Acceptance Model [64].

Based on the TAM Model, a connection can be discerned between teachers' acquisition of digital competence and their behavioral intention of using this competence [68,69]. Based on the above, it is evident that a number of factors influence digital competence directly such as the behavioral intention of using digital technologies or indirectly such as attitudes, subjective norms, and perceived behavioral control as set forth by the Theory of Planned Behavior [74] and Decomposed Theory of Planned Behavior [75].

1.3. Rational and Questions

Science teachers face challenges in using digital technologies in their teaching practices [57] which could reflect on the level of their digital competence and lead to the aimlessness of their use of digital technologies, thereby preventing the optimal employment of such technologies in the educational environment [76]. Therefore, educational institutions worldwide have had to develop standards that describe and measure the digital competence of their staff [77]. In Saudi Arabia, the Ministry of Education has set as one of its goals the building of a knowledge society anchored in knowledge economy and digital competitiveness through developing teachers and learners' digital experience in compliance with the goals of the Human Capability Development Program [78]. To that end, the ministry has launched a number of national initiatives for science teaching such as virtual laboratories and educational platforms such as Madrasati; introduced blended learning; and an established digital skills curricula. The lack of national studies that addressed

the digital competence of science teachers in Saudi Arabia and the worldwide increase in technical difficulties affecting teachers' acquisition of digital competence, particularly science teachers, refs. [51,73] were the motivations for this study.

Therefore, this study sought to investigate the digital competence level of science teachers in Saudi Arabia and explore their perceptions towards it. Furthermore, this study aims to propose a model, in accordance with educational models and theories, that described the factors affecting teachers' digital competence level. In achieving these goals, this study seeks the answers to the following questions:

1. What is the level of science teachers' digital competence in Saudi Arabia according to DigCompEdu?
2. What are the perceptions of science teachers in Saudi Arabia towards using digital technology in the educational process?
3. What are the factors affecting the level of science teachers' digital competence in Saudi Arabia according to DigComEdu?
4. How do science teachers in Saudi Arabia use digital technologies in the educational environment?

1.4. Significance and Contribution of the Study

The significance of this study lies in its alignment with the global directions of including digital technologies in educational environments and its compliance with the initiatives of the Saudi Human Capability Development Program, namely Initiative 1.6.1, 1.31, and 3.1.4 that target digital skills as key skills for teachers and learners [78]. This study is thought to be a valuable, worldwide contribution to the educational studies on digital competence with its proposed model that describes the factors affecting teachers' digital competence, which is expected to direct future research efforts towards this area of study. This study is also supposed to inform educational policy makers as well as the developers of educational curricula and teachers' professional training programs on the inclusion of digital skills in educational programs and curricula. Finally, this study could enlighten science teachers as to their level of digital competence, the weaknesses they could remedy, and the strengths they could reinforce.

1.5. Operational Definitions of the Study Terms

Digital competence is defined as the optimal use of digital technologies in the educational process in a safe and responsible manner for the purposes of learning, work, and participation in society [31]. Operationally, it is defined as the digital competence of science teachers and their ability to acquire digital skills and use digital technologies in the educational process according to DigCompEdu in six areas: professional engagement; digital resources; teaching and learning; assessment; empowering learners; and facilitating learners' digital competence.

Teachers' perceptions towards using digital technologies are defined as the beliefs that teachers have about the benefits of digital applications; their readiness to use them; their attitudes towards them; and the challenges they face in integrating technology into their teaching practices [79]. These perceptions include attitudes, values, opinions, and affective behaviors [80]. Operationally, they are defined as the beliefs that science teachers have about using digital technologies in the educational environment including the following: perceived usefulness; ease of use; compatibility with the standards and trends of the science subject; and subjective norms about believing that an individual or a group of individuals, such as a principal, an educational supervisor, peers, or students, would support a behavior like teachers' use of digital technologies.

Digital tools are defined as electronic hardware that covers a range of devices such as computers, laptops, data projectors, interactive whiteboards, tablets, and mobile learning environments [81–84].

Digital applications and technologies are defined as software applications, which include various digital tools such as social media platforms, educational websites, simulations, multimedia applications, animations, games, and videos [81,85,86].

2. Materials and Methods

This study adopted a mixed-methods approach with an explanatory sequential design. The design consisted of three main stages. The first was the quantitative stage in which the data were collected through a questionnaire and then analyzed. The second was the qualitative stage involving developing an interview protocol and conducting interviews and focus groups for data collection, followed by data analysis. The third stage was the integration between the first two stages [87] whereby the quantitative results were used to provide a preliminary understanding of the study problem; then, the qualitative results were used to interpret the quantitative results more profoundly.

2.1. Study Population and Sample

The study's population encompassed all the science teachers in Saudi Arabia in the 2022–2023 academic year. After obtaining written consents from the Scientific Research Ethics Committee at Taif University and the Ministry of Education, the study's instrument, a questionnaire, was sent through the Center of Education Research Policies of the Ministry of Education to education departments all over Saudi Arabia. The education departments distributed the questionnaire to their teachers, and the data were randomly collected. The sample comprised 611 science teachers of different teaching stages, both males and females, with varying experience from different areas of Saudi Arabia, as shown in Table 1. For the qualitative part, the sample consisted of 13 teachers who were selected on the basis of their willingness to participate, teaching experience, and geographical distribution over Saudi Arabia. Tables 1 and 2 show the characteristics of the selected teachers.

Table 1. Characteristics of the participants in the questionnaire.

Variable	Number	%
Gender		
Male	233	38.1
Female	378	61.9
Level of Education		
Elementary	233	38.1
Middle	171	28
High school	207	33.9
Years of experience		
Less than 5 years	128	21
5 to less than 10 years	85	13.9
10 to less than 15 years	186	30.4
15 years and more	212	34.7

Table 2. Characteristics of the participants in the interview.

N	Code	Subject	Gender	Degree	Years of Experience
1	MT1	Science	Male	Bachelor's	13
2	MT2	Chemistry	Male	Bachelor's	10
3	MT3	Physics	Male	Bachelor's	14
4	MT4	Physics	Male	Bachelor's	11
5	MT5	Chemistry	Male	Bachelor's	3
6	MT6	Geoscience	Male	Bachelor's	17
7	MT7	Science	Male	Bachelor's	13
8	FT1	Biology	Female	Master's	12
9	FT2	Biology	Female	Master's	8
10	FT3	Geoscience	Female	Bachelor's	9
11	FT4	Chemistry	Female	Bachelor's	11
12	FT5	Biology	Female	Bachelor's	7
13	FT6	Physics	Female	Bachelor's	5

2.2. Study Instruments

2.2.1. The Questionnaire

The questionnaire consisted of three sections. The first section contained questions about the participants' characteristics, i.e., gender, academic degree, and years of experience. The second covered digital competence based on DigCompEdu [36]. This section was based on DigCompEdu for a number of reasons. First, DigCompEdu is a comprehensive framework that covers various fields and competences shared by other global frameworks that target the development of teachers' digital competence [88]. It can easily be applied to various educational stages from early childhood to adulthood [36]. It is adaptable according to technical capabilities and variables that may arise in the future [37]. It is widely used on a global scale beyond the European Union (e.g., [44,50,51]). Finally, it was used to measure teachers' digital competence in societies that are culturally similar to the Saudi society such as the Emirati society [50].

The DigCompEdu Measure [89] based on the DigCompEdu Check-In Self-reflection Tool [73] was adapted into the items of the second section of the questionnaire after it was translated into Arabic, the native language of the participants. This measure was organized into six areas: professional engagement; digital resources; teaching and learning; assessment; empowering learners; and facilitating learners' digital competence [89]. For the purposes of this study, the items were adapted and phrased as statements, each of which had five choices, and each choice represented a level whereby the first choice represented the "not used" level, the second "beginner", the third "medium", the fourth "expert", and the fifth "innovative". The "not used" level means that a teacher is aware of digital technologies but never or hardly ever uses them. The "beginner" level means that, in addition to a teacher's awareness of digital technologies, they use it irregularly and without compatibility with teaching strategies or educational scenarios and situations. The "medium" level indicates that a teacher is aware of digital technologies and uses them regularly and methodically in several educational contexts but without high confidence in how to use them in accordance with teaching strategies or educational scenarios and situations. The "expert" level shows a teacher who employs digital technologies with high confidence to enhance their professional and educational practices and chooses digital technologies methodically and proficiently to suit teaching strategies or educational scenarios and situations. The "innovative" level signifies a teacher who regularly and consistently employs digital technologies with a high level of proficiency, confidence, and effectiveness; has a complete awareness of digital technologies, their limits, shortcomings, and suitability to teaching strategies or educational scenarios and situations; and always seeks new educational technologies and employs modern ones.

The third section of the questionnaire was dedicated to revealing teachers' perceptions towards using digital technology. This section was divided into four areas: the "perceived usefulness", "ease of use", "compatibility", and "subjective norms" formed under the influence of the principal, supervisor, peers, and learners. The items in this section were adopted and re-phrased after reviewing the relevant literature [51,69,90,91]. A five-point Likert scale (strongly agree–agree–medium–disagree–strongly disagree) was used for each item in this section. Each of these choices represented a level whereby "strongly agree" meant "very high", "agree" meant "high", "medium" meant "medium", "disagree" meant "low", and "strongly disagree" meant "very low", as shown in Table 3.

Table 3. Levels of teachers' digital competence and perceptions.

N	Digital Competence	Perceptions	Mean	(%)
First	Not Used	Very Low	Less than 1.80	Less than 20
Second	Beginner	Low	From 1.81 to less than 2.60	From 20 to less than 40
Third	Medium	Medium	From 2.61 to less than 3.40	From 40 to less than 60
Fourth	Expert	High	From 3.41 to less than 4.20	From 60 to less than 80
Fifth	Innovative	Very High	From 4.2 to 5	From 80 to 100

To verify the content of the Arabic version of the digital competence measure used in the second section of the questionnaire and the accuracy of translating the Arabic version from English, it was presented to three specialists in curricula and teaching methodologies who were fluent in both English and Arabic. The whole questionnaire was then refereed by a panel of nine experts in the field of science education and educational technology to verify its face and content validity and to provide feedback on the items phrasing, clarity, simplicity, and their representativeness and relevance to the main areas of the study.

The Cronbach's Alpha coefficient was calculated to verify the reliability of the questionnaire by applying the questionnaire in its preliminary form to a pilot sample of 50 participants. The Cronbach's Alpha coefficient (α) yielded an overall high-reliability coefficient of (0.96), with the digital competence section at (0.94) ranging from (0.84 to 0.89) while the perceptions section being at (0.93) ranging from (0.85 to 0.92). These high-reliability coefficients attest to the questionnaire's ability to achieve the study's goals. Based on the results of the pilot study and the experts' feedback, the questionnaire was modified to its final form of 52 items in the second and third sections, in addition to 3 items for personal characteristics.

2.2.2. The Interview

The interview was structured to collect detailed data about the study's questions and to reach a profound understanding of the quantitative results in order to interpret them. The data collected were analyzed through a number of stages starting with organizing the data, coding them, recording responses, identifying patterns, and then phrasing and verifying the results using the MAXQDA software (23) for qualitative data analysis. The interview was applied to 13 teachers in a semi-structured format. The participants were chosen with consideration given to the variety in their teaching experiences, genders, and geographical distributions over Saudi Arabia. The interviews were conducted through Zoom individually or as focus groups ranging from 60 to 90 min. They involved a number of questions regarding which digital technologies were used by the teachers, how they were used, as well as the benefits and challenges of using them.

To ensure credibility and trustworthiness of the interview, triangulation was achieved through the variety of the data, researchers, and data sources as well as by ensuring data saturation. The questions were revised in terms of face and content validity by subjecting them to rounds of revision and modification before being applying them to the study's sample. In addition, to ensure accuracy and credibility, the interviews were recorded after obtaining the participants' permission, transcribed, summarized, and then shared with the participants to verify the accuracy of the data. For ethical considerations and to maintain confidentiality, each participant was assigned a specific code.

3. Results

3.1. The Quantitative Part

3.1.1. The First Question

The study's first question was, "what is the level of science teachers' digital competence in Saudi Arabia according to DigCompEdu?" To answer this question, the means, standard deviations, and percentages of each of the digital competence areas were calculated. The items were sorted according to their means in a descending order each area at a time and, when they had equal means, they were sorted according to the smallest standard deviation, as shown in Table 4.

Table 4. The means, percentages, and levels of the areas of the digital competence section (N = 611).

Area	Item No	Items	Mean	SD	%	Level
Professional Engagement	4	Participating in remote training opportunities (such as training courses, workshops, virtual conferences, and courses through open platforms such as MOOCs).	3.52	1.15	70.4	Expert
	3	Actively working on developing digital teaching skills.	2.93	1.14	47.8	Medium
	1	Using various digital channels to communicate with parents and peers (such as emails, blogs, school’s website, Madrasati platform, WhatsApp, etc.).	2.62	1.09	52.4	Medium
	2	Using digital technologies to work with peers (teachers) at and out of school.	2.56	1.06	51.2	Beginner
		Area Mean	2.91	0.78	58.2	Medium
Digital Resources	7	Preserving sensitive data and content (such as exams, learners’ marks, and personal info).	3.09	1.18	61.8	Medium
	6	Designing digital resources and tools independently and improving the existing ones to fit teaching needs.	2.92	1.24	58.4	Medium
	5	Choosing and using websites and search engines to access digital sources.	2.68	1.07	53.6	Medium
		Area Mean	2.9	0.87	58	Medium
Teaching and Learning	11	Familiarizing students with digital technologies that help them plan, research, and engage in their own learning.	2.92	1.25	58.4	Medium
	9	Checking on learners while performing virtual activities and experiments in remote, interactive learning environments.	2.82	1.35	56.4	Medium
	10	Learners’ use of digital tools while working in groups (cooperative learning) to reach trusted scientific proofs and evidence.	2.74	1.09	54.8	Medium
	8	Careful planning of the mechanism and time for using digital technologies (such as virtual labs, augmented reality, simulation software, etc.) in the classroom.	2.71	1.02	54.2	Medium
		Area Mean	2.8	0.92	56	Medium
Assessment	12	Using digital assessment tools to evaluate learners’ progress.	3.04	1.01	60.8	Medium
	14	Using digital technology tools to provide effective feedback to students.	3.03	1.1	60.6	Medium
	13	Analyzing available data to identify learners in need of extra help (data here refer to learners’ personal info, marks, attendance, interaction, participation, etc.).	2.69	1.17	53.8	Medium
		Area Mean	2.92	0.9	58.4	Medium
Empowering Learners	15	Taking into consideration potential technical problems and troubleshooting them when creating digital assignments for learners.	3.55	1.09	71	Expert
	17	Using digital technologies to motivate learners to participate in and interact with classroom activities.	3	1.02	60	Medium
	16	Using digital technologies to provide individual learning opportunities (such as digital assignments suitable for learners’ needs, interests, and curiosity).	2.81	1.3	56.2	Medium
		Area Mean	3.12	0.9	62.4	Medium
facilitating learners’ digital competence	19	Assigning learners tasks that require them to use technological means in order to communicate and interact.	3.15	1.21	63	Medium
	20	Assigning learners tasks that require them to create technological content (such as images, audio, video, presentations, etc.).	3.09	1.06	61.8	Medium
	22	Encouraging learners to use modern digital technologies to solve problems that they face while performing scientific activities.	2.97	1.1	59.4	Medium
	18	Training learners in evaluating information credibility and identifying incorrect or biased information.	2.81	1.11	56.2	Medium
	21	Guiding learners on how to safely and responsibly use online information.	2.68	1.12	53.6	Medium
		Area Mean	2.94	0.86	58.8	Medium
	Overall Mean	2.92	0.71	58.4	Medium	

Table 4 indicates that the general level of the teachers’ digital competence in all areas was “medium” with a total mean of (2.92) and a percentage of (58.4%). The individual

means of the digital competence areas, professional engagement; digital resources; teaching and learning; assessment; empowering learners; and facilitating learners' digital competence were (2.94, 3.12, 2.92, 2.80, 2.90, and 2.91), respectively, which shows that the level of all areas was "medium". The items that were achieved the most were "taking into consideration potential technical problems and troubleshooting them when creating digital assignments for learners" at (3.55) and "participating in remote training opportunities (such as training courses, workshops, virtual conferences, and courses through open platforms such as MOOCs)" at (3.52). The items with the lowest achievement, however, were "using digital technologies to work with peers (teachers) at and out of school" at (2.56) and "using various digital channels to communicate with parents and peers (such as emails, blogs, school's website, Madrasati [The official K-12 Education platform in Saudi Arabia], WhatsApp, etc.)" at (2.62).

3.1.2. The Second Question

The study's second question was, "what are the perceptions of science teachers in Saudi Arabia towards using digital technology in the educational process?" To answer this question, the means, standard deviations, and percentages of the areas of the third section were calculated. The items were sorted according to their means in a descending order each area at a time and, when they had equal means, they were sorted according to the smallest standard deviation, as shown in Table 5.

Table 5. The means, standard deviations, and percentages of the areas of the teachers' perceptions towards using digital technology section (N = 611).

Area	Item No	Items	Mean	SD	%	Level
Perceived Usefulness	2	I think that using digital technologies improves my explanation of the science course materials.	4.42	0.64	88.4	Very High
	1	I think that using digital technologies enables me to plan my lessons better.	4.37	0.67	87.4	Very High
	3	I think that using digital technologies enables my students to comprehend the science course materials.	4.33	0.7	86.6	Very High
	4	I think that using digital technologies increases learners' motivation.	4.32	0.71	86.4	Very High
	5	I think that using digital technologies helps me use different assessment methods.	4.25	0.71	85	Very High
	6	I think that using digital technologies improves learners' grades.	4.08	0.83	81.6	High
		Mean	4.29	0.58	85.8	Very High
Ease of Use	7	I think that using digital technologies in educational and professional settings is easy for me.	4.15	0.76	83	High
	8	I think I have the knowledge background to blend digital technologies into teaching practices.	3.99	0.8	79.8	High
	9	I think that learning the skills of using and employing digital technologies is easy for me.	3.84	0.93	76.8	High
	10	I think that flexibility of the educational system at school enables using and interacting with digital technologies in the educational process.	3.84	0.95	76.8	High
		Mean	3.95	0.68	79	High
Compatibility	11	I think that using digital technologies is in keeping with modern directions and trends in the subject I teach.	4.23	0.69	84.6	Very High
	13	I think that using digital technologies agrees with the teaching methods I use.	4.19	0.67	83.8	High
	12	I think that using digital technologies agrees with the professional standards of the science subject.	4.18	0.69	83.6	High
	14	I think that using digital technologies suits learners' needs.	4.15	0.75	83	High
	Mean	4.19	0.6	83.8	High	

Table 5. Cont.

Area	Item No	Items	Mean	SD	%	Level	
Subjective Norms	30	My students interact with me when using digital technologies.	4.16	0.7	83.2	High	
	19	My educational supervisor encourages me to use digital technologies in teaching.	4.13	0.74	82.6	High	
	26	My peers provide help and support when I ask them about using digital technologies in teaching.	4.07	0.73	81.4	High	
	16	The school's principal directs me to use digital technologies in teaching.	4.06	0.76	81.2	High	
	23	My peers use digital technologies in teaching.	4.03	0.7	80.6	High	
	22	When evaluating me, my educational supervisor takes into consideration my use of digital technologies.	4.02	0.8	80.4	High	
	15	The school's principal directs me to use digital technologies to communicate with the school's management, learners, parents, peers, and relevant parties.	4	0.78	80	High	
	28	My students have positive attitudes towards using digital technologies in their learning.	3.98	0.75	79.6	High	
	25	My peers encourage me to use digital technologies in teaching.	3.98	0.75	79.6	High	
	20	My educational supervisor supports me in using digital technologies (offering directions, training courses, and workshops).	3.98	0.87	79.6	High	
	18	My educational supervisor encourages me to use social media to communicate with teachers in other schools.	3.95	0.86	79	High	
	24	My peers encourage me to use digital technologies to communicate with the school's management, learners, parents, peers, and relevant parties.	3.93	0.78	78.6	High	
	21	My educational supervisor uses remote technological supervision techniques through suitable technological applications.	3.87	0.88	77.4	High	
	17	The school's principal offers incentives for teachers to use digital technologies in teaching.	3.67	1.02	73.4	High	
	27	My students communicate with me using different digital technologies.	3.35	0.79	79	High	
	29	My students demonstrate good skills in using digital technologies in various educational scenarios.	3.3	0.87	76.8	High	
	30	My students are interactive when I use digital technologies in teaching.	4.16	0.7	83.2	High	
			Overall Mean	3.9	0.5	78	High

Table 5 indicates that the science teachers possessed positive perceptions towards using digital technologies at high a level with a percentage of (78%). In the “perceived usefulness” area, the total mean and the individual means of the items, excluding item 6, all reflected a high level. In the “ease of use” area, the total mean and the means of all items pointed to a high level of ease. In the “compatibility” area, the participants’ responses reflected the belief that using digital technologies was highly compatible with modern directions, trends, professional standards, and teaching methods in their specialty. In the “subjective norms” area, the responses showed that the participants believed the principal, educational supervisor, peers, and learners had a high level of influence on supporting them to use digital technologies in the educational environment.

3.1.3. The Third Question

The study’s third question was, “what are the factors affecting the level of science teachers’ digital competence in Saudi Arabia according to DigComEdu?” To answer this question, the preliminary proposed model of the factors affecting digital competence, Figure 3, was created based on the TAM model, a theoretical framework that is widely used to determine the factors affecting individuals’ technology acceptance [64]; the Theory of Planned Behavior, which can be applied to understand and predict factors influencing technology use [74]; the Decomposed Theory of Planned Behavior, which expands upon of

the principles of the Theory of Planned Behavior [75]; and previous studies [68,69]. Then, the following hypotheses were formed:

- Hypothesis 1 (H1): The “perceived usefulness” directly and positively affects digital competence.
- Hypothesis 2 (H2): The “ease of use” directly and positively affects digital competence.
- Hypothesis 3 (H3): “Compatibility” directly and positively affects digital competence.
- Hypothesis 4 (H4): “Subjective Norms” directly and positively affect digital competence.

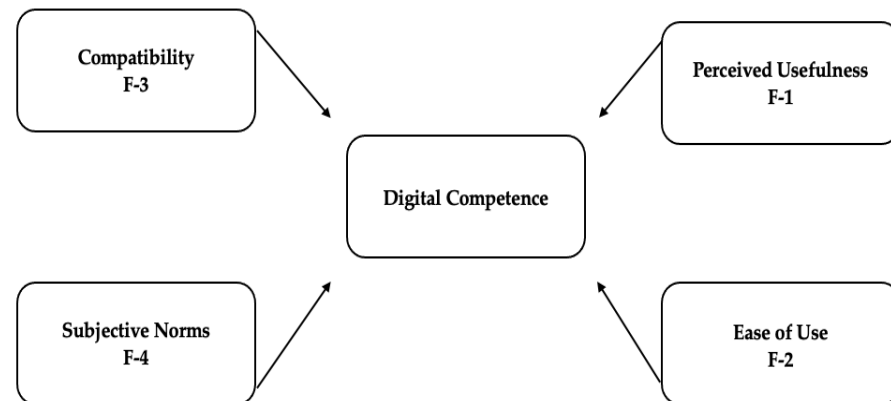


Figure 3. The preliminary proposed model of the factors affecting digital competence.

Structural equation modeling was used to test the proposed model. Figure 4 shows the final suggested model and the results of the structural relations between the study’s variables and the standardized path coefficients.

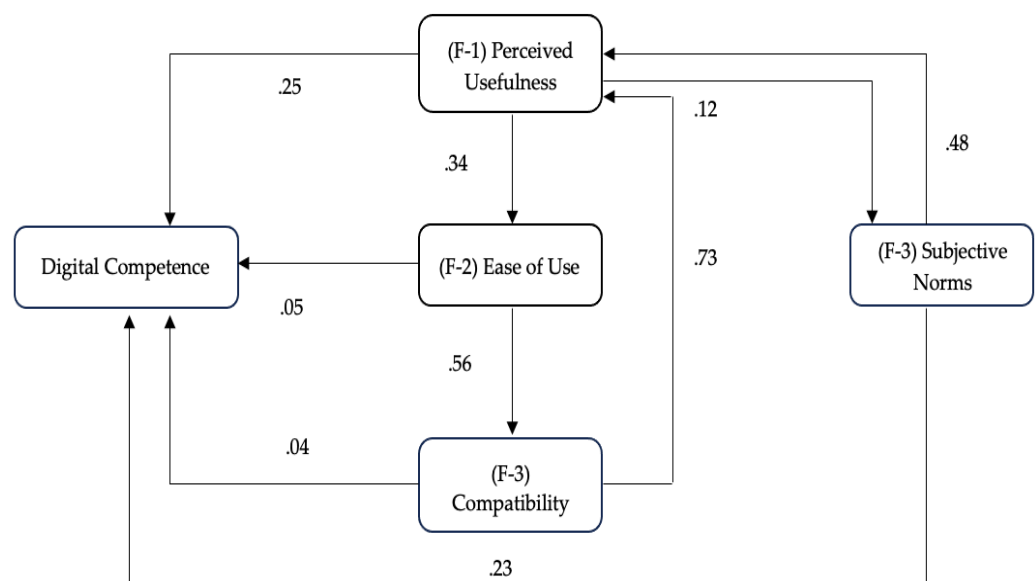


Figure 4. The model of the factors affecting digital competence.

Figure 4 shows the path analysis of the “perceived usefulness”, “ease of use”, “compatibility”, and “subjective norms” as independent variables and the “digital competence” as a dependent variable. The results of the path analysis of the model of the factors affecting digital competence (the final proposed model) indicate that the first variable, “perceived usefulness,” and the fourth, “subjective norms,” directly affected the level of teachers’ digital competence with path coefficients of (0.25 and 0.23), respectively. On the other hand, the “ease of use” and “compatibility” variables did not directly affect the digital competence level. The model also points out that the four independent variables (“perceived usefulness”, “ease of use”, “compatibility”, and “subjective norms”) directly affected each

other and served as mediating variables indirectly affecting digital competence, with path coefficients of (0.17, 0.27, 0.18, and 0.13), respectively.

To evaluate the suitability of the final proposed model, five common indicators were used. The first was Root Mean Square Error of Approximation (RMSEA) with a value of (0.041), indicating the model's fitness since a value of 0.05 or less is an indicator of a model's suitability [92,93]. In addition, the following values were calculated (RFI = 0.90, NFI = 0.99, CFI = 0.99, and TLI = 0.91), and all of these values fell within the required range of (0–1) and were greater than (0.90), as introduced in the previous literature [94,95]. Having been deemed fit, the model was applied to the four hypotheses of the study where Hypotheses 2 and 3 were rejected and Hypotheses 1 and 4 were accepted, as demonstrated in Table 6.

Table 6. Hypotheses Results and Path Coefficients.

Hypothesis	Path	Path Coefficients	Z-Value	p	Significance	Decision
H1	F1→DigComp	0.25	4.88	0.001	Significant	Accepted
H2	F2→DigComp	0.05	0.788	0.431	Not Significant	Rejected
H3	F3→DigComp	0.04	1.08	0.277	Not Significant	
H4	F4→DigComp	0.23	5.55	0.001	Significant	Accepted
	F4→F1	0.46	4.41	0.001	Significant	Accepted
	F1→F2	0.34	7.77	0.001	Significant	Accepted
	F2→F3	0.56	16.5	0.001	Significant	Accepted
	F3→F1	0.73	12.3	0.001	Significant	Accepted
	F1→F4	0.81	10.8	0.001	Significant	Accepted

3.2. The Qualitative Part

This part was dedicated to answering the study's fourth question, "how do science teachers in Saudi Arabia use digital technologies in the educational environment?" The qualitative analysis of the interview responses led to their classification into the following categories.

First: The Digital Tools and Technologies Used and How They Were Used

The results revealed a variety of digital tools and technologies used by teachers. They were divided into groups. The first group was electronic hardware such as computers, tablets, and data shows. Participants FT4 and MT5 pointed out that they mainly used these tools in the classroom for explaining scientific laws, theories, and phenomena instead of the traditional board. The second was digital applications, social media platforms, and educational websites. Participant FT5, a holder of a Master's in Educational Technologies, indicated that she employed these technologies to create interactive activities in a flipped classroom after presenting the theoretical part of the material. Participant FT4 claimed that some scientific experiments were too difficult or too dangerous to do in the school's lab; therefore, she used websites such as PhET that offer simulation software. Similarly, participant FT2, a holder of a Master's in Educational Technologies, said, "I use augmented reality and virtual reality technologies to make scientific phenomena more comprehensible to students." Figure 5 presents the applications that were cited the most in the participants' responses.

Second: The Benefits of Using Digital Technologies and Tools in the Educational Environment

The analysis of the interview responses revealed a number of benefits from using digital technologies and tools. These benefits were saving time and effort; enhancing learners' motivation; their use for learners' assessment and performance analysis; their use for communication with the educational community; and maintaining the continuity of learning and training through virtual platforms.



Figure 5. The digital applications most mentioned in the participants' responses.

When it comes to saving time and effort as well as enhancing learners' motivation, participant FT3 stated that she used "digital applications to motivate students and liven the class up since they were more appealing to students." In the same context, FT1 claimed that, "digital applications save time in getting information across, attract students' attention, and break the monotony of the traditional class".

As for using digital technologies in learners' assessment and performance analysis, participants, FT4, FT3, and MT6 cited their use of digital technologies in following up on learners' progress, identifying their levels, providing feedback to them, capturing marks and grades on the Madrasati platform, and preparing statistical reports about their performance. Participant FT4 pointed out that she used "digital technologies in assessing students individually because the class time was insufficient to do so".

Communication with the educational community as a benefit of digital technologies was referred to by participant MT6 who said that, at his school, "WhatsApp groups were used to communicate memos and duties from the management and supervisory staff". Participant FT5 echoed this idea saying that she used "social media to communicate with fellow teachers creating professional communities to exchange ideas and teaching materials such as lesson plans and educational websites".

Citing the continuity of learning and training through virtual platforms during exceptional circumstances, participant MT1 stated that, "when school was suspended due to weather conditions, classes were still delivered remotely through the Madrasati platform and Microsoft Teams".

Third: The Challenges that Encountered Science Teachers in Acquiring and Employing Digital Technologies

1. Challenges Related to Technology Acceptance

Male teachers, unlike female teachers, expressed unwillingness to implement all that is technologically new in the educational process. Participant MT5 stated that, "some teachers still preferred the traditional marker-and-whiteboard way of teaching", adding another important point which is that "some parents did not see the importance of using technology in the educational process". This idea was corroborated by MT4 who pointed out that, "in some rural areas, people saw digital technologies as merely means of entertainment not education".

2. Challenges Related to Teachers' Knowledge and Skills

Teachers indicated that training courses in using digital applications and resources were almost nonexistent and, even when some were offered, they were led by non-specialists in technology, which rendered them ineffective. Participant MT2 supported this common opinion saying, "for the past two years, my educational supervisor did not offer me any training programs that familiarized me with using modern technologies in teaching science".

3. Challenges Related to Limited Accessibility to Digital Equipment and Technologies

Participants MT7, MT6, MT2, and MT1 referred to the scarcity at some schools of the technological equipment needed to implement the activities of the science course. They also claimed that most schools either had no internet connection or the internet

was too slow. They added that most free digital applications were difficult to use or had limited privileges.

4. Challenges Related to Time Limitations as well as Teaching and Administrative Loads

Some teachers referenced the multiplicity of teaching and administrative loads they had, which hindered their ability to use digital technologies. Participant MT7 mentioned that he “had 24 science classes a week in addition to different administrative duties” which meant that he “did not have the time to look for and use digital technologies in class”, while participant MT3 indicated that, “the class time was insufficient to use digital technologies” and that he might “fall behind on the teaching material because of them”.

5. Challenges Related to Students and Their Behaviors

A large number of students did not have enough experience with digital technologies, which meant that teachers had to teach them how to use such technologies. Participant MT4 expressed this idea saying that her “students did not know how to use some digital technologies and had to be taught how to use them every step of the way”. This may be a result of the fact that many students did not own computers at home to do their homework. Furthermore, some students exhibited behaviors that needed educational treatment. Participant MT3 confirmed this concern saying that, “some student behaviors such as bullying or unwanted messages forced us to either temporarily suspend digital applications or permanently discard them”.

4. Discussion and Conclusions

The aim of this study was to assess the digital competence of science teachers in Saudi Arabia and examine their perceptions towards it. Additionally, the study aimed to identify the factors affecting the level of science teachers’ digital competence according to DigComEdu. To achieve these aims, a mixed-methods approach was employed. The data collection process involved administering a questionnaire to a sample of 611 science teachers in Saudi Arabia. Furthermore, semi-structured interviews were conducted with 13 science teachers to gather more in-depth insights.

The quantitative results of the study indicated that the majority of the participants rated themselves as “medium” in the six areas of the DigCompEdu framework. Empowering learners emerged as the highest-scoring competence among the six areas, while the remaining five areas achieved nearly comparable scores. This finding was in accordance with those of [16,49,50,52,54]; however, it was inconsistent with the results of [44,45,47,48,53].

Hence, it comes as no surprise that science teachers were found to have a medium level of digital competence. This can be attributed to a number of factors that were addressed in the qualitative part where the participants’ responses pointed to a number of challenges that limited their digital competence level. Among these challenges were the limitedness of teachers’ technological knowledge and skills as a result of the insufficiency of professional training programs in digital technologies. Such professional development programs are vital for raising teachers’ digital competence level [3]. When it comes to the challenges that limit teachers’ digital competence level, the findings of this study supported those of [57,96,97].

The teachers’ digital competence level can be further explained by the qualitative results that alluded to the educational community’s reluctant acceptance of digital technologies and of their significance in the educational process. According to the qualitative results, some teachers still preferred traditional teaching methods, and this could be a result of weak internal motivation for using modern digital technologies in teaching. This idea was mirrored in [12], which claimed teachers prefer the traditional methods they are used to and, therefore, lack the internal motivation to invest in learning and applying new technologies.

Furthermore, some schools faced challenges in providing the needed equipment and digital technologies such as computers, data shows, and internet services. Some teachers also found it difficult to use free digital applications due to their limited and restricted

services and had to pay for subscription to utilize the full privileges of such applications. These challenges expressed in the participants' responses to the interview may explain the quantitative results about their digital competence level. In other words, it could be difficult for some teachers to enhance their digital skills due to limited accessibility and availability of technological resources. It can be inferred that teachers who have limited access to digital resources and tools are less likely to engage in online professional development programs and are more likely to refrain from incorporating professional digital technology into their classrooms, indicating a lower level of digital competence. Such findings conformed to other studies which found that the quality, accessibility, as well as the availability of digital tools and applications affected teachers' digital competence level [51,56,57,73]. This challenge hinders teachers from utilizing digital technologies effectively to reach students in remote or underserved areas. Unequal access to resources can create disparities in educational opportunities, hindering the achievement of equitable and inclusive sustainable education that the SDG4 focuses on.

As for the teachers' perceptions, the quantitative results revealed that they had a high level of positive perceptions towards using digital technologies. The findings indicated that all four perception areas including perceived usefulness, ease of use, compatibility, and subjective norms yielded high ratings. This finding supported those of previous studies such as [56,58,69,72].

For the "perceived usefulness" area, and based on the findings, teachers believed that using digital technologies in their teaching methods would enhance their educational approach, increase students' motivation, and ultimately improve students' performance in terms of grades. All the items in the "perceived usefulness" area reflected a high level, echoing the findings of [56,68,69] and confirming the teachers' responses in the qualitative part where they discussed the benefits of digital technologies and their influence on the educational environment. The results revealed that adopting technology into educational practices, in designing instructional activities, assessing student assignments, and homework can accelerate science learning, motivation, interaction in online discussions, and stimulate students' creative thinking. This observation was supported by [9–11,13,14]. Furthermore, the qualitative part of the study corroborated the quantitative findings, further emphasizing the usefulness of digital technology in both educational and professional settings. This utility was evidenced by digital technology's ability to save time and effort; enhance learners' motivation; facilitate learners' assessment and performance analysis; enhance communication with the educational community; and maintain the continuity of learning and training through virtual platforms. The qualitative results were consistent with [10,12,56,58,97].

In terms of the "ease of use" and "compatibility" areas, science teachers expressed their belief that incorporating digital technology in both educational and professional settings was effortless for them and aligned with the current trends, directions, and standards of their subject matter and career. Additionally, they believed that acquiring the essential knowledge and skills to integrate such technology was also straightforward. These findings validate previous studies conducted by [69,72].

"Subjective norms" are crucial in determining the adaptation and utilization of digital technology within an educational setting. The adoption of digital technology among science teachers was influenced by the perspectives and experiences of their peers, principals, supervisors, and students. Engaging in positive interactions and discussions with peers about the benefits of digital technology will encourage them to use it [89]. Additionally, guidance, encouragement and support provided by principals and supervisors play a significant role in motivating its implementation. When science teachers witness role models who effectively use, encourage, and support the use of digital technology in the educational environment, and see its outcomes on their students, it can help alleviate their doubts and uncertainties. This, in turn, boosts their confidence to integrate technology into their classrooms, lessons, and communication. These findings align with studies of [66–68].

The quantitative results indicated there was a high level of belief that the principal, educational supervisor, and peers had a strong influence on the teachers' interest and use of digital technologies. However, the teachers pointed out in the qualitative part that their school management and educational supervisors did not provide support in using digital technologies such as training courses and workshops. This discrepancy could be explained by the fact that verbal motivation would be insufficient if not supported by actions such as providing professional development programs that trains teachers in dealing with digital technologies. On the other hand, there was an adverse effect of learners' lack of digital experience on teachers' interest in using digital technologies. For example, the items "My students communicate with me using different digital technologies" and "My students demonstrate good skills in using digital technologies in various educational scenarios" reflected a low level of belief. The qualitative part confirmed these results, indicating that many learners lacked the necessary experience for using several digital applications. Ensuring the engagement of all students in classroom activities is crucial. Nonetheless, there is a concern that introducing new technology could create a division among students, separating students into knowledgeable, skilled, and equipped with technology from those who lack knowledge, skills, access, and familiarity [98]. Therefore, teachers should make sure that their students comprehend the tasks and activities linked with implementing new technology, actively involving every student in such tasks and activities [99].

Finally, when it comes to the factors affecting digital competence level, the existing literature [51,64,68–73] has noted that the level of digital competence is influenced by several factors, including perceived usefulness, ease of use, and subjective norms. However, this study's findings specifically indicate that perceived usefulness and subjective norms significantly impacted the digital competence of science teachers. That is, whoever perceives of digital technologies as useful and upholds subjective norms in learning and teaching of science would be more likely to possess a high level of digital competence. These findings are aligned with the findings of [100], which demonstrated that the perceived usefulness of digital technology directly influenced teachers' acceptance and integration of it within their classrooms. Additionally, Alshalawi [69] has shown that social norms, including the influence of peers, principals, supervisors, and students, played a significant role in shaping teachers' adoption and incorporation of digital technology in the educational setting.

On the other hand, a direct impact of the "ease of use" and "compatibility" variables on the level of digital competence was not observed. However, the results of the structural model, Figure 3, indicated that the model highlights that the four independent variables (perceived usefulness, ease of use, compatibility, and subjective norms) had direct positive effects on each other and acted as mediating variables, indirectly influencing digital competence. This finding is in accordance with [66–69,72]. It also agrees with [71] in the perceived usefulness factor but differs from it in the subjective norms factor.

5. Recommendations and Implications

Building on this study's findings, teachers' professional development training programs in digital technologies need to be reconsidered. Such programs should include digital skills and be delivered using various strategies. The study also recommends improving technological infrastructure such as technological equipment as well as digital applications and platforms that enable teachers to maximize the benefits from using technology in the educational environment.

The findings of this study could inform future research into digital technologies in the educational environment. There could be an investigation of other factors that may affect digital competence such as teachers' internal motivation to use digital technologies. Future studies could also target various subjects as this study was limited to science. The inclusion of digital technologies in teaching practices is another area for potential research. Furthermore, research could be conducted to reveal the extent to which curricula include activities that help teachers use digital technologies in their teaching practices.

6. Limitations

This study was limited to exploring the levels of digital competence of (611) science teachers in Saudi Arabia, according to DigCompEdu, who participated in a self-reported electronic questionnaire as well as (13) science teachers who were interviewed via Zoom in the second semester of the 2022–2023 academic year. To ensure credibility and trustworthiness, great attention was given to achieving the highest levels of accuracy and comprehensiveness in both the qualitative and quantitative aspects of this study. However, one of the limitations of this study was the inability to conduct face-to-face interviews because of the geographical distribution of the study's sample all over Saudi Arabia.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Scientific Research Ethics Committee of Taif University with code number 44-074 and date of approval in November 2022.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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