The impact of the digital teaching competencies of in-service science teachers on students' attitudes toward learning science

Jielan Elsayed Kamel[1*], Amina Ossama Abuelmakarem[2]
[1*]Ph.D. in education technology in department of curricula and instruction, Faculty of education, Ain Shams University, Egypt.
[1*]E-mail: jielan_elsayed@edu.asu.edu.eg
[1*]ORCID ID: https://orcid.org/0000-0002-5325-8254
[2] Ph.D. in science education in department of curricula and instruction, Faculty of education Ain Shams University, Egypt.
[2] E-mail: aminaabuelmakarem@edu.asu.edu.eg
[2] ORCID ID: https://orcid.org/0009-0009-5409-5088

Abstract

This study aimed to investigate the impact of delivering a program based on digital competencies for in-service science teachers on students' attitudes toward learning science. The program was conducted in an online environment by using Microsoft Teams as a virtual classroom and other technological tools to support teaching and learning. The program delivered to professional diplomas in postgraduate programs specializing in education technology and prepared teaching materials for the faculty of education, at Ain Shams University, EGYPT, .This study uses a quantitative method to measure the impact of the digital competencies program on students' attitudes toward learning science, . The researchers design a self-assessment of digital competencies that adapted from the DIGCOMPEDU framework to determine which level in-service science teachers regarding digital competencies. They further design a science attitudes scale to measure students' attitudes toward learning science,. The research sample size of science teachers participated in a program was (n=11) 11 for in-service science teachers and the sample size of students in primary stage was (n=60) 11.The results show that there is a significant difference in in-service science teachers' digital competencies, which is reflected in their practices in classrooms and therefore affects their students’ attitudes toward learning science.

Keywords: digital teaching competencies, students’ attitudes, in-service science teachers, virtual classrooms

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[1*]ORCID ID: https://orcid.org/0000-0002-5325-8254
[2] Ph.D. in science education in department of curricula and instruction, Faculty of education Ain Shams University, Egypt.
[2] E-mail: aminaabuelmakarem@edu.asu.edu.eg
[2] ORCID ID: https://orcid.org/0009-0009-5409-5088

Introduction

With the advent of the COVID-19 pandemic, the impact of digital tools has been rapid at all educational levels; the digital revolution has substantially impacted education; and the development of technologies used in education has been gradual and different, mostly depending on teaching professionals' preparation and skills. In addition, the role of the educator is critical in this new model, confirming the necessity to have technical resources and qualified educators to improve students' competence for them to work successfully in the digital economy (Núñez-Canal et al., 2022).

Teacher training programs are needed to inform in-service teachers about the right attitude and knowledge regarding utilizing digital technologies and which strategies to apply to meet the different needs of students, in addition to creating digital technology that is easily accessible to them and, consequently, how they can sustainably develop their digital teaching competencies (Spiteri & Chang Rundgren, 2020).

Thus, the main purpose of digital teaching competence is not to add technology to teaching only but to distribute a series of knowledge, values, and procedures that make it possible to design learning opportunities for students while facilitating personal and professional teacher development on a basis (Tárraga-Mínguez, et al., 2021), and digital teaching competence is part of new teacher professional development programs and a crucial part of their training and lifelong learning (Ala-Mutka, et al., 2008); thus, (Mercader & Gairín, 2021) currently determine different reference frameworks for defining and analyzing teachers' digital competence. These frameworks tend to produce instruments (questionnaires, rubrics, tools, etc.) for self-analysis and self-perception of teachers' digital competence.

Accordingly, teachers' digital competence is a crucial aspect for the effective usage of technologies in education, and it relies on various frameworks and instruments that have been developed to measure it (Cattaneo et al., 2022). Currently, digital competence is considered a vital factor in our society, especially after the COVID-19 pandemic, and it is considered an indicator of quality education understanding in the 21st century (Çebi & Reisoğlu, 2020). The role of digital competencies should be considered for successful technology integration (Çebi, et al., 2022). In addition, the importance of developing teachers' digital competencies increases, and teachers must improve their knowledge, skills, and attitudes to provide an effective learning environment for their students (Basantes-Andrade, et al., 2022).

Consequently, Tárraga-Mínguez et al. (2021) emphasized that studies have focused more on the self-perception of digital teaching competence, and it is vital to conduct studies that analyze students' perceptions of their teachers' digital competence.

Several factors can influence students' attitudes toward science learning. Studies have shown that attitudes toward science can be related to commitments to participating or acting, affective commitments to science ideas and practices, or identification with scientific ways of thinking and working. Many studies have shown that the implementation of inquiry pedagogy in classrooms can positively impact students' attitudes toward science and their selfefficacy in science. Additionally, engaging in science programs introduced early on can help shape students' attitudes, beliefs, and ideas about science. Furthermore, science learning experiences can have a positive influence on students' attitudes and beliefs about science, which in turn can affect their career expectations in science-related fields.

Research questions.

RQ1: What is the outline of the digital competencies program for in-service science teachers?

RQ2: What is the impact of a program based on digital teaching competencies on in-service science teachers?

RQ3: What is the impact of science teachers’ digital competencies on students’ attitudes toward learning science?

Research hypothesis.

The hypotheses posited are as follows:

H1: There is a statistically significant difference between the average score of the experimental group pre- and post-application of the self-assessment digital competencies scale in favor of post application.

H2: There would be a statistically significant difference between the average score of the experimental group in the pre- and post-application of students’ attitudes toward learning science scale in favor of post application.

Literature review

Digital teaching competencies

Digital teaching competence is defined as the ability to use digital tools with a formative and educational purpose at various educational levels, along with its specific expression in the classroom, school, and educational community, with the instructional, organizational, ethical, and communicative aspects controlling its integration (Mercader & Gairín, 2021).

Furthermore, Garzón-Artacho et al. (2021) defined digital teaching competencies as the skills and abilities that allow teachers to search for, critically select, obtain, and process appropriate information using ICT to convert it into knowledge. While being able to communicate such information using various digital tools, acting responsibly, respecting socially created rules, and taking advantage of these tools to inform, learn, solve problems, and communicate in different situations of interaction, based on this concept, international institutions have had the objective of developing a conceptual framework around this term to represent a common reference for all educational plans and curricula.

Consequently, digital teaching competencies allow teachers to enrich their teaching and professionally develop them (Esteve-Mon et al., 2020), and Fernández-Batanero, et al., 2020, emphasize the importance of digital teaching competencies as one of the current challenges facing teachers. There is a lack of teachers' training or insufficient training considering teachers' needs and abilities.

According to Núñez-Canal et al. (2022), there is a positive relationship between developing digital teaching competencies and students' learning processes.

Therefore, different institutions have stated different indicators or standards that describe teachers' digital competence, and these standards classify the competencies that teachers must develop according to different dimensions and sub competences (Cabero-Almenara, et al., 2020).

Digital competency frameworks:

According to Yoon (2022), three digital competence frameworks for educators have been developed: the ISTE standards, the UNESCO ICT Competency Framework for Teachers, and the Digital Competence Framework for Educators, DigCompEdu.

In addition, Basantes-Andrade et al. (2022) stated that several studies addressed digital competencies in several areas, and some of those studies aimed to determine the relationship between demographic variables such as gender and digital competencies (Yoon. 2022), in terms of improving digital competencies for educators or students (Lucas, et al., 2021), with the aim of improving digital competencies, (Tárraga-Mínguez, et al., 2021;

Mercader, & Gairín. 2021; Garzón-Artacho, et al., 2021) aim to analyze the opinions of teachers or experts about the frameworks, and the different frameworks used according to the purpose of each study, as shown in Table 1, reveal the main frameworks addressed in numerous studies (Basantes-Andrade et al., 2022).

Table 1

Teacher digital competence conceptual frameworks (Basantes-Andrade,* et al.*,2022).

Conceptual framework	Publication	Areas of dimensions	Levels
UNESCO ICT Competency Framework for Teachers	**2019**	● **Understanding the role of ICT in education** ● **Curriculum and evaluation** ● **Pedagogy** ● **Use of digital skills** ● **Organization and administration Teacher Professional learning**	● **knowledge acquisition** ● **Knowledge deepening** ● **Knowledge creation**
Digital Competence Framework for Educators (DigCompEdu)	**2017**	● **professional Engagement** ● **Digital Resources** ● **Teaching and Learning** ● **Assessment** ● **Empowering Learners** ● **Facilitating Learners' Digital Competence**	● **Newcomer (A1)** ● **Explorer (A2)** ● **Integrator (B1)** ● **Expert (B2)** ● **Leader (C1)** ▪ **Pioneer (C2)**

Table 1

Teacher digital competence conceptual frameworks (Basantes-Andrade, et al.,*2022).*

Conceptual framework	Publication	Areas of dimensions	Levels
International Society for Technology in Education (ISTE) Framework for teachers	**2017**	• **Empowered professional.** • **Learning catalyst**	• **Apprentice** • **Leader** • **Citizen** • **Collaborator** • **Designer** • **Facilitator** • **Analyst**
Common Digital Competence Framework for Teachers (INTEF)	**2017**	• **Information and Information Literacy Communication and collaboration** • **Digital content creation** • **Security** • **Problem solving**	• **Basic** • **Intermediate** • **Advanced**

Furthermore, Tondeur et al. (2023) attempted to compare frameworks and generate a new framework for teachers' digital competencies in higher education named the HeDiCom framework, which contains four dimensions: teachers' digital literacy, teachers' professional identity, teaching and learning with technology, and empowering students. with two or three subdimensions.

European Framework of Digital Competencies for Teachers, DigCompEdu

Redecker (2017) developed a digital competency framework for educators. The competencies categorized under educators' professional competencies, pedagogy competencies, and learners' competencies include twenty-two indicators in six areas.

1. Professional engagement: Teachers have the capacity for reflective practice and actively develop their digital pedagogical practice and digital continuous professional development (CPD) to use digital sources and resources for continuous professional development (Zafer & Hilal, 2024).
2. Digital resources: Teachers can select digital resources to identify, assess, and select digital resources for teaching and learning; create and modify digital resources; manage, protect, and share digital resources to organize digital content and make it available to learners, parents, and other educators (Caena & Redecker, 2019).
3. Teaching and learning: Teachers can plan and implement digital tools and resources in the teaching process to enhance collaboration, self-regulated learning, and interaction with learners individually and collectively to enable learners to plan, monitor, and reflect on their learning, provide evidence of progress, share insights, and develop creative solutions (Cabero et al., 2022).

   In assessments, teachers could apply formative and summative assessment strategies to use digital technologies. The evidence was analyzed and interpreted, and feedback was delivered (Bayrak Karsli et al., 2023).
4. By empowering learners, teachers can ensure that all students have access to digital resources, differentiation, and personalization to use digital technologies to address learners’ diverse learning needs by engaging them in the use of digital technologies to foster learners' activity and creativity (Zafer & Hilal, 2024).
5. Facilitating learners’ digital competence: Teachers can deliver learning activities, assignments, and assessments that require learners to find, organize, analyze, and evaluate information and resources in digital environments effectively and responsibly to use digital technologies, and teachers can express themselves through digital means and modify and create digital content, further empowering learners to manage

risks and use digital technologies safely and responsibly (Caena & Redecker, 2019).

According to Christine (2017), there are proficiency levels, which include the following: Newcomers (A1), described as in-service teachers who have had very little contact with digital tools and need guidance to expand their repertoire; Explorers (A2), described as in-service teachers who have started using digital tools without, however, following a comprehensive or consistent approach; Integrators (B1), described as in-service teachers who use and experiment with digital tools, trying to understand which digital tools work best in which contexts; and Experts (B2), described as in-service teachers who use a variety of digital tools confidently, creatively, and critically to enhance their professional activities. They constantly develop their repertoire of practices. Leaders (C1) rely on a broad repertoire of flexible, comprehensive, and effective digital strategies. They are a model of inspiration for others, and finally, Pioneers (C2) describe themselves as in-service teachers who question the capability of ongoing digital and pedagogical practices, of which they are experts. They lead innovation and are role models for younger teachers.

Furthermore, Caena and Redecker (2019) identified reasons for following the DigCompEdu framework in their study. They described it as the best framework for 21st century challenges because it is elastic to applying different educational settings and allows for adaptation to technological possibilities. Additionally, it could be used as a criterion for the recruitment and selection of teachers in professional development programs and could be a tool for identifying the outcomes of teacher education. Furthermore, it provides teachers with clear insights into their roles, promotes attitudes toward professional reflection practices, and self-builds their progress, in the study of Cabero-Almenara et al. (2020), it aims to evaluate frameworks according to experts' opinions, and the results reveal that most of the experts recommend using the DigCompEdu framework.

Therefore, in this study, we will follow the DIGCOMPEDU framework and adjust it to be adequate for our Egyptian context and for our in-service science teachers. Additionally, we will exclude the facilitating learners' digital competence dimension and address five competency dimensions with a total of 15 subcompetencies that are adequate for our Egyptian context. Furthermore, we will modify the sub competencies to cope with the Egyptian context by adding some topics and excluding others. Moreover, we rearrange the competencies dimensions to cope with the professional diploma program, and we suggest a different arrangement of competencies dimensions; therefore, we concentrate on the following competencies: teaching and learning science, digital teaching resources, professional engagement, assessment and evaluation, and empowering learners.

Students' attitudes toward science

Attitudes towards science, scientists, and learning science have always been a focal point for science educators, prominently featured in discussions surrounding issues in science education (Osborne et al., 2003). Attitude, a term used extensively across various contexts, is defined as the amalgamation of feelings, beliefs, and values held about a given object, which in this context could be science as a discipline, school science, the societal impact of science and technology, or scientists themselves. Scientific attitude, as delineated by Osborne et al. (2003), embodies the inclination to seek knowledge, question assertions, gather and interpret data, pursue verification, and contemplate consequences.

The exploration of student attitudes towards science has been a significant area of investigation (Osborne et al., 2003; Potvin & Hasni, 2014). As highlighted by Koballa (1988), attitudes stand apart from beliefs and values, persist over time, are acquired through learning, and are closely intertwined with behavior, serving as reflections of individuals' sentiments toward specific entities. Attitudes typically encompass three primary components: cognitive (related to beliefs), conative (pertaining to intentions for action), and affective (concerning emotions) (Koballa, 1988). This study concentrates on attitudes specifically towards science, emphasizing the affective component, consistent with prior scholarly inquiries (Koballa, 1988; Potvin & Hasni, 2014).

Attitudes towards science represent individuals' positive or negative viewpoints regarding science, shaped by their perceptions of science's role in education, society, and human endeavors (Osborne et al., 2003). Such attitudes are inherently dispositional and evolve gradually, exerting a profound influence on individuals' perceptions, perspectives, and values pertaining to science, as well as their inclination towards pursuing careers in scientific domains. According to the expectancy-value theory (Eccles & Wigfield, 2002; Wigfield & Eccles, 2000), a student's attitude towards school science is elucidated by two primary factors: their expectations of success and the value they attach to achieving success. These factors encompass beliefs regarding one's competence in school science, expectations of success in the subject, and the perceived usefulness and importance of school science.

Moreover, attitudes towards science not only serve as an outcome of teaching efforts but also hold considerable significance as an influential factor in students' academic achievements and knowledge acquisition (Bybee & McCrae, 2011; Newell et al., 2015). Such influence may manifest directly or indirectly through its impact on students' engagement, motivation, or persistence in scientific pursuits. While much of the research denotes students' positive attitudes towards science (Osborne et al., 2003), the correlation between attitude and academic achievement underscores the pivotal role of attitude in fostering sustained interest and learning in science subjects (Pell & Jarvis, 2001).

Hence, attitude emerges as a pivotal metric for evaluating science education, given its association with students' academic performance and retention in scientific disciplines. Prior investigations have delved into the intricate interplay between attitudes towards science, students' learning experiences, and the educational milieu. However, a concerning trend emerges wherein students' attitudes towards science tend to diminish during middle and high school years (George, 2000; Potvin & Hasni, 2014). Consequently, interventions aimed at bolstering middle-school students' attitudes towards science are imperative for nurturing and retaining student interest in science education.

Methodology

Researchers designed a program based on digital teaching competencies, and we were guided by the DigCompEdu framework in designing the framework of the program to determine the effects of the program on in-service science teachers. Researchers designed a self-assessment digital competencies scale for in-service science teachers and applied it before conducting the program and after finishing it.

In this study, researchers adapt the DIGCOMPEDU framework for Egyptian in-service science teachers and the Egyptian context. The researchers exclude the Facilitating Learners' Digital Competencies dimension, focus on five key dimensions with 15 subcompetencies relevant to the Egyptian context, and modify subcompetencies by adding and removing topics to better fit the context. Rearrange dimensions: Align with the professional diploma program structure. Finally, the researchers suggest a new order: teaching and learning science, digital teaching resources, professional engagement, assessment and evaluation, and empowering learners.

Essentially, we tailor the framework to the specific needs of Egyptian science teachers, offering a modified version with a different structure and a focus on relevant competencies.

Moreover, the program is conducted online via Microsoft Teams as a virtual classroom; it consists of twelve sessions, each lasting three hours. For one session each week, the program starts on February 14, 2022, and ends on May 9, 2022; it is conducted in the Arabic language.

Regarding the topics of the program, Table 2 shows the framework of the program based on digital competencies.

Table 2

Program proposal framework based on digital competencies

Topics	Subtopics	Learning outcomes	Sessions
Teaching and learning science. 1. Introduction (multimedia theory- learning theory- instructional design standards and models)	● Teaching to plan ● Guidance: to use digital technologies- collaborative learning- ● Self-regulated learning	● Use digital tools to implement innovative pedagogic strategies. ● Develop new forms and formats for offering guidance and support, using digital technologies. ● Use digital technologies to invent new formats for collaborative learning. ● Develop new digital formats and/or pedagogical approaches to foster self-directed learning	Two
Professional engaging 1. Self-learning techniques 2. MOOCs 3. Searching techniques (Egyptian knowledge bank "EKB" as an example)	● Reflective practice- ● Digital continuous professional development	● Develop, individually or in collaboration with peers, a vision or strategy for improving educational practice by digital technologies. ● Use the internet for professional development, e.g. By participating in online courses, webinars, or consulting digital training materials and video tutorials	One

Table 2

Program proposal framework based on digital competencies

Topics	Subtopics	Learning outcomes	Sessions
Digital teaching resource 1. Augmented reality 2. Blogs 3. Mind mapping. 4. Infographics	• Selecting digital resources- • Creating and modifying digital resources- • Managing, protecting, and sharing digital resources- • Managing suitable teaching and learning resources, and sessions per time, activities, and behaviors	• Guide colleagues on effective search strategies and suitable repositories and resources. • Creating apps or games to support my educational objectives. • Annotate the resources I digitally share and enable others to comment, rate, modify, rearrange, or add to them.	Four
Assessment and Evaluation 1. Online exams and forms 2. E-portfolio	• Assessment strategies • Analyzing evidence • Feedback and planning • Self-reflections and group reflections	• Develop new digital formats for assessment, which reflect innovative pedagogical approaches and allow for the assessment of transversal skills. • Implement advanced data generation and visualization methods into the digital activities I employ, e.g., Based on learning analytics. • Reflect on, discuss, re design, and innovate teaching strategies in response to the digital evidence I find, as concerns learners' preferences and needs as well as the effectiveness of different teaching interventions and	Two

Table 2

Program proposal framework based on digital competencies

Topics	Subtopics	Learning outcomes	Sessions
		learning formats	
Empowering learners 1. Interactive videos 2. Games and gamification 3. Interactive online activities	● Accessibility and inclusion- ● Differentiation and personalization- ● Actively engaging learners	● Reflect on, discuss, re design, and innovate strategies for equal access to and inclusion in digital education. ● Reflect on, discuss, re design, and innovate pedagogic strategies for personalizing education through digital technologies. ● Reflect on, discuss, re design, and innovate pedagogic strategies for actively engaging learners.	Three

Regarding each theme of digital competencies, we will expose each theme as follows:

Teaching and learning science:

Regarding the teaching and learning science theme, we are concerned about teaching science by presenting multimedia theory principles, instructional design standards, instructional design models such as SAMR-TPACK, etc., and how to apply different learning theories and principles and give them assignments and tasks to plan and design a science lesson and try to apply learning theory principles, use the ID model, and follow the ID standards. Each in-service teacher presents a science lesson, and we conduct a group reflection to reflect on their work; they modify it according to the comments and represent it again in the next session.

Performance Engaging:

With respect to performance engagement, we investigated topics related to self-learning techniques and how to develop these techniques and delivered the EKB Egyptian Knowledge Bank, which is considered a repository of articles and researchers and contains numerous databases, such as Elsevier, Spring Nature, the Web of Science, and anyone in Egypt who had access to this repository discussed with in-service teachers if anyone tried those techniques to share their experiences. Moreover, we investigated topics related to MOOCs and asked in-service teachers for several assignments related to analyzing one of the platforms that delivered online courses; moreover, they enrolled in certain online courses with certificates, and at the end of the course, they discussed what the benefit of this course was.

Digital teaching resources:

Regarding digital teaching resources, we present different trusted resources of scientific content, and in-service teachers share some of the resources that they rely on in preparation and planning their lessons. We reflect on sessions about teaching and learning and how to select suitable digital tools that will be relevant to learning objectives and how to design digital tools based on ID standards and multimedia theory principles. We conduct examples of digital tools that facilitate teaching science, including infographics, mind maps, augmented reality, and blogs; each of those tools that we use to design it based on ID standards; the applications that facilitate design it; and how to integrate each of the digital tools in a science lesson to achieve learning objectives. After delivering each digital tool, we asked the in-service teachers to apply it to a specific science lesson. At the end of the sessions on this theme, we asked them to integrate different digital tools they preferred in a science lesson and apply the lesson to their students. After that, we conducted a group reflection to discuss with in-service teachers their performance and students' interactions regarding delivering science lessons integrated with digital tools.

Assessment and evaluation

Regarding the assessment and evaluation theme, we introduce the assessment strategies, differentiate between the assessment and evaluation process, and describe the digital tools that help in-service teachers facilitate assessment, evaluate their students, and follow their progress. We asked in-service teachers to apply the assessment and evaluation tools they preferred to their students. At the end of the sessions on this theme, we asked them to integrate different digital tools they preferred and apply them to assess their students. After that, we conducted a group reflection to discuss with in-service teachers their vision and insights about using assessment and evaluation tools with their students and students' interactions. Finally, we asked in-service science teachers to create an e-portfolio about their achievements in this course, and they presented it at the end of the course.

Empowering Learners

In this theme, we focus on delivering different digital tools to support in-service teachers in empowering their students and engaging them in the learning process; we address electronic interactive activities, games, and interactive videos; and we present how to create and integrate those tools in science lessons and how to design them to cope with students' different learning styles. After delivering each digital tool, we asked the in-service teacher to apply it to a specific science lesson. By the end of the sessions on this theme, we asked them to integrate different digital tools they preferred in a science lesson and apply the lesson to their students. After that, we conducted a group reflection to discuss with in-service teachers their performance and students' interactions regarding delivering science lessons integrated with digital tools.

Additionally, to measure the impact of in-service science teachers' digital competencies on students' attitudes toward learning science, we designed and asked in-service teachers to apply the science learning attitude scale to their students.

Instruments

To accomplish the aim of this study, which is to determine the impact of the digital teaching competencies of in-service science teachers on students’ attitudes toward learning science, the researchers designed the following instruments:

Self-assessment scale of digital competencies:

The five themes of digital competencies, as revealed in Table 3, are teaching, and learning science, professional engagement, assessment and evaluation, digital science teaching resources, and empowering learners. The five themes included seventeen closed questions with six items for each statement, with scores ranging from 0 to 5.

Table 3

Self-assessment scale Distributions and numbers of questions

Themes	Questions	N of questions	Total Scores
teaching and learning science	1,2,3,4	4	20
professional engaging	5,6	2	10
assessment and evaluation	7,8,9,10	4	20
digital science teaching resources	11,12,13,14	4	20
empowering learners	15,16,17	3	15

Students’ attitude scale:

The 45 closed-ended questions were evaluated with a three-item Likert scale for each statement (Drinkwater, 1965) to express their level of attitude, with each statement ranging from “agree” =1 to “disagree” =3 (Pintrich et al., 1993).

Test of reliability

Reliability was tested at an earlier stage with in-service science teachers, and the following table shows a reliability analysis of the instruments using IBM SPSS software, assessed by calculating Cronbach’s alpha confident (Cronbach, 1951). The coefficients show that the items for the digital competencies scale and the students' attitudes scale have acceptable internal consistency; almost all values of reliability exceeded the generally accepted minimum of 0.70 (Nunnally, 1978), and Table 4 illustrates the value of each scale.

Table 4

Reliability Statistics of instruments

Scales	Cronbach's Alpha	N of Items
Self-assessment digital competencies scale	0.93	17
Students' attitudes toward learning science	0.79	45

Participants

In-service science teachers n = 11 in a professional diploma post program at the faculty of education, Ain Shams University, Egypt. In addition, their students n = 60.

Findings

Results of the digital competency scale

The researchers examined the first hypothesis: "There would be a statistically significant difference between the average score of the experimental group in the pre- and post-application of the self-assessment digital competencies scale, in favor of the post application."

Moreover, to test this hypothesis, the researchers compared the average scores of pre- and post self-assessed digital competencies as a whole and in each domain individually for the students in the experimental group by using Wilcoxon tests for paired-sample groups to determine the significant differences after studying the proposed program based on digital competencies, as shown in Table 5.

Table 5

pre/post applying results of the experimental group students in each theme of the self-assessment digital competencies scale

Digital competence's themes	Experimental group	Total scores	The average	Std. Deviation	Z value	sig
teaching and learning science	Pre	20	8.4	17.9	2.85	0.01
	Post		16.4	5		
Professional engaging	Pre	10	4.4	4.9	2.67	0.01
	Post		8.6	1.7		

Table 5

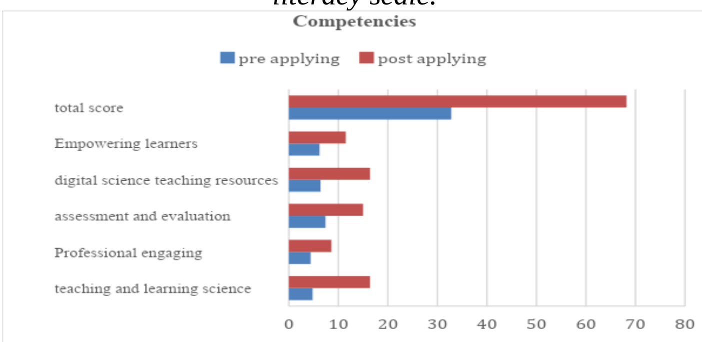
pre/post applying results of the experimental group students in each theme of the self-assessment digital competencies scale

Digital competence's themes	Experimental group	Total scores	The average	Std. Deviation	Z value	sig
Assessment and evaluation	Pre	20	7.4	2.7	2.75	0.01
	Post		15	1.4		
Digital science teaching resources	Pre	20	6.4	4.8	2.84	0.01
	Post		16.4	1.3		
Empowering learners	Pre	15	6.2	4.3	2.54	0.01
	Post		11.5	1.6		
Total	Pre	85	32.8	3.7	2.84	0.05
	Post		68.2	1.8		

The previous table shows that there is a significance level for all aspects of the scale that exceeds 0.05. Specifically, for the self-assessment digital competencies scale, the average scores of the post-application for all the themes were greater than the average scores of the pre-application for all the themes and for the total scale. Consequently, there was a significant difference between the average scores of the pre-and post-application of the self-assessment digital competencies scale for the experimental group students in favor of the post, as shown in Figure 1.

Figure 1

A graph showing the average score for each aspect of the self-assessment media literacy scale.



In summary, the results compare the average scores of the experimental group pre- and post-application of the self-assessment digital competencies scale in favor of the post-application.

Results of students' attitudes toward learning science scale:

To measure the impact of teachers' performance after studying a program based on digital competencies on students' attitudes toward learning science, researchers ask teachers to apply the students' attitudes scale.

Moreover, researchers have examined the second hypothesis: "There would be a statistically significant difference between the average score of the experimental group in the pre- and post-application of students' attitudes toward learning science scale, in favor of the post application."

Moreover, to test this hypothesis, the researchers compared the average scores of pre- and post-screening students' attitudes toward learning science as a whole for the experimental group's students by using a t test for paired-sample groups to discover the significant differences after in-service teachers received the proposed program based on digital competencies, as shown in Table 6.

Table 6

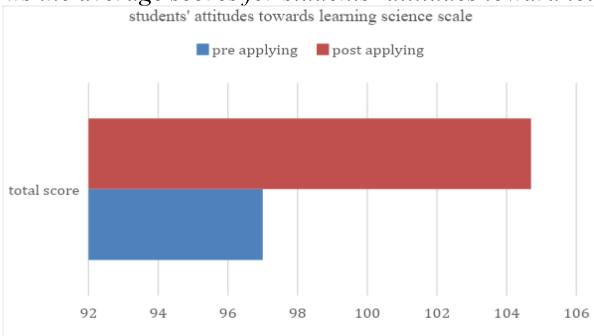
pre/post applying results of the experimental group students in each theme of the student's attitudes toward learning science scale

students' attitudes toward learning science	Experimental group	Total scores	Mean	Std. Deviation	DF	T value	sig
Total	Pre	135	97	18.71	59	4.45	0.01
	Post		104.7	16.73			

The previous table shows that there was a significance level exceeding 0.01 for students' attitudes toward learning science; specifically, the mean score for post application was greater than the mean score for pre application; consequently, there was a significant difference between the average scores for pre- and post-application students' attitudes toward learning science among the experimental group students in favor of post application, as shown in Figure 2:

Figure 2

The graph shows the average scores for students' attitudes toward learning science.



In summary, the results compare the average scores of the experimental group before and after the application of the students' attitudes toward learning science scale in favor of post application.

Discussion and conclusion

In the pursuit of enhancing the digital competencies of in-service science teachers, our study aimed to develop a program framework tailored to the Egyptian educational context. Leveraging the DigCompEdu framework as a foundation, we made adjustments to better address the needs of in-service science educators. Our framework emphasized five competence dimensions: teaching and learning science, digital teaching resources, professional engagement, assessment and evaluation, and empowering learners. We excluded the dimension of facilitating learners' digital competencies. Additionally, we adapted subcompetencies by incorporating or omitting topics to align with Egyptian requirements and reorganizing the dimensions to suit the structure of the professional diploma program. Specifically, we proposed the following arrangements: teaching and learning science, digital teaching resources, professional engagement, assessment and evaluation, and empowering learners.

Our findings revealed a statistically significant improvement in the digital competencies of in-service science teachers, as depicted in Figure 1. This outcome is consistent with previous research by Marais (2023), who highlighted the importance of integrating digital competencies with content and pedagogical knowledge for future teachers' success. Moreover, the effectiveness of programs focusing on digital competencies in enhancing teaching performance was supported by the results of Haşlaman et al. (2023) and Bayrak Karsli et al. (2023). Notably, we underscored the significance of considering contextual and cultural factors in interpreting our findings, a consideration that was integrated into our adjusted framework.

Furthermore, our analysis identified professional engagement as the dimension with the highest scores, with a post assessment mean score percentage of 86%. This dimension predominantly addressed self-learning techniques and their development, catering to the interests and professional growth of in-service teachers, thus fostering sustainable development within the educational context.

Following professional engagement, the subsequent dimensions of teaching and learning science and digital science teaching resources demonstrated notable performance, with a post assessment mean score percentage of 82%. These two dimensions exhibit interrelatedness, as teaching and learning science focuses on the application of learning theories and cognitive multimedia principles within digital content. Conversely, digital science teaching resources delve into adherence to instructional design standards (ID) and methods to ensure alignment with established principles and standards. This symbiotic relationship ensures that digital teaching resources not only incorporate pedagogical theories but also adhere to best practices in instructional design, thereby optimizing the educational experience for both teachers and students.

According to the findings, the preeminent dimension observed was professional engagement, for which the mean score percentage for the post assessment reached 86%. Notably, this dimension primarily encompassed topics pertinent to self-learning methodologies and their cultivation. The significance of this dimension lies in its potential to facilitate sustainable development among in-service educators. Furthermore, subsequent dimensions, Teaching and Learning Science, and Digital Science Teaching Resources, exhibited a mean post assessment score percentage of 82%. These dimensions exhibit a symbiotic relationship, wherein teaching and learning science emphasize the application of learning theories and cognitive multimedia principles within digital contexts, while digital science teaching resources concentrate on adhering to instructional design standards and refining digital designs to align with established principles and standards.

Furthermore, within the domain of empowering learners, the mean post assessment score recorded was 76.6%. Notably, this program represents an effort to provide support to in-service teachers and their students through the integration of digital tools. The program's innovative approach involves supporting in-service teachers with digital resources and requiring them to apply these tools in their educational practices with students. Such a methodology fosters a novel form of engagement wherein group reflections serve as a mechanism for ongoing support and evaluation, a departure from traditional programs that often lack such interactive components. Consequently, this dimension stands out for its emphasis on the active application of digital tools in conjunction with student involvement, reflecting a paradigm shift in in-service teacher training.

Within the assessment and evaluation dimension, the mean post assessment score percentage was 75%. This dimension is primarily concerned with distinguishing between assessment and evaluation processes and equipping in-service teachers with digital tools to facilitate both assessment and evaluation procedures while monitoring student progress.

Moreover, an examination was conducted to assess the impact of teachers’ performance on their students’ attitudes toward learning science. The findings revealed a statistically significant difference in the improvement of students’ attitudes toward learning science, aligning with previous research by Chen and Howard (2010), which underscores the efficacy of leveraging technology tools to enhance students' attitudes toward learning science.

Limitations and future studies

Several limitations of this study warrant caution when interpreting its findings. Overall, this study focused only on the experiences of teachers in Egypt during their studies in the postgraduate program at the Faculty of Education at Ain Shams University. We followed the DIGCOMPEDU framework and adjusted it to be adequate for our Egyptian context and in-service science teachers. Additionally, we excluded the Facilitating Learners' Digital Competence dimension and approached five competency dimensions with a total of 15 subcompetencies that are adequate for our Egyptian context. Furthermore, we modified the sub competencies to cope with the Egyptian context, added some topics, and excluded others. Moreover, we rearranged the competency dimensions to cope with the professional diploma program (postgraduate program), and we suggested a different arrangement of competency dimensions; therefore, we concentrated on the following competencies: teaching and learning science, digital teaching resources, professional engagement, assessment and evaluation, and empowering learners.

The sample size of the study was small: n = 11 in-service teachers and their students n = 60. This small sample size may limit the representativeness of the results. and the majority of the participants in this study were female.

This study focused primarily on the impact of digital teaching competencies and basic skills on communication in science teaching, and other factors that may influence competence in digital environments were not explored. Moreover, this study used Microsoft Teams as a virtual classroom to conduct the program.

Future studies may include large numbers of participants and use different samples with different variables. Additionally, future studies could examine the impact of digital competencies on specific performances regarding teachers' practices in classrooms, include in-service teachers in different majors, and use different platforms to conduct virtual classrooms.

Data availability:

The datasets generated during and/or analyzed during the current study are available from the authors upon reasonable request.

Declarations

of non-financial interests to disclose.

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