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Digital Education Skills for In-service Biology Teachers of the Secondary-stage Biology Curriculum (An evaluative study)

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ABSTRACT

This research aimed at identifying the digital education skills necessary for in-service biology teachers at the secondary stage, and investigating how far they possessed these skills. It also aimed at proposing a training program for developing their skills. Descriptive and experimental methods were used for the purposes of this research. Instruments and materials included a checklist and a rubric of digital education skills, a questionnaire to identify the level of the teachers in these skills, and a proposed framework of a training program for in-service biology teachers to develop their digital education skills. The program was administered to a group of secondary-stage biology teachers (N=18) at Damietta Governorate in the first semester of the 2022-2023 school year. The research findings revealed that the research group had poor digital education skills, and proved the training program effective in developing those skills.

KEYWORDS:

digital education skills - In-service Biology Teachers - biology curriculum.

مهارات التعليم الرقمي لدى معلمي الأحياء بالمرحلة الثانوية أثناء الخدمة لتدريس منهج الأحياء (دراسة تقويمية)

الملخص

هدف البحث إلى تحديد مهارات التعليم الرقمي اللازمة لمعلمي الأحياء بالمرحلة الثانوية أثناء الخدمة، والتعرف على مدى توافرها لديهم، وتقديم تصور مقترح لبرنامج تدريبي لمعلمي الأحياء بالمرحلة الثانوية لتنمية تلك المهارات، وتم استخدم المنهج الوصفي والمنهج التجريبي، وتكونت أدوات البحث من قائمة بمهارات التعليم الرقمي، واستبانة للتعرف على مدى توافر مهارات التعليم الرقمي لدى معلمي الأحياء بالمرحلة الثانوية، برنامج تدريبي مقترح لمعلمي الأحياء أثناء الخدمة لتنمية تلك المهارات، وبطاقة ملاحظة لمهارات التعليم الرقمي، وطبق البرنامج على مجموعة من معلمي الأحياء بالمرحلة الثانوية، بلغ عددها (١٨) معلمًا بمحافظة دمياط في الفصل الدراسي الأول للعام (٢٠٢٢-٢٠٢٣م)، وأشارت النتائج إلى توافر مهارات التعليم الرقمي لدى معلمي الأحياء بالمرحلة الثانوية بدرجة ضعيفة، كما توصلت النتائج إلى فاعلية البرنامج التدريبي في تنمية مهارات التعليم الرقمي لدى معلمي مجموعة البحث.

الكلمات المفتاحية:

مهارات التعليم الرقمي- معلمي الأحياء أثناء الخدمة – منهج الأحياء.

Introduction

Today's world is witnessing several challenges as a result of the tremendous scientific and technological changes, developments and discoveries in all aspects of life. These challenges have impacts on various life activities, most among which is the educational process. Thus, there is a pressing need for educational institutions to keep up with the demands of the new digital age, and prepare individuals who are capable of responding to those demands.

The demands of the digital have significant impacts on education. For example, knowledge resources have diversified, teaching and learning activities are less traditional and more innovative, and individuals no more rely on external sources to access information. That is, modes of learning/teaching have significantly changed. Instead of relying on the teacher as the transmitter of knowledge, students are more engaged on student-centered activities. Moreover, new types of education have emerged, such as distance education, computer-assisted education, online learning (e-learning), and virtual learning environments (Balyer & Öz, 2018,811).

The Ministry of Education and Technical Education (MOETE) was keen on taking measures towards gradual digital transformation of the educational system in Egypt. That is, it provided digital educational content to help students find learning resources other than traditional textbooks. The digital resources included a platform for direct broadcasting of virtual classes, the Edmodo platform for communication and research presentation, the Egyptian Knowledge Bank platform, the learning management platform (LMS), and the electronic examination platform designed for secondary school students (Ministry of Education, 2021,1).

Pre-service and in-service preparation programs for biology teachers, thus, should be restructured in ways that manifest the optimal outcomes of curriculum development and implementation. Towards this purpose, it is necessary to integrate digital education into the educational process and qualify teachers who are capable of delivering digital resources and curricula. It is also necessary to promote the use of digital teaching methods, strategies and assessment mechanisms, as well as create conducive digital educational environments. In this sense, the educational development processes in this digital age should place more emphasis on teachers who are considered the cornerstone of optimal educational reform. Teachers play a very important role in educating students in the best ways to achieve educational outcomes. This huge responsibility requires teachers to change their traditional roles from transmitters of knowledge and rote-teaching to new "facilitator" roles that keep pace with the digital

transformation era and adapt to new technologies and curricula (Kavak, Arik, Çakir, & Arslan, 2016, 309).

In order for digital education to achieve its purposes, it is imperative to integrate information and communication technology in the teaching and learning processes. It is equally necessary for teachers to understand and comply with the current demands that enable them to achieve these goals. These demands were evident in recent research (e.g. Al-Haroun & Barakat, 2019; Nawar, 2019; Hassan, 2019; Ibrahim, 2020; Al-Jizawi, 2020).

Statement of the Problem

Digital technology has become basic demand in societies nowadays, imposing many challenges on the educational systems. Traditional educational institutions, thus, can no longer keep up with contemporary developments. New modes of education, such as digital education, were developed in order to achieve the sustainable development strategy and Egypt's Vision 2030 toward educational reform. Consequently, teachers must possess the digital competencies necessary for the new educational reform and use those competencies that are most suitable for teaching the content of the biology curriculum.

Conference recommendations highlight the need for promoting teachers' digital and pedagogical competencies. For example, "Education and the Future" conference, which was organized by the Sharjah Teachers Association in the United Arab Emirates, discussed a "digital teacher model". In that conference, educators emphasize the need for digitally qualified teachers to keep pace with the information revolution and scientific and technological developments (Al Shamsi, 2018). Moreover, the first international conference at Cairo University for Digital Education entitled Digital Education in the Arab World - Challenges and Prospects, stress the need to provide teacher-preparation institutions with digital education programs. It also highlights the need to train teachers on how to use digital competencies for the best avail of the educational process (The Arab Institution for Education, Science and Arts, 2018).

Recent research, however, indicates that teacher preparation and training programs are inadequate to provide the skills necessary for teachers in the digital age. For example, a study by Bedir (2019) indicates that pre-service teacher preparation programs are rather focused on general teaching skills. Another study conducted by Ibrahim, Adzra'ai, Sueb, & Dalim (2019) reveals that mainstream teacher training programs hardly contribute to developing future teachers' skills that are necessary for the profession. Moreover, several studies recommend professional development for teachers and call for training teachers on modern trends and solutions in digital education (e.g. Al-Shammari, Al-Taie, & Mohamed,

2019; Al-Sari et al., 2021; Zaragoza, Díaz-Gibson, Caparrós & Solé, 2021). Accordingly, educational programs should provide teachers with knowledge and skills that enable them to use technology in their teaching, deal with electronic curricula and assessments, and stay connected with learners using electronic media and devices.

Research Problem

In this respect, there was a compelling need to investigate digital education skills necessary for in-service biology teachers. Thus, the current research was an attempt to answer the following questions:

1. **What are the digital education skills necessary for in-service secondary school biology teachers to enable them to deliver the biology curriculum?**
2. **To what extent do the in-service secondary school biology teachers possess these digital education skills?**
3. **What is the proposed framework of a training program for developing the in-service secondary school biology teachers' digital education skills?**
4. **How effective is the proposed training program in developing the in-service secondary school biology teachers' digital education skills?**

Research Objectives

1. **Determining the digital education skills needed for in- service secondary-stage biology teachers, and how far they possess these skills.**
2. **Preparing a training program to develop in-service teachers' digital education skills.**
3. **Investigating the effectiveness of the proposed training program in developing in-service biology teachers' digital education skills.**

Research Significance

1. **Keeping pace with modern trends that emphasize the need to employ technology in the educational process.**
2. **Shedding light on the reality of in-service biology teachers' practices of digital education skills.**
3. **Directing the attention of those in charge of designing training programs for science teachers in general and biology teachers in particular to the importance of developing digital education skills.**
4. **Supporting biology instructors by providing a checklist of digital education skills that represent a frame of reference to be used when evaluating the performance of biology teachers with regard to digital education.**

Research materials and tools

The following materials and tools were prepared: (prepared by the researcher)

1. **A checklist of digital education skills necessary for secondary-school biology teachers.**
2. **A questionnaire to measure how far in-service secondary-school biology teachers possess these digital education skills.**
3. **A proposed framework of a training program for developing in-service biology teachers' digital education skills.**
4. **An observation checklist for measuring the digital education skills of the biology teachers.**

Research delimitations

1. **The questionnaire was administered to a group of 40 in-service biology teachers to determine the availability of digital education skills**
2. **The training program was administered to a group of in-service biology teachers at the secondary stage (N=18) at Damietta Governorate.**
3. **A training program via Zoom in the first semester of the academic year 2022/2023 AD.**

Research Method

1. **The descriptive method was used in this research for preparing a questionnaire about the digital education skills necessary for in-service secondary school biology teachers, as well as the proposed training program and the observation checklists.**
2. **The experimental method was used to investigate the effectiveness of the proposed program in developing in-service secondary school biology teachers' digital learning skills (one-group pre-post design).**

Research terminology

In view of a number of different definitions, these terms can be defined operationally as follows:

Digital Education Skills:

A set of knowledge and skills that enable the biology teacher at the secondary stage to use educational content, including activities, educational techniques, and tests digitally, to achieve the objectives of teaching the biology curriculum. They are measured by the score that the teacher obtains on the observation checklist prepared for that purpose.

In-service Secondary-stage Biology Teachers:

The person officially appointed by the Ministry of Education to be in charge of all aspects of the educational process pertaining to the secondary-stage biology curriculum to achieve optimal educational outcomes.

Review of literature and related studies

First: Digital Education

Digital technology is gaining grounds in all facets of life, and it has become one of the basic requirements in the field of education in particular. Thus, there is a pressing need to find new methods and curricula that keep pace with the requirements of this digital era. In response to this, digital education has emerged as one of the new alternative types of education. Recent research addressed various definitions of digital education. For example, Abdul-Ati, Abu Khatwa, and al-Husari (2012, 22) defined it as the use of technology in delivering information to learners with the least time and effort. It, they maintained, involves synchronous and asynchronous learning, inside or outside the classroom. Al-Sawry (2019, 37), on his part, defined it as education that achieves instant communication between students and teachers through electronic networks. Moreover, Sayed and Abdel Qader (2020, 533) referred to it as education that depends on electronic media to achieve communication between teachers, learners and educational institutions, and aims at creating technology-rich interactive environments that enable students to access learning resources at any time and from anywhere. Furthermore, Kamal (2022, 10) defined it as a type of education that takes place in a digital environment. It depends on the use of digital electronic media of all kinds in the processes of planning, implementing and evaluating instruction and aims at providing educational content, activities, skills and tests in digital form to make room for electronic interaction and communication between teachers and students. Al-Adil and Al-Adil (2022, 681) also pointed out that it is the process of facilitating learning by using multiple digital media or technologies to provide educational content to students through computers, mobile phones and the internet. All previously mentioned definitions indicate that digital education aims towards delivering content and promoting interaction between teachers and students using electronic and web-based resources to achieve optimal educational outcomes.

Digital education could play a major role in promoting teachers' twenty-first century skills. That is, it could help them become fully engaged in the learning process, breaking through the time and space limitations. Moreover, it could help them to communicate, collaborate and stay connected, as well as develop their skills of using multimedia and complete their learning process through online platforms (Kamal, 2022, 4). It also aims at meeting various academic and educational needs of students to make learning fun and achieve the goals of the educational process (Harb, 2017, 100).

Al-Tamizi (2013) equally highlighted several advantages of digital education. For one thing, learners could be provided with immediate

feedback while working on digital tasks and tests. Furthermore, asynchronous digital education would offer opportunities to have new paradigms for learners to study at their own pace and have access to the same resources at the same time. Moreover, it would provide personalized, time-saving educational methods that attract learners' attention and address large numbers of learners at the same time.

Sayed and Abdul Qadir (2020, 526) indicated that integrating digital education could possibly contribute to creating an educational environment that provides learners with functionally diverse and engaging learning experiences, promotes lifelong learning, and fosters information use. Ali and Ishalal (2011, 415) explained several types of digital education:

- **Direct digital education: It concerns with educational methods and technologies that rely on the web for delivering real-time content on education and/or training. It involves direct interaction between the teacher and students in virtual classes or through audio and video conversations.**
- **Indirect digital education: This type of digital education takes place in circumstances and conditions where learners are unable to attend classes physically. Thus, it is mediated through a set of training courses and classes that are indirectly organized between the teacher and learners using digital applications such as e-mail and social media.**

  Al-Adil, and Al-Adil (2022, 681:685) referred to a set of digital education tools, including Microsoft Teams, Power Point presentations, YouTube technology, Zoom platforms, and Google search engines. Moreover, Abdul-Ati, Abu Khatwa, and Al-Husari (2012, 28) highlighted some digital education resources, such as: electronic discussion forums, digital libraries, electronic conferences, electronic books and magazines, electronic whiteboards, and online educational websites.

Digital Education Skills for In-service Biology Teachers

Teachers are the cornerstone in the educational process, and they play a crucial role in achieving curriculum aims. Since the use of technology in the educational process is important to bring about global digital transformation, the professional development of teachers is a pressing need to keep up with these changes and demands. Moreover, the experience of online education, especially at the time of school lock-down due to COVID-19 pandemic, has raised many challenges and fears for teachers concerning activities, tasks and assignments, which required schools and teachers to be prepared and qualified with skills and capabilities to face such issues.

Therefore, digital education has imposed some requirements in general secondary schools which include reconsidering pertinent skills necessary for

teachers to implement digital education and developing these skills through continuous training and professional development. Hence, Al-Haroun and Barakat (2019, 429) identified these requirements including the need for change as the starting point. They also highlighted major requirements such as training students to manage time well when dealing with digital education applications, training teachers and administrators to use new technologies and web-based instructional materials, and developing detailed action plans to promote teachers' missing digital assessment skills. This requires educational stakeholders to provide conducive teaching and learning environments. This is only possible by qualifying teachers who are capable of using information and communication technology in education to achieve optimal outcomes and providing the necessary infrastructure for achieving that (Shewei, 2011).

Training teachers to use modern technologies has become an academic and professional demand. That is, using technological applications in education and assessment has become an inevitable necessity, and teachers need to employ modern technology in the educational process, unlike his/her former role which solely confined to initiation (Al-Sherman, 2013). A study conducted by Gorbunova and Hiner (2019) confirmed that the changes witnessed in digital educational environments had impacts on teachers. Namely, teachers were required to develop their teaching processes and skills to keep pace with the digital age demands. Moreover, Hassan's study (2019) consisted with Gorbunova and Hiner's regarding the importance of providing electronic professional development for teachers to foster their skills in using different technologies, preparing conducive learning environments, and developing needs-assessment plans to estimate current and future needs.

Research addressed several classifications of digital education skills necessary for teachers. Gruszcznska, Merchant and Pountney (2013, 203) identified them as a set of skills that an individual should possess to access online resources, to search for and edit digital information, and to interact with information online. Al-Jizawi (2020, 283) defined them as a set of digital twenty-first century skills necessary for pre-service biology teachers for success at the personal and professional levels. These skills, she maintained, include technology research, information literacy; obtaining, using and managing information; information and communication literacy, and learning with technology. Al-Yami (2020, 44- 45), on her part, defined them as the knowledge and skills that the teacher needs for teaching; whether teaching is completely or partially digital, in what is called the digital or the twenty-first century age that is centered on digital technology. She identified these skills in the following:

- **Digital skills: they include attaining content of open-source electronic courses, using appropriate technological tools for tasks and using digital techniques as a learning tool.**
- **Communication and collaboration skills: Examples include using various media and techniques, connecting with oral, written and digital communication skills as well as working effectively and flexibly with different teams.**
- **Thinking skills: They include integrating thinking skills in teaching, training students on solving and dealing effectively with problems as well as managing discussions among students.**
- **Digital knowledge management skills: They include managing the flow of information from various sources, attaining information effectively using various sources and sharing information.**
- **Life and professional skills: They involve benefitting from feedback in improving performance, embrace work morals and holding responsibility towards others.**

Sharma (2017, 13-14) pointed out that in the digital age teachers need theoretical knowledge besides practical skills to keep pace with changes in the educational environments. Therefore, the teacher has to possess several teaching skills such as communication skills, technological skills like creating YouTube videos and making discussions through the internet and thinking skills like critical thinking, creative thinking, problem solving as well as managing knowledge and obtaining it from various sources.

Furthermore, Ibrahim (2020, 325) stated that the most important skills that a teacher should possess are the ability to foster students' cooperative learning through group-learning tasks, and the ability to interact via educational platforms. Ibrahim further argued that the most common channels to interact with students digitally are WhatsApp and Facebook groups. Serezhkina (2021, 1-2) defined digital education skills as a set of knowledge, skills, and attitudes that allow teachers to achieve educational outcomes through using digital technologies in education and promote their digital literacy. These skills, Serezhkina maintained, include digital and general twenty-first century skills required by teachers such as technology, information and communication management, collaboration, creativity, critical thinking, problem solving, ethical awareness, cultural awareness, flexibility, self-reliance and continuous learning. Kamal (2022, 18) classified digital education skills in three main categories; use of digital learning resources in lesson planning, in implementing, and in assessment. Finally, Thoms, Colberg, Heiniger and Huwer (2022, 4) highlighted six important skills for science education: documentation, presentation, collaboration/communication, information search and evaluation, data acquisition, data processing, simulation and modeling.

In this context, the current researcher defined digital education skills necessary for biology teachers as a set of knowledge and skills that enable the biology teacher at the secondary stage to use educational content, including activities, educational techniques, and tests, digitally to achieve the objectives of teaching the biology curriculum. These objectives include the following main skills: dealing with the computer and the internet, dealing with learning management systems (LMS) for teaching biology, dealing with the content of digital biology curricula, using digital education strategies in teaching biology, and digital evaluation of biology learning outcomes.

Several studies emphasized the importance of developing digital education skills among science teachers in general and biology teachers in particular. For example, Al-Shammari, Al-Taie, and Mohamad (2019) investigated the training needs of science teachers in Saudi Arabia in light of modern educational trends. They recommended that in-service science teachers be trained on using e-learning and virtual experiences in the classroom. Moreover, Al-Jizawi's study (2020) was an attempt to improve the digital skills of biology student teachers at faculties of education in Egypt, using a program based on augmented reality. The study revealed the effectiveness of the proposed program in developing the target skills.

In addition, Al-sarie et al. (2021), on their part, investigated the digital education skills of middle-school science teachers in Riyadh. Their research findings indicated that middle-school teachers' digital education skills were developed to intermediate levels. The study concluded with recommendations pertinent to the need for preparing training courses for science teachers in the field of digital education. Thoms, Colberg, Heiniger and Huwer (2022) equally investigated the digital competencies needed to teach scientific subjects and train student teachers on them at Thurgau University of Education in Switzerland. Findings indicated that teachers would need subject-specific digital competencies in addition to general pedagogical digital competencies to teach science. These competencies include using storage systems (such as school cloud storage, WLAN storage, and NAS) and using social media applications (e.g. Zoom, Microsoft Teams, Skype, MS Teams, Webex, Skype or Adobe Connect). Other competencies include data documentation and archiving (e.g. genes, databases), using digital representations of some processes (e.g. slow motion animation and 3D simulations of molecular vibrations), and using virtual laboratories for temperature, voltage and pH measurements.

Research hypotheses:

In the light of previous studies and literature, the current research sought to validate the following hypotheses:

1. **The level of availability of digital learning skills for in-service biology teachers is less than the adequacy limit, which is 75% [*].**
2. **There is a statistically significant difference at ≤ 0.05 between the mean rank scores of the research group in the pre and post applications of the digital education skills observation checklist as a whole and for each of its dimensions in favor of the post application.**

Research Procedures

To answer the first question: "What are the digital education skills required for in-service secondary-stage biology teachers to teach biology curriculum?", the researcher prepared a checklist of these skills according to the following steps:

- **Determining the aim of the checklist: to identify the digital education skills required for secondary stage biology teachers.**
- **Identifying the sources of preparing the checklist: reviewing literature and previous studies pertinent to digital education skills, (e.g. Al-Haroun & Barakat, 2019; Al- Jizawi, 2020; Al-Sarie et. al., 2021; Ibrahim, 2020; Shabana, Al-Dahshan & Badawi, 2021; Egypt vision for sustainable development 2030).**
- **Preparing the checklist in its initial version: the researcher specified a number of 5 main skills and 28 sub-skills and submitted it to a jury of specialists in science curriculum and instruction to express their opinions and suggestions about the importance of these skills.**
- **Setting the checklist in its final version after modifying it in the light of the jury members' opinions. The checklist contained 5 main skills and 28 sub-skills (Appendix 1)[*] as shown in table 1.**

Table 1

Digital educational skills required for secondary stage biology teachers

No.	Main skill	Subskills
1	Dealing with computer and the internet	7
2	Dealing with learning management systems (LMS) for teaching biology	5
3	Dealing with the content of digital biology curricula.	5
4	Using digital education strategies in teaching biology	6
5	Digital evaluation of biology learning outcomes	5
	Total	28

To answer the second question: "To what extent do in-service secondary-stage biology teachers possess digital education skills?", the researcher prepared a questionnaire according to the following steps:

[*] The sufficiency limit is 75%, which is equivalent to an arithmetic mean greater than (2.25).

[*] Appendix 1: Digital education skills list

- **Identifying the aim of the questionnaire: How far biology teachers master digital education skills.**
- **Preparing the initial version of the questionnaire: it consisted of 5 main domains including 28 items designed in light of the checklist.**
- **Submitting the questionnaire to a jury of specialists to express their opinions and suggestions about the importance of these skills. Then, the researcher modified the questionnaire according to their opinions.**
- **Piloting the questionnaire: The questionnaire was piloted, administering it to a group of 10 biology teachers in Damietta governorate to identify the following:**
  - **Reliability: The researcher used Alpha Cronbach's Coefficient to calculate the reliability of the questionnaire that was estimated as 0.87. This indicates that the questionnaire is highly reliable.**
  - **Internal validity: The correlation coefficient between the score of each domain and the total score of the questionnaire was calculated and shown in table 2.**

Table 2

Correlation coefficient between each domain and the total score of the questionnaire

No.	Domains	Items	Correlation coefficient
1	Dealing with computer and the internet	7	0.82
2	Dealing with learning management systems (LMS) for teaching biology	5	0.80
3	Dealing with the content of digital biology curricula.	5	0.80
4	Using digital education strategies in teaching biology	6	0.81
5	Digital evaluation of biology learning outcomes	5	0.83

Table 2 indicates that the correlation coefficient between each domain and the total score of the questionnaire is statistically significant at 0.01. This means that all the domains are correlated with the questionnaire and the items are highly valid.

- **The final version of the questionnaire: it was set in its final version [*](see appendix 2) which included 5 main domains and 28 items. A 3-point Likert scale was used to grade the teachers' responses (3 for highly available, 2 for available with average degree and 1 for unavailable or weak). The criterion of judging the availability of the skills is calculated according to the mean value as shown in table 3.**

[*] **Appendix 2: A questionnaire to determine the availability of digital education skills among biology teachers**

Table 3

3-point Likert scale and estimating the degree of verification according to the mean score

Availability degree	High	Average	Weak
Weight	3	2	1
Probable mean	2.34- 3	1.67- 2.33	1- 1.66

To answer the third question: What is the proposed framework of a training program for developing digital education skills for in-service secondary stage biology teachers? The training program was prepared according to "COMP" model for instructional design (Al-Saraya, 2007) as follows:

1. **Identifying the general aim of the training program; that is developing digital education skills for in-service biology teachers.**
2. **Identifying the program target group and their characteristics: in-service Biology teachers at the secondary stage.**
3. **Identifying the learning objectives of the program.**
4. **Determining the duration of the program: it lasted for 20 hours distributed on five weeks with two sessions a day. Each session took two hours.**
5. **Determining the content of the proposed program: It included a group of main topics for developing digital education skills (The basics of digital education, LMS learning management systems, programs used in the virtual classroom, digital education strategies, and digital evaluation of biology learning outcomes) divided on ten sessions. as shown in table 10.**

Table 10

The content of the training program and timeline

Week	Content	Number of sessions	Number of hours
First	The basics of digital education	2	4
Second	LMS learning management systems for Biology Teaching	2	4
Third	programs used in the virtual classroom to teach the content of digital biology curricula.	2	4
Fourth	Digital education strategies in teaching biology	2	4
Fifth	Digital evaluation of biology learning outcomes	2	4
Total		10	20

6. **The pretesting: the trainees' prior experiences were detected through applying the observation checklist before the program.**
7. **Choosing the training methods: Training methods vary from lecture, discussion, presentations, Zoom platform and workshops.**
8. **Identifying the teaching aids and instructional techniques: Some electronic websites, educational videos and practical illustrations were used.**

9. **Determining the evaluation methods: The performance of the trainees during the training program, the interaction between the trainer and the trainees as well as the practical application of skills were evaluated through individual and group worksheets. In addition, the final evaluation is done using observation checklist. Besides, the trainers' performance is evaluated at the end of each training session using a special form that each trainee fills.**
10. **Adjusting the proposed framework: it was submitted to a group of specialists in science curriculum and instruction to express their opinions on how applicable it is, and the modifications were made according to their opinions. The final version of the framework is shown in appendix 3[*].**

To answer the fourth question "What is the effectiveness of the proposed training program on developing in-service secondary-stage biology teachers' digital education skills?"

The researcher prepared an observation checklist for digital education skills using the following procedures:

- **Determining the aim of the observation checklist to identify the level of biology teachers' digital education skills.**
- **Designing the observation checklist in light of the pre-determined 5 digital education skills and 28 associated indicators. The researcher assigned 5 performance levels (very high, high, medium, low and very low) corresponding to the following grades (4, 3, 2, 1, 0) respectively.**
- **Submitting the checklist to a jury of specialists to express their opinions about the clarity of the checklist statements and their appropriateness to measure the level of these skills. The necessary modifications were made in light of their opinions and suggestions.**
- **Checking the checklist's reliability: It was administered to 10 biology teachers (other than the study group) and its reliability was 0.90 as calculated by Cronbach's alpha coefficient, which proved that the checklist was highly reliable.**
- **To ascertain the checklist reliability: The reliability was calculated using the inter-rater agreement method. The researcher asked another colleague specialized in biology to apply the observation checklist and the agreement percentage was calculated. The average percentage of inter-rater agreement was 87% and it is considered a high rate, indicating that the observation checklist is valid and reliable.**

[*] **Appendix 3: A training program for in-service secondary stage biology teachers**

- **The final version of the checklist: It was valid to administer to the study group and it consisted of 28 indicators distributed as follows: 7 for the first skill, 5 for the second, 5 for the third, 6 for the fourth and finally 5 for the fifth[*].**

Experimental Research Procedures:

- **The research group: The research was applied on 18 in-service secondary stage biology teachers in the first semester of the academic year 2022/2023.**
- **Implementation of the program:**
  - **The pretesting of the research tool: The observation checklist was administered to biology teachers to measure their digital educational skills before the experiment. The researcher asked each trainee to plan one of the biology topics digitally to identify how far he/she master digital education skills and evaluating him/her before teaching the program.**
  - **Teaching the program: The program lasted for 20 hours with two sessions per week. Every session took two hours and the program covered five weeks.**
  - **The post testing of the research tool: After teaching the program, the researcher asked each trainee to plan one of the topics in biology to check how far they mastered the digital educational skills. The lesson was assessed using the observation checklist. The results were observed and statistically analyzed.**

Research results, discussion and interpretation

First: The research results

To verify the first hypothesis: ***The level of availability of digital learning for in-service biology teachers is less than the adequacy limit, which is 75%,*** **the mean scores and the degree of availability of each digital education skill were calculated as follows:**
The results of the first domain (Dealing with the computer and the interne) are shown in table 4.

[*] **Appendix 4: Digital education observation checklist**

Table 4

The frequencies, percentage and mean scores for the availability of the skills of the first domain and their ranks

No	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
		χ	%	χ	%	χ	%			
1	Dealing with different computer programs	9	22.5 %	10	25%	21	52.5 %	1.7	average	4
2	Using different operating systems such as windows, Android.	8	20%	22	55%	10	25%	1.95	average	3
3	Creating and managing electronic files.	7	17.5 %	11	27.5%	22	55%	1.62	weak	6
4	Using cloud storage services such as Google Drive.	7	17.5 %	11	27.5%	22	55%	1.62	weak	6
5	Having conversations over the internet.	10	25%	23	57.5%	7	17.5 %	2.07	average	2
6	Using search engines in the educational process.	12	30%	21	52.5%	7	17.5 %	2.13	average	1
7	Using the electronic mail in the educational process.	6	15%	14	35%	20	50%	1.65	weak	5
Dealing with the computer and the internet								1.82	average	

Table 4 indicates that the mean score of *dealing with the computer and the internet skill* is 1.82, which lies within the average level of availability according to table 3. This indicates that this skill is available among teachers with an average degree except the skill of *using electronic mail in the educational process*, which was inadequately exhibited (mean = 1.65) and came in the fifth rank. After that skill comes the skills of *creating and managing electronic files* and *using cloud storage services such as Google Drive* with a mean of 1.62, and they came in the sixth rank.

The results of the second domain (Dealing with learning management systems (LMS) for teaching biology) are shown in table 5.

Table 5

The frequencies, percentage and mean scores for the availability of the skills of the second domain and their ranks

No.	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
		χ	%	χ	%	χ	%			
1	Using learning platforms such as Google Classroom in biology teaching	6	15%	9	22.5%	25	62.5%	1.52	weak	4
2	Creating a virtual classroom to teach the biology	5	12.5%	10	25%	25	62.5%	1.5	weak	5

No.	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
		χ	%	χ	%	χ	%			
	curriculum.									
3	Adding scientific topics and activities to the virtual classroom.	7	17.5%	12	30%	21	52.5%	1.65	weak	3
4	Organizing the presentation of topics and discussions among students.	6	15 %	2322	55%	12	30%	1.85	average	1
5	Monitoring students' activities online.	6	15%	20	50%	14	35%	1.8	average	2
Dealing with learning management systems								1.66	weak	

Table 5 indicates that the mean score of *dealing with learning management systems (LMS) for teaching biology* is 1.66, which indicates that it is scarcely available among teachers. The skill *of organizing the presentation of topics and discussions among students* is the most exhibited by the biology teachers in their practice at an average level (mean score = 1.85), and it comes in the first rank. Then, the skill of *monitoring students' activities online* comes in the second rank (mean =1.8) and the rest of the skills were barely available. Finally, the least available skill is *creating a virtual classroom*, which comes in the fifth rank with a mean of 1.5.

The results of the third domain "Dealing with the content of digital biology curricula" are shown in table 8.

Table 8

The frequencies, percentage and mean scores for the availability of the skills of the third domain and their ranks

No.	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
		χ	%	χ	%	χ	%			
1	Using digital educational content for the biology curriculum.	6	15%	11	27.5%	23	57.5 %	1.57	weak	3
2	Searching in digital repositories within the ministry's website and the Knowledge Bank	6	15%	10	25%	24	60%	1.55	weak	4
3	Using digital educational technologies related to	7	17.5%	10	25%	23	57.5 %	1.6	weak	1

No.	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
	biology topics such as YouTube and e-books.									
4	Using scientific drawings in the virtual classroom.	5	12.5%	9	22.5%	26	65%	1.48	weak	5
5	Preparing electronic activities for allowing students to search though the internet.	7	17.5%	9	22.5%	24	60%	1.58	weak	2
Dealing with the content of digital biology curricula								1.54	weak	

Table 8 indicates that the mean score of *dealing with the content of digital biology curricula skill* is 1.54, which indicates that it is barely available among teachers. The skill of *using digital educational technologies related to biology topics* is the most exhibited skills by biology teachers in their practice with a mean score 1.6, and they come in the first rank. The least available and practiced skill is *using scientific drawings in the virtual classroom* which comes in the fifth rank (mean =1.48).

The results of the fourth domain (Using digital education strategies in teaching biology) are shown in table 6.

Table 6

The frequencies, percentage and mean scores for the availability of the skills of the fourth domain and their ranks

No.	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
		χ	%	χ	%	χ	%			
1	Using teaching strategies appropriate to the content of the digital biology curriculum.	5	12.5%	13	32.5%	22	55%	1.58	weak	4
2	Explaining biology lessons using digital programs.	6	15%	14	35%	20	50%	1.65	weak	3
3	Using suitable programs for the virtual classroom, such as Microsoft teams - Zoom.	5	12.5%	13	32.5%	22	55%	1.57	weak	5
4	Controlling the programs used in the virtual classroom to	5	12.5%	11	27.5%	24	60%	1.52	weak	6

No.	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
	control and follow up students.									
5	Managing time well when dealing with digital education applications.	6	15%	22	55%	12	30%	1.85	average	2
6	Employing digital learning resources (text, pictures, audio and videos) to make students more active.	45	12.5%	25	62.5%	10	25%	1.87	average	1
Using digital education strategies in teaching biology								1.67	average	

Table 6 indicates that the mean score of *using digital using digital education strategies skill* is 1.67, which indicates that it is moderately available among teachers. The skill of *employing digital learning resources* is the most commonly exhibited by the biology teachers in their practice at an average level (mean score = 1.87), and it comes in the first rank. Then, the skill of *managing time well* comes in the second rank. The rest of the skills were barely available, and the least available skill is *controlling the programs used in the virtual classroom*, which comes in the sixth rank (mean = 1.52).

The results of the fifth domain "Digital evaluation of biology learning outcomes" are shown in table 7 below.

Table 7

The frequencies, percentage and mean scores for the availability of the skills of the fifth domain and their ranks

No	Statement	highly available		available with average degree		unavailable		Mean	D.f	Rank
		χ	%	χ	%	χ	%			
1	The use of different types of evaluation electronically (pre, structural, diagnostic, final)	3	7.5%	8	20%	29	72.5%	1.55	Weak	2
2	Diversity of digital evaluation methods and tools (short exams, achievement files)	6	15%	12	30%	22	55%	1.6	Weak	1
3	Preparing electronic question banks for students.	5	12.5%	10	25%	25	62.5%	1.5	Weak	3

4	Preparing electronic assignments and tests.	5	12.5%	14	35%	21	52.5%	1.6	Weak	1
5	Evaluation of instructional assignments electronically.	7	17.5%	10	25%	23	57.5%	1.5	weak	3
Digital evaluation of biology learning outcomes								1.55	weak	

Table 7 indicates that the mean score of using *digital evaluation* skill is 1.55, which indicates that it is barely available among teachers. The skill of *diversity of digital evaluation methods* and the skill of *preparing electronic assignments and tests* are the most exhibited skills by biology teachers in their practice with a mean score 1.6, and they come in the first rank. The least available skills are *preparing electronic question banks and evaluation of instructional assignments electronically,* and they come in the third rank with a mean of 1.5.

Thus, the digital educational skills exhibited by in-service secondary stage biology teachers according to the questionnaire as a whole are ranked in the following table

Table 9

The mean scores and the degree of availability for the total digital educational skills of in-service secondary stage biology teachers and their rank

No.	Subskills	Mean	D.f	rank
1	Dealing with the computer and the internet	1.82	average	1
2	Dealing with learning management systems (LMS) for teaching biology	1.66	weak	3
3	Dealing with the content of digital biology curricula	1.56	weak	4
4	Using digital education strategies in teaching biology	1.67	average	2
5	Digital evaluation of biology learning outcomes	1.55	weak	5
Total digital educational skills		1.65	weak	

Table 9 indicates that the mean score of the total digital educational skills for secondary stage biology teachers is 1.65, and this shows that these skills are inadequately available among teachers. The mean scores of the sub-skills ranged between 1.55 and 1.82, and the skill of *dealing with the computer and the internet* comes at the top of the digital education skills, followed by the skill of *using digital education strategies in teaching biology*, then the skill of *dealing with learning management systems*, followed by the skill of *dealing with the content of digital biology curricula* and finally the skill of *digital evaluation, All of them less than sufficiency limit 75%.*

Thus, the first hypothesis is verified.

To verify the second hypothesis: ***There is a statistically significant difference at ≤ 0.05 between the mean rank scores of the research group in the pre and post applications of the digital education skills observation checklist as a whole and for each of its dimensions in favor of the post application*****, the non-parametric statistical method Wilcoxon Test for correlated samples was used to verify the difference significance between the mean ranks of the pre and post applications of the observation checklist. The effect size was calculated to determine the effectiveness of the proposed program. The results were shown in table 11.**

Table 11

Difference significance between the mean ranks of the research group in the pre and post measurements on the digital educational skills observation checklist and for each skill

skills	Rank	No	Mean Rank	Sum of Ranks	Value (Z)	P-value	Effect size
Dealing with the computer and the internet	Negative	0	0	0	3.74	0.01	0.88
	Positive	18	9.5	171			
	Ties	0	0	0			
Dealing with learning management systems	Negative	0	0	0	3.75	0.01	0.88
	Positive	18	9.5	171			
	Ties	0	0	0			
Dealing with the content of digital biology curricula	Negative	0	0	0	3.77	0.01	0.89
	Positive	18	9.5	171			
	Ties	0	0	0			
Using digital education strategies in teaching biology	Negative	1	2.5	2.5	3.43	0.01	081
	Positive	15	8.9	133.5			
	Ties	2	0	0			
Digital evaluation of biology learning outcomes	Negative	0	0	0	3.73	0.01	0.88
	Positive	18	9.5	171			
	Ties	0	0	0			
Total skills	Negative	0	0	0	3.72	0.01	0.87
	Positive	18	9.5	171			
	Ties	0	0	0			

Table 11 shows the following:

- **The calculated Z-value for each subskill and the for the total digital education skills were all statistically significant at 0.01. Hence, this result indicates that there is a statistically significant difference between teachers' mean ranks in the pre and post applications of the observation**

checklist as a whole and for each of the assessed skills in favor of the post application. This could be ascribed to the training program.

- **To calculate the effectiveness of the program in developing these skills, the effect size values for each of the subskills and the total digital education skills were calculated. They ranged between 0.81 and 0.89 which are all greater than 0.7 and less than 0.9 (Abdel Hafeez, Bahi & Al-Nashar,2004, 68). Thus the program had a large effect size on developing the total digital education skills and each of its subskills.**
- **Hence, the second hypothesis was verified.**

Discussion of results

First: The results of the availability of the digital education skills among in-service secondary-stage biology teachers revealed that these skills were poor. The skill of *dealing with the computer and the internet* came in the first rank followed by the skill of *using digital education strategies*, then the skill of *dealing with learning management systems*, and the skill of *dealing with the content of digital biology curricula* and finally the skill of using *digital evaluation*. This result is attributed to the following:

- **Teacher's negative attitudes towards digital education, which makes them demotivated or not keen enough to improve their skills continuously.**
- **The limited courses offered to biology teachers in the field of digital education. Even current courses failed to keep up with the technological developments nor consider the actual needs of teachers, such as identifying electronic teaching strategies and evaluation methods, preparing electronic tests, dealing with digital curricula and books as well as training them to communicate electronically with students.**
- **The poor professional development programs for biology teachers and their use of traditional methods to present content.**
- **Combining face-to-face and digital education represents a difficulty for teachers to organize their time. This difficulty is also noticeable in their interaction with new methods of teaching, using digital content and activities in biology curriculum and employing digital evaluation methods without being trained on them.**

These results were consistent with the results of the study of Al-yami (2020) in Saudi Arabia and Al-Sarie et al. (2021) in Riyadh in the sense that both confirmed the poor levels of digital education skills among middle school teachers as these skills were available with an average degree.

Second: The results of implementing the proposed training program indicated the effectiveness of the program in developing biology teachers' digital education skills. The researcher attributes this result to:

- **Varying the training methods and activities that contributed to motivating the participants and attracting their attention during the training, which encouraged them to develop their skills.**
- **Training trainees to carry out many activities that develop digital education skills.**
- **Linking the program content to many digital education skills. Moreover, the program allowed trainees to acquire the skills of dealing with modern digital technology and employing it in teaching biology, using digital methods, strategies and evaluation methods and dealing with digital curricula.**
- **Providing constant avenues for interaction between the trainer and the trainees and offering them opportunities to discuss their ideas and send their activities and exercises online to evaluate them which contributed to boosting the participants' motivation to acquire these skills.**
- **Providing trainees with continuous feedback in the evaluation process and benefitting from it in the development of scientific content and training methods.**

These results were consistent with the results of previous studies (e.g. Abdel Wahab, 2016; Al-Shammari, Al-Taie & Mohammed, 2019; Al-Red, 2019; Shabana, Al Dahshan, & Badawi, 2021; Zaragoza, Díaz-Gibson, Caparrós & Solé, 2021). They all highlight the necessity of preparing and implementing training programs for in-service teachers to develop their digital technology use in teaching, designing electronic curricula and courses, monitoring electronic classrooms and preparing various forms of tests.

Recommendations

In light of the findings, the researcher recommends the following:

1- **Holding workshops and training courses for secondary-stage biology teachers to develop their digital education skills.**
2- **The necessity of training student teachers at faculties of education on digital education skills.**
3- **Holding scientific symposiums to promote biology teachers' attitudes towards digital education.**
4- **Providing a guideline for biology teachers to help them teach digital curricula.**

Further research

1. **Evaluating professional development programs of biology teachers in the light of digital education skills.**

2. **The effectiveness of the biology teacher preparation program in the faculties of education in developing digital education skills.**
3. **The effectiveness of the proposed training program in developing digital education skills for science teachers at preparatory stage.**

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