International Journal of Learning, Teaching and Educational Research
Vol. 21, No. 9, pp. 174-196, September 2022
https://doi.org/10.26803/ijlter.21.9.10
Received Jun 28, 2022; Revised Sep 8, 2022; Accepted Sep 28, 2022

Impact of a Digital Repository on Producing e-Courses for Mathematics Teachers

Essa A. Alibraheim
Imam Abdulrahman Bin Faisal University, Saudi Arabia

Hassan F. Hassan
Al-Azhar University, Egypt

Mohamed W. Soliman
Alexandria University, Egypt

Abstract. In light of the rapid and increasing spread of technology in all aspects of life, developing the skills for producing e-courses for teachers has become an important need. This empirical research aims at designing a digital repository based on interactive learning objects and measuring its impact on developing the skills necessary for producing e-courses based on Quality Matters (QM) standards for middle school mathematics teachers. We apply both a descriptive analytical approach and an experimental approach to achieve this objective. This empirical research was conducted on a random sample of 60 schoolteachers, who were randomly divided into two groups: an experimental one, consisting of 30 schoolteachers who were trained using the digital repository based on interactive learning objects; and the control, consisting of 30 schoolteachers who were trained using the traditional training method. The research tools consisted of an achievement test and a quality assessment card for e-courses based on QM standards. To analyse the data, an independent sample t-test was used. The results revealed that, in contrast with the control group, the experimental group acquired superior skills in designing and producing e-courses, as well as in the quality of e-courses. These results confirm the importance of using digital repositories based on interactive learning objects as one of the modern directions for future development in the production of e-courses based on QM standards for middle school teachers.

Keywords: digital repository; interactive learning objects; mathematics teachers; producing e-courses; quality matters standards

1. Introduction

Conducting education and training programs through the internet have recently gained greater importance as it ensures the components of education and training

* Corresponding author: Essa A. Alibraheim; *ealibraheim@iau.edu.sa*

are more easily accessible in comparison to conventionally conducted programs. However, designing these online educational and training components pose a major challenge in terms of choosing the instructional strategies, learning media, and learning style that allow the creation of digital content of high scientific value with efficient interoperability on most devices.

Part of e-courses' success as important educational resources relates to their availability at anytime, anywhere, without any need for conventional classroom settings. Also, running e-courses does not necessitate the presence of computers at the university or school campus. Additionally, students can use the e-course several times, with the ability to regularly watch the lectures (Aboukhatwa, 2010).

Several studies (e.g., Abu Azmah et al., 2012; Mousa et al., 2013) have emphasized the need to develop the skills in designing and producing e-courses for schoolteachers. On the other hand, those studies have also confirmed the existence of many challenges associated with the process of developing e-courses, such as the existent inaccuracies in many of the elements of developing these courses, which – more or less – look like a printed book, yet in electronic form. Furthermore, the results of those studies emphasize the need to pay attention to setting standards for developing e-courses.

Quality Matters (QM) standards are among the tools for evaluating modern e-courses and ensuring quality in e-learning in terms of their increasing recognition in United States, and abroad. According to the standards' website, QM standards have now become the most widely used criteria in evaluating the design of electronic courses (Quality Matters, n.d.).

Digital learning repositories can be employed in training programs to develop teachers' e-course design and production skills. It is worth noting that the application of what is known as the learning objects involves, among others, development, interaction, reuse, and the possibility of sharing the educational material for the training of teachers and students. It is to be noted that interactive learning objects refer to individual multimedia or hypermedia that can be used in various learning processes and stages (Abdelrahman, 2022). Those digital objects, which stand as independent entities, are easy to place within digital repositories across the web, are part of the learning process, and do greatly assist students in carrying out their cognitive processes (Yigit et al., 2014).

Cameron and Bennett (2010) show that the basic idea behind learning objects is that designers can create a small learning object that is flexible and unique, can be reused and adapted to suit different learning contexts, and can be stored on different digital media such as CD-ROM or DVD.

Abouelmmaati et al. (2015) emphasized the effectiveness of designing digital learning objects based on the combination of interaction patterns and audio media broadcasting technology to develop listening skills among first-year secondary students. Elnajar's study (2014) also confirmed a significant impact of learning objects in the e-learning environment in developing engineering drawing skills

and the tendency towards their use among Al-Aqsa University students in Palestine.

Digital Repositories are places to store and manage interactive learning objects in a practical and organized manner, with the possibility of search and retrieval through the metadata accompanying the learning objects available within them (Azmy, 2014).

Several studies (e.g., Khalil, 2012; Salem, 2011) emphasized the importance of digital repositories. Salem (2011) studied the effectiveness of designing and building an electronic repository of digital objects and publishing it online to develop English language teaching skills. Through his studies, Salem prepared a proposed model for designing and building digital repositories. Similarly, Khalil's study (2012) pivoted on the effectiveness of the digital learning units' repository in developing e-content design skills for graduate students in view of e-learning quality standards.

It is clear from the above that developing the skills of designing and producing e-courses for teachers is as important as employing digital learning repositories in both education and training arenas, as it can contribute to the development of design and production skills. In view of the foregoing, developing e-course production expertise according to the QM standards among middle school mathematics teachers is necessary. This need might be achieved through the design of a digital repository based on interactive learning objects.

1.1. Aims of the research

The current research's objectives are to:

1. Reveal the effect of designing a digital repository based on interactive learning objects in the process of developing the cognitive aspect of e-course production skills based on the QM standards that must be developed for middle school mathematics teachers,

2. Reveal the effect of designing a digital repository based on interactive learning objects in the process of developing the skills for producing e-courses based on the QM standards that must be developed for middle school mathematics teachers.

1.2. Questions of the research

The problem addressed in this work is illustrated by the recommendations of many studies (e.g., Abu Azmah et al., 2012; Mousa et al., 2013) that teachers possess the skills for designing and producing e-course due to its importance and educational effectiveness. Similarly, the results of the study of Hayat and Nouby (2015) confirmed the effectiveness of electronic courses in the educational process. Although there are studies that have dealt with the development of teachers' skills in producing e-courses, these studies did not address the development of these skills according to QM standards for Saudi Arabian middle school mathematics instructors. These skills can be achieved by designing a digital repository based on interactive learning objects.

Before conducting the current study, an exploratory study was administered to identify the level of teachers' electronic course design and production skills. Fifty middle school mathematics schoolteachers were interviewed through the Directorate of Education in the Eastern Province, Saudi Arabia, and the results showed that: (1) 95% of middle school mathematics teachers agreed that they do not possess the skills to produce e-courses; (2) all middle school mathematics teachers agreed that it is greatly important for middle school teachers to possess the skills to produce electronic courses, especially in view of the spread of the Corona virus (COVID-19); (3) all of them indicated that they are not aware of the QM standards for the production of e-courses; and (4) all middle school mathematics teachers emphasized that e-environments can help them to possess the skills to produce e-courses.

Accordingly, there is an evident need for developing the skills for producing e-courses based on the QM standards for mathematics teachers at the intermediate stage. This goal can be achieved by designing a digital repository based on interactive learning objects. Therefore, the research problem of the current study can be addressed by answering the following main problematic: How can a digital repository based on interactive learning objects be designed to develop the skills of producing e-courses based on the QM standards for middle school mathematics teachers? The study also addressed the ensuing questions in detail:

1. What is the effect of designing a digital repository based on interactive learning objects, aiming at developing the cognitive aspect of e-course production skills based on the QM standards that should be developed among middle school mathematics teachers?

2. What is the effect of designing a digital repository based on interactive learning objects, aiming at developing the skills of producing e-courses based on the QM standards that need to be developed among middle school mathematics teachers?

1.3. Hypotheses

The current research sought to test the following two hypotheses:

1. There are no statistically significant differences at (0.05) between the mean scores of the experimental group teachers who used a digital repository based on interactive learning objects and the mean scores of the control group teachers who used traditional training in the post application of the achievement test related to the skills of designing and producing e-courses based on the QM standards,

2. There are no statistically significant differences at (0.05) between the mean scores of the experimental group teachers who used a digital repository based on interactive learning objects and the mean scores of the control group teachers who used traditional training in the post application of the quality assessment card for e-courses based on the QM standards.

1.4. Research delimitations

Population Delimitation: Middle school mathematics teachers.
Objective Delimitation: Skills of producing e-courses based on the QM standards.
Temporal Delimitation: The academic year's first term 2019-2020.

Spatial Delimitation: Middle Schools within the Directorate of Education in the Eastern Province, Dammam, Saudi Arabia.

1.4.1. Research terms

The researchers of the current study defined the study terms operationally as follows:

Digital repositories: A database in which a large number of interactive digital learning objects related to the development of e-course production design skills for middle school teachers is stored, whereby those objects are indexed based on Metadata standards, thus making it easy to retrieve and reuse them quickly and at any time.

Interactive digital learning objects: Digital components of a relatively small size. It could be text, image, audio, video, animation, etc. It can be used in training in interactive and repetitive forms to develop the skills required for designing and producing e-courses in view of Metadata Standards, copyright, and use.

E-courses: An electronic educational system consisting of objectives, content, activities, teaching methods, learning resources, and assessment methods, which are produced and presented using the computer and the Internet.

E-course production skills: The set of knowledge and tools that enable middle school math teachers to design and produce e-courses using Articulate-Storyline program and Moodle system, as will identify in the procedures section.

Quality Matters (QM) Standards: The most prominent means of evaluating e-courses and ensuring quality in e-learning in terms of its increasing recognition, whether at the level of the United States of America or abroad, recently becoming, according to the QM's website, the most widely used criteria in evaluating the quality of e-course design.

1.5. Research importance

The importance of the current research lies in the following:

1. Directing attention towards the application of the digital repository based on interactive learning objects in training by providing a practical model for digital repositories that can be emulated when preparing other similar training programs with the aim of developing the training needs of teachers in general and the skills of designing e-courses in particular, and

2. Directing the attention of those responsible for designing e-training programs and applications to the importance of developing the skills of producing e-courses based on the QM standards among teachers in general and middle school mathematics teachers in particular.

2. Theoretical Framework and Literature Review

2.1. First Axis: E-Training

E-training, which is an integral part of the e-learning process, is of great importance to trainees, for reasons including: (1) Self-reliance and self-confidence (Riel & Fulton, 2011), (2) availability of participation and interaction among the trainees through communication technologies, such as e-mail, mailing groups, discussion panels, and chat, whilst exchanging experiences and creating knowledge, (3) enhancement of trainees' e-training abilities to search for and build knowledge (Roblyer & Ekhaml, 2000), (4) and providing trainees with access to multiple forms of digital training resources through hypermedia and available links, thus reducing anxiety, stress and boredom from training and practice and eventually creating knowledge and gaining experiences (Alvarez-Trujillo, 2008).

Derek Stockley (n.d.) defined e-training as the process of distributing and receiving training or educational programs using electronic tools and media, including the use of a computer and a smartphone, and any other means that can facilitate the training process and help achieve the training goals.

Ramayah et al. (2012) indicates that e-training is similar to e-learning in terms of implementation methods and technology employed; however, it includes a much shorter time frame than the learning process. E-training is specifically designed to achieve a specific goal or skill that is acquired or developed through training.

Not only does the e-training environment have many advantages, but it also has some uniqueness that is not found in any other training system, such as interactive and participatory; integration; freedom of training, learning and control; continuity; training flexibility; diversity; privacy; and organization (El-Ghool, 2015).

2.2. Second Axis: Digital Repositories

With the rapid pace of development, the increase in the volume of information, and the diversity of its sources, the need has increased to provide digital information sources that are presented in a correct manner and properly prepared, in addition to the interest in updating them on an ongoing basis. Digital repositories are a form of dissemination and availability of digital information resources through the free and unimpeded exchange of information. The existence of digital repositories is linked to e-learning environments, as the integration between them brings many advantages to learners and teachers. Incorporating digital materials makes it easier for learners to locate and retrieve these materials. Also, this integration works to raise the informational awareness of learners, encourages teachers and learners to interact and exchange experiences, and helps them discover knowledge with the possibility of searching and retrieving information sources in their various forms. Hence, repositories support the teaching and learning process in e-learning environments.

There are many terms for digital repositories, such as self or free archives, free access repositories, future library management systems, and institutional repositories. All the previous terms have the same meaning, as indicated by

several studies (e.g., Azmy, 2014; He et al., 2010). Digital repositories aim to create a reliable and trustworthy collection of information that provides minimal services for searching and controlling digital contents.

Digital repositories support communication and provide the possibility of communication between users so that this contributes to searches and to finding learning elements that suit the characteristics and needs of learners. Therefore, many studies (e.g., Al-Bassam & Al-Yami, 2013; Hafez, 2010) have identified the importance of digital repositories as follows:

1. Helping educational institutions to facilitate access to electronic content, which includes activities, electronic exams, texts, and videos, thereby moving learners from learning by traditional methods to learning in which the learner becomes the focus of the educational process,

2. Providing a variety of services, which are represented in the search and retrieval of learning objects. These services also help in organizing and indexing the learning objects based on metadata standards, and keeping the learning objects long-term and securely so that they are easily accessible and reused, which saves the learners time,

3. Serving as a platform for exchanging experiences, educational and training resources. Also, these repositories provide open and free access to many lessons, seminars, courses, and exercises,

4. Allowing institutions to publish their work, research, and activities, which increases opportunities to improve learning and experiences, and encourages collaboration between different groups and disciplines.

Several studies (e.g., Hansen, 2006; Hendawy, 2011; Metwally, 2013; Huang, 2007; Khalil, 2012; Thomas & McDonald, 2007) have addressed the importance of digital repositories in providing a space for digital publishing of learning resources and facilitating the process of accessing them. Metwally's study (2013) seeked to develop a proposed scenario for employing and developing social networks that support repositories of learning objects to help teachers produce computer programs based on educational and technical standards of production. The study showed that digital repository helped in developing the skills for producing these programs. Khalil (2012) aimed to identify the effectiveness of the digital learning unit repository in developing skills in preparing electronic tests and designing question banks among university students. The study found the importance of digital learning repositories in developing the cognitive and performance aspects related to these skills. Hendawy (2011) attempted to design and build a proposed model for the online educational unit repository based on quality standards and measure its impact on some aspects of students' learning. The results showed that the repository of learning items contributed to the development of cognitive achievement, the development of the ability to think innovatively, and the development of positive attitudes towards the use of online educational units in learning. Huang (2007) sought to identify common factors among small groups

using digital repositories. The results confirmed that working in groups can contribute to sharing information and digital resources, while facilitating the process of searching and retrieval within the digital repository. The study by Thomas and McDonald (2007) attempted to use digital repositories in the scientific publishing of research and measured its impact on the attitude towards the repository. The results showed the effectiveness of the digital repository in scientific publishing and its impact on increasing the positive attitude towards it. Hansen's study (2006) aimed to create and develop a repository of learning objects in the field of culture and language that serves learners and teachers. The study concluded that the repository contributed to improving the quality of teaching and learning for both learners and teachers.

Therefore, digital repositories are considered as a new and important model for scientific publishing with a set of features that provide them with a distinctive interactive role in encouraging preservation, search, and retrieval processes. Several studies (e.g., Gombiro et al., 2008; Heery & Anderson, 2005) have indicated the characteristics of digital repositories as follows: stability, flexibility, non-repetition, and diversity, among others.

Digital repositories preserve e-learning resources in a way that allows users the freedom to choose and search, where the search process is one of its most important functions. Several studies (e.g., Abdel-Gawad, 2009; Alfano & Henderson, 2007) indicate that the functions of digital repositories lie in the following points: search, deliver, request, store, submit, and quality control.

2.3. Third Axis: Interactive Learning Objects

There are many definitions of digital learning objects. Abu-Shama and Al-Jabbour (2013) define digital learning objects as one of the modern electronic applications, which is based on the modern idea of activating the use of digital media. These digital media may be in the form of text, audio, image, still and animation, video clips, and interactive simulations in teaching subjects. This is done by preparing banks or repositories for a large number of independent and self-existing digital media particles and presenting them to teachers for reuse several times in a new educational framework and in different generalized situations than those for which they were produced. It takes between 1-15 minutes for each of these digital media to be displayed in the learning situation.

Many studies (e.g., Ritzhaupt, 2010; Salas & Ellis, 2006) emphasized the characteristics of interactive learning objects, as follows: understandability, learner-control, goal-orientation, time, interactivity, multiple representation of information, motivation, differentiation, flexibility, autonomy, collaboration, variation, accessible, reusable, interoperable, and adaptable.

3. Research methodology

In order to come up with a suitable design for the digital repository, which serves as the empirical treatment of the current research, an analytical descriptive approach to monitoring and analysing Arabic and English studies and literature that dealt with digital repositories was used.

Quasi-experimental approach is used to find out the impact of the independent variable (designing a digital repository based on interactive learning objects) on the dependent variable (e-course production skills based on QM standards.

Thus, the current research employs the quasi-experimental design that is known as the randomization control group pre-test post-test, where participants were randomly assigned in both groups. Table 1 describes the current study design.

Table 1: Research Design of the randomization control group pre-test post-test

Group	Pretest	Treatment	Posttest
Experimental	Achievement test	Training on a digital repository based on interactive learning objects	- Achievement test. - Quality assessment card for the production of e-courses based on the QM standards.
Control		Traditional training	

3.1. Research population and sample

The research population was middle school mathematics teachers within the Directorate of Education in the Eastern Province, Dammam, Saudi Arabia, and the application of the research was limited to a random sample representing the research population, consisting of 60 schoolteachers. Simple random selection was used to split the participants into two groups after making sure that the two groups were equivalent: the first one was an experimental group consisting of 30 teachers who were trained in using the digital repository based on interactive learning objects, and the second one was a control group consisting of 30 teachers who were trained in the traditional way.

3.2. Variables of the research

The following were the research variables:

1. The independent variable: The training style has two levels: training using a digital repository based on interactive learning objects, and training in the traditional way.

2. Dependent variable: E-course production skills based on the QM standards.

3.3. Research procedures

To answer the research questions and verify their hypotheses, the work in the current research proceeded based on the following procedures:

1. Preparing an initial list of e-course production skills based on the QM standards: An initial list of e-course production skills has been reached based on the QM standards that need to be developed. The list of skills included 8 main skills, and 41 sub-skills.

2. Preparing a list of digital repository design standards based on interactive learning objects: A list of digital repository design standards based on interactive

learning objects as developed. The list included 7 main standards, and 57 indicators.

3. We used the general model of educational design (ADDIE) by following:

First stage: The analysis stage: This stage includes many steps, which were as follows: 1) identify general goals; 2) determine educational needs and problems; 3) analyse the characteristics of the trainees; and 4) analyse resources and constraints in the educational environment.

Second stage: The design stage: The subsequent actions were part of this phase:
i. Setting training goals: The researchers prepared a list of training objectives and presented to a set of experts in educational technology. The list of objectives in its final form consisted of 62 educational objectives,

ii. Identifying educational content: The researchers reviewed many previous studies and literature that dealt with the skills of producing e-courses based on the QM standards. Then, the researchers prepared educational content that includes e-course production skills based on the QM standards,

iii. Determining a content organization strategy for the digital repository: In organizing the content, the researchers considered that it is determined based on the nature of the digital repository, and it is sequenced in the form of objectives followed by educational activities and interactions, where the teacher moves from one training task to another in a way that leads to the achievement of the previously specified training goal,

iv. Identifying training activities and tasks,

v. Determining the training pattern and strategies for its implementation in the digital repository,

vi. Choosing and employing electronic resources: Researchers designed media and electronic resources that fit the nature of the digital repository environment. These media were text files (pdf), images, videos, flash files, and links. These media were employed in the digital repository environment,

vii. Interaction design within a digital repository environment: The researchers designed the training interactions as follows: Interaction between the trainees and the content; Interaction among the trainees; and Interaction between trainees and researchers,

viii. Designing an educational scenario for a digital repository environment: The educational scenario is designed for the digital repository environment in the form of a screen-by-screen story board, which is often used with e-training environments.

After completing the formulation of the basic scenario in its initial form, the researchers presented the educational scenario to experts in the field of educational technology to get their comments. The scenarios were finalized in preparation for the production of the experimental processing materials (digital repository environment).

Third stage: The production stage: The researchers hired a company specialized in designing digital repository environments based on interactive learning objects.

Fourth stage: The evaluation stage: This stage aims to ensure the validity of the digital repository environment that was produced for the application. The website was presented to a group of arbitrators, who used a standard list for this evaluation. Based on the arbitrators' suggestions, the researchers made the necessary modifications in the digital repository environment. Finally, the digital repository was prepared in its final form in preparation for a field trial on a pilot sample of teachers to ensure the validity of use.

3.4. Research tools

The research tools were created by the researchers. The tools were an achievement test to measure the cognitive aspect of e-course production skills based on the QM standards and a quality assessment card for the production of e-courses based on the QM standards. Therefore, the researchers followed the following stages:

3.4.1. Test objective

The test aims to measure the extent to which middle-level mathematics schoolteachers have mastered the cognitive components connected to the skills of producing e-courses based on the QM standards.

The researchers formulated the achievement test vocabulary in the form of multiple choice. The number of test questions in its initial form was 62 questions (See Table 2). The duration of the test was 60 minutes.

Table 2: Characteristics of achievement test based on the QM standards

Subject	# Cognitive goals	# Test questions
Concepts about the quality of e-courses based on the QM standards	10	10
Analysis stage	13	13
Design stage	16	16
Production stage	12	12
Experimentation stage	2	2
Display stage	2	2
Evaluation stage	7	7
Total	**62**	**62**

3.4.1.1. Test validity

The face validity was used to determine the test's validity. The result of the arbitrators' agreement on the test items was more than 85%, and thus the test became characterized by internal validity.

After verifying the face validity of the achievement test, the internal consistency validity was verified on an exploratory sample of 20 teachers (not the research sample). The Pearson correlation coefficient was calculated between the score of each test question and the overall test score (See Table 3).

Table 3: Pearson correlation coefficients between each question and the overall test score

Question	Pearson Correlation	Question	Pearson Correlation	Question	Pearson Correlation
1	0.736*	22	0.640*	43	0.765*
2	0.569*	23	0.693*	44	0.641*
3	0.694*	24	0.503*	45	0.607*
4	0.765*	25	0.745*	46	0.624*
5	0.577*	26	0.694*	47	0.533*
6	0.736*	27	0.650*	48	0.694*
7	0.574*	28	0.621*	49	0.650*
8	0.736*	29	0.628*	50	0.621*
9	0.577*	30	0.645*	51	0.628*
10	0.694*	31	0.612*	52	0.645*
11	0.608*	32	0.569*	53	0.612*
12	0.610*	33	0.694*	54	0.562*
13	0.594*	34	0.765*	55	0.589*
14	0.594*	35	0.885*	56	0.634*
15	0.786*	36	0.607*	57	0.615*
16	0.547*	37	0.647*	58	0.664*
17	0.885*	38	0.621*	59	0.792*
18	0.607*	39	0.562*	60	0.649*
19	0.647*	40	0.589*	61	0.506*
20	0.621*	41	0.634*	62	0.597*
21	0.564*	42	0.615*		

Note. * Correlation is statistically significant at 0.01.

3.4.1.2. Pilot study for the test

After confirming the validity of the initial form of the achievement test and the validity of its vocabulary based on the opinions of the arbitrators, the researchers conducted the pilot study of the test on a random sample of 20 teachers (not the research sample).

3.4.1.3. Test Reliability Coefficient

The researchers used the split-half reliability method, in which they calculated the Spearman-Brown coefficients to calculate the correlation coefficient. The correlation coefficient between the scores of the single questions and the scores of the paired questions for the test questions was 0.95. This result means that the test was largely reliable.

3.4.2. Quality assessment card for the production of e-courses based on the QM standards

The purpose of the card is to evaluate the production quality of middle-level mathematics schoolteachers based on the QM standards. The QM e-course production standards were referenced and translated to build the assessment card. The QM standards have been modified to suit the purposes of the current research.

Each main standard includes a set of sub-indicators that represent the set of performances that teachers engage in when developing an e-course based on the QM standards.

3.4.2.1. Initial image of the assessment card

In the initial form, the card included 8 main skills (standards) and 32 sub-performances (indicators) to judge teachers' performance of e-course development skills based on the QM standards.

3.4.2.2. Assessment card validity

Five arbitrators received the card's first form to confirm its validity. Some of the standards have been changed according to the recommendations of the arbitrators. Those amendments were limited to the reformulation of some standards. The five arbitrators unanimously agreed on the validity of the card for application after making the proposed modifications, and the card was ready for application in its final form.

3.4.2.3. Assessment card reliability

The assessment card was applied to a pilot sample of 20 teachers to calculate the reliability of the tool. Teachers' works were evaluated using two supervisors, in addition to one of the three researchers. The reliability coefficient was calculated using Cronbach's alpha, where it reached 0.92, which indicates a high coefficient of reliability. Therefore, the card is valid for the application.

In its final form, the card included 8 basic skills (standard) and 32 sub-skills (indicator). Table 4 describes the assessment card form.

Table 4: The basic skills and sub-skills contained in the assessment card

Basic skills	Sub-skills
Overall design of the content	The presence of the e-course instructions provided clearly.
	An introduction to the components of the e-course.
	An introduction to the rules of ethics for the e-course.
	An introduction to the knowledge and competencies required in advance of studying the e-course.
	The provision of a definition of the electronic course preparer.
	The provision of an opportunity for students to introduce themselves to their peers.

General objectives of the content	To correctly formulate the overall objectives of the content.
	To correctly formulate the educational objectives of the lessons included in the e-course units.
Assessment strategies	Choosing assessment tools that measure the identified learning objectives.
	Using clear wording of the grading policy.
	Providing specific and codified criteria for evaluating student performance and participation.
	Choosing regular, varied, and appropriate assessment tools.
	Giving students several opportunities to see their learning development.
Educational materials	The educational materials contribute to achieving the educational objectives of the e-course.
	A clear explanation of the purpose of the educational materials and how to use them is provided.
	The educational materials and resources used in the e-course are correctly documented.
	The educational materials used in the e-course are characterized by modernity.
	The educational materials vary according to the content of the e-course.
	There is a clear explanation of the distinction between basic materials and enrichment materials.
Employing a real, meaningful interaction	Educational activities achieve different interaction patterns.
	Educational activities provide many opportunities for interaction.
	The teacher's plan to respond to students and provide feedback is clearly stated.
	The requirements for student interaction are stated and clear.
Navigating the e-course	The materials and tools used in the e-course support student participation.
	Navigating through the elements of the e-course is logical, consistent, and effective.
	There is ease of access for students to the required components in the e-course.
	The techniques used in the e-course are modern to support the learning objectives.
Student access to necessary institution services	There is a link to technical support and how to access it in the e-course.
	A link to the policies followed in the institution is available in the e-course.
	A link to the academic support services in the institution is available in the e-course.
Multimedia design	Standards are available for text, images & still graphics, video clips & animation, and audio.

3.4.3. Pilot Study for the research

The researchers conducted a pilot study of the digital repository environment based on interactive learning objects on 20 middle school mathematics teachers (volunteers) in the city of Dammam (not the study sample).

Based on what the pilot sample agreed on, the researchers made the necessary adjustments in the digital repository environment and prepared it in its final form in preparation for its field trial on the main research sample.

3.5. Pre-application of research tools

The achievement test was pre-applied to the experimental and control groups, and the list of evaluating the skills of designing and producing e-courses was not applied due to the lack of those skills in the research sample.

Table 5: Independent samples t-test results in the pre-application of the achievement test

Group	Mean	Standard Deviation	Count	t	Significance Level
Experimental	13.60	2.372	30	0.178	0.859
Control	13.50	1.961	30		

Table 5 shows that the test significance level is equal to 0.859, which means the test significance level is above 0.05. Thus, this result indicates that there are no statistically significant differences between the two groups in the pre-application. Therefore, the experimental and control groups were equivalent, and any difference that occurs in the post application is due to the experimental treatment used.

The two groups' average scores in the preliminary application of the achievement test related to the cognitive aspect of e-course design and production skills were as follows: the mean score of experimental group = 13.6, and the mean score of control group = 13.5.

4. Results

4.1. The effect of a digital repository on the cognitive aspect

First Hypothesis: There are no statistically significant differences at (0.05) between the mean scores of the experimental group teachers who used a digital repository based on interactive learning objects, and the mean scores of the control group teachers who used traditional training in the post application of the achievement test related to the skills of designing and producing e-courses based on the QM standards.

Table 6 reveals statistically significant differences (p = 0.000) between the mean achievement test scores of the two groups (experimental and control group) in favour of the experimental group (*Mean* = 38.07). Thus, the first null hypothesis of the research is rejected and the alternative hypothesis is accepted, which states that, there are statistically significant differences at (0.05) between the mean scores of the experimental group teachers who used a digital repository based on interactive learning objects, and the mean scores of the control group teachers who

used traditional training in the post application of the achievement test related to the skills of designing and producing e-courses based on the QM standards. This means that the use of a digital repository based on interactive learning objects made a difference in post application of the achievement test in favor of the experimental group. To ensure that the statistical significance is due only to the effect of the independent variable (the digital repository), the researchers calculated the effect size using Cohen's d. Table 6 shows that the size of the digital repository's effect is medium (d = 0.732) because 0.5<d<0.8 (Cohen, 1988). This value means that there is an impact of the digital repository in developing the cognitive aspect related to the skills of producing e-courses based on the QM standards.

Table 6: Independent samples t-test results in the post application of the achievement test

Group	Mean	Standard Deviation	Count	t	Cohen's d	Significance Level
Experimental	38.07	1.818	30	12.712	0.732	0.000*
Control	31.67	2.073	30			

Note. * The p-value is significant at the p < 0.05 level.

The result of the current research shows the experimental group teachers' average scores and the control group teachers in the post application of the achievement test related to the cognitive aspect of e-course design and production skills (Mean score of experimental group = 38.07, and mean score of control group = 31.67).

To verify the effect of designing a digital repository based on interactive learning objects in developing the cognitive aspect related to the cognitive aspect of e-course design and production skills among middle school teachers, the researchers used the Eta equation to calculate the effect size. Therefore, the effect size for the first hypothesis is 0.73, which means that the effect size is high.

4.2. The effect of a digital repository on the production quality

Second Hypothesis: There are no statistically significant differences at (0.05) between the mean scores of the experimental group teachers who used a digital repository based on interactive learning objects, and the mean scores of the control group teachers who used traditional training in the post application of the quality assessment card for e-courses based on the QM standards.

Table 7 reveals statistically significant differences (p = 0.000) between the average quality assessment card scores of the two groups in favor of the experimental group (*Mean* = 203.70). Thus, the second null hypothesis of the research is rejected, and the alternative hypothesis is accepted, which states that there are statistically significant differences at (0.05) between the mean scores of the experimental group teachers who used a digital repository based on interactive learning objects and the mean scores of the control group teachers who used traditional training in the post application of the quality assessment card for e-courses based on the QM standards. This means that the use of a digital repository based on interactive learning objects made a difference in after applying the quality assessment card in favour of the experimental group. To ensure that the statistical significance is

due only to the effect of the independent variable (the digital repository), the researchers calculated the effect size using Cohen's d. Table 7 shows that the size of the digital repository's effect is medium (d = 0.585) because 0.5<d<0.8 (Cohen, 1988). This value means that there is an impact of the digital repository in developing the quality of production of e-courses based on the QM standards.

Table 7: Independent samples t-test results in the post application of the quality assessment card

Group	Mean	Standard Deviation	Count	t	Cohen's d	Significance Level
Experimental	203.70	5.279	30	9.136	0.585	0.000*
Control	182.87	11.319	30			

Note. * The p-value is significant at the p < 0.05 level.

The finding of this research also shows the experimental group teachers' average scores and the control group teachers in the post application of the quality assessment card related to the cognitive aspect of e-course design and production skills (Mean score of experimental group = 203.7, and mean score of control group = 182.87).

To investigate the effect of designing a digital repository based on interactive learning elements in developing the level of e-course production among middle school teachers, the researchers used the Eta equation to calculate the effect size. Therefore, the effect size for the second hypothesis is 0.585, which means that the effect size is high.

5. Discussion

The results of this research are based on the principles of behavioural theory, which emphasizes that the success of the learning process depends on defining training objectives in an observable and measurable manner (Delprato & Midgley, 1992). This principle was achieved through the provision of learning directions in the interactive learning objects, which included educational objectives and instructions that explain how to implement the required activities and tasks. The principles of constructivist theory also explain the results of this study, which shows that the success of the learning process requires providing support and assistance to trainees, enhancing their responses, and providing them with feedback so that they can process information and build their own knowledge (Fosnot, 2005). This principle was achieved in the repository of digital learning objects, which contributed to the development of the cognitive and performance aspects of electronic content production skills in accordance with QM standards.

In addition, the trend of using a digital repository based on interactive learning objects has been supported by several models, such as the TPACK model developed by Koehler & Mishra (2009). The TPACK model describes how technology, pedagogical knowledge, and content can be integrated to produce effective teaching appropriate to the technology and communications revolution. This integration produces a new, three-pronged model called the TPACK framework. The TPACK framework focuses on the new knowledge that results from the combination of the three main kinds of knowledge either bilaterally or tripartite, resulting in four additional kinds of knowledge that are different in

content from the basic kinds of knowledge (Gür & Karamete, 2015). The digital repository based on interactive learning objects allowed middle school mathematics teachers to acquire the skills for producing e-courses based on QM standards, and also according to the TPACK integrative model effectively by taking advantage of the modern technology represented in the digital repository.

Additionally, the outcomes of the current study were consistent with those of numerous other investigations (e.g., Khalil, 2012; Metwally, 2013), which all recognized the effectiveness of digital repositories in the development of cognitive and performance aspects.

The researchers attribute the explanation of these results to the following:
1. E-training using a digital repository based on interactive learning objects has helped in increasing teachers' abilities to cognitively represent new information. A digital repository provides teachers with new and specific information, and presents it to them in a clear, detailed, and structured manner. This is within the framework of integration with the previous cognitive structure that exists in the trainee's mind, which made it easier for them to build the new structure of knowledge and encode it for sustainable storage in their long-term memory. This increased the ability to retain information for as long as possible and recall it when needed. Perhaps, this is due to the feature of flow in the content that is achieved by the digital repository based on interactive learning objects.

2. The ability to view and review the learning objects in the repository allows teachers to view the learning objects and download them to their devices before making any modifications for reuse in achieving a new educational goal. This contributed to the development of e-course design and production skills.

3. Teachers view and review the content of the digital repository based on educational interactive learning objects that clarify the educational and technical standards necessary for designing and producing e-courses in addition to the models of learning objects that have been produced and submitted to the repository by other teachers. This may have helped in advancing the knowledge portion of the abilities needed to create and produce e-courses.

4. E-training using the digital repository based on interactive learning objects helped reduce mental stress and cognitive load while properly accessing the correct information and linking them with prior knowledge.

5. This trend towards using the digital repository based on interactive learning objects has been supported by many theories, such as the Motivation Theory. One of the most important motivational factors is a curiosity to learn. Curiosity is a cognitive process that is aroused by the information itself, where this information struggles with the learner's prior knowledge and expectations (Locke & Latham, 2004; Purwoko et al., 2019). This struggle occurs when the information is incomplete, where it pushes the learner to search for new and complementary information. This can be provided by the use of a digital repository based on interactive learning objects.

6. Recommendations

In view of the results of the research and its discussion, the researchers recommend the following:

1. Using digital learning repositories based on interactive learning objects if the target learning outcome is cognitive skills learning in its performance and cognitive aspects,

2. Educating teachers about the importance of educational digital repositories based on interactive learning objects that store content and provide a large number of links. Also, encouraging the Ministry of Education in the Kingdom of Saudi Arabia to build digital learning repositories based on interactive learning objects for different curricula and for different educational stages,

3. Establishing centres for designing and producing the content of interactive learning objects in various fields and supporting them financially, and then uploading them to a digital repository for the benefit of all teachers in the Kingdom of Saudi Arabia.

7. Research ideas for the future study

In view of the findings of this study, the researchers suggest conducting further research in the following research topics:

1. This research was limited to addressing the impact of the independent variable represented in digital repositories based on interactive learning objects on middle school mathematics teachers, so it is possible for future research to measure the impact of using interactive video supported by virtual reality technology in e-training through digital learning repositories,

2. Adaptive learning objects could be developed in digital repositories and their impact measured on developing creative thinking skills for middle school mathematics teachers,

3. A digital repository, based on navigation methods and its impact measured on developing the knowledge and skills of teachers of different curricula at the middle level, could be designed.

8. Conclusion

The purpose of this study was to design a design a digital repository using interactive learning objects and measuring its impact on developing the skills of producing e-courses based on QM standards for middle school mathematics teachers in Saudi Arabia. An independent samples t-test results procedure estimated that the experimental group was superior in the skills of designing and producing e-courses, as well as in the quality of those e-courses based on QM standards.

The current research supports the application of the digital repository based on interactive learning objects in developing the training needs of teachers by providing a practical model for digital repositories that can be emulated. The

findings of this study may help people responsible for creating e-training programs focus their efforts to the importance of developing e-course production skills according to QM standards for middle school mathematics teachers.

9. References

Abdel-Gawad, S. (2009). برامج المستودعات الرقمية المؤسساتية مفتوحة المصدر: دراسة تقويمية [Open-source institutional digital repositories software: an evaluation study]. *Journal of Faculty of Arts, 2*(21), 1177-1282. http://dx.doi.org/10.21608/jfab.2009.53590

Abdelrahman, F. (2022). المستودعات الرقمية ودورها في دعم الوصول الحر للمعلومات العلمية: المستودع الرقمي لجامعة غرب كردفان أنموذجا [The digital repository and its role in supporting free scientific access: The digital repository of West Kordufan as a model]. *Rehan Journal for Scientific Publishing,* (21), 245-286. https://drive.google.com/file/d/1MG1nyohwOXJlgt2aNvtlJCWL_ZNLYNv3/view

Abouelmmaati, A., Hassan, B., Alsharqawi, & J., Badawi, M. (2015). تصميم كائنات تعلم رقمية قائمة على الدمج بين أنماط التفاعل وتقنية بث الوسائط الصوتية لتنمية مهارة الاستماع لدى طلاب الصف الأول الثانوي [Designing digital learning objects based on blending between the interaction types and podcasting to develop listening skills among secondary school students]. *Journal of Arab studies in education and Psychology,* (64), 165-202 http://dx.doi.org/10.12816/0022559.

Abu Azmah, N., Hendawy, A., & Mahmoud, I. (2012). أثر برنامج تدريبى مقترح لتنمية مهارات تصميم وإنتاج المقررات الإلكترونية لدى أعضاء هيئة التدريس جامعة طيبة [The impact of a training program proposal for the development of Foals design and production of e-courses of the members of the faculty at the University of Taibah]. *Journal of Arab studies in education and Psychology, 1*(27), 35-76.

Abu-Shama, F., & AL-Jabbour, S. (2013, May 14-15). *درجة ممارسة الكفايات التدريسية لاستخدام التداول الرقمي للاستثمار من وجهة نظر معلمي تكنولوجيا المعلومات في المرحلة الثانوية بمحافظات غزة* [The degree of practicing the teaching competencies necessary to use digital learning objects from the point of view of ICT teachers for the secondary stage in Gaza governorates]. Fourth School Day Conference: Educational Technology... An invitation to break out of the norm. Gaza, Palestine.

Al-Bassam, A., & Al-Yami, H. (2013, February 4-7). لضمان جودة محتوى المستودعات الرقمية (LOR) [Digital repositories (LOR) to ensure the quality of e-learning content: opportunities and challenges from the viewpoint of faculty members in Saudi universities]. Third International Conference e-Learning and Distance Education, Riyadh.

Alessi, S., & Trollip, S. (2001). *Multimedia for learning: Methods and development* (3rd ed.). Allyn and Bacon.

Alfano, C., & Henderson, S. (2007). Repositories. In P. T. Northrup (Ed.), *Learning objects for instruction: Design and evaluation* (pp. 16-28). Pamela Taylor Northrup. https://doi.org/10.4018/978-1-59904-334-0

Aboukhatwa, E. (2010, April 6-8). *مبادئ تصميم المقررات الإلكترونية المشتقة من نظريات التعلم وتطبيقاتها التعليمية* [The principles of e-courses design derived from learning theories and their educational applications]. Conference of the Role of e-Learning in Promoting Knowledge Societies. Manama, Bahrain.

Alvarez-Trujillo, H. (2008). Lecture: Benefits and Challenges for the Online Learner [pdf file]. Thomas Jefferson University: https://ponce.inter.edu/cai/Comite-investigacion/Estudiantes-Invitados/Benefits_Challenges_Online_Learner.pdf

Azmy, N. (2011). *التصميم التعليمي للوسائط المتعددة* [Multimedia instructional design] (2nd ed.). Dar Alhuda.

Azmy, N. (2014). بيئات التعلم التفاعلية [Interactive learning environments] (2nd ed.). Dar Elfikr Elarabi.

Cameron, T., & Bennett, S. (2010). Learning Objects in Practice: The Integration of Reusable Learning Objects in Primary Education. *British Journal of Educational Technology, 41*(6), 897-908. http://dx.doi.org/10.1111/j.1467-8535.2010.01133.x

Cohen J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge Academic. https://doi.org/10.4324/9780203771587

Delprato, D., & Midgley, B. (1992). Some fundamentals of B. F. Skinner's behaviorism. *American Psychologist, 47*(11), 1507–1520. https://doi.org/10.1037/0003-066X.47.11.1507

Derek Stockley. (n.d.) *E-learning definition and explanation (elearning, online training, online learning).* Derek Stockley. http://www.derekstockley.com.au/elearning-definition.html

Elgazzar, A. (2014). Developing e-learning environments for field practitioners and developmental researchers: A third revision of an ISD model to meet e-learning and distance learning innovations. *Open Journal of Social Sciences, 2*(2), 29-37. https://doi.org/10.4236/jss.2014.22005

El-Ghool, R. (2015). فعالية برنامج تدريبي إلكتروني قائم على التعلم التشاركي في تنمية مهارات استخدام بعض خدمات الجيل الثاني للويب لدى معاوني أعضاء هيئة التدريس [The effectiveness of an electronic training program based on participatory learning in developing the skills of using some second generation web services among faculty assistants]. *Journal of The Faculty of Education - Mansoura, 1* (78), 287-329.

Elnajar, H. (2014). أثر كائنات التعلم في بيئة التعليم الإلكتروني في تنمية مهارات الرسم الهندسي والاتجاه نحو استخدامها لدى طلبة جامعة الأقصى [The impact of learning objects in electronic learning environment in developing Al-Aqsa University students ability of geometric drawing and their attitudes towards using them]. *The Educational Journal,29*(113), 181-220.
http://pubcouncil.kuniv.edu.kw/joe/homear.aspx?id=8&Root=yes&authid=1615

Fosnot, C. (2005). *Constructivism: Theory, perspectives, and practice* (2nd ed.). Teachers College Press.

Gombiro, C., Munyoka, W., Hove, S., Chengetanai, G., & Zano, C. (2008). The need for data warehousing in sharing learning materials. *Journal of Sustainable Development in Africa, 10*(2), 422-449.

Gür, H. & Karamete, A. (2015). A short review of TPACK for teacher education. *Educational Research and Reviews, 10*(7), 777-789. https://doi.org/10.5897/ERR2014.1982

Hafez, S. (2010, October 6-8). *المستودعات الرقمية للرسائل الجامعية العربية: دراسة تقويمية* [Digital repositories of Arab university theses: an evaluation study]. Twenty-first Conference of the Arab Federation for Libraries and Information, Beirut.

Hansen, K. (2006). *Developing a Nisga'a Learning Objects Repository for Use in the Schools* [Unpublished Doctoral dissertation]. Nova Southeastern University. https://nsuworks.nova.edu/gscis_etd/566/

Hayat, H., & Nouby, A. (2015). فعالية تصميم مقرر إلكتروني قائم على استراتيجيات الاحتفاظ بالمعلومات في التحصيل وبقاء أثر التعلم لطالبات قسم التربية البدنية بكلية التربية الأساسية في دولة الكويت [The effectiveness of designing an electronic course based on the strategies of retention of information in achievement and the conservation for students of the department of physical education faculty of basic education in the state of Kuwait]. *Journal of the Gulf and Arabian Peninsula Studies, 41*(157), 209-240. https://doi.org/10.34120/0382-041-157-006

He, D., Peng, Y., Mao, M., & Wu, D. (2010). Supporting information access in e-learning by integrating digital libraries and ontology. *Online Information Review, 34*(5), 704-728. https://doi.org/10.1108/14684521011084582

Heery, R., & Anderson, S. (2005). *Digital repositories review*. Available at: http://www.jisc.ac.uk/uploaded_documents/digital-repositories-review-2005.pdf

Hendawy, S. (2011). نموذج مقترح لمستودع الوحدات التعليمية عبر الإنترنت في ضوء معايير الجودة وأثره على بعض جوانب التعلم لدى طلاب كلية التربية [A proposed model for the repository of educational units online based on quality standards and its impact on some aspects of learning for students at the College of Education] [Doctoral dissertation]. Helwan University.

Huang, M. (2007). *Why Would You Save Your Files in a Group Folder?---Motivations for Information Sharing Through Digital Repositories in Project Groups* [Doctoral dissertation]. University of Illinois at Urbana-Champaign. http://hdl.handle.net/2142/87535

Khalil, H. (2012). بناء مستودع وحدات تعلم لتنمية مهارات إعداد الاختبارات الإلكترونية وتصميم بنوك الأسئلة لدى طلاب كلية التربية بجامعة المنصورة [Building a repository of learning units to develop the skills of preparing electronic tests and designing question banks for students of the college of education at Mansoura University]. [Doctoral dissertation]. Mansoura University.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary issues in technology and teacher education, 9*(1), 60-70.

Locke, E., & Latham, G. (2004). What should we do about motivation theory? Six recommendations for the twenty-first century. *The Academy of Management Review, 29*(3), 388-403. https://doi.org/10.1108/14684521011084582

Metwally, A. (2013). فاعلية توظيف الشبكات الاجتماعية التعليمية لدعم مستودعات عناصر التعلم على جودة إنتاج البرامج الكمبيوترية للمعلمين [The effectiveness of employing social networks to support repositories of learning objects on the quality of production of computer programs for learners]. [Master thesis]. Helwan university.

Mousa, M., Mahmoud, H., El-Desouky, M., & Farag, M. (2013). مهارات تصميم المقررات الإلكترونية الواجب توافرها لدى طلاب تكنولوجيا التعليم [E-course design skills that educational technology students must have]. *Educational Technology: Studies and Research*, 335-374.

Purwoko, R., Nugraheni, P., & Instanti, D. (2019). Implementation of pedagogical content knowledge model in mathematics learning for high school. *Journal of Physics: Conference Series, 1254*, 1-6. https://doi.org/10.1088/1742-6596/1254/1/012079

Quality Matters. (n.d.). *QM and the International Education Community*. https://www.qualitymatters.org/index.php/qm-membership/faqs/international-engagement

Ramayah, T., Ahmad, N., & Hong, T. (2012). An assessment of e-training effectiveness in multinational companies in malaysia. *Educational Technology & Society, 15*(2), 125-137. https://www.jstor.org/stable/jeductechsoci.15.2.125

Riel, M., & Fulton, K. (2011). The role of technology in supporting learning communities. *Phi Delta Kappan, 82*(7), 518-523. https://doi.org/10.1177/003172170108200708

Ritzhaupt, A. (2010). Learning object systems and strategy: A description and discussion. *Interdisciplinary Journal of E-Learning and Learning Objects (IJELLO), 6*(1), 217-238. https://doi.org/10.28945/1306

Roblyer, M., & Ekhaml, L. (2000). How interactive are your distance courses? A rubric for assessing interaction in distance learning. *Online Journal of Distance Learning Administration, 3*(2), 1-6. http://eta.health.usf.edu/pto/module3/unit4/articleoninteractivityrubric.pdf

Salas, K., & Ellis, L. (2006). The development and implementation of learning objects in a higher education setting. *Interdisciplinary Journal of E-Learning and Learning Objects (IJELLO), 2*(2), 22. https://doi.org/10.28945/398

Salem, O. (2011). *فاعلية مستودع إلكتروني مقترح للكائنات التعليمية عبر الإنترنت في تنمية مهارات تدريس اللغة الإنجليزية لدى الطالب المعلم بكليات التربية* [The effectiveness of a proposed electronic repository of educational objects via the Internet in developing the English language teaching skills of student teachers in colleges of education]. [Master thesis]. Zagazig University.

Thomas, C., & McDonald, R. (2007). Measuring and comparing participation patterns in digital repositories. *D-Lib Magazine, 13*(9/10). https://doi.org/10.1045/september2007-mcdonald

Yigit, T., Isik, A., & Ince, M. (2014). Multi criteria decision making system for learning object repository. *Procedia - Social and Behavioral Sciences, 141*, 813-816. https://doi.org/10.1016/j.sbspro.2014.05.141