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The effect of different interaction patterns in e-training environments in developing the skills of producing interactive lessons for middle school mathematics teachers

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Abstract

The aim of this research is to treat the shortcomings of teacher training programs in Saudi Arabia. Some of these programs are not able to fulfill the requirements of professional development because they neglect the impact of different interaction patterns (group and content–individual, content, and trainer–group, content, and trainer) within the e-training environment. This research used the experimental approach with a quasi-experimental design. The research sample was limited to a random sample consisting of 60 mathematics teachers, who were randomly divided into three experimental groups, equally. The results revealed that there are statistically significant differences at 0.05 between the average scores for middle school mathematics teachers in the post application of the cognitive achievement test, observation card, and product evaluation card related to the skills of producing interactive lessons due to the impact of the different interaction patterns in the e-training environment.

Keywords: interaction patterns, e-training environments, interactive lessons, mathematics teachers, middle school

INTRODUCTION

Interactive lessons are an important learning resource. Interactive lessons are always open, and students can use them anytime and anywhere. Also, interactive lessons do not require classrooms, and computers do not have to be available at the university or school, as they can be used from home. Students can use the interactive lessons several times, and they can view the scientific material of the course and the lectures at any time.

Interactive lessons are among the most important technological innovations that have emerged in recent times and have many educational advantages, so that makes employing them in the educational process has become a necessity. Salmon (2004) believes that interactive lessons allow the learner to connect to a world filled with multimedia, thereby addressing several of the learner's senses, increasing the likelihood of learning taking place. The interactive lessons also help the learner to be free to roam around in the world of information at a level of complexity that is appropriate for their level of learning. In addition, interactive lessons help break free from rigid and immutable schedules.

Bersin (2004) indicates that the most important characteristic of interactive lessons in the educational process is flexibility, such as flexibility related to time, related to content, related to enrollment conditions, related to the curriculum and learning resources, and related to delivering content and providing assistance to the learner.

The interest in training teachers on the skills of producing interactive lessons is in line with what was confirmed by a study of Khalili (2008) on the effectiveness of interactive lessons in developing different skills and knowledge among learners, which means that having the skills of producing interactive lessons for mathematics teachers would be reflected in the knowledge and skills of their students. Also, Abdul Majid (2008) confirmed the effectiveness of training programs in developing the skills of interactive lessons among student teachers, where it indicated the need for

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Contribution to the literature

- Although there are many teacher training programs in Saudi Arabia, few of these programs are able to fulfill the requirements of professional development.
- This study attempts to contribute to the educational research by investigating the impact of different interaction patterns (group and content–individual, content, and trainer–group, content, and trainer) within the e-training environment.
- This study provides evidence on the effectiveness of the trainees' interaction style with their colleagues, the content, and the trainer in the e-training environment in exchanging information, ideas, and experiences.

teachers to acquire the skills of designing and producing interactive lessons during the service.

On the other hand, the philosophy of e-training is based on providing training to everyone who wants it. In addition, it employs information and communication technology to provide training opportunities for all teachers, or those who desire training regardless of age, gender, place of residence, presence, or economic and living conditions. E-training is based on the idea that it is better for a person to train on the professional knowledge that he/she needs. In addition, the knowledge should be of value and meaning to the person, and be provided to him/her at the right time and place, and by the appropriate means (Blackmur et al., 2013).

Interaction is an important and essential component when designing e-training environments. Several previous studies (e.g., Baxter & Preece, 1999; Chou, 2003; Elhlafawy, 2018; Kirby, 1999) identified the patterns of e-training interactions that are required to be available in e-training environments as the interaction between the trainee and the content, between the trainee and the trainer, between the trainee and the trainee, and between the trainee and the training environment interface.

The results of studies differed in determining the most effective patterns. Jung et al. (2010) concluded that the interaction of the trainee with the trainee is more important than other types of interaction, as working in cooperative groups achieves a high level of satisfaction. Reisetter and Boris (2004) found that trainees were less interested in the interaction of the trainee with the trainee compared to the interaction of the trainee with the content, and the trainee with the trainer.

Due to the different results of previous studies on the impact of the interaction pattern in e-training environments, which is one of the most important components of designing e-training environments, the current study dealt with these patterns by research and showing the impact on developing the skills of producing interactive lessons for middle school mathematics teachers.

Research Problem

During their visit to intermediate schools in Dammam, Saudi Arabia, the researchers noticed a low achievement of students in mathematics. When looking into the reasons by conducting interviews with intermediate school mathematics supervisors, the researchers found that the reasons for this decline in students' achievement in mathematics are due to the following:

1. Weak interaction between the mathematics teachers and their students in the classroom.
2. A lack of diversification of the teachers' teaching methods to attract the attention of the students, where their performance is predominantly lecturing.
3. The lack of time allocated to the lesson, which causes the inability to increase and diversify the examples of mathematical problems that help students to understand deeply and meaningfully.
4. The insistence by mathematics teachers on following the traditional form in providing educational content.
5. The lack of intentional efforts to develop the abilities and skills of mathematics teachers in the production of electronic interactive lessons.

Through the above study, the problem of the current research is determined to be the weak skills of mathematics teachers at the middle school level in Saudi Arabia to produce interactive lessons, and the impact of this on achieving the goals of teaching mathematics, and the low level of academic achievement for middle school students in mathematics. Therefore, this matter necessitates the need to search for new systems and methods for training and professional development of mathematics teachers at the middle school level.

Research Questions

The problem of the current research is stated in the following main question: What is the effect of the difference in the interaction pattern in an e-training environment in developing the skills of producing interactive lessons for middle school mathematics

teachers? From this main question, the following sub-questions are derived:

1. What is the impact of the differences in the interaction patterns in an e-training environment on the development of the achievement of mathematics teachers at the middle school level of the cognitive aspects related to interactive lesson production skills?
2. What is the effect of the different interaction patterns in an e-training environment on developing the performance of middle school mathematics teachers' interactive lesson production skills?
3. What is the effect of the difference in the interaction patterns in an e-training environment on the quality of the interactive lessons produced by mathematics teachers at the middle school level?

Research Objectives

The aim of the current research is to provide the skills of producing interactive lessons for middle school mathematics teachers through:

1. Detecting the impact of the different interaction patterns in an e-training environment on developing the achievement of middle school mathematics teachers of the cognitive aspects related to interactive lesson production skills.
2. Detecting the impact of the different interaction patterns in an e-training environment on developing the performance of middle school mathematics teachers of interactive lesson production skills.
3. Detecting the impact of the different interaction patterns in an e-training environment on the quality of the interactive lessons produced by middle school mathematics teachers.

Hypotheses

The research hypotheses tested are as follows:

1. There are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the achievement test for the cognitive aspects related to the skills of producing interactive lessons due to the effect of the different interaction patterns in the e-training environment.
2. There are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the teachers' performance observation card for the skills of producing interactive lessons due to the effect of the different interaction patterns in the e-training environment.
3. There are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the interactive lesson quality evaluation card produced by teachers due to the effect of the different interaction patterns in the e-training environment.

Research Importance

The current research has a theoretical and an applied importance that highlights its educational value, and it is represented in the following.

Theoretical importance

1. The current research deals with a new type of training, which is e-training, as a formula for developing the teacher training process and making a qualitative leap in it, and as an entry point for the professional development of teachers.
2. The current research comes in response to the recommendations of many educational conferences and studies in recent years, which strongly suggested the need to adopt new formulas for teacher training and professional development, and to pay attention to development in this field.

Practical importance

1. The research presents to those concerned with teacher training programs in Saudi Arabia a proposed integrated conception of the procedures and requirements for designing an e-training environment based on the different modes of interaction (group and content–individual, content, and trainer–group, content, and trainer) to develop the skills of producing interactive lessons for middle school mathematics teachers.
2. This study will attempt to determine the best interaction patterns in the e-training environment (group and content–individual, content, and trainer–group, content, and trainer) to develop the skills of producing interactive lessons for middle school mathematics teachers.

Research Delimitations

In this research, the researchers adhered to the following delimitations.

Population delimitation

Mathematics teachers in at the middle school level.

Objective delimitation

Skills of producing interactive lessons in mathematics.

Temporal delimitation

The current research was applied in the first term of the academic year 2020-2021.

Spatial delimitation

Middle Schools in Dammam, Saudi Arabia.

Research Terms

The researchers define the current research terms operationally, as follows.

E-training environment

A training environment that allows the trainee to participate in the production of content, interact with it, and reuse it again in a framework of human interactions between individuals and various groups of trainees.

Interaction pattern

The trainees participate freely and fully through the e-training environment tools which include three different interaction patterns (group and content–individual, content, and trainer–group, content, and trainer) according to the steps of e-training, with the aim of developing the skills of producing interactive lessons for middle school mathematics teachers.

Interactive lessons

It is the transformation of the usual lessons into an interactive electronic image that enables the learner to study, search, interact, feel suspense, and experience excitement because of what it contains in the way of texts, images, videos, animations, etc. It is also easy to circulate inside and outside the school through a website.

THEORETICAL FRAMEWORK & LITERATURE REVIEW

Theoretical Framework

First axis: Interaction in e-training environments

Hirumi (2002) points out that the most important component of training success is interaction between participants. These interactions help relieve feelings of isolation, get rid of the feeling of dissatisfaction and poor performance, and are training methods centered on the trainee. Moore (1989) indicates that there are three levels of interaction centered on the trainee: the interaction of the trainer and the trainee, the trainee and the content, and the trainee and the trainee. This means that interaction in e-training in general is not just clicking the computer mouse and surfing the Internet, but interaction requires high thinking skills, such as the ability to present new ideas, the ability to analyze and interpret, and other skills. This type of interaction encourages trainees to present their questions and contradictory information to the trainers directly or indirectly. The interaction occurs at three levels:

1. Interaction of a group of trainees with the training content.
2. The trainee's interaction with the training content and the trainer.
3. Interaction of a group of trainees with the training content and the trainer.

Designers of e-training programs can control these three levels by working with specialized work teams, each according to its field. Therefore, they are required to produce high quality training programs that can compete with traditional training programs. It is important to talk in some detail about these three levels, as follows:

1. **Interaction of a group of trainees with the training content:** When producing e-training content, it is necessary to think in the first place about how to design the content, so that it is able to provide the trainees with information, instructions for using the program, and instructions related to the training content, as well as providing the trainees with immediate feedback to their questions and inquiries. It is also necessary when designing e-training content to give the trainees adequate opportunities to evaluate themselves, and to identify their abilities and skills. This is done by providing brief questions that are answered quickly and with short answers, so that the feedback is immediate and direct.
2. **Interaction of the trainee with the training content and the trainer:** In the e-training environment, the trainer becomes a mentor and guide for the trainees. In this case the trainees need to feel comfortable and confident when they interact with the trainer. For this to happen, the trainer must build a sense of comfort and trust between him/her and the trainees by adhering to the standards that define the relationship between the trainer and the trainees. Theoe standards are usually included within the e-training programs when they are designed (Algodian, 2009).

   Salmon (2004) considers that the willingness of the trainees to participate and interact is one of the important things that the trainer in e-training should pay attention to, because many of those who are enrolled in this type of training are beginners in the use of computers and the Internet. Therefore, the best way to help them is to

guide and teach them how to use interactive e-learning tools, put them first, and then follow up and encourage them to gradually incorporate what they have learned into their personal experience.

3. **Interaction of a group of trainees with the training content and the trainer:** People in general are social, and they are also social in an environment like e-learning. Therefore, it is very important to provide opportunities to activate this social nature by placing small groups of trainees with each other to carry out some activities, whether these activities are directly related to the training content or to social activities.

Second axis: Interactive lesson production skills

Interactive lessons are very different from traditional lessons. Objective considerations must be considered when building and preparing the interactive lesson, so that the interactive lesson is not a traditional lesson wrapped in some interactive covers such as the use of a computer, a smart board, or other items. The interactive lesson is not a goal in itself, but rather an advanced method that helps to achieve educational and learning behavioral goals with great accuracy.

Concept of interactive lessons: Through the researchers' review of many definitions of the concept of interactive lessons (e.g., Abdulhamid, 2005; Aldhafeeri, 2004; Clarke, 2008; Elfar & Shahin, 2001; Khames, 2003), *interactive lessons* can be defined as lessons that are published on the Internet, in which students interact with each other and with the teacher, using online interaction tools, where students can study the course at any time during the day and anywhere in a manner that suits their needs.

Characteristics of interactive lessons: Several studies (e.g., Abdulhamid, 2005; Allan & Lawless, 2003; Zineldin, 2011) indicate that the characteristics of interactive lessons are characterized by:

1. *Connectivity:* Discussion rooms or discussion boards help students to connect with each other. They also help students to create new environments for group thinking, problem solving, and cooperative education, and to provide them with the necessary knowledge and skills.
2. *Not relying on physical attendance:* Online interactive lessons help students overcome temporal and spatial barriers to access information wherever they are.
3. *Ease of access to the teacher:* The interactive online lessons help students to reach their teacher easily.

Classification of interactive lessons: Abdelaziz (2013) indicated that interactive lessons can be categorized into:

1. *Simultaneous interactive lessons:* They are lessons in which communication between the teacher and the student is made at the same time, or students registered on the site are logged in at the same time to exchange research, in which case the student receives immediate feedback from their teacher (Hyder, 2007).
2. *Asynchronous interactive lessons:* In this case, the teacher places some resources or references for the lesson, and the students enter at the time they want, following the teacher's instructions (Abdelaziz, 2013).

Literature Review

Several studies emphasized the need to develop skills for designing and producing electronic lessons. An example of these studies is the study of Amasha (2011), which aimed to identify the impact of a training program based on smart web technologies for e-learning on their use in designing and broadcasting electronic lessons for faculty members in light of their training needs. The study found that there were statistically significant differences between the mean scores of faculty members in the pre and post application of the cognitive test and the observation card on the use of smart web technologies in designing and broadcasting electronic lessons via the web.

Mahmoud (2012) aimed to reveal the effectiveness of the use of electronic blogs in developing the skills of producing electronic lessons for the educational technology specialist. The results of the study found a statistically significant difference between the mean scores of the experimental group in the two applications, the pre and post applications, on the achievement test related to the skills of electronic lessons, and the skillful performance of electronic lesson design skills in favor of the post application of the experimental group.

Hedayah (2012) sought to identify the effectiveness of an electronic program based on the use of social networks in developing the skills of producing and publishing electronic lessons among graduate students in the College of Education. The results indicated that there were statistically significant differences at the level 0.05 between the average grades of the students of the second experimental group that taught through the program based on social networks in the pre and post application of the achievement test related to the cognitive aspect and the observation card for the skills of producing and publishing electronic lessons in favor of the post application.

Hammada (2013) investigated the effectiveness of free and controlled forums in developing the skills of designing electronic educational lessons for female students of the College of Education at the Islamic University of Gaza. The results showed that the use of educational forums in teaching PowerPoint is more

effective and positive than teaching PowerPoint through the traditional method. The results also showed that the controlled forums are more effective than the free forums.

The study of Alnemari and Kafafy (2015) tested the effectiveness of the different types of blended training and e-training in developing the skills of producing interactive lessons for computer teachers in the city of Taif. The study concluded that the second experimental group that used blended training was superior to the first experimental group that used e-training in the post-measurement of cognitive and performance achievement test.

Al-Absi (2017) aimed to measure the effectiveness of a programmed educational package in training female teachers to design and prepare interactive lessons for teachers. The results showed that there were statistically significant differences between the mean scores of the sample members in the pre and post measurements, on the dimensions of the test for preparing electronic interactive lessons and the total score for it in favor of the post measurement. This result confirmed the success of the educational package in training teachers to prepare interactive lessons.

The study of Zaghlol (2017) aimed to investigate the impact of learning the skills of using the interactive whiteboard through blogs in developing electronic lesson design skills and practical teaching skills for female students at the College of Education in Zulfi and measuring their attitudes towards teaching on the interactive whiteboard. The study found that there are statistically significant differences at the level 0.05 between the mean scores of the female students in the pre and post measurements of the achievement test and teaching skills in favor of the post application and the presence of positive attitudes of the students towards teaching using interactive lessons.

Designing & producing electronic lessons in mathematics

In addition, some studies emphasized the need to develop skills for designing and producing electronic lessons in mathematics. An example of these studies is the study of Abdul Majid (2008), which aimed to develop the skills of student teachers at the Faculty of Education in Egypt to design and produce electronic lessons in mathematics and their attitudes towards e-learning. Moodle software was used to train students to design electronic lessons as well as an observation card to measure students' skills in designing and producing electronic lessons. The results showed that the training program helped students to prepare mathematics lessons on the Internet effectively, due to the comprehensiveness of the program and its containing of multiple media and a detailed explanation of the steps for preparing electronic lessons.

Elsayed and Soliman (2011) used a training program based on semantic web tools (web.3) to develop electronic lesson production skills and motivation towards e-learning among mathematics students in Oman. The results showed the effectiveness of the web.3-based training program in developing students' skills in producing electronic lessons in their academic majors. In addition, the study recommended the necessity of training mathematics students before and during the service to produce electronic lessons instead of using lessons designed by companies or individuals who have no knowledge of educational foundations in electronic design.

Aljehani (2017) investigated the effectiveness of e-training based on learning management systems in developing the skill of producing interactive lessons for mathematics teachers in Jeddah. The results found a statistically significant difference between the mean scores of the experimental and control group teachers in the cognitive and performance aspects of the skills of producing interactive lessons in favor of the experimental group, which shows the effectiveness of the training program in developing these skills.

Musa and Siam (2021) aimed to investigate the extent to which mathematics teachers in basic education in Syria possess and employ the skills of designing interactive lessons from their point of view. The results revealed that the total degree of the sample's use of interactive lesson design skills came to a medium degree. Also, there are statistically significant differences in favor of teachers who took computer training courses compared to others.

METHODOLOGY

This study was based on:

1. An analytical descriptive approach, used to monitor and analyze both Arab and foreign literature that dealt with e-training environments to arrive at the appropriate design of the e-training environment for the experimental treatment of the current study.
2. An experimental approach, used to achieve the research objectives, which is to find out the effect of the independent variable (the difference in the interaction pattern in the e-training environment) on the dependent variable (developing the skills of producing interactive lessons for middle school mathematics teachers); the researchers employed the experimental approach in its quasi-experimental design of three experimental groups with a pre and post measurement.

Research Population and Sample

All middle school mathematics teachers in the Eastern Province, Saudi Arabia, were the population of

this study. The application of the research was limited to a random sample representing the research population consisting of 60 teachers, who were divided in a simple random manner equally into three experimental groups.

Research Variables

The research variables were, as follows:

1. **Independent variable:** The difference in the interaction pattern in an e-training environment, and it has three levels:
   a. Group and content interaction pattern in the e-training environment.
   b. Individual, content, and trainer group interaction pattern in e-training environment.
   c. Group, content, and trainer interaction pattern in the e-training environment.
2. **Dependent variable**
   a. Acquisition of the cognitive aspects related to the skills of producing interactive lessons.
   b. Teachers' performance of interactive lesson production skills.
   c. Quality of interactive lessons produced by teachers.

Research Procedures

The researchers adopted the Aldisuki (2012) model in developing the training environment based on different interaction patterns because it is a comprehensive model, which includes design and educational development processes. The Aldisuki (2012) model corresponds to the logical steps of planning, preparing, and designing e-training environments.

Below is a detailed description of the procedures that were followed in each stage:

First stage: Analysis stage

This stage includes several steps that the designer must follow meticulously, namely:

1. *Identifying general goals:* The general objective of this research was to develop the skills of producing interactive lessons for middle school mathematics teachers.
2. *Determine learning tasks:* To determine the main and sub-skills needed to develop the skills of producing interactive lessons, the researchers reviewed a set of previous literature that dealt with the skills of producing interactive lessons (e.g., Al-Absi, 2017; Aljehani, 2017; Alnemari & Kafafy, 2015; Amasha, 2011; Hammada, 2013; Hedayah, 2012; Mahmoud, 2012; Zaghlol, 2017). After listing those skills, they were divided into basic skills, and under each basic skill a group of related sub-skills were listed. The list of skills for producing interactive lessons was finalized (main skills=8, sub-skills=44).
3. *Analysis of the characteristics of the target audience:* The physical, mental, cognitive, emotional, and special characteristics of the target group of this research were determined. Also, the access behavior was determined and measured through the researchers' conducting interviews with middle school mathematics teachers to identify their computer and internet skills, and their previous experience related to the subject of training. Through these interviews, the researchers concluded that middle school mathematics teachers possess computer and Internet skills, and have no previous experience with the skills of producing interactive lessons.

Second stage: Design stage

This stage included the following steps:

1. *Formulating training objectives:* The training objectives were formulated to develop the skills of producing interactive lessons for middle school mathematics teachers.
2. *Designing the training content:* To design the training content, the researchers took a number of steps, as follows:
   a. **Determining the ideal performance.**
   b. **Comparing the current level of performance with the levels of desired performance:** The researchers compared levels of current performance with levels of desired performance, and found that there is a need to develop the skills of producing interactive lessons for middle school mathematics teachers.
   c. **Organizing content elements:** The researchers relied on the hierarchical sequence, to organize the skills from top to bottom (from general to specific) in a longitudinal form, because it is commensurate with the required educational tasks.
3. *Design appropriate multimedia:* The researchers designed appropriate multimedia such as text writing, still image production and processing with Adobe Photoshop, and video clips and processing with Snagit8 software to create effects and video clips in small areas that can easily work.
4. *Determining the method of evaluating teachers:* The researchers relied on the achievement test, the performance observation card, and the interactive lesson production quality evaluation card as tools for evaluating teachers.
5. *Determining the standards for developing the e-training environment:* The researchers built a list of e-training standards based on the interaction

pattern in the e-training environment by referring to some previous studies (e.g., Abd-Elaatty & Aboukhatwa, 2012; Azmy, 2018; Khames, 2003; Kafafy, 2009), where the standards included two areas, educational and technical standards, and each area included a set of sub-standards.

6. *Designing the educational scenario:* The scenario is a detailed description of the screens that were designed by programming languages and that were used to design e-training based on the interaction pattern in the e-training environment, including multimedia elements (texts-images-graphics-video-colors-etc.).
7. *Designing the interfaces and the interactions between the participants:* The researchers were keen to achieve all objectives through training based on interaction patterns in the e-training environment, as the interaction patterns varied to include (a group of trainees with the content - a trainee with the training content and the trainer - a group of trainees with the training content and the trainer):
    a. **Interaction of a group of trainees with the content:** This is achieved when the trainees interface with the e-training environment, pressing the buttons, reading the existing texts, and watching the videos available within the lesson.
    b. **Interaction of a trainee with the training content and the trainer:** This type of interaction takes place by navigating between the electronic pages of the e-training environment. When designing the pages of the e-training environment, it was taken into account that they contain a set of buttons or menus to interact with them. Through these buttons or menus, the trainee can navigate between the pages of the e-training environment.
    c. **Interaction of a group of trainees with the training content and the trainer:** This is done through social networking tools where the interaction between them occurs asynchronously or synchronously. Trainees send their inquiries, and the trainer answers them at a later time.

Third stage: Production stage

In light of the designed scenario, the electronic training environment based on different interaction patterns (a group of trainees with the content - a trainee with the training content and the trainer - a group of trainees with the training content and the trainer) was produced using Moodle.

Fourth stage: Evaluation stage

1. **Presenting the training environment based on interaction patterns to a group of specialists.**
2. **The e-training environment based on different interaction patterns is made available to the pilot group:** The e-training environment based on the different interaction patterns in the e-training environment (a group of trainees with the content–a trainee with the training content and the trainer–a group of trainees with the training content and the trainer) was tested on a pilot group to achieve the following objectives:
    a. Ensuring the clarity of the scientific material included in the e-training environment.
    b. Determine the difficulties and problems that may arise during the implementation of the main research experiment, and then develop a plan to address them.

The pilot study was conducted on 30 middle school mathematics teachers.

Fifth stage: Application stage

The e-training environment based on the different interaction patterns in the e-training environment was applied to a random sample of 60 teachers, who were divided equally and in a simple random way into three experimental groups: the first experimental group training in an interaction mode (group and content) using the e-training environment, the second experimental group training in an interaction pattern (individual, content, and trainer) using the e-training environment, and the third experimental group training in an interaction pattern (group, content, and trainer) using the e-training environment.

Research Tools

The researchers prepared following research tools.

Achievement test

This test aims to measure the achievement of a sample of middle school mathematics teachers in the cognitive aspect of the skills of producing interactive lessons based on Bloom's cognitive levels. The test measures three levels of Bloom's cognitive levels, which are knowledge, comprehension, and application. In **Table 1**, a sample item of the achievement test based on Bloom's cognitive levels is provided.

Test validity: Content validity was verified by presenting the test in its initial form to five experts in the field of educational technology. The modifications recommended by the experts were made to the initial form of the achievement test, which included 60 items. Thus, the test was valid and ready to apply to the pilot group to calculate its reliability coefficient.

Table 1. Sample Items of the achievement test

Training objective	Objective's level	Item
Trainee defines the steps of the interactive lesson design stages.	Knowledge	Determining the objectives of learning the e-course is one of the most important steps in the stage of ...: a-planning. b-design. c-analysis. d-evaluation.
Trainee adjusts the properties of the images after inserting them into the slide.	Comprehension	After inserting image into the slide, you can adjust its properties from ...: a-home. b-insert. c-view. d-format.
Trainee creates a new scenario devoid of content and coordination.	Application	To create a new scenario devoid of content and format, you choose ...: a-new project. b-import quiz maker. c-record screen. d-browse.

Pilot study for the test: The pilot study sample was 30 middle school mathematics teachers. The index of difficulty and ease were calculated for the test items. The ease coefficient ranged between 0.52-0.80, which are acceptable. The difficulty coefficient ranged between 0.28-0.44, which are acceptable as well. The discrimination coefficient for each item of the achievement test ranged between 0.20-0.25, which are acceptable.

Test reliability coefficient: The reliability of the test was calculated using the Cronbach's alpha coefficient. The reliability coefficient was 0.82, which is a good value.

After these procedures, the achievement test in its final form became valid for application.

Observation card for interactive lesson production skills

The researchers followed the following procedures in preparing the interactive lesson production skills observation card:

Observation card objective: The observation card aimed to determine the level of performance of middle school mathematics teachers in the skills of producing interactive lessons.

Performances included in observation card: The performances were determined by relying on the final form of the list of interactive lesson production skills. The list of interactive lesson production skills included 8 skills, and the total number of items were 44. The skills were arranged in a logical order on the observation card.

Observation card validity: The validity of the observation card was estimated by the face validity. The observation card was sent to a group of arbitrators and experts specialized in the field of educational technology. All experts' recommendations and suggestions were taken into consideration.

Observation card reliability coefficient: The reliability coefficient of the observation card was calculated by the method of multiple observers on the performance of one teacher, and then the percent agreement between their estimates was calculated using Cooper's (1974) equation. The researchers evaluated the skills performance of five middle school teachers, and the percent agreement between the three researchers was calculated. The average agreement of the observers on the performance of the five teachers is 96.88%, which is considered a high stability coefficient.

Quality evaluation card

The evaluation card for the quality of middle school teachers' production of interactive lessons was designed according to the following steps:

Evaluation card objective: The card aims to measure the quality of middle school mathematics teachers' production of interactive lessons.

Evaluation card items: The evaluation card included two main fields. The first field represented the educational standards, which included three standards, and 14 indicators. The second field represented the technical standards, which included six standards and 29 indicators. Therefore, the number of evaluation indicators for the whole card is 43 indicators for evaluating the teachers' production of interactive lessons.

Initial form of the evaluation card: The initial form of the card included nine main standards, including 43 indicators to judge the quality of the production of interactive lessons for middle school mathematics teachers.

Evaluation card validity: To verify the validity of the card, the initial form of it was sent to a group of arbitrators. Some standards have been modified, and the card was in its final form ready for application.

Table 2. Pre-application of the achievement test

Variable	Variance	Sums of squares	df	Mean squares	F	P
Interaction pattern in the e-training environment	Between-groups	0.212	2	0.106		
	Within-groups	3945	63	6.223	0.017	0.983
	Total	392.258	65			

Table 3. Pre-application of the observation card

Variable	Variance	Sums of squares	df	Mean squares	F	P
Interaction pattern in the e-training environment	Between-groups	0.212	2	0.106		
	Within-groups	2051.545	63	32.564	0.003	0.997
	Total	2054.758	65			

Evaluation card reliability: The reliability of the evaluation card was calculated by applying it to the pilot study sample. The coefficient of agreement was calculated using Cronbach's alpha equation (Ismail, 2009). The Cronbach's alpha coefficient was 0.96, which indicates a high reliability coefficient.

Implementation of the Research

The researchers started this research in the second semester of the academic year 2020/2021 and lasted about a month. The research went through the following steps.

Prepare for the application

The preparing stage for applying the research went through the following steps:

1. The researchers ensured that the computers in the lab were connected to the web.
2. The researchers ensured that there were headphones so that each teacher could hear the training content individually without being distracted by the other teachers.
3. The researchers held an introductory session with middle school mathematics teachers, the research sample, in order to familiarize them with the research experience and its purpose, and ensure the clarity of instructions for using the e-training environment.

Pre-application of research tools

The researchers applied the two research tools previously (achievement test - observation card) and monitored the trainees' scores in order to ensure that the three research groups were equal.

The equivalence of the research groups for the achievement test

The researchers calculated the scores of middle school mathematics teachers in the pre-application of the achievement test related to the skills of producing interactive lessons, and used one-way ANOVA to analyze the data. They then calculated the F-value to test the differences between the mean scores of middle school mathematics teachers in the three experimental groups in the pre-application of the achievement test for the cognitive aspects related to the skills of producing interactive lessons (**Table 2**).

Table 2 indicates that F=0.017 and p=0.983, which means that there are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the pre-application of the achievement test of the cognitive aspects related to the skills of producing interactive lessons.

The equivalence of the research groups for the observation card

The researchers calculated the scores of middle school mathematics teachers in the pre-application of the observation card related to the skills of producing interactive lessons, and used one-way ANOVA to analyze the data in the pre-application of the observation card related to the skills of producing interactive lessons (**Table 3**).

Table 3 shows that F=0.003 and p=0.997, which means that there are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the pre-application of the observation card related to the skills of producing interactive lessons.

Statistical Methods

The researchers used SPSS.21 program to test the research hypotheses. The researchers used the following statistical methods:

1. One-way ANOVA and
2. Scheffe' test to determine the trends of differences according to the pattern of interaction in the e-training environment.

RESULTS

First Hypothesis

There are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the achievement test for the cognitive aspects related to the skills of producing interactive lessons due to the effect of

Table 4. The results of the one-way ANOVA for the post application of the achievement test

Variable	Variance	Sums of squares	df	Mean squares	F	P
Interaction pattern in the e-training environment	Between-groups	916.485	2	458.242		
	Within-groups	220.000	63	3.492	131.224	0.000
	Total	1136.485	65			

Table 5. Scheffe' test results to determine the trends of differences based on the interaction style in the e-training environment in the pre-application of the achievement test

	Research groups (I)	Research groups (J)	MD (I-J)	SD	Sig.
Achievement test	Third experimental group (interaction between group, content, & trainer)	First experimental group (interaction between group & content).	5.818*	0.563	0.000*
		Second experimental group (interaction between individual, content, & trainer)	9.000*	0.563	0.000*
	First experimental group (interaction between group & content)	Third experimental group (interaction between group, content, & trainer)	5.818*	0.563	0.000*
		Second experimental group (interaction between individual, content, & trainer)	3.182*	0.563	0.000*
	Second experimental group (interaction between individual, content, & trainer)	Third experimental group (interaction between group, content, & trainer)	9.000*	0.563	0.000*
		First experimental group (interaction between group & content)	3.182*	0.563	0.000*

Note. MD: mean difference; SD: Standard deviation

Table 6. The results of the one-way ANOVA for the post application of the observation card

Variable	Variance	Sums of squares	df	Mean squares	F	P
Interaction pattern in the e-training environment	Between-groups	37288.394	2	18644.197		
	Within-groups	5567.727	63	88.377	210.963	0.000
	Total	42856.121	65			

the different interaction patterns in the e-training environment.

Table 4 shows the results of one-way ANOVA analysis (F=131.224, p=0.000), which means that the first hypothesis is rejected. Therefore, the alternative hypothesis is accepted, which states that there are statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the achievement test for the cognitive aspects related to the skills of producing interactive lessons due to the effect of the different interaction patterns in the e-training environment.

To find out the trends of the differences between the three groups, the researchers used the Scheffe' test (**Table 5**).

The results of the Scheffe' test indicated that the statistically significant differences between the averages of middle school mathematics teachers in the post application of the achievement test was in favor of the third experimental group that depends on the interaction pattern (group, content, and trainer).

Second Hypothesis

There are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the teachers' performance observation card for the skills of producing interactive lessons due to the effect of the different interaction patterns in the e-training environment.

Table 6 provides the results of one-way ANOVA analysis (F=210.963, p=0.000), which means that the second hypothesis is rejected. Therefore, the alternative hypothesis is accepted, which states that there are statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the teachers' performance observation card for the skills of producing interactive lessons due to the effect of the different interaction patterns in the e-training environment.

To find out the trends of the differences between the three groups, the researchers used the Scheffe' test (**Table 7**).

The results of the Scheffe' test indicated that the statistically significant differences between the averages of middle school mathematics teachers in the post application of the observation card were in favor of the third experimental group that depends on the interaction pattern (group, content, and trainer).

Third Hypothesis

There are no statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the interactive lesson quality evaluation card produced by teachers due to the effect of the different interaction patterns in the e-training environment.

Table 7. Scheffe' test results to determine the trends of differences based on the interaction style in the e-training environment in the pre-application of the observation card

	Research groups (I)	Research groups (J)	MD (I-J)	SD	Sig.
Observation card	Third experimental group (interaction between group, content, & trainer)	First experimental group (interaction between group & content).	35.955*	2.834	0.000*
		Second experimental group (interaction between individual, content, & trainer)	57.636*	2.834	0.000*
	First experimental group (interaction between group & content)	Third experimental group (interaction between group, content, & trainer)	35.955*	2.834	0.000*
		Second experimental group (interaction between individual, content, & trainer)	21.682*	2.834	0.000*
	Second experimental group (interaction between individual, content, & trainer)	Third experimental group (interaction between group, content, & trainer)	57.636*	2.834	0.000*
		First experimental group (interaction between group & content)	21.682*	2.834	0.000*

Note. MD: mean difference; SD: Standard deviation

Table 8. The results of the one-way ANOVA for the post application of the quality evaluation card

Variable	Variance	Sums of squares	df	Mean squares	F	P
Interaction pattern in the e-training environment	Between-groups	3086.576	2	1543.288		
	Within-groups	1003.364	63	15.926	96.901	0.000
	Total	4089.939	65			

Table 9. Scheffe' test results to determine the trends of differences based on the interaction style in the e-training environment in the pre-application of the quality evaluation card

	Research groups (I)	Research groups (J)	MD (I-J)	SD	Sig.
Quality evaluation card	Third experimental group (interaction between group, content, & trainer)	First experimental group (interaction between group & content).	7.591*	1.203	0.000*
		Second experimental group (interaction between individual, content, & trainer)	16.727*	1.203	0.000*
	First experimental group (interaction between group & content)	Third experimental group (interaction between group, content, & trainer)	7.591*	1.203	0.000*
		Second experimental group (interaction between individual, content, & trainer)	9.136*	1.203	0.000*
	Second experimental group (interaction between individual, content, & trainer)	Third experimental group (interaction between group, content, & trainer)	16.727*	1.203	0.000*
		First experimental group (interaction between group & content)	9.136*	1.203	0.000*

Note. MD: mean difference; SD: Standard deviation

Table 8 shows the results of one-way ANOVA analysis (F=96.901, p=0.000), which means that the first hypothesis is rejected. Therefore, the alternative hypothesis is accepted, which states that there are statistically significant differences at 0.05 between the average scores of middle school mathematics teachers in the post application of the interactive lesson quality evaluation card produced by teachers due to the effect of the different interaction patterns in the e-training environment.

To find out the trends of the differences between the three groups, the researchers used the Scheffe' test (**Table 9**).

The results of the Scheffe' test indicated that the statistically significant differences between the averages of middle school mathematics teachers in the post application of the quality evaluation card was in favor of the third experimental group that depends on the interaction pattern (group, content, and trainer).

DISCUSSION

The researchers attribute the current research results to the following:

1. The interaction of the trainees with their colleagues, the content, and the trainer in the e-training environment allowed the exchange of information and ideas about the learning process. This interaction was done under the supervision of the trainer in more than one form, such as discussion groups, project implementation groups, and training activities implementation groups.
2. The interaction of the trainees with their colleagues, the content, and the trainer in the e-training environment allowed the trainees to add to their information some new knowledge resulting from their interaction with their colleagues and the experiences exchanged between them, under the trainer's supervision.

3. The interaction of the trainees with their colleagues, the content, and the trainer in the e-training environment made it easy for the trainees to communicate with each other, and to exchange information, ideas, and experiences.

The results of this research agree with many theories such as

1. the activity theory (Leont'ev, 1978), where the trainee relies in the e-training environment on electronic educational interactions and the activity carried out by the trainee, its design that contains topic, goal, social sharing, and division of work,
2. the theory of educational interactions (Anderson, 2004), which depends on the occurrence of interactions during learning in the e-training environment, and is based on the foundations of participatory learning through the sharing of information, ideas, and continuous discussions between the trainees and each other, and
3. the social constructivism theory (Vygotsky, 1978), which suggests that interaction between trainees helps in meeting the needs of the trainee and communication between his/her colleagues.

Moreover, the results of this research agree with the results of the study of Jung et al. (2010) and Sher (2009). On the other hand, the results of this research differ from

1. the results of some studies (e.g., Barg, 2009; Naimat, 2011; Vu, 2009), which found that the trainee's interaction individually with the content and the trainer is better than other interaction patterns,
2. the results of the study of Sabry and Baldwin (2003), which suggested that the trainee's interaction with the content only is the best mode of interaction, and
3. the results of Reisetter and Boris (2004), which found that the interaction between the trainees with each other makes the interaction less serious and reduces their attitudes towards training.

Recommendations

In light of the research results, discussion and interpretation, the researchers recommend the following:

1. Employing the three interaction patterns (group and content–individual, content, and trainer–group, content, and trainer) presented in this research in the design of e-training environments.
2. Taking into account the diversity of the interaction patterns in the design of e-training programs, and not being limited to one type to take into account individual differences.
3. Making use of the measurement tools of this research (achievement test, observation card, quality evaluation card) in evaluating the performance of middle school mathematics teachers in producing interactive lessons.

Suggestions for Future Research

Considering the results of the current research, and by reviewing previous studies related to the topic of research, we suggest the following research topics:

1. The effect of the interaction between the timing of providing support and the cognitive style in the e-training environment on developing the skills of producing interactive lessons for middle school mathematics teachers.
2. The current research was limited to dealing with the effect of some independent variables on mathematics teachers, so it is possible that future research will address these variables on a different sample of teachers. Therefore, it is possible that the results will differ due to the different characteristics of teachers.

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