Int. J. Nonlinear Anal. Appl. 13 (2022) 2, 2585–2596
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2022.26529.3341

Evaluation of the effectiveness of e-learning systems in teaching mathematics (Case study: 10th grade mathematical physics and experimental sciences students in North Khorasan province- Iran)

Mohammad Alizadeh Jamal*

Department of Mathematics Education, Farhangian University, Tehran, Iran

(Communicated by Mohammad Bagher Ghaemi)

Abstract

The purpose of the present study was to investigate the effectiveness of e-learning systems in teaching mathematics to tenth-grade students in both fields of study mathematical physics and experimental sciences disciplines in North Khorasan province (Northeastern Iran). This research was conducted as applied research and by a descriptive-survey method. The statistical population of the present study includes all tenth-grade students of both mathematical physics and experimental sciences in North Khorasan province (2900 students) and finally, about 340 students were selected using Krejcie and Morgan selection table. The research data collection tool is the standard e-learning questionnaire of Watkins et al. [24]. This questionnaire includes 25 questions and 6 factors (access to technology, motivation, ability to learn through the media, Internet group conversations, and important issues for success in e-learning). In order to test the research hypotheses, the structural equation modelling method with LISREL software version 8.8 was used. The results of factor analysis showed that among the items of skills and continuous communication only two items were ma1 and ma4, among the items of motivation, only item a1, among the items of access to technology only item d2, and among the items of the ability to learn through the media, the two items t1 and t2, among the items of Internet group conversations, only the item g3 and among the items of important issues for success in e-learning, the two items m1 and m3 were approved. Because the factor load of these items is more than 0.4 and also the value of the computational t-statistic is more than the standard value of 1.96. In other words, the more students are equipped with these items, the more successful they will be in learning mathematics through electronic systems. The results also showed that among the variables affecting the evaluation of the success of electronic systems, only the value of the motivation t-statistic (1.97) is higher than the standard value of 1.96. In other words, the results indicate that the more motivated students are, the more they will learn mathematics through electronic systems.

Keywords: Electronic Learning Effectiveness, Mathematics Course of Study, E-learning Systems, Math Learning
2020 MSC: 97D40, 9702

*Corresponding author
Email address: alizadehjamal.m@gmail.com (Mohammad Alizadeh Jamal)

Received: January 2022 *Accepted:* April 2022

1 Introduction

Mathematics, as one of the logical sciences and a knowledge that can be studied with the help of the laws and principles of rational axioms, puts the field of intellectual and logical activity of the human mind in the range by which the principles and unknowns of the world of creation are discovered. The principles that underlie the interpretation of many more specialized sciences [12]. Whether we consider mathematics to be a general science that is related to other sciences or to a specific science with its own characteristics, it has components and a range of concepts that have been located in the human being mined from birth. When the baby sees the obvious components of the mother's face and recognizes them on a screen of distinct colours, he or she rushes to the universal perception that quantity, size, width, surface, and volume are its inseparable components. Concepts such as number, size, smallness, equality, addition and subtraction, multiplication and division, reasoning power, problem-solving, comparison of dimensions in length, width, height, area, volume, etc. can all be inseparable components of mathematical science [15].

With the rapid growth of the Internet, the tremendous advances in information and communication technology have affected virtually every aspect of modern life. The information system has penetrated and integrated with almost all sectors of organizations, industries, education and business activities in order to achieve the desired goals and related benefits [11]. The education sector is one of the most promising and lucrative sectors, which is more affected by the acceptance of technology due to its increased ability to provide high-quality education. However, the e-learning environment is affected by the level of acceptance of e-learning [1, 14]. At present, most universities and schools and their administrations around the world rely on the Internet in their educational functions, because the Internet has facilitated unlimited operations regardless of geographical segregation [16]. Given that the e-learning system is a combination of students and educators, the use of the Internet by both has shown that it can change the traditional learning methods used with an interactive online system, however, most further previous research has focused on students' perspective [16, 21, 23]. Today, the electronic learning system has begun to play a role beyond education because it allows access to learning resources without time or space constraints [3]. Teaching and learning systems have undergone extraordinary changes in the last decade, which have also been approved in the research review [4, 17]. The e-learning system has been used globally in the education sector for many years. Over the past two decades, e-learning has been used in the form of communication courses, audio and videotapes, video conferencing and television broadcasting. Currently, the Internet is the optimal medium for electronic learning. Internet-based distance learning is considered the largest implementation of common e-learning technology in information and communication technology [5]. Also, the rapid growth of technology has been considered on a significant scale due to the exponential growth of the use of smart devices such as smartphones and advanced laptops. Recent technologies and applications in smart devices have become key elements of e-learning, communication, resource sharing and management for both students and educators. The e-learning system, like the blackboard, has completely redefined traditional classrooms and turned them into web presentations and provided direct links to classes, meetings, exams, uploading and downloading files, discussions, as well as students asking questions and providing feedback [6, 7]. According to what has been said, the purpose of the present study is to evaluate the effectiveness of e-learning systems in learning mathematics for tenth-grade students of mathematical physics and experimental sciences in North Khorasan province- Iran. In other words, the main question of the present study is whether e-learning systems have been effective in learning the mathematics course of tenth-grade students of mathematical physics and experimental sciences in North Khorasan province?

2 Theoretical Foundations and Research Background

E-learning is rapidly evolving, and a variety of technologies and devices are available to access learning resources such as laptops, computers, smartphones, and tablets. Technology has a profound effect on teaching, learning and teaching methods in mathematics. In the past, access to learning materials has been limited to a few range of people. Collaboration and communication were also limited to the students in the same classroom. Today, a large number of learning resources in various formats (such as text, photos, audio files, and video files) are available through the Internet, which fosters step-by-step learning and transcends geographical boundaries in [2]. Due to the constant evolution of technology, there is no single agreed definition for e-learning. Lee et. al. in [13] have defined e-learning as an information system that can integrate different learning materials (via audio, video, and text media) and transmit them via email, live chat sessions, online discussions, and forums, quizzes and assignments. Other researchers have used the concept of e-learning as the meaning of the actions of technology in the learning process [22].

Ghoraeian [10] in a study examined the success of e-learning systems in using the virtual education system for interactors in improving the quality of e-learning. The first role of this study was to develop a comprehensive and multidimensional model for evaluating the success of e-learning. This model has been developed based on a thorough review of articles and analysis of four approaches to evaluate the success of e-learning: the DeLone and McLean Model of

Information Systems Success, technology acceptance model (TAM), Users Satisfaction Model, and E-learning Quality Models. The estimation model in this study was a comprehensive model because various aspects were considered in relation to the satisfaction and benefits of using the e-learning system, and these cases are the main components of the existing approaches. In the present study, 7 types of quality factors were proposed as the priority items of perceived satisfaction, perceived effectiveness, use and benefits, and then were examined experimentally (with the titles of technical system quality, information quality, service quality, educational system quality, support system quality, learner quality, teacher quality). All of these factors were valid and are important scales that are involved in identifying e-learning success factors. Ghalyan and Zalpour [9], in a study identified the success factors of e-learning among physical education students of Shahid Chamran University of Ahvaz- Iran. The statistical population of their study was 342 physical education students of Shahid Chamran University of Ahvaz, of which about 160 students were selected using the Morgan table. In this study, 4 factors affecting the implementation of e-learning, including the quality of services and units, quality of information, interaction in the online environment and the quality of the system and infrastructure were examined and prioritized by a researcher-made questionnaire. The results showed that all four components of quality of services and units, quality of information, interaction in the online environment and quality of system and infrastructure are the factors affecting the success of students' e-learning. According to the results of the TOPSIS test, infrastructure quality is the most important factor and the variable of interaction in the online environment is the least important. Olyaei et al. [19], identified the criteria for measuring the success of the e-learning system of the Technical and Vocational Training Organization of Iran. In this study, two categories of statistical population were considered: 1-E-learning experts; 2-Users of the organization's e-learning system. Questionnaire number one was designed to identify the criteria for measuring the success of e-learning system and the questionnaire number two was designed to explain the current status of the e-learning system of the Technical and Vocational Education Organization of Iran, which was processed using SPSS software. One-sample t-test was used to analyze the data. 7 criteria and 28 effective indicators in the success of the final e-learning systems and the position of the e-learning system were evaluated based on these criteria. Mirjalili [18] examined the status of factors affecting the quality assurance of e-learning from the perspective of student teachers. This descriptive survey was conducted among 314 student teachers of Farhangian University. Samples were selected using simple stratified random sampling method in April 2021. The status of effective factors on quality assurance of e-learning was assessed using a researcher-made questionnaire. Data were analyzed in SPSS software version 23 using one-sample t-test and all statistical tests were performed at a significant level of 0.05. The results showed that the status of students' skills components is at a desirable level. But the situation of factors such as technology infrastructure, teachers skills, ease of access to services and management structure in implementing the quality of e-learning were not favorable. Al-shargabi et al. [8] in a study examined the acceptance of e-learning system using the information systems success model: a case study of Jazan University. Data were collected from 568 respondents. And SPSS v.26.0 was used to analyze the data and one-way variance analysis was used to test the hypothesis. The overall results of this study point to the fact that there is a significant relationship between the factors of information system success model and the acceptance of e- learning systems. The results showed that the information system success model has a strong cost-benefit associated value with the acceptance of e-learning systems throughout Jazan University, which may be extended to other Saudi Arabia universities. Ouajdouni et al. [20] in a study examined the success of e-learning systems, and the data from students of higher education institutions in Morocco. Data were collected from students of Moroccan higher education institutions. This data was collected through a self-administered online questionnaire from a sample of 264 students. Responses were collected from students at 12 Moroccan universities and 31 Moroccan educational institutions. The Data then were analyzed using structural equation modeling under the partial least squares (PLS) approach. According to the results, the quality of the system has a positive and significant effect on the perceived usefulness and satisfaction of the e-learner. On the other hand, social impact has a significant impact on the use of e-learning systems. At the same time, perceived usefulness helps explain e-learning satisfaction. In contrast, learner computer anxiety has a significant and negative effect on e-learner satisfaction. Finally, perceived usefulness, the use of e-learning systems, and e-learner satisfaction greatly explain the success of the e-learning system.

3 Research Method

The present research is of applied type and descriptive-survey method. The statistical population of the study includes all tenth-grade students of both Experimental Sciences and Mathematical Physics disciplines in North Khorasan province- Iran (2900 students), and finally, about 340 students were selected using the Morgan selection table. The research data collection tool is the standard e-learning questionnaire of Watkins et al. [24]. This 26-item questionnaire consists of two parts. The first part is related to personal information, including gender and educational group. The second part includes questions related to the student's readiness to participate in e-learning, which is in the form of 6 factors (access to technology, motivation, ability to learn through the media, Internet group discussions, and important issues for success in electronic learning). For the score, a 5-point Likert scale was used (strongly agree: 5, agree: 4, neither agree nor disagree: 3, disagree: 2, strongly disagree: 1). Reliability was calculated using Cronbach's alpha coefficient and composite reliability. The values of these two coefficients for all research variables were above 0.7, which indicates the reliability of the measurement tool. The reliability and validity coefficients mentioned for the research questionnaire can be seen in table 1. According to the table, the reliability of the dimensions is confirmed because Cronbach's alpha and the composite reliability coefficient are above 0.7 and also ($AVE > 0.5$). Convergent validity is confirmed because ($CR > 0.7$); ($CR > AVE$); ($AVE > 0.5$) and divergent validity is also confirmed because ($MSV^1 < AVE$) and ($ASV^2 < AVE$), in which MSV^1 is the maximum Shared Squared Variance (MSV) and ASV^2 is Average Shared Squared Variance (ASV).

Table 1: The extracted mean variance coefficient and the composite reliability coefficient

Component	Cronbachs Alpha	CR	AVE	MSV	ASV	Continuous Skills and Communications	Motivation	Technology Availability	Learning Ability via Media	Internet Groups Discussions	Important issues for success in e-learning
Continuous Skills and Communications	0.72	0.87	0.61	0.37	0.28	0.72	–	–	–	–	–
Motivation	0.80	0.85	0.67	0.35	0.29	0.59	0.79	–	–	–	–
Technology Availability	0.79	0.86	0.59	0.53	0.29	0.49	0.54	0.84	–	–	–
Learning Ability via Media	0.74	0.89	0.69	0.52	0.31	0.42	0.46	0.38	0.77	–	–
Internet Groups Discussions	0.79	0.80	0.68	0.42	0.25	0.51	0.55	0.47	0.52	0.79	–
Important issues for success in e-learning	0.72	0.81	0.63	0.41	0.28	0.23	0.41	0.40	0.57	0.60	0.84

In the present research, in order to analyze the data, two sections of descriptive and inferential statistics will be used. In the descriptive section, frequency percentages, tables and graphs will be used to describe demographic features. Also, in order to describe the research variables, mean, standard deviation, skewness and Kurtosis will be used. It should be noted that the software used in the descriptive part was SPSS V23. In order to test the research hypotheses, the structural equation modelling method with LISREL software version 8.8 was used. It should be noted that in this test, three methods including measurement model fit, structural model fit and general model fit were discussed.

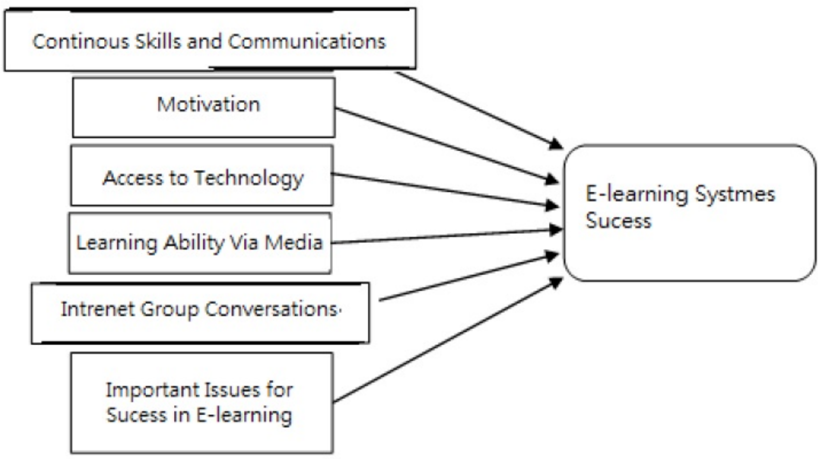

Figure 1: Conceptual model of research

4 Data Analysis

4.1 Demographic Statistics of the Respondents

According to table 2, it can be seen that 191 of the statistical sample are boys with a frequency of 56.1769 percent. Also, 149 of the statistical sample are girls with a frequency of 43.8352%.

Table 2: Investigation of frequency distribution of gender variables

Gender	Frequency	Frequency Percent	Cumulative frequency percentage
Boy	191	56.1769	56.1769
Girl	149	43.8235	100
Sum	340	100	–

According to table 3, it can be seen that 128 students from the statistical sample with a frequency of 37:67% belong to the Mathematical Physics group and 212 students from the statistical sample with a frequency of 62:352% belong to the Experimental Sciences group.

Table 3: Frequency distribution of the educational department

Gender	Frequency	Frequency Percent	Cumulative frequency percentage
Mathematical physics	128	37.647	37.647
Experimental Sciences	212	62.352	100
Sum	340	100	–

4.2 Variables Descriptive Statistics

The following table presents the descriptive statistics of the research variables including mean, variance, skewness and kurtosis. As can be seen, all research variables have been studied in terms of descriptive statistics, and in terms of skewness and kurtosis, all variables are in good condition. The highest and lowest averages are related to the ability to learn through media (3.6471) and motivation (2.333), respectively. Also, the highest standard deviation is related to motivation and the lowest is related to continuous skills and communications.

Table 4: Descriptive Statistics of the Research Variables

Variable	Mean	Standard Deviation	Variance	Skewness	Kurtosis
Continuous Skills and Communications	2.6471	0.48264	0.233	−0.234	−1.665
Motivation	2.3333	1.40949	1.987	0.578	−1.164
Access to Technology	3.6275	1.16552	1.358	−1.031	0.435
Learning Ability via Media	3.6471	1.23002	1.513	−0.69	−0.375
Internet Group Conversations	2.5882	0.87852	0.767	−0.374	−0.481
Important Issues of Success in E-Learning	3.6275	0.87088	0.758	0.442	−0.941

4.3 Analysis of Measurement Model

In evaluating the measurement part of the model, the researcher should examine the relationships between latent variables and explicit variables of the model. The purpose here is to determine the validity and reliability of the measurements in question. In terms of validity, the question is whether explicit indicators or variables measure what the researcher is looking for or something else. In contrast, the issue of trust or reliability deals with the issue of how accurately the indicators are used to measure the issue.

4.4 The Normality of the Data

In this section, we first examine the normality of the variables using the Kolmogorov-Smirnov test. If the significance level of the test is less than 0.05, the null hypothesis is rejected and it can be said with 95% confidence that the data distribution is not normal. If the significance level of the test is more than 0.05, the null hypothesis will be accepted and the data distribution is normal. According to the results, and considering that the probability level of all research variables is more than the standard value of 0.05%, so the null hypothesis of the research is accepted and the research variables are normal.

Table 5: Checking the normality of the distribution of variables

Variable	Statistic K.S	Sig	Result
Continuous Skills and Communications	1.784	0.742	Normal
Motivation	1.745	0.254	Normal
Access to Technology	2.965	0.356	Normal
The Ability of Learning via Media	2.247	0.421	Normal
Internet Group Conversations	1.254	0.587	Normal
Important Issues of Success in E-Learning	3.324	0.654	Normal

4.5 Sample Differentiation According to the Questionnaire Items

In this section, the questions of the questionnaire based on the coding (strongly agree: 5, agree: 4, neither agree nor disagree: 3, disagree: 2, strongly disagree: 1) are examined. The closer the mean of the answer to the number five, it can be concluded that the respondents completely agree with the factor raised in that question, and the closer the mean is to one, it indicates that the respondents do not agree with the factor raised in that question. The mean in the range of 1-2.3 is evaluated as low, 2.31-3.7 as medium and 3.71-5 is evaluated as high. According to the results, the highest average is related to the item "I am equipped with previous experiences related to continuous technologies in e-learning." with an average of 4.235 and the lowest average is related to the item "I am equipped with a computer with the appropriate hardware features." With an average of 2.333.

4.6 Confirmatory Factor Analysis of the Structure of the Questionnaire

In order to analyze the structure of the questionnaire and discover the components of each structure, factor loads were used (The factor load indicates the effect of each variable or item in explaining the variance of the variable scores or the main factor). In other words, factor load indicates the correlation of each observed variable with the hidden variable (factors). The results of factor loads of the research variables are summarized in table 7, and figures 2 and 3. If the factor load among the questionnaire questions and the latent variable is more than 0.4, it indicates that the question which has been used for that structure measured the latent variable well. The results of factor analysis showed that among the items of skills and continuous communication, only two items, ma1 and ma4, were approved because the amount of factor load of these two items is more than the standard value of 0.4. Also, the value of the t-statistic of these two items is more than the value of 1.96. Therefore, it can be said that there is a significant relationship between these two items and the success of e-learning systems. In other words, the more students are equipped with basic computer skills and participate in an electronic workshop several times a week, the more they will learn mathematics through electronic systems. Among the motivation items, only item a1 has a factor load greater than 0.4 and the t-statistic has more than 1.96. In other words, the more students constantly maintain their motivation when the teacher is not present, the more they will learn mathematics through electronic systems. Among the technology access items, only item d2 has a factor load greater than 0.4 and the t-statistic has more than 1.96. In other words, the more students are equipped with computers with hardware features, the more they will learn mathematics through electronic systems. Among the items of ability to learn through media, two items t1 and t2 have a factor load greater than 0.4 and t-statistics have more than 1.96. In other words, the more students are equipped with the ability to communicate the content of video clips, continuous information, and books, and the more they are able to take notes while watching a computer video, the more they will learn math through electronic systems. Among internet group chat and conversation items, only the g3 item has a factor load greater than 0.4 and the t-statistic has more than 1.96. In other words, the more students are equipped with the ability to have a continuous conversation while typing, the more they will learn mathematics through electronic systems. Also, among the items of important issues for success in e-learning, two items, m1 and m3, have a factor load of more than 0.4 and a t-statistic of more than 1.96. In other words, the more e-learning students are in regular contact with the instructor and the e-learning is equipped with previous experiences related to continuous technologies, the more they will learn in mathematics through electronic systems. The results of factor analysis for each of the research variables are given in the following figures. As the results show, among the variables affecting the evaluation of the success of e-learning systems, only the value of the motivation t-statistic (1.97) is higher than the standard value of 1.96. In other words, the results indicate that the more motivated students are, the more they will learn math through electronic learning systems. To evaluate the overall evaluation of the research model, the GOF Fit Criteria Goodness Index was used. For this fitting index, the values of 0.01, 0.25 and 0.36 have been introduced as weak, medium and strong values, respectively. Its formula is as follows:

Table 6: Distribution of questionnaire questions

Row	Variable	Item	Mean	SD	Status
1	CSC	I am equipped with basic computer skills	3.986	0.452	High
2	CSC	I am equipped with basic Internet search and information access skills	3.425	1.125	Medium
3	CSC	I am equipped with the ability to send emails along with other files	2.726	0.412	Medium
4	CSC	I attend an e-workshop several times a week	2.980	1.303	Medium
5	CSC	I am equipped with the ability to communicate with others through online technologies	3.803	1.233	High
6	CSC	I am equipped with the ability to use online tools	2.431	0.781	Medium
7	CSC	I am equipped with the ability to ask questions and comment in writing	3.725	1.021	High
8	CSC	I am equipped with the ability to express my feelings and moods through writing	2.588	0.852	Medium
9	CSC	I am equipped with the ability to manage time to respond to teachers and learners	2.392	0.021	Medium
10	M	I keep my motivation constantly in the absence of the teacher	2.647	0.483	Medium
11	M	I am equipped with the ability to get things done even with network disruptions	3.372	1.165	High
12	M	I am equipped with the ability to finish work even in the presence of disruptive factors in the house	3.745	0.976	High
13	AT	I have access to a computer connected to the Internet	3.607	1.217	Medium
14	AT	I am equipped with a computer with suitable hardware features	2.233	1.409	Medium
15	AT	I have access to the required software	3.156	1.419	Medium
16	ALM	I am equipped with the ability to communicate between the content of video clips, continuous information and books	3.313	1.174	Medium
17	ALM	I have the ability to take notes while watching a computer video	3.549	1.221	Medium
18	ALM	I am equipped with the ability to understand the content of the lesson that is broadcast via video	3.627	1.165	Medium
19	IGC	I have the ability to chat with others over the Internet using tools like Yahoo Messenger	3.784	1.006	High
20	IGC	I have the ability to spend more time preparing the answer to a question	3.414	1.176	Medium
21	IGC	I have the ability to have a continuous conversation while typing	3.529	1.254	Medium
22	IIES	During e-learning process I am in regular contact with the instructor	3.464	1.230	Medium
23	IIES	During e-learning I am technically and managerially supported quickly	3.313	1.104	Medium
24	IIES	During e-learning I am equipped with previous experiences related to continuous technologies	4.235	0.971	High
25	IIES	In e-learning I participate continuously in courses	3.764	1.106	High
		CSC: Continuous Skills and Communications			
		M: Motivation			
		AT: Access to Technology			
		ALM: The Ability of Learning via Media			
		IGC: Internet Group Conversation			
		IIES: The Important Issues in E-learning Success			

$$Gof = \sqrt{\overline{R}^2 \times \overline{communality}}$$

Considering that the obtained value of goodness-fit index is 0.549 (more than 0.36), it can be said that the model has a strong fit.

Table 7: Results of factor loads of research items

Symbol	Item(Observed Variable)	Factor Load	T-Statistic	Validity
ma1	I am equipped with basic computer skills	0.52	2.086	Confirmed
ma2	I am equipped with basic Internet search and information access skills	0.35	1.214	Not Confirmed
ma3	I am equipped with the ability to send emails along with other files	0.24	1.704	Not Confirmed
ma4	I attend an e-workshop several times a week	0.41	2.331	Confirmed
ma5	I am equipped with the ability to communicate with others through continuous technologies	0.24	0.623	Not Confirmed
ma6	I am equipped with the ability to use continuous tools	0.39	1.061	Not Confirmed
ma7	I am equipped with the ability to ask questions and comment in writing	0.24	0.807	Not Confirmed
ma8	I am equipped with the ability to express my feelings and moods through writing	0.23	1.867	Not Confirmed
ma9	I am equipped with the ability to manage time in order to respond to teachers and learners	0.34	0.879	Not Confirmed
a1	I keep my motivation constantly in the absence of the teacher	0.65	2.951	Confirmed
a2	I am equipped with the ability to get things done even with network disruptions	0.20	0.303	Not Confirmed
a3	I am equipped with the ability to finish work even in the presence of disruptive factors in my house	0.31	0.586	Not Confirmed
d1	I have access to a computer connected to the Internet	0.24	1.281	Not Confirmed
d2	I am equipped with a computer with suitable hardware features	0.74	2.873	Confirmed
d3	I have access to the required software	0.29	1.500	Not Confirmed
t1	I am equipped with the ability to communicate between the content of video clips, continuous information and books	0.97	2.554	Confirmed
t2	I have the ability to take notes while watching a computer video	0.48	2.218	Confirmed
t3	I am equipped with the ability to understand the content of the lesson that is broadcast via video	0.24	0.072	Not Confirmed
g1	I have the ability to chat with others over the Internet using tools like Yahoo Messenger	0.24	0.656	Not Confirmed
g2	I have the ability to spend more time preparing the answer to a question	0.37	0.853	Not Confirmed
g3	I have the ability to have a continuous conversation while typing	0.92	2.269	Confirmed
m1	During e-learning I am in regular contact with the instructor	0.72	1.753	Confirmed
m2	During e-learning I am technically and managerially supported quickly	0.24	0.642	Not Confirmed
m3	In the e-learning I am equipped with previous experiences related to continuous technologies	0.94	2.803	Confirmed
m4	During e-learning I participate continuously in the courses	0.17	0.241	Not Confirmed

Table 8: GOF fit goodness criterion results

GoF	R^2	communality
0.758	0.685	0.541

5 Conclusion

The purpose of the present study was to evaluate the effectiveness of e-learning systems in learning mathematics for tenth-grade students in both Experimental Sciences and mathematical Physics fields of study in North Khorasan province- Northern East of Iran. This research was of the applied type and conducted by the descriptive-survey

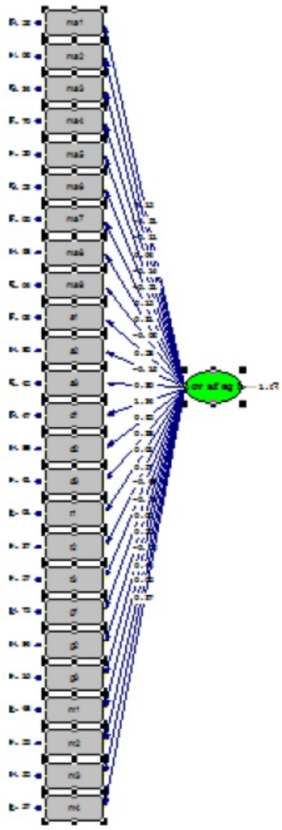

Figure 2: Confirmatory factor analysis of non-standard research items

method. E-learning, as a direct consequence of the integration of technology and education, has emerged as a powerful learning medium, especially with the use of Internet technologies. The undeniable importance of e-learning in education leads to the widespread growth of the number of e-learning courses and systems providing different types of services. Therefore, evaluating e-learning systems is crucial to ensure successful delivery, efficient use, and a positive impact on learners. The results of confirmatory factor analysis showed that all items of the study have acceptable values of t (more than 1.96) and factor load (more than 0.4). In other words, e-learning systems have been useful in learning students' math lessons. As the results showed, among the variable items, the continuous skills and communication, had the most factor load (the question: I am equipped with basic computer skills). Also, among the items of this variable, the least factor load was related to the question: I am equipped with the ability to send an e-mail along with other files. Among the variable items of motivation, the most factor load is related to the question: I keep my motivation constantly during the absence of the teacher. Among the variable items of access to technology, the most factor load is related to the question: I am equipped with a computer with appropriate hardware features. The results showed that among the variable items of the ability to learn through the media, the most factor load is related to the question: I am equipped with the ability to communicate between the content of video clips, continuous information and books. Among the items of Internet group conversations, the most factor load is related to the question: I have the ability to have a continuous conversation while typing. Also, among the important issues for e-learning success, the most factor load is related to the question: In the e-learning, I am equipped with previous experiences related to continuous technologies. The results of the research showed that e-learning of mathematics through electronic systems has been effective for students and students have shown great interest in learning mathematics through these systems. The results of the present study are in line with the research in [8, 9, 10, 18, 19]. Due to the limitations of traditional educational methods to meet the educational needs of society and the strengths of e-learning to overcome these limitations, the process of using this powerful educational system in universities, schools and educational systems is growing. Evidence of this can be seen in the number of universities, schools and higher education institutions that currently use this system. Of course, the mere use of these tools cannot be equated with the success of educational systems to achieve their goals, but the e-learning environment includes a set of tools, facilities and software that require effective knowledge of skills and attitudes. Therefore, it cannot be said that just using e-learning equals the success of the educational system that uses it. Rather, how it is used in accordance with scientific standards, can increase

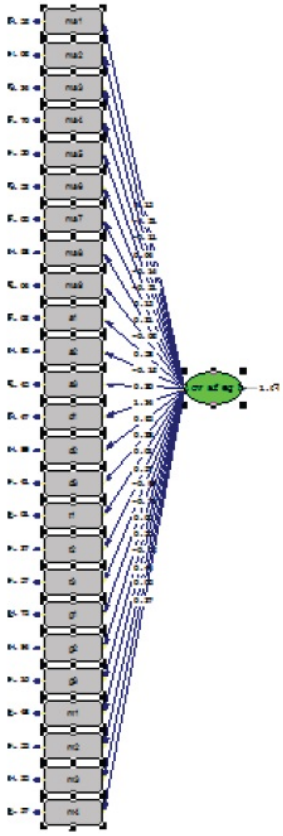

Figure 3: Confirmatory factor analysis of research items in standard mode

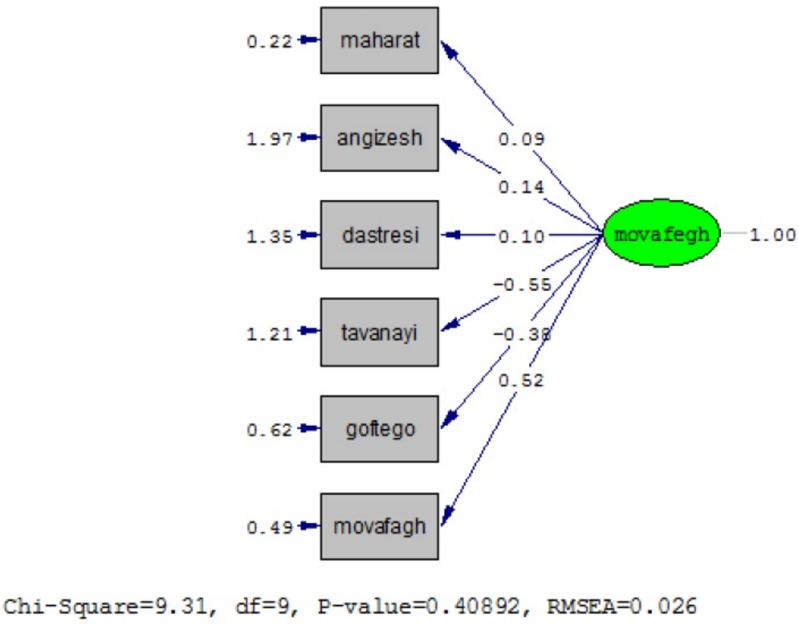

Figure 4: Confirmatory factor analysis of research variables in standard mode

the success rate of these systems. This application with scientific standards and principles includes a wide range of standards, on one side of which are the principles and technical standards of designing e-learning environments, and on the other side, are the educational principles based on educational design models and patterns. It is suggested that due to the growth and expansion of e-learning in university and school courses, advanced electronic systems based on

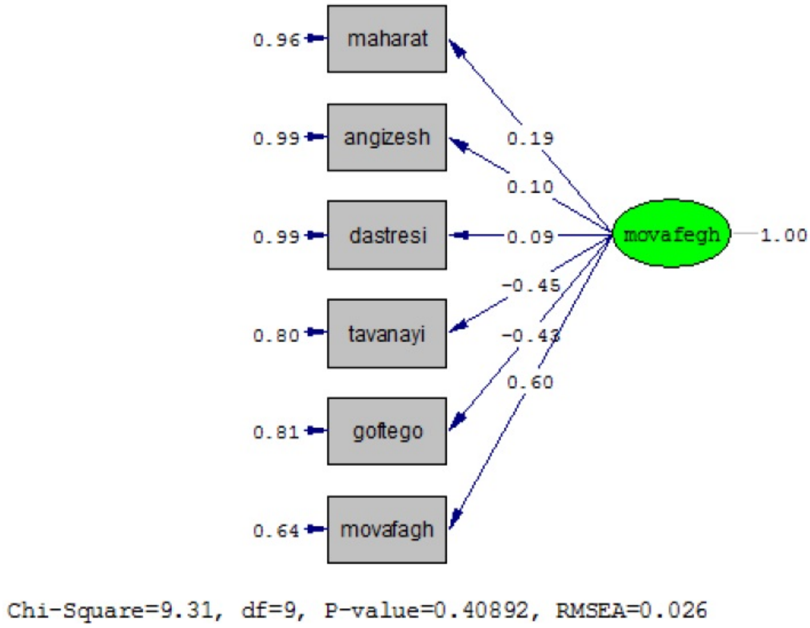

Figure 5: Confirmatory factor analysis of non-standard research variables

the needs of students be provided to them in order to improve efficiency and increase learning. It is also suggested that evaluations be made based on the components that affect the success of electronic systems and their results be compared. The present study is quantitative in terms of the infrastructure paradigm. It is suggested to qualitatively address the issue of evaluation of e-learning systems and combine qualitative results with quantitative to get a clearer and more comprehensive picture of the status of e-learning systems.

References

[1] A.M. Al-Asmari and M.S. Rabb Khan, *E-learning in Saudi Arabia: past, present and future*, Near Middle East. J. Res. Educ. **2014** (2014), no. 1, 1–11.

[2] F. Al-Balooshi and E.M. Alkhalifa, *Multi-modality as a cognitive tool,special issue: Innovations in learning technology*, J. Int. Forum Educ. Technol. Soc. **5** (2015), no. 4, 40–55.

[3] D. Al-Fraihat, M. Joy, R. Masadeh and J. Sinclair, *Evaluating E-learning systems success: An empirical study*, Comput. Human Behav. **102** (2020), no. 2, 67–86.

[4] A. Alhabeeb and J. Rowley, *Critical success factors for eLearning in Saudi Arabian universities*, Int. J. Educ. Manag. **31** (2017), 131–147.

[5] H. Al-Harrasi, Z. Al-Khanjari and M. Sarrab, *Proposing a new design approach for M-learning applications*, Int. J. Software Eng. Appl.**9** (2015), no. 11, 11–24.

[6] M. Alksasbeh, M. Abuhelaleh, M.A. Almaiah, M. Al-Jaafreh and A.A. Karaka, *Towards a model of quality features for mobile social networks apps in learning environments: An extended information system success model*, Int. J. Interact. Mobile Technol. **13** (2019), no. 5, 75.

[7] M.A. Almaiah, M.M.A. Jalil and M. Man, *Empirical investigation to explore factors that achieve high quality of mobile learning system based on students perspectives*, Eng. Sci. Tech.: Int. J. **19** (2016), no. 3, 1314–1320.

[8] B. Al-Shargabi, O. Sabri and S. Aljawarneh, *The adoption of an e-learning system using information systems success model: A case study of Jazan University*, PeerJ Comput. Sci. **7** (2021), e723.

[9] S. Ghalyan and A. Zalpour, *Identifying factors of success in e-learning case study: Physical education students at Shahid Chamran university of Ahvaz*, J. Educat. Dev. Jund-i-Shapour **10** (2019), no. 2, 135–143.

[10] L. Ghoraeian, *The success of e-learning systems in using the virtual education system for interactors in improving the quality of e-learning*, Third Conf. Manag. Educ. Soc. Psyc. Sci. Mashhad, 2021.

[11] A. Ibrahim, *Factors affecting the adoption of ICT by administrators in the university for development studies tamale: Empirical evidence from the UTAUT model*, Int. J. Sustain. Manag. Info. Tech. **4** (2018), no. 1, p. 1.

[12] B. Kim and M.J. Park, *Effect of personal factors to use ICTs on e-learning adoption: Comparison between learner and instructor in developing countries*, Info. Tech. Dev. **24** (2018), no. 4, 706–732.

[13] Y.H. Lee, Y.C. Hsieh and C.N. Hsu, *Adding innovation diffusion theory to the technology acceptance model: Supporting employees' intentions to use e-learning systems*, J. Educ. Tech. Soc. **14** (2011), no. 4.

[14] J.K. Lee and W.K. Lee, *The relationship of e-learners self-regulatory efficacy and perception of e-Learning environmental quality*, Comput. Human Behav. **24** (2008), no. 1, 32–47.

[15] E. Lwoga, *Critical success factors for adoption of web-based learning management systems in Tanzania*, Int. J. Educ. Dev. ICT **10** (2014), no. 1.

[16] H.D. Martin, S.S. Modi and S.S. Feldman, *Barriers and facilitators to PDMP iS success in the US: A systematic review*, Drug Alcohol Depend. **219** (2021), no. 1, 108460.

[17] J. Martins, F. Branco, R. Gonalves, M. Au-Yong-Oliveira, T. Oliveira, M. Naranjo-Zolotov and F. Cruz-Jesus, *Assessing the success behind the use of education management information systems in higher education*, Telemat. Inf. **38** (2019), 182–193.

[18] M.A. Mirjalili, *The study of the status of factors affecting the e-learning quality assurance from the student teachers point of view*, Interdiscip. J. Virtual Learn. Med. Sci. **12** (2021), no. 4.

[19] K. Olyaei, A. Ramezani Esfeden M. Jahantighi and R. Shirzadi, *Introduction of a model to evaluate and explain the current status of e-learning system in Iran*, Tvto J. Skills Train. **3** (2015), no. 11, 49–65.

[20] A. Ouajdouni, C. Khalid and O. Boubker, *Measuring e-learning systems success: Data from students of higher education institutions in Morocco*, Data Brief. **35** (2021), 106807.

[21] M. Salam and M.S. Farooq, *Does sociability quality of web-based collaborative learning information system influence students satisfaction and system usage?* Int. J. Educat. Tech. Higher Educ. **17** (2020), no. 1, 1–39.

[22] P.C. Sun, R.J. Tsai, G. Finger, Y.Y. Chen and D. Yeh, *What drives a successful elearning? An empirical investigation of the critical factors in uencing learner satisfaction*, Comput. Educ. **50** (2008), no. 4, 1183–1202.

[23] J. Wang, D. Solan and A. Ghods, *Distance learning success a perspective from socio-technical systems theory*, Behav. Info. Tech. **29** (2011), no. 3, 321–329.

[24] R. Watkins, D. Leigh and D. Trainer, *Assessing readiness for e-learning*, Perf. Improv. Quart. **17** (2004), no. 4, 66–79.