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Evaluating the Impact of E-Learning Effectiveness Factors and Self-Regulated Learning on University of Tehran Students, with Personality Traits as Mediators

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ABSTRACT

This quantitative research study explores the relationship between factors that impact e-learning effectiveness and self-regulated learning, focusing on the mediating role of personality traits. Three standardized questionnaires collected data on e-learning effectiveness, self-regulated learning, and personality traits. The study included 351 students from University of Tehran. The sample size was determined using SPSS Sample Power software, and convenience sampling was employed. The data analysis step examined relationships between variables and generalized results to the target population, using SPSS Amos structural equation modeling software. The research utilized Pearson correlation coefficient tests, structural correlation models, multiple regression models, and mediation models to test hypotheses. The results indicated a positive relationship between factors influencing e-learning effectiveness and self-regulated learning, with the mediating roles of personality traits discussed in detail.

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Introduction

Electronic education has a rich history; the emergence of online universities in the 1980s, 1990s, and 2000s marked a significant period of development for this field (Doo et al., 2023; Wani et al., 2021). Effective e-learning is the future of education, as it has been steadily growing and providing new opportunities for students, teachers, educational planners, and institutions (Hernández-Ramos et al., 2021; Khan et al., 2021). While some studies reveal consistent factors influencing the effectiveness of e-learning across various dimensions, there are instances where they may differ (DePietro et al., 2021; Shi et al., 2021). The quality of education in electronic learning courses depends on multiple interrelated factors (Hong et al., 2021). Therefore, electronic education is successful when it encompasses dimensions such as 1) learner characteristics (computer and internet self-efficacy, attitudes towards e-learning) (Gupta et al., 2021; Mitra et al., 2021; Tsekea & Chigwada, 2021), 2) instructor characteristics (timely response, self-efficacy, technology control, focus on interaction, attitude towards learners, and other characterstics) (Li et al., 2021; Nikou & Maslov, 2021; Ray et al., 2021), 3) educational institution and service quality (computer literacy, program flexibility) (Ambarwati, 2021; Vladova et al., 2021), 4) infrastructure and system quality (internet quality, system performance, and others) (Li et al., 2021; Valverde-Berrocoso et al., 2020), 5) course and information quality (course relevance, flexibility, and others) (Rania Al Omari, 2020; Suppan et al., 2021), and 6) extrinsic motivation (perceived usefulness, goal clarity, and others) (Cataudella et al., 2021; Kuleshov et al., 2020).

Electronic learning is an intermediate learning environment facilitated by computers. Therefore, the student's ability to control the e-learning environment can help them manage learning activities (Cataudella et al., 2021). According to educational psychology, learners may need more motivation or be adequately prepared for the new e-learning environment (Abouzeid et al., 2021). Initial research on electronic education focused on the design aspects of the electronic education system. Subsequently, other elements of electronic education, such as learner characteristics, technology design, instructional strategies, psychological processes, learning behaviors, and outcomes, have also received attention. However, less research has focused on the psychological processes that users engage in (Dwivedi et al., 2021; Yang et al., 2021).

On the other hand, fewer studies have focused on the psychological processes that users engage in (Gope et al., 2021; Yang et al., 2021). Considering the importance of measuring these factors in achieving the primary goal of educational system design and learning, there is a recognized need for an appropriate approach to learning within electronic education systems. Hence, based on studies (Rania Al Omari, 2020; Shrivastava & Shrivastava, 2020), many researchers have considered the importance of self-regulated learning as an appropriate learning approach for e-learning. Additionally, considering that students significantly differ from each other and have distinct behavioral patterns that contribute to their identity, it is essential to regard personality as a separate and relatively stable variable of students' thinking, feeling, and actions that shape their response to a specific situation for identifying practical factors in teaching and learning (Pelikan et al., 2021; Giannakos et al., 2021).

According to statistics, 84% of students are satisfied with physical classes, and 16% with electronic education (ISNA News Agency, 2021). The head of the e-learning task force of the Ministry of Science, Research, and Technology has mentioned Iran's progress in electronic education, stating that if the world has advanced by, for example, 25% in this field, Iran has made progress of about 10%, and we were relatively slower than many. Since the inception of electronic education at the University of Tehran, there has been dissatisfaction and a decline in learning performance.In in the last decade of higher education In Iran, due to challenges and problems, such as increasing demand for higher education and insufficient budget, lack of full-time faculty members, and the need to remove geographical restrictions, e-learning, and education have received serious attention. For example, universities such as Shiraz (the pioneer and leading university in 2004), Science and Technology, Amir Kabir, Khajeh Nasiruddin Tousi, Hadith Sciences, Isfahan, Shahid Beheshti, Tehran, Sahand Tabriz, and non-profit universities, such as Tehran Institute of Higher Education, Noor Toubi, Mehr Alborz, and other universities have all turned to electronic education, primarily through virtual courses. Most large public universities in Iran have established electronic learning centers within their complex, leading to a significant increase in the number of students in electronic classes, from 235 in 2013 to 19,000 in 2015 (Ahmadi et al., 2022).

Given that the level of dissatisfaction and academic performance vary among students, there is a need to investigate the factors that increase the effectiveness of the electronic education system by considering the differences among students (personality traits). As e-learning methods continue to dominate education and demand increases, especially after COVID-19, it is crucial to examine this relationship to provide guidelines for enhancing the effectiveness of electronic education. Therefore, due to the research gap in this field in the country and the reasons above, this study aims to answer the question: "Is there a relationship between effective factors of e-learning and self-regulated learning of students with the mediating role of their personality traits?"

Literature Review

E-Learning and Self-Regulated Learning

E-learning, a crucial application of information technology, is delivered in various forms, such as computer-based training, online learning, network-based learning, and web-based learning (Daulae, 2020). Ehlers & Pawlowski (2006) has outlined five objectives for e-learning, including its potential to overcome geographical, cultural, economic, individual, and existing educational system limitations (Ehlers & Pawlowski, 2006). The transformative power of e-learning in the worldwide higher education system, potentially leading to a global university, is a concept held by e-learning theorists. Therefore, a comprehensive understanding of this type of education's characteristics and influential factors is paramount for designing and implementing an effective e-learning model (Dwivedi et al., 2021; Dai, 2024). Specific missions and goals drive educational systems, and achieving these goals necessitates identifying, controlling, and resolving obstacles and challenges that may hinder the optimal implementation of educational processes (Gope et al., 2021). To effectively evaluate the quality of e-learning courses and programs, examining the integration and interconnection of these elements is more crucial than assessing them in isolation (Wang et al., 2021; ElSayad, 2024).

Learning is a functional process through which knowledge, behaviors, abilities, or existing/new choices are understood, reinforced, or modified, potentially leading to a significant change in data combination, depth of knowledge, approach, or behavior regarding the type and scope of experiences (Fisher et al., 2021; Hong et al., 2021). Learning does not occur instantaneously, but it builds upon past knowledge. Therefore, learning is an ongoing process (Hernández-Ramos et al., 2021). In humans, learning can be part of the educational process, personal development, and practice, which may be deliberate or motivated (Giannakos et al., 2021). One factor that can significantly impact students' academic performance is self-regulated learning, which refers to a self-monitoring process based on self-observation, continuously regulating behavior to achieve desired goals (Maldonado-Mahauad et al., 2018). Experts agree that self-regulated learning encompasses three essential components: cognition, metacognition, and motivation (Yang et al., 2021). Understanding involves the necessary skills for decoding, memorizing, and recalling information (Pintrich & De Groot, 1990; Zimmerman, 2008). Metacognition includes skills that enable learners to control and understand cognitive processes (Bandura, 1982a). Motivation encompasses beliefs and attitudes that influence the growth of cognitive and metacognitive skills (Bandura, 1982b; Zimmerman & Bandura, 1994). All three of these core components are necessary for self-regulation. According to a study conducted by Fida (2020), the influential factors in increasing the effectiveness of e-learning include:

- technological infrastructure,
- attention to student's learning styles,
- alignment of instructional goals with students' motivation, and
- the use of appropriate resources for e-learning.

The study found no statistically significant difference in the role of e-learning methods in enhancing students' self-regulated learning skills. Therefore, all students, at all levels, need to employ the following four-stage process to control their learning through constructive motivational learning and to make progress during their studies (Suppan et al., 2021). Moreover, self-regulated learning is proved essential for successful online learning (Fida, 2020).

Personality Traits and Their Impacts on Self-Regulated Learning and E-Learning Systems

Several models are available for describing personality, with one of the most well-researched and examined theoretical frameworks being the Five-Factor Model (or Big Five), introduced by Costa and McCrae (1992). This model portrays personality through five broad dimensions: neuroticism, agreeableness, openness, extraversion and introversion, and conscientiousness (Costa & McCrae, 1992). While there are numerous studies on personality in the context of technology acceptance, there needs to be more research on e-learning adoption in underdeveloped or developing countries. The increasing interest in e-learning acceptance in developing countries emphasizes the impact of personality factors on the acceptance of computer-based learning (Lai et al., 2020; Van Overwalle et al., 2020). Various factors influence the approval of new technologies, including self-technology awareness, attitudes, motivation, interaction platforms, and user characteristics (Hertel & Karlen, 2021). Understanding the acceptance of technology and its factors, such as infrastructure, attitudes, motivation, and interaction platforms, are crucial for self-regulated learning and the impact of personality dimensions on learning (Tsekea & Chigwada, 2021).

Personality traits are stable individual differences that capture an individual's inclination toward specific behavioral patterns, cognition, and emotions. Studies in the self-regulated learning literature have shown that different self-regulated learning components are associated with academic achievement and student performance (Nikou & Maslov, 2021). Operationalizing these five major traits requires self-regulation tendencies (Fisher et al., 2021). For example, conscientiousness includes reliability, responsibility, planning, organization, and perseverance in pursuing success. Researchers have previously introduced the idea that personality is related to learning. The core features of personality may be responsible for stability in information processing, measured as a learning trait (Vo et al., 2021; Wat et al., 2020). Among the Big Five factors, conscientiousness is associated with motivation and, in particular, time and persistence (Barros et al., 2021). Understanding personality traits and their relationship with self-regulated learning can provide valuable insights for educational practices and interventions.

There is a positive relationship between conscientiousness and systematic and analytical learning (Bruso et al., 2020). The relationship between extraversion or neuroticism and self-regulated learning strategies may be complex. On the one hand, extraversion can facilitate social behaviors such as helping others and peer learning. On the other hand, extroverts may have weaker reflective problem-solving abilities, as they tend to seek cognitive closure (i.e., exiting the problem) prematurely. Furthermore, higher education involves complex tasks that often require substantial resource investment. The sociability and distraction from extraversion can hinder individuals with this trait from effectively regulating their time and effort in these tasks, usually accompanied by a lack of practical cognitive skills in the case of neuroticism (Bruso et al., 2020). However, there is evidence that neuroticism can facilitate motivation and effort, similar to defensive pessimism, where anxious individuals increase their effort to prevent any potential failure.

Nevertheless, the overall effect of neuroticism is more negative than positive. The links between conscientiousness, intelligence, and agreement with self-regulated learning components have greater theoretical and empirical justifications than extraversion (Vo et al., 2021). Personality can be considered to have a distal, yet pervasive influence on students' performance, with self-regulated learning being a more direct determinant of academic progress. Therefore, it may impact academic grades directly. Vetrugno et al (2021) demonstrated a link between personality traits and academic self-efficacy, acceptance, and course progress; meanwhile, an association between personality traits and the determinants of self-regulated learning is also indicated (Hertel & Karlen, 2021). Table 1 presents a summary of the research conducted in this field. In the end, we will mention the innovation of the current research compared to other studies.

Table 1. Summary of Literature Review

Author(s) (Year of publication)	Research Title	Research Method	Summary of Results
Sung-Hee Jin, Kowloon Im, Mina Yoo, Ido Roll, & Kyoungwon Seo (2023)	We are supporting students' self-regulated learning in online education using artificial intelligence applications.	Qualitative method	The results indicated that learners perceived AI applications as helpful in supporting metacognitive, cognitive, and behavioral regulation across different SRL areas, but not for regulating motivation. Next, regarding the role of AI applications to support SRL, learners requested consideration of three pedagogical and psychological aspects: learner identity, learner activeness, and learner position. The findings of this study offer practical implications for designing AI applications in online learning to support students' SRL.
Utami et al. (2023)	Development of online web learning with ethnomathematics content on self-regulated learning.	Quantitative method	First, to achieve learning outcomes and objectives, content from the ethnomathematics aspect is needed in the KPK and FPB materials. This content helps students learn mathematics and understand how elements of local culture can foster an appreciation for it. Second, they proposed prioritizing using images, audio, and video over text. This multimedia approach significantly enhances student interest and engagement. Third, the utilization of applications can support learning, particularly in situations where time is a constraint.Subsequently, they suggested conducting large group trials and tests on student self-regulated learning to ensure the effectiveness of the products.
Xu et al. (2022)	A meta-analysis of the efficacy of self-regulated learning interventions on academic achievement in online and blended environments in K-12 and higher education.	Meta-analysis	They investigated possible differential effectiveness due to substantive features of the included studies, such as different educational levels of learners (e.g., elementary, secondary, and higher education), academic subjects (STEM vs. non-STEM), and learning contexts (e.g., online learning, blended learning, web-based learning, mobile learning). Consistent with previously published meta-analyses, the present meta-analysis confirmed SRL intervention's positive and moderate effect (ES = 0.69) on learners' academic achievement in online and blended environments for learners in elementary, secondary, and higher education and informal adult education settings.
Ulfatun, Septiyanti, & Lesmana (2021)	University students' online learning self-efficacy and self-regulated learning during the COVID-19 pandemic.	Quantitative method	First, the study found that students exhibit a high level of online learning self-efficacy and online self-regulated learning. Second, the results of this study revealed a strong positive correlation between students' online self-efficacy and online self-regulated learning ($r = 0.67$, $p < 0.0005$), indicating that students' high levels of online self-efficacy correlate with their high levels of self-regulated learning.
Mishra, Gupta, & Shree (2020)	Online teaching and learning in higher education during the lockdown period of the COVID-19 pandemic.	From both quantitative and qualitative methods	On the whole, the majority of students and professors express satisfaction with the current method. It is worth noting, however, that they have also found value in using platforms like WhatsApp, Telegram, and email for homework, and communication with Joe Saamneha. A significant portion of professors (32%) have adopted Google Classroom, and 45% have utilized Zoom/Cisco WebEx/Google Meet for holding classes. Students' feedback underscores the importance of professors fostering friendly relationships and, where feasible, creating a more intimate environment within groups, programs, or any other operating system. This feedback also highlights the need to upgrade information and communication technology facilities to facilitate this approach. As indicated by students, the most crucial teaching skill is the personalization of learning, a powerful tool that can significantly enhance the educational experience.

Table 1.

Author(s) (Year of publication)	Research Title	Research Method	Summary of Results
Al-Fraihat et al. (2020).	Evaluating e-learning system success: An empirical study.	Quantitative method	Four constructs determine the use of e-learning: the quality of the educational system, the quality of the support system, the quality of the learner, and the perceived usefulness. These account for 34.1% of the variance in the benefits of e-learning. Finally, one can explain 64.7% of the variance in the benefits of e-learning by the perception of usefulness, perceived satisfaction, and actual use.
Elzainy, El Sadik, & Al Abdulmonem (2020)	Experience in e-learning and online assessment during the COVID-19 pandemic at the College of Medicine, Qassim University.	Observation method and event recording	The implementation of Six hundred twenty virtual classrooms over 994 hours was successful. The classes included theoretical lectures, PBL sessions, seminars, and tutorials. During online sessions, female students' mean PBL grades significantly increased. Of the primary-year students and staff, 58.82% expressed high satisfaction with virtual classrooms, online assessments, and online workshops.
Carter Jr et al. (2020)	Self-regulated learning in online education environments: strategies for remote learning.	Quantitative method	Main types of strategies introduced in previous studies include asking students to consider their online learning process, providing pacing support, monitoring engagement, and supporting families.
Viberg et al. (2020)	Self-regulated learning and learning analytics in online education environments: a review of empirical research.	Quantitative method	Improvements in learning outcomes (20%), learning support and teaching (22%), the rare use of LA, and few studies (15%) approaching research ethically were noted. The findings show that conducting LA research is primarily for measurement purposes rather than to support SRL. Therefore, a need to exploit LA support mechanisms further is critical to foster student SRL in online learning environments.

Reviewing previous research, we have made an essential finding: In the past few decades, researchers have conducted numerous studies on electronic learning, its advantages and disadvantages, and its consequences. However, the research results in this field must sometimes be consistent. Discrepancies regarding variables under investigation, such as self-regulated learning and personality traits, have been noted. Based on these comparisons, It can be proved from the research background that the factors affecting effective e-learning and self-regulated learning, with the role of personality traits as an independent and discussed framework, has yet to be thoroughly examined. However, given the relative similarities in methodology and literature reviewe in previous studies, the researchers in this present study have used the scientific findings of prior research to develop hypotheses and theoretical frameworks, enhancing the research findings. Therefore, when examining empirical studies, no unique study specifically focused on this research topic was identified..

Our research is within the broader context of electronic education, which has gained significant importance in recent years. While various studies have been conducted at national and international levels, most research has been carried out in developed countries, underscoring the importance and novelty of our study, which focuses on variables related to student performance, such as e-learning and self-regulated learning, that have not been studied in the context of Iran's higher education system.

In Iran, higher education has grappled with many challenges in the last decade, including increasing demand, budget constraints, a shortage of full-time faculty members, and the need to remove geographical restrictions. These challenges have underscored the urgency and relevance of e-learning and education, making this study all the more pertinent.

Figure 1 depicts the conceptual framework of the research undertaken in this study with the following hypotheses:

H1: There is a relationship between the factors that affect e-learning effectiveness and self-regulated learning.

H1.1: The dimensions that affect e-learning effectiveness (error prevention, visibility, flexibility, course management, interactivity, feedback, accessibility, consistency and

functionality, assessment strategies, memorability, completeness, aesthetics, and reducing redundancy) significantly impact self-regulated learning.

H2: Personal traits mediate the relationship between the factors that affect e-learning effectiveness and self-regulated learning.

Conceptual Framework

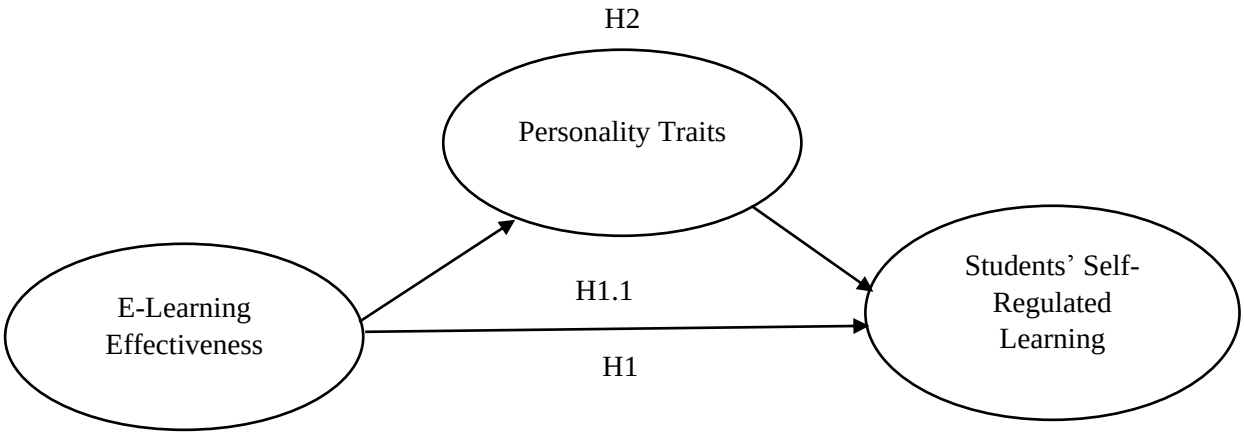

Fig. 1. Conceptual Model of Research

Scientific references and prior research with a fresh structure have developed the current study and its theoretical framework. As a result, research has yet to be carried out in Iran on E-learning effectiveness and self-regulated learning, with the mediating role of personality traits, based on the studies conducted thus far. Hence, according to Figure 1, the study's theoretical framework has been chosen in line with the existing literature.

Research Methodology

This research falls into the category of applied research based on its purpose. Figure 2 presents the overall flowchart of the research steps. The data is quantitative in nature and survey-based, making it primarily data research. The data collection method used is field research with a questionnaire technique.

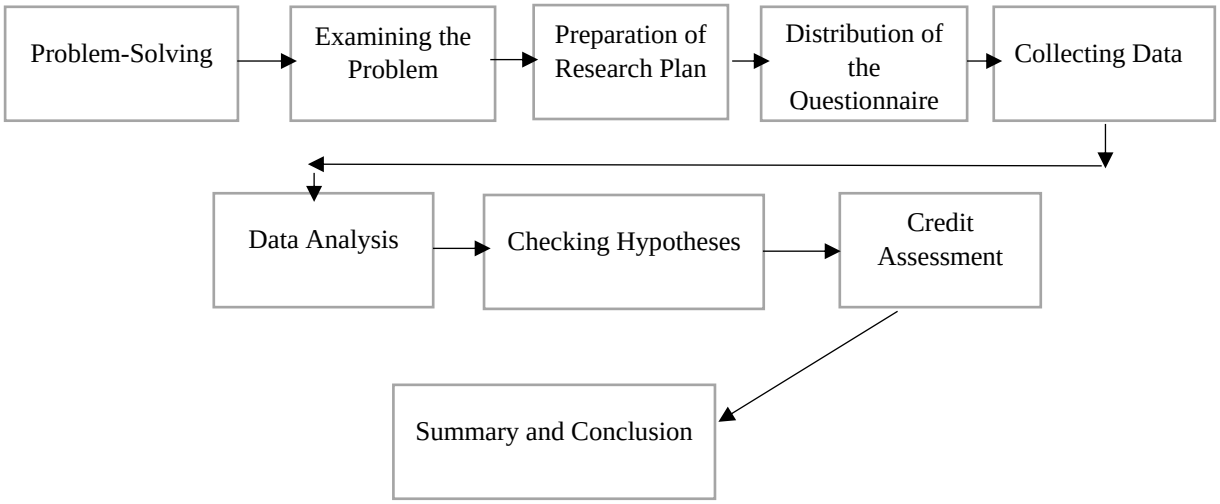

Fig. 2. Flowchart of the Research Steps

This research's primary data collection tools (the NEO Personality Inventory, Factors of E-Learning Effectiveness by Uselearn (2010), and Self-Regulated Learning by Barnard et al (2010)) are widely recognized and validated. We used the Likert scale to evaluate the data, and analyzed statistical

data using SPSS and AMOS for structural equation modeling. The reliability of these tools was confirmed based on Cronbach's alpha test, with values of 0.72 for the E-Learning Effectiveness questionnaire, 0.75 for the Self-Regulated Learning questionnaire, and 0.80 for the NEO Personality Inventory questionnaire. These high-reliability scores highlight the robustness of our methodology and the validity of our findings. The statistical population for this research is the students from University of Tehran, with a sample size of 351 individuals determined using SPSS SAMPLE POWER software. The sampling method used in this research is convenience sampling.

A comprehensive set of statistical tests and models were employed to determine the relationship between variables and estimate and generalize the results obtained from the sample to the statistical population. These include the Pearson correlation coefficient, which measures the strength and direction of the linear relationship between two variables; the structural correlation model, which examines the relationships between latent variables; the multiple regression model, which predicts the value of one variable based on the values of other variables, and the mediation model, which tests the indirect effect of a variable on the outcome through a mediator variable. The sample size was calculated carefully by sample power, ensuring a 95% confidence level and a 5% error rate. The sample size of 351 individuals allows for confident generalization of the results to the statistical population. The estimation of coefficients in the models was reported with a 95% confidence level and a 5% error rate, further supporting the generalization of the results. The accuracy and expertise of the researcher in distributing the questionnaire and monitoring the data, along with the use of models with hidden variables, contribute to the accuracy of the results. Additionally, using multiple models provides a more realistic representation of social life. Figure 3 depicts the research sampling used.

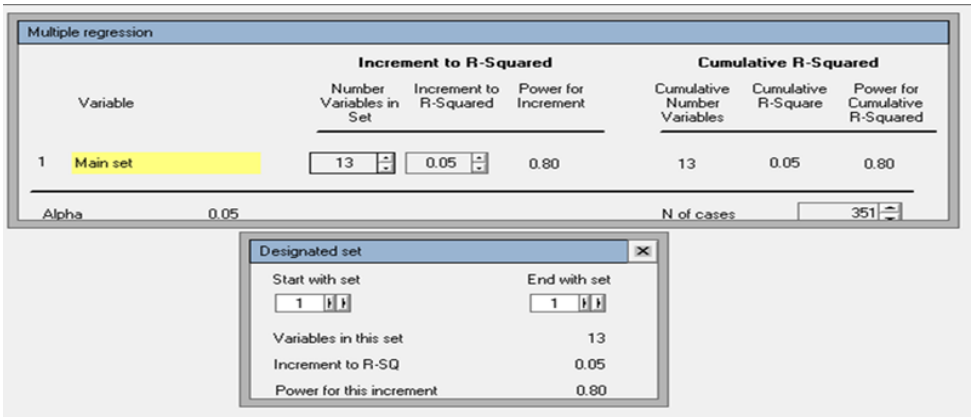

Fig. 3. Research Sampling

Results and Discussion

Table 2 presents the demographics of the research participants.

Table 2. An Overview of Respondents

Characteristics		Frequency (n)	Percentage (%)
Gender	Male	201	57.3
	Female	150	42.7
Age	18-25	310	88.3
	26-30	17	4.8
	31-35	18	5.1
	36-40	6	1.7
Education Level	Bachelor	302	86
	Master	32	9.1
	Doctorate	17	4.8
Study Group	Technical and Engineering	29	8.3
	Humanities	302	86
	Basic Sciences	8	2.3
	Arts and Languages	4	1.1
	Medicine	8	2.3

The average acquisition of personality trait variables is 183.21, with a standard deviation of 19.15, as shown in the Table above.

Research Results

The average score for the e-learning effectiveness variable is 2.96, with a standard deviation of 0.59. The average score for self-regulated learning is 3.27, with a standard deviation of 0.55. Notably, Table 3 provides crucial information on the measures of central dispersion (mean and standard deviation). In contrast, Table 4 offers significant data on the normality of the variables, as determined by the Kolmogorov-Smirnov test.

Table 3. Displays the Measures of Central Dispersion, Including the Mean and Standard Deviation

Measures	Mean	Standard deviation
Personality Traits	183.21	19.15
Factors of E-learning Effectiveness	2.96	0.59
Self-regulated Learning	3.27	0.55

Table 4. Kolmogorov-Smirnov Test of Normality

Measures	Significance level	Result
Personality Traits	0.11	Normal distribution
Factors of E-Learning Effectiveness	0.28	Normal
Self-Regulated Learning	0.23	Normal

The significance level is more than 0.05, indicating that the variables follow a normal distribution.

Hypothesis testing for the relationship between the factors affecting e-learning effectiveness and self-regulated learning, using the Pearson correlation test and correlation model, are shown in Table 5.

Model 1: Pearson correlation test and correlation model

> **H1:** There is a meaningful relationship between the factors affecting e-learning effectiveness and self-regulated learning.

Figure 4 presents a crucial finding, demonstrating the relationship between the factors influencing e-learning effectiveness and self-regulated learning. The software's output serves as a tangible representation of this relationship. The test results, with a significance level of 0.001, presented in the Table of Pearson correlation test, and the standardized covariance output (Amos model), underscore the importance of our findings. This value, which is smaller than the critical level and has a standard error of 0.05, confirms our hypothesis. The strong positive correlation is evidant, indiated by a correlation coefficient of 0.53 in the Amos software.

The research employed the Multiple Regression Model to comprehensively assess the influence of dimensions of factors affecting e-learning effectiveness on self-regulated learning. Table 6 and Figure 5 depict the correlation model of the research.

Model 2: Multiple regression model of the influence of dimensions of factors affecting e-learning effectiveness on self-regulated learning for evaluating the 12 sub-dimensions.

The research identified factors significantly impacting e-learning effectiveness, including error prevention, visibility, flexibility, course management, interactivity, feedback and assistance, accessibility, stability and functionality, assessment strategies, memorability, completeness, aesthetics, and reducing redundancy in self-regulated learning.

Table 5. Pearson Correlation Coefficient Test

Measures	Number	Pearson Coefficient	Significance Level
Factors Affecting E-Learning Effectiveness	351	0.38	0.0001
Self-regulated learning	351		
Standardized covariance output table			
The relationship between the factors affecting E-Learning Effectiveness and self-regulated learning.	Standardized Value	Critical Point	Significance Level
	0.53	6.69	0.0001

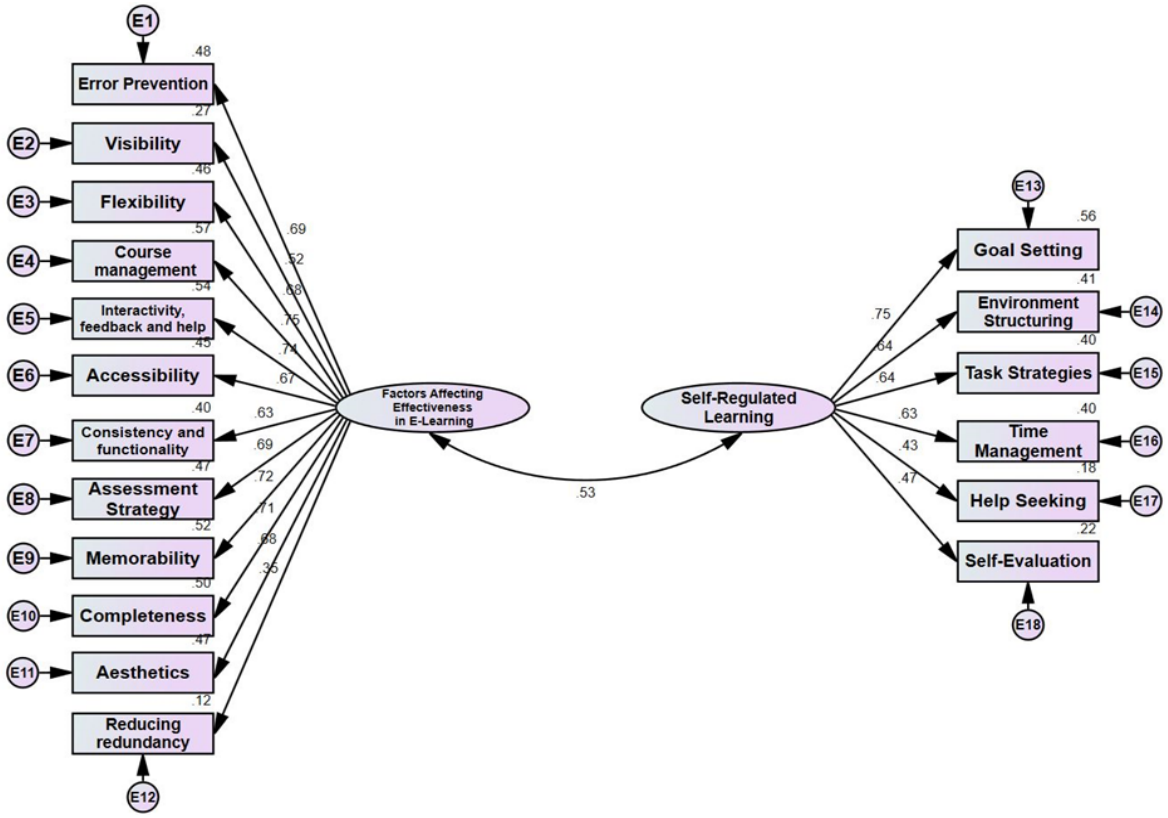

Fig. 4. Pearson Correlation Coefficient Plot

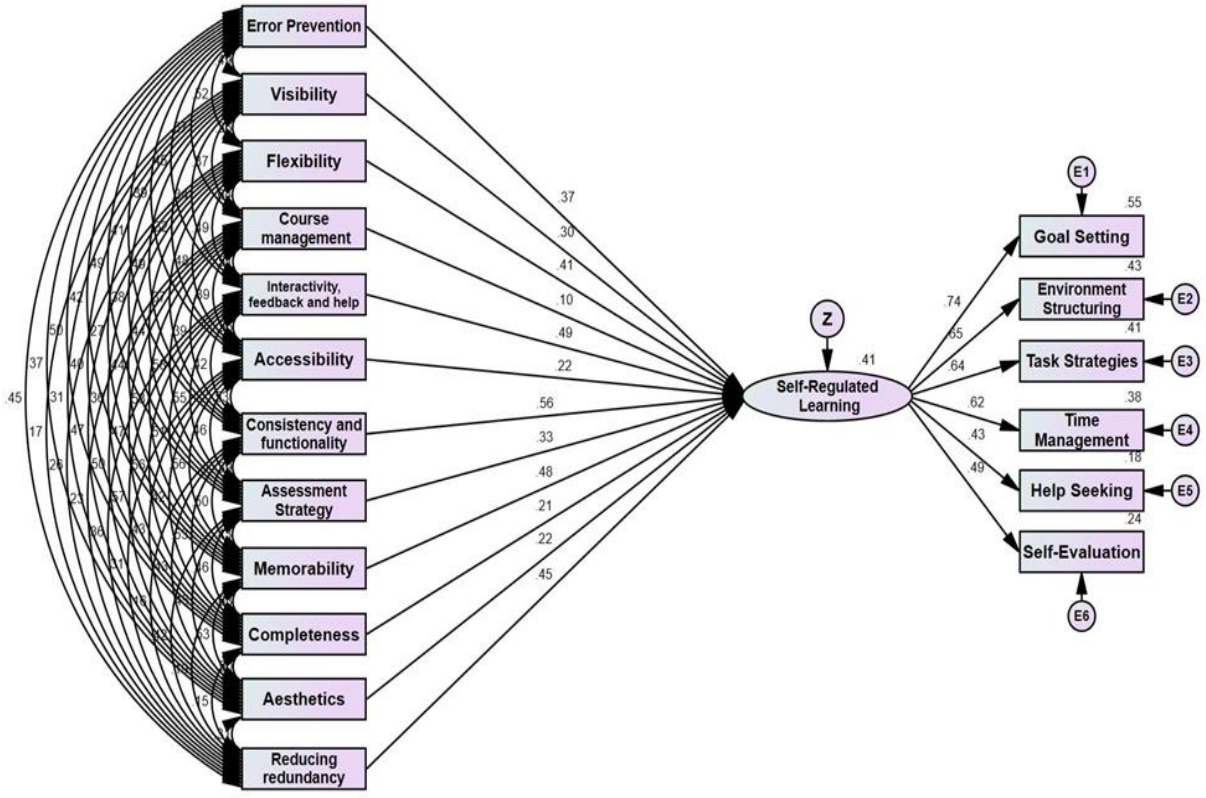

Fig. 5. Research Correlation Model

Table 6. Perpetual Regression Weights and Bootstrap Test Results

Standardized regression weights output			
Measure	**Standardized Output**	**Critical Ratio**	**Significance Level**
Impact of Error Prevention on Self-Regulated Learning	0.37	6.44	0.005
Impact of Visibility on Self-Regulated Learning	0.30	6.21	0.02
Impact of Flexibility on Self-Regulated Learning	0.41	6.63	0.0001
Impact of Course Management on Self-Regulated Learning	0.10	3.11	0.03
Impact of Interactivity, Feedback, and Help on Self-Regulated Learning	0.49	6.58	0.0001
Impact of Accessibility on Self-Regulated Learning	0.22	5.34	0.01
Impact of Consistency and Functionality on Self-Regulated Learning	0.56	7.12	0.0001
Impact of Assessment Strategies on Self-Regulated Learning	0.33	6.35	0.009
Impact of Memorability on Self-Regulated Learning	0.48	6.80	0.0001
Impact of Integrity on Self-Regulated Learning	0.21	5.33	0.01
Impact of Aesthetics on Self-Regulated Learning	0.22	5.36	0.01
Impact of Reducing Redundancy on Self-Regulated Learning	0.45	6.71	0.0001
Bootstrap Test Output			
Standardized Value (R2) in Bootstrap Test	Lower limit	Upper limit	Sig. level
0.41	0.35	0.53	0.0001

Our research, conducted using the multiple regression model and standardized output in Amos software, has yielded significant findings. All 12 factors we studied profoundly impact self-regulated learning, with a significance level for all cases less than 0.05. This model's coefficient of determination (R2) reveals that 41% of the variance in self-regulated learning can be attributed to the dimensions of the factors influencing e-learning effectiveness. These factors, including error prevention, visibility, flexibility, course management, interactivity, feedback and help, accessibility, consistency and functionality, assessment strategies, memorability, completeness, aesthetics, and reducing redundancy, play a crucial role in shaping the effectiveness of e-learning.

With a reported significance level smaller than 0.001 and the lower and upper limits not reaching zero, our findings indicate that the dimensions affecting e-learning effectiveness considerably impact self-regulated learning. Importantly, these findings allow for the prediction of self-regulated learning based on these factors in the population, demonstrating the practical implications of our research.

In our study, we employed a regression model to explore the mediation effect, with Figure 6 illustrating the mediating role of personality traits, and comprehensive analysis of the factors influencing e-learning effectiveness and self-regulated learning based on this model. Additionally, we present the standardized regression weight outputs in Table 7, values for direct, indirect, and total effects in Table 8, and significance levels for these effects using the bootstrap test in Table 9.

Our study delved deeper into the factors influencing e-learning effectiveness and self-regulated learning. Model 3, which we developed, depicts analyzing the mediating effect through a regression model and evaluating the second main hypothesis. We found that personality traits, acting as a mediating variable, play a significant role in the relationship between the factors influencing e-learning effectiveness and self-regulated learning, adding a layer of complexity to our research.

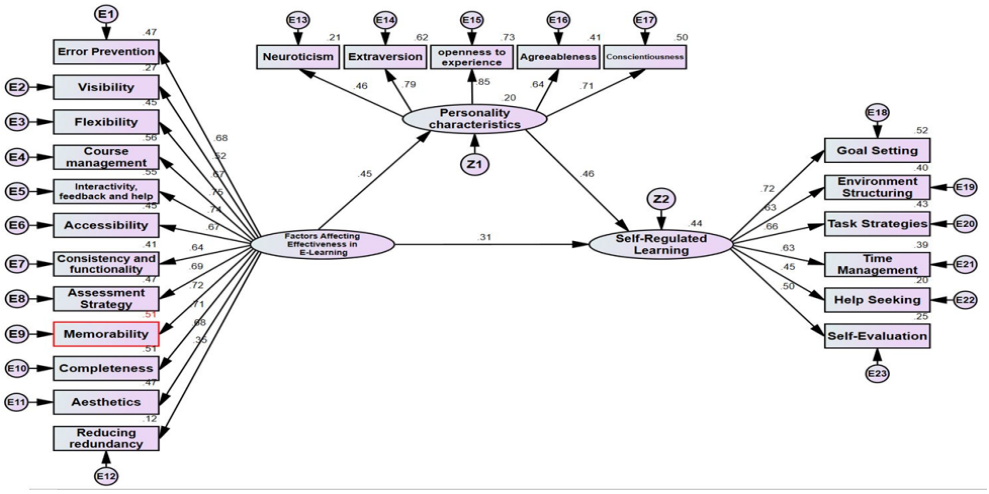

Fig. 6. The Mediating Role of Personality Traits

Table 7. Standardized Regression Weight Outputs

Measures	Standardized Values	Critical Point	Sig. Level
The Impact of Factors Affecting E-learning Effectiveness on Self-Regulated Learning	0.31	4.80	0.0001
The Impact of Factors Affecting E-learning Effectiveness on Personality Traits.	0.45	5.76	0.0001
The Impact of Personality Traits on Self-Regulated Learning	0.46	5.53	0.0001

Table 8. Values of Direct, Indirect, and Total Effects

Indicators	Direct effect	Indirect effect	Total effect
The Impact of Factors Affecting E-learning Effectiveness on Self-Regulated Learning	0.31	0.20	0.52
The Impact of Factors Affecting E-learning Effectiveness on Personality Traits	0.45	***	***
The Impact of Personality Traits on Self-Regulated Learning	0.46	***	***

Table 9. Levels of Significance for Direct, Indirect, and Total Effects Using the Bootstrap Test

Indicators	Direct effect	Indirect effect	Total effect
The Impact of Factors Affecting E-learning Effectiveness on Self-Regulated Learning	0.001	0.0001	0.0001
The Impact of Factors Affecting E-learning Effectiveness on Personality Traits	0.0001	***	***
The Impact of Personality Traits on Self-Regulated Learning	0.0001	***	***

Based on the model above, the regression weights and significance levels of direct and indirect effects, the following conclusions could be made:

-The direct and indirect effects of factors affecting e-learning effectiveness on self-regulated learning are significant.

-The direct effect of factors affecting e-learning effectiveness on personality traits is significant.

- The direct effect of personality traits on self-regulated learning is significant.

Discussion

The confirmation of the first hypothesis, the Pearson correlation coefficient test results, and the correlation model used to evaluate this hypothesis indicate that the correlation coefficient between these two variables in the Amos software is 0.53, suggesting a significant and positive correlation between the factors affecting e-learning effectiveness and self-regulated learning. Therefore, we can infer that these two variables have a significant positive relationship. The regression slope in the scatter plot of the data is also positive, indicating that as the factors affecting e-learning effectiveness increase, self-regulated learning will also increase, and vice versa. In the following sections, we will explain each dimension and their relationships. The coefficient of determination in this model indicates that 41% of self-regulated learning is related to the dimensions of the factors affecting e-learning effectiveness. Each of the 12 dimensions uniquely impacts the effectiveness of the e-learning system. Still, since these dimensions form a whole or a system, they have commonalities and interconnected effects. For example, the dimension of visual aesthetics and the ability to observe or prevent errors and reduce rework can have a shared impact. Therefore, in explaining the 12 hypotheses, we will have a practical effect in improving the effectiveness of the e-learning system.

Consistent with the studies of Mahmoud (2021), Yue et al. (2021), Al-Fraihat et al. (2020), our findings indicate a positive relationship between visual design or visual aesthetics, such as display features and dimensions of visual aesthetics, proper text composition, graphic features, color selection, and visual effects suitable for various disciplines in the e-learning course. These factors attract learners' attention, improve learning and ease of use, and motivate students to stay longer in the e-learning environment and spend more time learning. Accessibility, which provides diverse paths and considers user preferences, makes students comfortable with e-learning. Effective strategies for enhancing memorability, such as providing sufficient frequently asked questions (FAQ), human

support, using familiar cases, and applying staged presentations, providing information in organized and readable sections, are related to the task strategy dimension of self-regulated learning and improve students' self-regulated learning process. On the other hand, the results of this study show that interaction, feedback, and assistance, which mainly reflect the conversation between the user and the computer, are essential, not only for self-regulated learning and student collaboration, but also for instructors' understanding of the effectiveness of their communications. Visibility involves logically categorizing different options in the university e-learning system, designing clear and understandable options, and appropriately linking course content to the home page.Additionally, online assessment and evaluation strategies, performed using various useful tools, such as out-of-class tests, multiple-choice tests (including fill in the blanks, watching clips, and answering questions), surveys, electronic submission of assignments, and other tools, are related to the help-seeking dimension of self-regulated learning.

In line with the findings of Mahmoud (2021), Ulfatun et al. (2021), and Mishra et al. (2020), our research also demonstrates that both completeness and flexibility are crucial. This includes adding content resources and learning objects, personalizing the learning environment, and implementing effective course management strategies. These strategies involve providing user support during system operation, offering essential information for system use, providing supplementary materials and resources to enhance student learning, ensuring easy file downloading and uploading, and employing effective teaching methods. Furthermore, the quality of information produced and transmitted closely links to the goal-setting aspect of self-regulated learning. Consistent with the studies of Utami et al. (2023), Carter Jr et al. (2020), and Viberg et al (2020), maintaining consistency and functionality within the e-learning system is essential. This includes using consistent shapes and styles for different titles and topics, ensuring compatibility of icons, buttons, labels, and interfaces with tasks, incorporating a back button for easy navigation, and minimizing redundancy. These practices not only enhance the learnability of the system, but also reduce cognitive load for users. Completeness in design involves communication between windows, menus, symbols, as well astheir size, position, and scheduling within the e-learning system. General images and connections between different sections of the educational system must be harmonious. Additionally, effective time management is closely related to self-regulated learning.

According to the research of Utami et al. (2023), Carter Jr et al. (2020), Yue et al. (2021), Al-Fraihat et al. (2020) and Mahmoud (2021), students who may lack technical expertise and network knowledge require an e-learning system that can prevent incorrect inputs and performance errors. Solutions and measures should be readily available for easy compensation in case of errors. These factors, along with accessibility and flexibility, such as simple design interfaces, compatible with control toolbars and menus, enhance student access and contribute to the advancement of the e-learning system, fostering a meaningful connection with the self-regulated learning environment. The confirmation of the second hypothesis and the results of the mediation model used to assess this hypothesis, indicates that personality traits partially mediate the relationship among factors influencing e-learning effectiveness and self-regulated learning.

The correlation between personality traits and learning is a well-established concept. Fundamental personality traits may contribute to consistency in information processing, a measurable learning attribute. The influence of inherent personality traits on students' academic performance and learning in the e-learning setting enhances the impact of self-regulatory dimensions on student learning. For instance, the absence of face-to-face interaction in e-learning courses requires unique characteristics in individuals with introversion or heightened sensory skills, such as attention to detail, symbols, and signs. Based on the research by Rivers (2021) and Elzainy, El Sadik et al. (2020), it can be concluded that achieving a high level of influential factors in the e-learning environment regarding students' self-regulation is influenced by their personality traits. Students' personality traits, including agreeableness, openness to new experiences, high conscientiousness, low neuroticism, and high extraversion, directly impact their self-regulated learning in the e-learning environment. For example, conscientiousness is associated with motivation and perseverance, particularly regarding time and effort.

On the other hand, introversion may lead to success and enhanced learning due to reduced face-to-face interactions. Neuroticism, while facilitating motivation and effort, has a more negative than positive effect overall. Studies by Rivers (2021) and Talelli et al. (2016) suggest that the links between

conscientiousness, agreeableness, and openness to new experiences have more robust theoretical and empirical justifications with the components of self-regulated learning. Therefore, students' personality traits positively determine the relationship between influential factors of e-learning and self-regulated learning. By considering learners' personality dimensions, various factors can be incorporated into the design of e-learning systems to enhance students' academic success and performance. There is no research in the current literature that contradicts the results of this hypothesis. The conducted studies and mentioned research emphasize the relationship and role of personality traits in the effectiveness of e-learning systems and self-regulated learning. The following suggestions are presented in Table 10 to improve the e-learning system:

Table 10. Practical Suggestions

Criteria	Suggestions
Flexibility	Universities should design their e-learning systems using course materials with smaller file sizes to ensure quick page loading. They should also emphasize the benefits of allowing users to personalize course pages to suit their preferences, making educators feel empowered and students feel valued. Each course should include dimensions and supplementary modules to meet individual needs. Human-like characters with realistic voices may assist users as needed. The course content should encourage increased interaction, with additional features for communication between students and instructors. Collaborative teaching methods can be particularly effective when utilizing advanced information technology tools. Additionally, specialized multimedia software should be available for students, incorporating various multimedia elements, such as text, design, graphics, videos, and images to convey the intended message effectively. Creating interactive multimedia content in virtual learning environments can enhance learner engagement and self-regulated learning. The pages' design must allow users to customize certain elements based on their preferences. For example, sections like "My Ongoing Tasks," "My Modules for This Week," "My Assignments," "My Weekly Schedule," and "My Class Hours" can be included, or users can have the option to personalize the theme and color of the pages to their liking.
Assessment Strategies, Interactivity, Feedback and Support	Strategies for assessment and measurement should utilize various methods and not rely solely on a specific approach. It is crucial to emphasize the role of feedback in improving learning outcomes, making educators feel impactful and students feel supported. Providing feedback is one of the essential and fundamental components of online sessions and classes. Knowing that the feedback contributes to creating an engaging, motivating, and practical electronic learning experience is necessary if one is an online instructor. It is essential to provide continuous and timely feedback throughout the online learning process so students can quickly identify areas where they need to improve their behaviors or skills. In this regard, group feedback can also be provided through the design of collaborative exercises, promoting interaction among individuals in an online class. The objectives should be clear at the beginning of each instructional course, and there should be objectives designed for teaching and assessment strategies. We should communicate defined objectives to students and provide them access to assess their current position and progress throughout the course. Collaborative tools within the electronic learning system, such as announcements, emails, chats, and discussions, encourage meaningful interaction among students, and between students and instructors. It can facilitate interaction between students and the software (the electronic learning system) as well. Numerous strategies can be utilized, such as enabling interaction between instructors, students, and content, providing appropriate feedback on learner performance, and offering necessary information about the learner's progress throughout the course. However, there are some points regarding improving the e-learning system, especially in measuring and providing feedback. The challenge is that we need to incorporate it into student assessment. Primarily, the electronic teaching system is designed to submit assignments. At the same time, we can employ other features, such as tests, surveys, feedback, as well as interaction rooms for receiving feedback from classmates, and consultation rooms with instructors to make learning more effective. Providing a platform for group feedback is essential. Feedbacks can be provided individually or in groups. We can get group feedback through the design of collaborative exercises. In addition to the direct impact of feedback on addressing and correcting learners' issues, we can also emphasize its indirect effect on group learning through analyzing and interpreting group information. The defined learning objectives for each course, instructional strategies employed for teaching each subject, and assessment methods of student performance in the e-learning system should be harmonized and aligned. This alignment is crucial to make educators feel guided and students think focused. It ensures that the learning process is straightforward and structured, leading to more effective learning outcomes.
Accessibility and Reducing Redundancy	Allocate more content space to essential elements and avoid heavy graphics that may slow down page loading speed. Provide diverse pathways for accessing content and activities with which students must engage during the course. Use different colors and appropriate graphics to guide and assist students throughout the courses. Strategies such as employing different but similar tasks, allowing users to return to initial choices and options, and using error messages or alerts can improve this aspect.

Table 10.

Criteria	Suggestions
Aesthetics	Design pages in an aesthetically pleasing manner so that looking at them is visually appealing and enjoyable. The success of an e-learning system largely depends on the visual presentation of tools, content, and support. Visual contradictions in the design of an e-learning system lead to confusion and a lack of interaction from the student's perspective. Therefore, the aesthetic appeal of the e-learning system only partially affects interaction, ease of use, and motivation. It can attract learners' attention and enhance self-regulated learning and retention. Engaging videos and educational softwares are another method of improving virtual learning. They solidify and reinforce instructional content, providing a foundation for enhanced learning.
Course Management	Keep the instructional modules short: Short instructional material can help students engage better. Communicating information in small chunks is more accessible in an e-learning system than dealing with a large content volume. The best approach is to divide the content into shorter sections and provide quick exercises, as the effectiveness of an online learning system lies in the concise and helpful nature of the content. To enhance course management, consider designing and creating mobile e-learning content. Since most learners and audiences now use mobile phones for learning, instructors need to recognize the importance of mobile learning. Ensure the electronic content is responsive and optimized for display on mobile phones, laptops, tablets, and other devices in a user-friendly format for online courses and related exams. Utilize pre-assessments to measure students' readiness for starting courses and educational programs, and regularly assess students to use the feedback obtained to guide the continuation of course activities.
Error Prevention and Visibility	Create a platform for performing various and similar assignments within the e-learning system and facilitate completing activities and settings within the existing electronic platform. Furthermore, the available options in the e-learning system should be transparent, categorized, and understandable, with clear and comprehensible functions for each option or choice. The content of each lesson should be linked clearly to its corresponding related instructional videos. For artistic disciplines or fields with predominantly practical courses, a section should be available where students can clearly understand the instructional materials, as well as the instructor's teaching space. In laboratory and medical fields, practical units, in general, can benefit from features like virtual reality and virtual reality goggles for better comprehension of the taught materials. Although using such facilities requires hardware and software prerequisites, if these capabilities are available in other contexts within the country, they can be implemented within the academic and university setting.
Consistency and Functionality	To ensure consistency in the design of the e-learning system, each section, such as assignments, exams, classes, and interaction rooms, should have uniform forms to prevent student confusion.
Completeness	E-learning courses should be user-friendly for students of different ages and educational backgrounds. They should also cater to a consistent level of digital literacy to enhance effective use. Standardized operational methods for teaching and learning processes are essential. Information announcements should be in a fixed position to aid students' comprehension of course content and self-regulated learning.
Memorability	A support team should provide technical support to assist students with presentations and exams, ensuring stress-free usage. The e-learning system should cater to a wide range of students by organizing information related to different fields, specializations, and courses. Sections dedicated to specific fields such as painting and design should provide high-quality support for effective learning. Similarly, sections should focus on presenting information quickly and clearly for computational fields.

As with any rigorous study, this research has identified crucial limitations that should be acknowledged and addressed in future studies. These limitations include:

1. The research findings apply only to students at the University of Tehran and may not be generalized to other universities and cities.

2. Some students, particularly those in higher education levels and non-humanities fields, required more encouragement to respond to the questionnaire due to the challenging nature of the questions and the need for extensive follow-up to convince them to participate.

3. The research relied on a single research method. Therefore, future studies must explore different research methods to provide a more comprehensive understanding of the topic.

Expanding the scope of the investigation is crucial. We recommend investigating the research variables in other universities to evaluate the status of e-learning nationwide, providing a more comprehensive understanding of the field. We suggest conducting a more comprehensive examination of these research variables among students in medical and paramedical fields and at the doctoral level. Moreover, there is sufficient room for further exploration of the impact of demographic differences, such as age and gender, on the variables under investigation.

Considering that the current study's underlying paradigm is primarily quantitative, we propose to address the evaluation of e-learning systems qualitatively, combining qualitative and quantitative results to acquire a more precise and comprehensive picture of the system's status.

Future research could compare the dimensions and factors derived from the opinions of students, university staff, and administrative personnel, individually and collectively.

Conducting this research and studying e-learning systems in face-to-face and virtual education settings is essential. This comprehensive approach will provide a better comparative perspective of students' viewpoints and ensure the continuous application of e-learning systems' benefits.

Due to the involvement of variables such as syntax and thinking style, and other intervening individual variables, such as learning styles, future research should consider these either as controlled variables or as part of the main research subject.

Conclusion

According to the findings of this research, there is a positive and meaningful relationship between the factors that affect the effectiveness of e-learning and self-regulated learning. However, it is essential to note that these findings are based on a specific context and may not be generalizable to all e-learning environments. As the number of factors affecting the effectiveness of e-learning increases, self-regulated learning also increases, and vice versa. These factors impact the learning environment's structure and how learners manage, plan, and reflect on their learning process. The e-learning system consists of various dimensions and factors, each of which influences the system's overall effectiveness. Some factors are more impactful than others in the e-learning process. When the factors of the e-learning system are more effective, students are more successful in setting goals, self-evaluating, planning and completing assignments, and collaborating with others in the learning environment, leading to improved performance and a more self-regulated approach to learning, ultimately resulting in higher levels of learning. Therefore, when designing an effective e-learning system to enhance efficiency, the factors must be related to the dimensions of learning mentioned above.

Self-regulated learning also influences the effectiveness of e-learning. Among the various factors that impact the effectiveness of e-learning (including error prevention, observability, flexibility, course management, interaction, feedback and help, accessibility, stability and functionality, assessment strategies, memory capabilities, completeness, physical beauty, and reduction of rework), there is a positive and significant relationship with self-regulated learning. The dimensions of factors affecting the effectiveness of e-learning (including error prevention, observability, flexibility, course management, interaction, feedback and help, accessibility, stability and functionality, assessment strategies, memory capabilities, completeness, physical beauty, and reduction of rework) are related to self-regulated learning. Therefore, these factors have an impact on self-regulated learning. It is possible to predict self-regulated learning based on the factors affecting the effectiveness of e-learning in the statistical population. Additionally, personality characteristics and all their dimensions (psychoticism, extroversion, introversion, eagerness for new experiences, agreeableness, conscientiousness) play a mediating role in influencing the factors that affect the effectiveness of e-learning on self-regulated learning.

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