A Review of the Effectiveness of e-learning on Knowledge and Skill Acquisition in Medical Education

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Abstract

A literature review study was conducted to analyze the effectiveness of e-learning to train or educate either physicians or medical students on a new skill or knowledge in a healthcare setting. Sixteen relevant research articles were identified and retrieved through different databases and were later analyzed. It was found that e-learning was employed to teach various healthcare topics, however, palliative care and infection control topics were most popular. e-learning was mostly employed to improve learners' knowledge on a particular topic. The effectiveness of e-learning to improve knowledge and skills acquisition varied, however, it was found to be at least as effective as traditional instructional method. Hence, the effects of e-learning to improve knowledge or skills acquisition may be contingent to the setting, subject matter, and the delivery method. Therefore, before blindly employing e-learning to medical education, it is imperative to assess its effectiveness to teach the specific knowledge or skill.

Introduction

The present medical curriculum has reached its capacity and it is not viable to remove some of the present content to make room for the new information. Additionally, increasing students required hours of instruction is not practically feasible (Ozuah, 2002). Along with this challenge, the field of medical education is also facing loss of clinical revenues. Therefore, in such situations providing information in a traditional setting is not plausible. By keeping the busy schedules of the physicians and medical students in mind, medical educators and trainers may opt to use non-traditional options to provide instruction that they can access at their convenience. Distance education is one such method that can be used to provide instruction to the learners to help educate them and reduce the gap in knowledge. This is an economical option and no changes to the current medical curriculum is required.

What is e-learning?

e-learning which is also known as online learning, web-based learning, distributed learning, computer assisted or internet-based learning (Ruiz, Mintzer, & Leipzig, 2006). The term e-learning now incorporate distance learning and computer-assisted instructions as internet becomes the integrating technology for e-learning. e-learning is defined as "learning conducted via electronic media, typically on the Internet" ("E-Learning," n.d.). e-learning is not merely a delivering agent or a broadcast of information through the medium of internet. It is rather a pedagogical approach that involves instructions that are learner-centered, flexible, and engaging for the learners. e-learning instructions also stimulate communication, collaboration, and interaction. This type of instruction is often used in asynchronous environments but it could be used in other environments as well (Ellaway & Masters, 2008).

Advantages of e-learning in Medical Education

There are some advantages of using e-learning compared to the traditional face-to-face instructions in medical education. Both educators and learners can benefit from the development of a good e-learning course. The following are some advantages of using e-learning instructions in medical education:

- e-learning is less expensive to deliver instructions compared to the face-to-face setting. That is, once the educators have developed an e-learning course on a given medical education topic, they are able to simultaneously administer the course to a vast number of medical students around the world compared to that in the face-to-face setting.
- e-learning provides consistent content to all learners. That is, all medical students receive same homogeneous instructions and training on a particular topic. This aids in creating a congruent medical educational system. In a face-to-face setting, the instructional content that is delivered to the medical students usually depends upon the instructor who is teaching the course. Different instructors may teach different information for the same topic. This may lead to medical students having dissimilar access to the instructional information or materials and thus, may create an inconsistent medical education system.
- Instructor can easily update the e-learning content. That is, if there is a situation where new medical procedures are developed and they need to be replaced with the older ones listed in the medical education curriculum, then the instructor of educator could easily update this information in an e-learning course. e-learning courses are self-paced. This provides learners (i.e. medical students) the autonomy to access the e-learning courses at any time. Students have control over their learning process as they can customize the learning materials according to their needs and can take as much time as they need to complete the instructions.
- e-learning is a faster method of teaching and learning than face-to-face instruction. Learners (i.e. medical students) can skip the materials that they already know to save the instructional and learning time.
- e-learning could also be used to help improve learners' retention by employing various types of content (i.e. images, sounds, and text). It is said to improve retention by incorporating many elements such as quizzes, audios, videos, and interactions among others to reinforce the message to the learners. Medical students can therefore learn from
- e-learning provides immediate feedback, and encourages interaction with other e-learners and e-instructors by using features such as chat room, discussion boards, and email among others (Cantoni et al., 2004). Medical students can receive immediate feedback on the practice activities and on the final assessments that are built into the e-learning course to foster learning.

Purpose of this Study

Despite the abovementioned advantages of employing e-learning instructions, there is still some uncertainty regarding its effectiveness on medical students' and physicians' learning. In the field of healthcare, erring is too costly. Therefore, it is extremely important for the medical students and physicians to have the appropriate level of skills and knowledge to practice medicine as they are responsible for human lives. Using e-learning to train medical students and physicians may be a faster and cheaper method to provide instructions. However, it is important to assess if e-learning is also effective in promoting learning in the healthcare setting. This is because, effectiveness plays an important role in learning. Instructions may be easy to use and economical to deliver but if it is not effective in educating or training the learners (i.e. medical students or physicians), then they are considered to be substandard instructions. Despite the importance of knowing the extent of effectiveness of e-learning in medical education, there is a paucity of research conducted on this topic.

To address this uncertainty, it is important to evaluate the use and effectiveness of e-learning in a particular setting and compare the results within that setting. Hence, this study focuses on the uses and effects of e-learning in healthcare. Previously, there have been research studies that have employed e-learning in the healthcare field to train healthcare personnel such as nurses, physicians, medical students, healthcare workers, and volunteers among others. However, in this study, effects of e-learning on medical students' and physicians' knowledge or skill acquisition will be assessed. This analysis will help us understand the effectiveness of e-learning in fostering knowledge or skill acquisition among medical students and physicians. The results of this study will guide future research and will provide suggestions for the use of e-learning in training and educating medical students and physicians.

Research Questions

The goal of this study was to analyze the research on the use of e-learning to train or educate either physicians or medical students on a new skill or knowledge. The following research questions guided the study:

- What subjects were taught in healthcare using e-learning?
- How has e-learning been used in healthcare to train medical students or physicians?
- To what extent, was e-learning effective in fostering medical students or physicians to acquire the intended knowledge or skills?
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Method

Selection Criteria

A literature review study was conducted to answer the abovementioned research questions. This study did not involve human subjects and thus, no internal review board (IRB) approval was sought for this study. Researchers established and adhered to some stringent selection criteria throughout the study. The research studies that focused only on e-learning in healthcare setting were selected for this study. The population of interest in these research studies were either medical students or physicians. Therefore, studies focusing on healthcare professionals other than medical students or physicians were excluded from this study. Additionally, research studies that focused on employing e-learning in government or industry settings were excluded from this study.

Additionally, it was required that the articles assessed the effectiveness of e-learning on learning and collected empirical qualitative or quantitative data supporting their claims. Research studies that employed either data extraction or experimentation method to collect data were included in this study. Review articles, or articles that presented authors' personal opinions or perspectives were excluded from this study.

Identification of Eligible Studies

Relevant research articles were identified and retrieved through a several search attempts across different databases. First, a general search was conducted using Google Scholar. Following this, additional searches were conducted in PubMed, ERIC, and Academic Search Complete databases to find relevant articles for this study. The following key terms were employed to retrieve suitable reference articles: "eLearning medical", "eLearning in medical education", "eLearning physician", "eLearning medical student", "eLearning in CME", and "eLearning medical rotations". This method generated a list of numerous articles. However, only 16 peer-reviewed articles met the abovementioned selection criteria set by the researcher.

The selected articles employed e-learning either in the form of independent or blended learning to teach a particular skill or knowledge to either medical students or physicians. These articles showcased the studies that employed e-learning in different disciplines within the healthcare setting. They also provided empirical evidences to support their claims and provided evidence on the effectiveness of e-learning. Studies with empirical data were chosen because relying on empirical sources would help make fewer errors when reporting and making inferences regarding the effectiveness of e-learning.

Analysis of the Study

The published studies were analyzed to identify the common themes for the uses and the effects of e-learning in educating and training medical students or physicians on healthcare topics. The studies were analyzed for the following characteristics: topic of instruction, population of interest, sample size, learning objective, type of e-learning, effectiveness of e-learning, and learners' perception towards e-learning. The results of the analysis are discussed in the following paragraphs.

Results

Topic of Instruction

A review of 16 papers indicated that e-learning has been used in different healthcare domains to teach different topics. e-learning was used to teach the following topics: palpation and ultrasound imaging of the knee, immunology, prescribing education, pediatric emergency medicine, how to use the CPAx, breaking bad news, core

communication, and epidemiologic and social topics in medicine (such as discussions around palliative care & medical test utility), endocrine pharmacology, infection control and congenital infections, healthcare-associated infection prevention and control, physiotherapy skills training, dermatology, occupational medicine (i.e. maternity protection, hepatitis B in a medical student & occupational asthma), palliative care, screening and brief intervention (SBI) for unhealthy alcohol use, and radiological anatomy. Based on the review, it was found that there were a variety of topics explored by different researchers to investigate the effects of e-learning on learning outcomes. However, palliative care, and infection control are topics that were more popular than the others.

Participants

Population of interest. Among the 16 reviewed articles, majority of the studies (*n* = 12) had medical students as their population of interest. There were four studies that had either trainee doctors, clinicians, residents, or interns as their population of interest (see Table 1). Medical students in these studies ranged from first year students to third year students. Six out of 12 studies had second year students as their population of interest. There was only one study that had both second year and third year students as their population of interest (see Table 2).

Sample Size. The sample size of the 16 studies varied substantially. The sample size of participants ranged from 16 to 688. Among these studies, there were 10 studies that had a sample size of more than 100 participants, 3 studies had participants between 50 and 100, and 3 studies had less than 50 (see Table 3).

Table 1. Population of Interest in the Reviewed Articles

Population of interest	*n*	Studies
Physicians (including residents, clinicians, and interns)	4	Brooks et al (2016); Chang et al (2014); Corner, Handy, & Brett (2016); Daetwyler, Cohen, Gracely, & Novack (2010)
Medical Students	12	Arroyo-Morales et al (2012); Gaikwad & Tankhiwale (2014); Silva, Souza, Filho, Medeiros, & Criado (2011); Khasawneh, Simonsen, Snowden, Heggins, & Beck (2016); Preston et al (2012); Boye, Moen, & Vik (2012); Day et al (2015); Smits et al (2012); Tan, Ross, & Duerksen (2013); Webb & Choi (2014); O'Neill et al (2011); Truncali et al (2011)

Table 2. Medical Students' Year in Medical School

Year in Medical School	*n*	Studies
First Year Students	2	Webb & Choi (2014); Truncali et al (2011)
Second Year Students	6	Arroyo-Morales et al (2012); Boye, Moen, & Vik (2012); Gaikwad & Tankhiwale (2014); Silva, Souza, Filho, Medeiros, & Criado (2011); Smits et al (2012); Preston et al (2012)
Third Year Students	3	Day et al (2015); Khasawneh, Simonsen, Snowden, Heggins, & Beck (2016); Tan, Ross, & Duerksen (2013)
Second & Third Year Students	1	O'Neill et al (2011)

Table 3. Reported Sample Sizes in the Reviewed Studies

Sample size	*n*	Studies
≤ 50	3	Arroyo-Morales et al (2012); Gaikwad & Tankhiwale (2014); Silva, Souza, Filho, Medeiros, & Criado (2011)
51-100	3	Daetwyler, Cohen, Gracely, & Novack (2010); Khasawneh, Simonsen, Snowden, Heggins, & Beck (2016); Preston et al (2012)
101-150	5	Boye, Moen, & Vik (2012); Day et al (2015); Smits et al (2012); Tan, Ross, & Duerksen (2013); Webb & Choi (2014)

| ≥ 150 | 5 | Brooks et al (2016); Chang et al (2014); Corner, Handy, & Brett (2016); O'Neill et al (2011); Truncali et al (2011) |

Learning Objectives

The studies were further categorized by their learning objectives. Three types of learning objectives namely knowledge, skills, and both (i.e. knowledge & skill) were identified for this study. Among the 16 studies, majority of the studies ($n = 10$) used e-learning to only improve learners' knowledge on a particular topic. There were only two studies that used e-learning to improve only the learners' skills, and there were four studies that used e-learning to provide knowledge and skills training to the learners (see Table 4).

Type of e-learning

Among the 16 studies, there were seven studies that incorporated e-learning as part of the curriculum, with lectures or practical tutoring (see Table 5). This type of e-learning is known as blended e-learning. The remaining studies employed e-learning as an independent resource to improve learners' skills or knowledge. This is known as independent e-learning. All studies focusing on improving knowledge or skills employed a didactic form of e-learning that involves employing web-based modules to provide instructions to the learners. Whereas, some studies focusing on improving skills employed didactic e-learning instructions along with other instructional strategies. For example, Webb and Choi (2014) employed virtual interactions (i.e. virtual patients in a clinical scenario). Whereas, some researchers embedded demonstrative videos into the e-learning modules. Preston et al. (2012) employed video-clips of patient therapist simulations, where Corner, Handy, and Brett (2016) employed video case studies of CPAx assessments in to the modules. On the other hand, Daetwyler, Cohen, Gracely, and Novack (2010) used a form of a role play method to provide learners the opportunity to practice communicating bad news to the standardized patients in a virtual environment (i.e. using video-conference).

Table 4. Review Articles Categorized by Learning Objectives

Learning Objectives	*n*	Studies
Knowledge	10	Brooks et al (2016); Chang et al (2014); Boye, Moen, & Vik (2012); Day et al (2015); Smits et al (2012); Gaikwad & Tankhiwale (2014); Silva, Souza, Filho, Medeiros, & Criado (2011); Khasawneh, Simonsen, Snowden, Heggins, & Beck (2016); O'Neill et al (2011); Tan, Ross, & Duerksen (2013)
Skills	2	Corner, Handy, & Brett (2016); Preston et al (2012)
Both (Knowledge & Skills)	4	Arroyo-Morales et al (2012); Daetwyler, Cohen, Gracely, & Novack (2010); Webb & Choi (2014); Truncali et al (2011)

Table 5. Type of e-learning Used in the Review Articles

Type of e-learning	*n*	Studies
Blended	7	Arroyo-Morales et al (2012); Boye, Moen, & Vik (2012); Daetwyler, Cohen, Gracely, & Novack (2010); O'Neill et al (2011); Preston et al (2012); Silva, Souza, Filho, Medeiros, & Criado (2011); Webb & Choi (2014)
Independent	9	Brooks et al (2016); Chang et al (2014); Corner, Handy, & Brett (2016); Day et al (2015); Smits et al (2012); Gaikwad & Tankhiwale (2014); Khasawneh, Simonsen, Snowden, Heggins, & Beck (2016); Tan, Ross, & Duerksen (2013); Truncali et al (2011)

Effectiveness of e-learning

When designing e-learning instructions, Instructional designers, instructors, and e-learning developers have a learning outcome in mind that they want to accomplish. Their aim is to develop instructions and use technologies

to create learning environments that are effective in fostering learning. In this section, the effectiveness of e-learning will be discussed. The effectiveness of e-learning is marked by its ability to achieve statistically significant effect on improving learners' knowledge or skills. Thirteen out of 16 studies, found that e-learning is effective in improving either knowledge or skill acquisition among medical students and physicians.

Knowledge. Among the studies that investigated the effects of e-learning on knowledge ($n = 10$), seven studies reported that there was a statistically significant effect of e-learning on the learners' knowledge. Several researchers have assessed pre-test and post-test scores to measure the effectiveness of e-learning modules or courses on the learners' knowledge. The researchers found that there was statistically significant improvement in learners' knowledge. The use of asynchronous e-learning modules led to an increase in learners' post-test scores (Boye, Moen, & Vik, 2012; Brooks et al., 2016; Chang et al., 2014; Gaikwad & Tankhiwale, 2014; O'Neill et al., 2011; Silva, Souza, Filho, Medeiros, & Criado, 2011; Tan, Ross, & Duerksen, 2013).

Tan, Ross, and Duerksen (2013) reported that including virtual patient (VP) cases in palliative care curriculum and allowing students to interact with the VP helped students gain knowledge about the topic. The results indicated that there was a significant increase in the post-test knowledge scores from the pre-test scores. Boye, Moen, and Vik (2012) reported that effects of e-learning vary. The e-learning module in this study provided coaching on immunology. It was found that student who used the e-learning modules had higher scores on the immunology test than students who did not use the e-learning module. Additionally, the researcher found that intermediately skilled students benefitted from the e-learning modules than the less skilled or best skilled students. The results indicate that e-learning could be used as a supplement to the traditional teaching to improve learning (Boye, Moen, & Vik, 2012).

Brooks et al. (2016) reported that trainees who spent less time completing the online modules had low pre-test scores on average and had inadequate improvement in their knowledge on the post-test scores compared to the trainees who spent more time completing the modules. This shows that the effectiveness of the e-learning module on improving learners' knowledge is dependent on how the learner interacts with the module and how much time they spend completing the modules. Therefore, along with creating good e-learning instructions, it is important to also create rules and regulations and monitor its use (Brooks et al., 2016).

The abovementioned studies found that e-learning was overall successful in improving learners' knowledge in different disciplines. However, contradicting results were reported by some researchers as they found no significant gain in knowledge from using e-learning modules. Day et al. (2015) found that there was no significant difference in students' knowledge after the doctoring sessions as assessed by the pre-test and post-test scores. However, there is a non-statistical trend showing that the students who completed eDoctoring session had more number of correct answers on the test compared to the students who completed the traditional small group doctoring session. Khasawneh, Simonsen, Snowden, Heggins, and Beck (2016) found that assessing e-modules did not improve students' knowledge and post-test scores. Similar results were reported by Smits et al. (2012). The researchers found that there was no difference in students' knowledge when they received case-based e-learning or text-based learning instructions. Majority of the studies found significant effect of e-learning on knowledge acquisition. However, there were some studies that did not find a significant effect of e-learning on knowledge acquisition. These results indicated that e-modules is not a widely successful instructional tool (Khasawneh et al., 2016).

Skills. Conducting the review of the articles revealed that e-learning is also effective in teaching skills to the learners. Among the 16 articles, there were two studies that assessed the effectiveness of e-learning on skill acquisition. Corner, Handy, and Brett (2016) used e-learning to teach clinicians how to use the Chelsea Critical Care Physical Assessment (CPAx) tool. The researchers found that after completing the e-learning modules, clinician felt that they could use the CPAx tool consistently and could also explain their colleagues how the CPAx score works. e-learning was also found to be effective in teaching physiotherapy skills to the medical students. Preston et al. (2012) reported that students who used the Physiotherapy eSkills Training Online resource scored higher on the practical exam than the students who only had access to the usual traditional teaching. This shows that e-learning can be an effective tool to teach practical skills to the learners.

Both knowledge and skills. Among the reviewed articles, four studies investigated the effects of e-learning on knowledge and skills simultaneously (Arroyo-Morales et al., 2012; Daetwyler, Cohen, Gracely, & Novack, 2010; Truncali et al., 2011;; Webb & Choi, 2014). Daetwyler et al. (2010) studied the educational interventions to improve interns' ability to communicate and break bad news to patients. In this study the researchers compared the use of didactic e-learning to the didactic and web encounter exercise based e-learning in teaching interns the necessary medical communication knowledge and skills. The results of the two-type of e-learning were compared to the scores of the interns' who were in the control group who did not receive any e-learning intervention. The researchers found that the interns in the e-learning groups performed better at communicating bad news to patients than the interns in

the control group. They also found that interns in the didactic and web encounter exercise based e-learning group outperformed the interns in the other group (i.e. control and didactic e-learning) in communicating bad news to patients during a practical assessment.

This shows that adding an online practice component to e-learning improved its effectiveness in enhancing the interns' ability to effectively communicate bad news (Daetwyler et al., 2010). All the studies except Arroyo-Morales et al. (2012) found that their e-learning modules were effective in improving both knowledge and skills among the learners. The researchers found that the e-learning module was effective in improving learners' palpation and ultrasound musculoskeletal examination skills. However, it was not effective in helping learners acquire knowledge.

Learners' Perception Towards e-learning

Along with assessing the effectiveness of e-learning instructions, is important to consider how learners perceive the e-learning instructions. Specifically, it is imperative to assess students' perceived satisfaction with and usability of e-learning. After reviewing the articles, it is found that overall students perceived e-learning modules as easy to use and had no technical difficulties (Truncali et al., 2011). Most of the clinicians (i.e. 93.6%, $n = 264$) who used the e-learning module to learn the CPAx tool reported that the module was simple to use (Corner, Handy, & Brett, 2016).

Additionally, the students perceived the e-learning modules to be useful for learning practical skills (Preston et al., 2012). Gaikwad and Tankhiwale (2014) found that the students accepted the e-learning activity and perceived it as "innovative, convenient, flexible, and useful" (p. 16). It was found that the students largely had good impression about the e-learning program. When students were asked how well did the e-learning course serve as a supplement to the regular teaching, 70% of the students reported it being good or very good (Boye, Moen, & Vik, 2012). Khasawneh et al. (2016) reported that approximately 70% of the students who completed the e-learning module on infection control and 72% of the students who completed the e-learning module on congenital infection some satisfaction or good satisfaction for using e-learning modules as learning tool. Similarly, Silva et al. (2011) also found that 90.9% of the students reported having good to excellent satisfaction with the online course (i.e. e-learning course).

Discussion

Conclusion

Medical students and physicians go through intensive medical training and education. They have busy schedules and are required to acquire specific knowledge and skills to complete their education or to continue their practice. In addition to the regular curriculum, practitioners have identified new skills and knowledge that need to be taught to the medical students and physicians in order for them to be up to date and competitive in the field. Asynchronous e-learning and blended e-learning are being used to provide instructions to the learners.

After reviewing the 16 identified articles, it is found that didactic e-learning courses were useful in providing instructions. Asynchronous and blended methods of e-learning were effective in improving learners' knowledge and skill acquisition. However, effectiveness may vary based on setting and discipline. Some studies reported no significant difference between e-learning and traditional instructions when measuring learners' knowledge and skills after the interventions. Whereas some researchers reported that there was a significant effect of e-learning on knowledge and skill acquisition. Therefore, there is no clear consensus on the effectiveness of e-learning as its effectiveness is highly contingent on the learner population, topic of instruction, design of e-learning, and the setting that it is employed in.

However, no study has reported adverse effects of e-learning on learners' knowledge and skill acquisition. Researchers have found that e-learning is at least as effective as traditional learning in enhancing knowledge and skill acquisition. Therefore, e-learning is not just a fad. It is an effective method to educate and train medical students and physicians on topics that are within and outside the curriculum in an economical and sustainable manner. To make e-learning effective, it is suggested that e-learning should be added as a supplement to the traditional teaching and must not replace traditional learning (Arroyo-Morales et al., 2012).

Limitations

This study was conducted to understand the effectiveness of e-learning on medical students' and physicians' knowledge and skills acquisition. Different types of research have been conducted in these studies. Researchers employed a randomized control group experiment, quasi-randomized control group experiment, and data gathering techniques, among others to measure the effectiveness of e-learning on learners' knowledge and skills acquisition. However, they all yielded more or less similar results regarding the effectiveness of e-learning.

There were differences in the studies' population, sample size, setting, and topic of e-learning. This makes it difficult to directly compare the results between studies and to make inferences from these studies. Additionally, some articles had unequal sample size in the groups being compared. This may have led researchers to make type I or type II errors when making comparisons and thus, may have affected the results. Hence, we must be cautious when making inferences based on such results.

Suggestions for Future Research

e-learning is being used as educational intervention in medical education. However, the benefits of e-learning may be contingent to the setting, subject matter, and delivery method. Therefore, it is important to be cautious about using online learning in the medical education. Before blindly employing e-learning in medical education, it is imperative to know if e-learning would be an appropriate method to teach the specific knowledge or skill and if it is effective in doing so. Because if even the online instructions are well designed, easy to use, and efficient but if they lack effectiveness in teaching a particular knowledge or skill, then it is worthless to use them. Therefore, it is important to evaluate the effectiveness of the instructions before employing it.

Since there is no consensus on the effectiveness of e-learning in healthcare, future research studies are warranted to evaluate the impact of e-learning in each healthcare setting to understand the effects and usefulness of the e-learning educational approach (Khasawneh et al., 2016). Most of the studies have compared the e-learning with traditional face-to-face instructions. From these studies we learned that e-learning is at least as effective as traditional instructions. However, there is a need to stop comparing e-learning (i.e. distance education) to the traditional instructions. Rather, we must shift our focus to evaluate the different components of e-learning and the different instructional strategies used in developing e-learning instructions.

It is important to study how instructional strategies, technologies, and learning theories can be employed to create effective e-learning environments. Conducting such studies will help us understand what strategies work best or less in asynchronous e-learning environments and how we can create effective learning experiences for our learners. Future researchers must consider conducting randomized experimental studies to evaluate the effectiveness of e-learning. This will help them control for confounding and extraneous variables and will help them identify the exact impacts and effects of e-learning on learners' knowledge and skills acquisition.

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