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Exploring the benefits of e-learning for life and earth sciences education in Moroccan high schools

Sofia Rachad[1] ✉ iD
Lahcen Oughdir[2] iD

(✉ Corresponding Author)

[1,2]*Faculty of Sciences and Techniques of Fes, Sidi Mohamed Ben Abdellah University, Morocco.*
[1]*Email: Sofia.rachad@usmba.ac.ma*
[2]*Email: Lahcen.oughdir@usmba.ac.ma*

Abstract

The reliance on online learning systems has increased during the COVID-19 epidemic to maintain education. The effectiveness of online life and earth science instruction is assessed in this study which involves 150 first-year high school students. Methodologically, it juxtaposes e-learning with traditional classroom teaching across various parameters. The study reveals that digital learning yielded better results across all considered variables ($p < 0.05$), irrespective of student gender ($p = 0.216$). Better performance was seen in subjects such as "man and the environment" and "greenhouse effect and climate change" when learning was carried out online ($p < 0.001$). However, no notable scoring differences were found in practical subjects such as " creation of ecological reserves to preserve biodiversity," "clean technologies to protect the environment" and " environmental education and sustainable development," ($p = 0.627$ and $p = 0.147$). Thus, e-learning proves to be a useful supplement to traditional instruction. It shouldn't be used in place of hands-on activities in all situations.

Keywords: COVID-19, Education, E-learning, High school, In-person teaching, Learning, Life and earth sciences.

Contents

Contribution of this paper to the literature
This study focuses on the impact of e-learning on specific life and earth science subjects in high school exploring the nuanced relationship between learning mode and academic performance in distinct subject areas.

1. Introduction

The rapid development of digital technologies over the past several years has transformed many aspects of our daily lives such as the way we work, inform ourselves and learn (Johnson, Adams Becker, Estrada, & Freeman, 2021). E-learning or online learning has become an increasingly common method of education, offering multiple advantages such as flexibility, accessibility and personalization (Wang, Chen, & Liang, 2020). The COVID-19 pandemic affected the entire world in 2020 pushing educational institutions to quickly adopt distance learning solutions (Adedoyin & Soykan, 2023). The pandemic has significantly changed how administration and services are operated (Bali & Liu, 2021). These changes have also impacted the educational sector where teachers and students adapt new modes of teaching and learning (Dhawan, 2020). E-learning platforms have provided effective means for institutions to deliver quality education despite the constraints imposed by the pandemic (Rapanta, Botturi, Goodyear, Guàrdia, & Koole, 2020).

Several studies highlighted the benefits and drawbacks of e-learning in the field of scientific education and were published in the Asian Online Journal. Li and Zhang (2023) examined the impact of online learning platforms on students' engagement and academic performance in biology classes. They found that students who actively participated in online activities and discussions achieved better academic results compared to those who had limited interaction with the platform. Furthermore, a study conducted by Adebunmi and Ogegbo (2021) explored the effectiveness of e-learning during the COVID-19 Pandemic. They compared the learning outcomes of students who took an online environmental sciences course to those who participated in a typical classroom course. The findings revealed that the online course not only facilitated access to various   educational resources but also promoted collaborative learning and critical thinking skills among students. The present study aims to further investigate the advantages of e-learning in teaching life and earth sciences to high school students based on these findings.

Several international studies have been conducted to evaluate the effectiveness and challenges of e-learning during the pandemic. For example, in China educational institutions quickly adopted online learning approaches to ensure pedagogical continuity (Zhang, Wang, Yang, & Wang, 2020). According to research by Means and Neisler (2020) in the United States, students adapted well to online learning, although issues such as the absence of social connection and difficulties with technology persisted. Similar experiences were observed in Europe where studies showed that e-learning allowed teaching to continue during lockdowns but improvements were needed to ensure equity and quality (Bozkurt & Sharma, 2020; Teräs, Suoranta, Teräs, & Curcher, 2020). Many researchers have also emphasized the importance of developing pedagogical strategies adapted to the constraints of e-learning (Bao, 2020; Hodges, Moore, Lockee, Trust, & Bond, 2020). For example, Kebritchi, Lipschuetz, and Santiague (2017) identified several key factors for successful e-learning such as student engagement, technical support and teachers' adaptation to new technologies. In addition, accessibility to the internet and digital equipment has been identified as a major issue in many countries where socioeconomic inequalities can limit access to e-learning for certain populations (Bali & Liu, 2021; Escudero-Viladoms, Sobrino, & Arroyo-Rodríguez, 2021). This research   examines the use of e-learning during the COVID-19 pandemic based on the results of a study conducted in a specific context highlights effective means to ensure students engagement and success. Finally, we analyze and discuss the results obtained to determine the advantages and challenges of e-learning in secondary education.

2. Materials and Methods

During our cross-sectional study, 150 first-year students from the Life and Earth Sciences program of the baccalaureate from Moulay Slimane High School in Fes, Morocco were selected. These students were divided into three groups: 50 students with below-average grades, 50 students with average grades and 50 students with a relatively high level. The results of our research were evaluated based on their grades before and after the introduction of an experimental approach in their classes. All students attended the same courses for the same number of hours for two semesters in order to ensure similarity and rigor in the study. This study focuses only on the subjects of life and earth sciences. The topics covered in the first semester included two sections:

Section 1   covered sources of life, pollution, exploration of groundwater sources and the formation of water reserves and groundwater reserves. Section 2 covered the topics of drinking water in households, modern water treatment techniques   and the water cycle.

Age, gender and academic history were taken into account as fundamental features of each student in this study which concentrated on the two sections of courses that were offered to all students. The first section titled "man and his environment" addressed natural imbalances and their consequences, atmospheric pollution and ozone layer depletion, greenhouse effect and climate change, the impacts of excessive use of chemicals, the consequences of deforestation, the extinction of species as well as clean technologies to protect the environment, environmental education and sustainable development. According to academic level, students were divided into two groups of 75 (25 with grades below average, 25 with average grades and 25 with fairly high grades).

The main difference between synchronous and asynchronous e-learning is real-time interaction. Synchronous e-learning offers real-time interactions between learners and teachers while asynchronous e-learning offers time-delayed interactions (Bonk & Graham, 2012). However, both modes of e-learning have advantages and disadvantages depending on the learning context and the needs of the learners.

The method used in this investigation was rigorous. The students voluntarily participated in this study ensuring their motivation and engagement. Anonymity was chosen by using unique identification codes for each participant to protect the confidentiality of individuals. The tools used to collect data and assess student performance were knowledge tests in both groups. These tests were designed by four teachers from the same school and presented in the form of a multiple-choice questionnaire scored out of 20 with only one correct answer. The courses started simultaneously for all students and the data were analyzed using the Cronbach Coefficient.

The results showed that the questions were reliable and valid with α results ranging from 0.80 to 0.89 indicating consistency and stability in the results. These results were obtained using the same evaluation and analysis methodology for each group ensuring equity between the two groups.

During our study, students were subjected to final semester exams. Those who chose in-person teaching were directly supervised in class by teachers while those who opted for distance exams were connected at the same time through the Zoom platform with their camera turned on. However, it is worth mentioning that our research was faced with several challenges. We provided connection modems to people in precarious situations to help them connect smoothly during exams and overcome these challenges. Finally, teachers attentively watched student webcams throughout exams to check for any indications of cheating in order to ensure exam integrity.

Figure 1 depicts an in-person classroom setting.

Figure 1. In-person classes.

After collecting the scores of the students in Life and Earth Sciences (LES), we conducted a detailed analysis of these results to compare the performances of those who took the exam online and those who were present in person. The Statistical Package for the Social Sciences (SPSS) software and   International Business Machines (IBM) identify the qualitative variables in each group based on their respective percentages. The ANOVA (Analysis of Variance) test was used to determine the means of each group. We considered a value < 0.06 as significant to assess the difference between the results of students who took the exam online and those who took it in person.

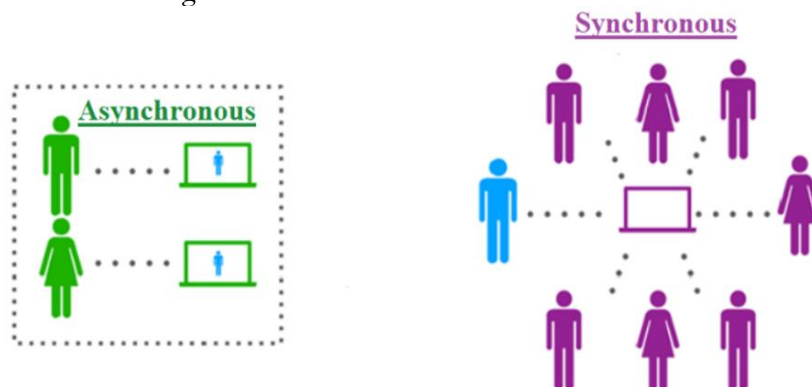Figure 2 illustrates online teaching.

Figure 2. Online classes.

3. Results

Our study focused on a sample of 150 students enrolled in the first year of the Bachelor's degree program, majoring in life and Earth Sciences. The collected data revealed that the majority of participants were women, (55.3%) while men accounted for 44,6%. Regarding academic results, students obtained an average score in the subject of life and Earth Sciences (LES) ranging from 12 to 14, with 80.6% of the students falling within this range. Furthermore, the majority of students were almost 17 years old at the time of the study (Table 1).

Table 1. Characteristics of first-year baccalaureate students (option: Life and Earth Sciences (LES)).

Variables		Frequency (Percent)
Gender	Female	83 (55.3%)
	Male	67 (44.6%)
Age	≤18	14 (9.3%)
	=17	101 (67.3%)
	≥16	35 (23.3%)
Grade point average	<12	3 (2%)
	12-14	121 (80.6%)
	>14	26 (17.3%)

The present study compares the results of courses obtained by students online and at a distance (Table 2). The findings indicate that online courses have yielded better results than those delivered in-person across all examined variables ($p<0.05$). Additionally, the relationship between the learning method and the student's gender was found to be insignificant ($P=0,216$), as male and female students experienced almost equivalent score increases during online instruction compared to in-person instruction. The results also showed that students of different age groups obtained similar average scores in both modes of learning ($P=0.547$). Moreover, the average difference between the two groups was significant ($p=0.026$). Students who scored below 12 experienced a higher increase in their average scores after taking online courses compared to in-person ones.

Table 2. Impact of the learning environment on life and earth sciences students' success according to their characteristics.

Variables		Learning methods ±			P-value	T**	DF
		In-Person	E-learning	Difference			
Gender	Female	15.1 ± 1.6	16.4 ± 1.5	1 ± 1.2	<0.001	-4.6	70
	Male	16 ± 1 .4	16.6 ± 1.6	0.7 ± 1.3	<0.001	-4.3	75
	P-Value	0.52	0.605	0.203			
	T*	-0.7	0.6	1.2			
	Df	121	121	121			
Age	≥ 16	15.8 ± 1.4	16.7 ± 1.6	0.6 ± 1.2	< 0.001	-3.7	58
	=17	16 ± 1.3	16.9 ± 1.4	0.8 ± 1.5	< 0.001	-4.6	58
	≤18	14.5 ± 1.6	15.2 ± 1.2	0.6 ± 1.4	0.046	-2.3	29
	P-value	0.113	0.130	0.543			
	F	2.3	2.1	0.8			
	Df	2.121	2.121	2.121			
Point	<12	13.2 ± 1	14.6 ± 1.2	1.7 ± 1.3	<0.001	-4.3	18
	12-14	14.7 ± 1.3	15.3 ± 1.3	0.8 ± 1.3	<0.001	-4.8	98
	>14	16.5 ± 0.8	17.3 ± 1.1	0.3 ± 1.1	<0.042	-2.1	29
	P-value	<0.001*	<0.001*	0.026			
	F	67.3	29.6				
	Df	2.121	2.121				

Note: T*: Independent sample T-test ; T** : Paired T-test ; F : Analysis of variance.

Table 3 presents a comparison of students' results for the main sections taught using both in-person and distance learning modes. Improvements in average grades in the "man and environment" and "greenhouse effect and climate change" sections after online courses were statistically significant compared to those in person (P<0,001). However, differences in average for the sections "creation of ecological reserves to preserve biodiversity", "clean technologies to protect the environment" and "environmental education and sustainable development" between the two learning modes were not statistically significant (P=0.627 and P=0.147). In addition, the average points of students showed a remarkably significant improvement during online courses.

4. Discussion

E-learning is a distance learning mode that uses information and communication technologies (ICTs) to provide interactive educational content to learners. There are different definitions of e-learning. According to Wiley (2000), e-learning is "the use of technology to create, distribute, support and manage learning". According to Moore and Kearsley (2005), e-learning is "the use of information and communication technologies to create interactive and stimulating learning environments". E-learning can be classified into two types: synchronous and asynchronous. Synchronous e-learning is a real-time teaching mode where learners and teachers interact simultaneously. Examples of synchronous e-learning include chat sessions, webinars, online conferences and virtual classes (Ally, 2004). On the other hand, asynchronous e-learning is a time-delayed teaching mode where learners and teachers interact at different times. Examples of asynchronous e-learning include discussion forums, blogs, wikis, and pre-recorded videos (Sadi, 2016).

The results of our study showed that online learning was more effective than in-person teaching in terms of student performance. Indeed, students obtained higher knowledge scores with online learning compared to in-person teaching. Additionally, significant differences were observed between the two methods based on variables such as gender, age and grades obtained.

Table 3. Comparison of the effectiveness of online learning and in-person teaching on participants performance in different units of the Life and Earth (LES) subject.

Variables	Learning methods ±			P-value	Test
	In-Person	E-learning	Difference		
Man and environment.	14.6 ± 2.3	15.7 ± 1.6	1.3 ± 1.7	<0.001	T=-7.3
Greenhouse effect and climate change.	16.3 ± 1.4	17.8 ± 2.3	0.2 ± 2.3	0.147	Z= -1.3
Creation of ecological reserves to preserve biodiversity.	14.6 ± 2.3	15.7 ± 2.3	1.3 ± 2.4	0.001	T=-6.7
Technologies to protect the environment.	16.1 ± 2.5	15.8 ± 2.2	0.2 ± 3.4	<0.627	T= -0.4
Environmental education and sustainable development.	16 ± 1.7	16.1 ± 1.7	2.3 ± 3.4	< 0.001	T = -1.3
Average of knowledge test scores	15.1 ± 1.4	15.7 ± 1.6	0.7 ± 1.6	< 0.001	T = -6.7

Note: T: Paired T-test; Z: Wilcoxon test.

Furthermore, research has shown that online teaching can offer advantages such as flexibility in terms of learning location and time as well as reduced transportation and housing costs (Mukti, Fitriani, & Destiawati, 2020). According to Indonesian research, students had good perceptions of online learning during the pandemic such as flexibility and opportunities for connection with classmates and professors (Mukti et al., 2020). According to Hodges et al. (2020), the need to assure fair and accurate student assessments as well as the requirement to provide students with dependable internet access remain problems for online education. The development of online teaching strategies that consider students' requirements has also been highlighted by research (Kimmerle, Moskaliuk, Oeberst, & Cress, 2015).

Studies highlight the effectiveness of online teaching as an alternative teaching method during the COVID-19 pandemic. Finally, it should be noted that the results of our study should not be generalized to all students as our study focused on a specific population of first-year high school students in a school in Fes/Morocco. Future researchers need to examine the effectiveness of online teaching in other contexts and at various educational levels.

One important aspect of e-learning is its potential to foster collaboration and social interaction among learners. Online platforms offer various tools and features that facilitate communication and group work, enabling learners to engage in collaborative activities despite being physically distant. For instance, collaborative document editing, video conferencing and virtual team projects are commonly used in e-learning (Kop & Hill, 2008). These collaborative opportunities not only enhance knowledge construction but also promote the development of critical thinking and problem-solving skills.

Furthermore, the accessibility of e-learning has been a key factor in its widespread adoption. With the increasing availability of internet access and mobile devices, learners can engage in learning anytime and anywhere. This accessibility is particularly beneficial for individuals with physical disabilities or those residing in remote areas with limited educational resources (Karampiperis & Demetriadis, 2017). E-learning has the potential to bridge the educational gap and provide equal learning opportunities for all learners, irrespective of their geographical location or physical limitations.

A meta-analysis conducted by Means, Toyama, Murphy, Bakia, and Jones (2019) found that students in online learning performed slightly better, on average than those in face-to-face classrooms. The study attributed this success to factors such as increased time-on-task, individualized pacing and the ability to revisit and review content.

The use of adaptive learning, through online platforms has shown promising prospects for personalizing the learning experience and addressing individual learner needs. Adaptive learning systems use data analytics and machine learning algorithms to adapt instructional content and delivery based on learner performance, preferences and learning styles (Brusilovsky & Peylo, 2003). This personalized approach can enhance learner engagement, motivation and overall learning outcomes. However, challenges exist in the implementation of e-learning such as social isolation and reduced social interaction among learners. Online platforms provide avenues for communication but the absence of face-to-face interaction can impact the development of interpersonal skills (Wang et al., 2020). Educators and instructional designers need to incorporate strategies that foster social presence and promote meaningful interactions within e-learning environments. Additionally, ensuring the quality and credibility of online educational content remains crucial. It is essential to promote critical digital literacy skills among learners with the abundance of information available on the internet. It is essential to teach students how to assess and confirm the validity of online sources to prevent misinformation and advance academic integrity (Mandernach, Gonzales, & Garrett, 2006). E-learning has emerged as a transformative mode of education enabled by advancements in technology. Its flexibility, accessibility, and potential for personalized learning experiences have made it increasingly popular in various educational contexts. Collaborative opportunities, research on learning outcomes, adaptive learning and addressing challenges such as social isolation and content quality are essential areas of focus for the further advancement and improvement of e-learning.

One of the significant recent trends in e-learning is the integration of mobile learning. Mobile learning offers the advantages of flexibility and convenience allowing learners to engage in short learning sessions during their daily routines (Sharples, Taylor, & Vavoula, 2007). It has enhanced learner motivation, engagement and knowledge retention (Viberg, Khalil, & Olsson, 2020). Moreover, mobile applications and gamified learning experiences have been developed to make learning more interactive and enjoyable for mobile learners (Liu, Li, Carlsson, & Chen, 2020).

Another area of recent development in e-learning is the use of learning analytics. Learning analytics involves the collection, analysis and interpretation of learner data to gain insights into learning behaviors and performance (Siemens & Long, 2011). These insights can be used to personalize instruction, identify at-risk learners, and improve the overall learning experience. Advanced learning analytics techniques such as predictive modeling and social network analysis have shown promising results in identifying patterns and predicting learner outcomes (Dyckhoff, Zielke, Bültmann, Chatti, & Schroeder, 2020). The integration of learning analytics provides valuable feedback to both learners and instructors.

The COVID-19 pandemic has brought e-learning to the forefront of education worldwide. Educational institutions and instructors rapidly transitioned to online teaching and learning to ensure continuity of education. This unprecedented shift has led to the exploration and implementation of innovative e-learning strategies. For instance, virtual laboratories and simulations have been used to provide practical learning experiences in STEM (science, technology, engineering and mathematics) subjects (Ferraro, Gargiulo, Mazzeo, & Vollaro, 2021). These simulations allow learners to engage in hands-on experimentation and exploration in a virtual environment compensating for the lack of physical laboratory access during the pandemic.

Additionally, the integration of social media platforms and online communities into e-learning has gained prominence. Social media platforms such as Twitter, Facebook and LinkedIn provide avenues for knowledge sharing, collaboration and networking among learners and educators (Veletsianos, 2012). Online communities of practice have emerged where learners with shared interests or goals come together to exchange ideas and resources. These communities foster a sense of belonging, promote peer learning, and provide ongoing support and professional development opportunities (Hew & Cheung, 2013). Furthermore, the concept of open educational resources (OER) has gained traction in e-learning. OER refers to freely accessible and openly licensed educational materials that can be used, modified and shared by educators and learners worldwide. OER initiatives aim to democratize education by removing cost barriers and promoting universal access to high-quality learning resources (Hilton, 2016). The availability of OER has expanded the range of educational materials available for e-learning allowing instructors to customize and adapt content to meet the specific needs of their learners.

E-learning continues to evolve with advancements in technology and the changing educational landscape. Recent developments in the field, such as mobile learning, learning analytics, virtual laboratories, social media integration and open educational resources have shaped the e-learning experience. The COVID-19 pandemic has further accelerated the adoption and innovation of e-learning.

5. Limitations of the Study

Online learning makes cheating one of the major problems for teachers (Zhang, Chen, Chen, Lin, and Han) (2021). Researchers faced challenges in comprehensively evaluating the various methods and facilitators of

cheating due to the inherent complexity of the phenomenon. The multifaceted nature of cheating makes it challenging to capture all possible techniques employed by students as they constantly evolve and adapt to new technological advancements. Therefore, further research is necessary to delve deeper into this complex issue and develop effective strategies for prevention.

Another limitation is that it did not delve into the long-term effects on knowledge retention. Understanding the long-term consequences of distance learning and its association with cheating is crucial for designing appropriate interventions and support systems. It is essential to explore how the shift to online education may influence students' ability to retain knowledge and apply it effectively in the future. These limitations emphasize the importance of conducting rigorous research to address the multifaceted challenges surrounding online cheating and its impact on student learning. Future studies should aim to explore a wide range of cheating methods, including both traditional and technologically facilitated approaches in order to develop comprehensive strategies to prevent and detect academic dishonesty. By addressing these limitations, we can gain a deeper understanding of the complexities involved in combating cheating in the context of distance learning and work towards fostering academic integrity and student success.

6. Conclusion

The conclusions drawn from our study demonstrate that e-learning is unlikely to be effective in secondary education given the need for practical work and interaction with the environment and biodiversity inherent in the field of life and earth sciences (LES). However, e-learning may represent a viable alternative in sensitive situations such as the COVID-19 pandemic. It is worth noting that in-person teaching is still more effective and allows for a greater acquisition of practical skills than e-learning.

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