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Original Paper

The Teachers' Perspectives on E-learning Usage and Its Identified Challenges toward Students' Biology Practical Skills Acquisition

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Abstract

The integration of e-learning with traditional learning methods enhanced the practical skills of students in scientific subjects like biology, while the perception of teachers' is decisive and become a challenge if they have poor experience in using e-learning or low intention to use it in biology classrooms. The aim of this study is to identify teachers' perspectives on the usage of e-learning and its challenges in developing biology practical skills among Grade-12 students in the United Arab Emirates (UAE). The study employed a quantitative research design, and questionnaire was utilized for collecting data. The study sample consisted of 226 biology teachers distributed over seven educational districts in government secondary schools in the UAE selected by stratified random sampling method. Descriptive statistics, Pearson Correlation coefficient and the simple linear regression analysis were employed to deduct the results and approving the study hypothesises. The results revealed that e-learning usage and biology practical skills acquisition are correlated to each other in a significant relationship ($r = 0.759$, $\rho = 0.000$) as well as e-learning challenges has a significant effect on biology practical skills acquisition for Grade-12 students ($r= 0.591$, $\rho = 0.000$), while e-learning challenges has a direct impact on e-learning usage in applying biology practical skills for Grade-12students in UAE schools ($r = 0.631$, $\rho = 0.000$). These findings contribute to the existing literature on e-learning implementation and provide valuable insights for educational policymakers, curriculum developers, and teachers seeking to enhance biology practical skills instruction using e-learning platforms.

Keywords: Biology Practical Skills, e-learning, Challenges, Teachers' Perspectives, Grade-12, UAE

1. Introduction

The worldwide technological revolution has remarkably effects on different walks of life politics, society, economics, and education, prompting significant changes in educational policies. Oke & Fernandes (2020) highlighted that technology and modern communication have led to reconsidering of educational methods, giving rise to e-learning. Industrial Revolution 4.0, rapid technological progress, including digital technology and Artificial Intelligent (AI) have transformed human life. Lase (2019) highlighted the technological progress impacts on education, driven by increased communication and digital system development. Fisk (2017) added that there are tendencies related to IR4.0 and education such as, learning can be done anytime and anywhere.

Education is a top priority for countries seeking to enhance human capital and interested in economic growth. Countries focus on equipping students with technical skills and promoting specialists to drive development and entrepreneurship.

Information technology has played a crucial role in education, particularly during the COVID-19 pandemic. As education systems shifted from traditional models to e-learning models, synchronous or asynchronous. Xie, Siau and Nah (2020) emphasized the importance of e-learning in maintaining education across schools, universities, and institutes during the pandemic, e-learning works as an alternative or complement to traditional learning in unusual circumstances.

e-learning, as highlighted by Al Rawashdeh et al. (2021) enables education anytime, anywhere. This strategy, boosted by electronic media, enhances learning efficiency and includes various platforms. In turn Chikhalkar (2020) pointed out that e-learning represents an advanced educational system employed for the facilitation of teaching and learning processes. Essentially, computers and the internet serve as mediums for processing skills and information. The spectrum of e-learning applications encompasses computer-based learning, virtual teaching tools and e-learning platforms

1.1 e-learning in UAE

e-learning has become a first priority in the current phase of the United Arab Emirates (UAE), particularly since information technology education tops the priorities of educational goals. Since the beginning of 2020, exactly in March, UAE has begun e-learning in all UAE educational institutions (public and private schools and higher education) because of the spread of COVID-19. The Ministry of Education (MOE) has carried out dense training programs for all teachers to cope with the new educational system which depended mostly on e-learning (U.AE, 2021).

UAE's Education Ministry introduced smart learning platforms and behaviour guidelines for e-learning. Free internet was provided to students. These measures have reinforced the success of the teacher-supervised e-learning strategy. Chikhalkar (2020) referred to e-learning as an advanced system that takes advantage of computers and the Internet in order to process skills and information.

Darayseh (2020) mentioned, it has been shown that the COVID-19 pandemic had an impact on teaching science in the UAE. As a result, it becomes obligatory needs to build and develop teachers' digital competencies in terms of creating hands-on/or practical activities, fostering interaction with students, managing students' behavior, assess students' learning and time management.

Bawa'aneh (2021) indicated, due to the COVID-19 pandemic, the UAE's Ministry of Education (MOE) fully embraced e-learning during the second trimester of the 2019-2020 academic year. Consequently, e-learning became the core across the whole educational system, affecting public and private institutions, even higher education. An e-learning infrastructure has been launched by the UAE, incorporating platforms and resources, as noted by Al Mansoori (2020). MOE presented diverse platforms, educational materials, and assessment tools, thoroughly evaluated and integrated into the Learning Management System (LMS). Bawa'aneh (2021) pointed out, the Learning Management System in UAE (LMS) was enriched by educational material from several platforms like, Microsoft Teams together with the existing Emirati platform Madrasa, Alef and Al-Diwan. For experiments, the LMS was provided with virtual labs from Praxilab platforms. Also, an agreement with McGraw Hill publishers helped in using their products through the e-learning implementation.

Post-pandemic the e-learning educational environment has continued after the school reopening by most of the countries, which has left the doors opened to discussion and criticism. Furthermore, it has created opportunities for research to evaluate and plan the future of education during and after the pandemic. The pandemic has led to a new era of learning, shaping future teaching strategies through electronic systems, with e-learning evolving from an emergency solution to an effective mechanism supporting traditional methods (Pokhrel & Chhetri, 2021). Furthermore (Al Rawashdeh, Mohammed, Al Arab, Alara and Al-Rawashdeh, 2021; Bawa'aneh, 2021) confirmed that this will require further studies and investigations to cover all educational aspects and achieve the requirements of effective e-learning.

1.2 Biology Practical Skills

When using information technology in the teaching of natural sciences, including biology, it is necessary to take into account the particularities of the educational biology content: living with objects, observing their life processes and experimenting. Akinwumi and Falemu (2020) asserted the students will acquire much knowledge and skills when there is greater practicality in the teaching process. Laboratory practices, as highlighted by Duban, Aydoğdu and Yüksel (2019) are necessary in bridging the theory-practice gap, offering students a comprehensive understanding of science concepts. It is believed that the teachers should focus more on laboratory activities so that the learners could accurately implement the scientific concepts and avoiding any misconceptions. Al-Duliami (2018) mentioned labs as a significant area to enhance teacher and learner experience. Bahtiar and

Dukomalamo (2019) noted that biology practical skills, like studying plant as well as animal tissues, benefit from structured laboratory experiments or field studies.

In teaching Grade-12 biology, practical skills through laboratory experiments are highly significant as they allow students to implement curriculum concepts, fostering their understanding by searching into theoretical ideas through hands-on experiments. The educational and skilful activities in biology vary in the United Arab Emirates (UAE) and correspond primarily to the prescribed curriculum of the Grade-12 student's book, and in line with international standards in formulating biology curricula and related skills (Ministry of Education UAE, 2020).

Teachers act as mediators between the changing world and students. Considering their perspectives in educational research enhances the results credibility and evaluates the effectiveness of their teaching methods (Yigit & Bagceci, 2017). Therefore, this study focuses on teachers' perspectives regarding the use of e-learning for biology practical skills.

Daouk and Aldalaien (2019) referred that few studies have focused particularly on the factors that affect the success of adopting e-learning instructional technologies among education institutions in UAE. But it did not directly address practical skills in biology, specifically for Grade-12 students. Thus, further studies should be carried out to investigate the fact of the e-learning application in teaching science in the UAE, its effectiveness challenges as well as the impacts on the practical skills acquisition.

The researcher's motive was to study teachers' opinions regarding the impact of e-learning on learning biology and developing practical biology skills among Grade-12 students in government schools in the United Arab Emirates. This exploration stems from efforts to enhance education to meet the requirements and achieve educational outcomes, as well as integrating e-learning into the educational framework of the United Arab Emirates.

1.3 Research Objectives

The aim of this study is:

i. To identify the perspectives of biology teachers towards the e-learning usage in teaching biology practical skills for Grade-12 students.

ii. To identify the perspectives of biology teachers on the challenges faced applying biology practical skills for Grade-12 students through e-learning.

1.4 Research Questions

This study will answer the following questions based on the perspective of biology teachers:

i. What are the biology teachers' perspectives towards e-learning usage in teaching biology practical skills for Grade-12 students?

ii. What are the biology teachers' perspectives on the challenges in implementing biology practical skills for Grade-12 students through e-learning.?

1.5 Research Hypothesis

Based on the above research questions the following hypothesis was generated:

H01: There is no significant relationship between e-learning usage and biology practical skills acquisition of Grade-12 students based on the teachers' perspectives.

H02: There is no significant relationship between e-learning challenges and e-learning usage based on the teachers' perspectives.

2. Methodology

This research, used the survey design method to collect the required data, which falls under the category of descriptive approach. This method was relevant to the study through collecting and analyzing quantitative and qualitative data from the intended sample of teachers (Gaur, Zimba, Agarwal, & Gupta 2020). Moreover, the survey design method is a useful tool for conducting

descriptive research. It provides valuable insights into the attitudes, behaviors, beliefs, or other characteristics of a population of interest (Ponto, 2015). Bhandari (2021) mentioned, a survey design involves several key steps, including selecting the appropriate survey mode and sample, developing a set of questions that are valid and reliable, as well as pretesting the survey instrument to ensure that it is clear and easy to understand.

In this research, a questionnaire was used to collect data from biology teachers among the public secondary schools in the UAE. It must be noted here that approval has been obtained from the competent authorities to implement this research in addition to the ethical approval from the human research ethics committee in the university.

After the teachers' responses to the questionnaire's items were collected, the data was processed using statistical methods descriptive statistics (Kaur, Stoltzfus, & Yellapu, 2018), Pearson correlation and simple linear regression (Hazra & Gogtay, 2016). The responses were analyzed to quantitative data in the form of numbers, ratios, arithmetic averages and standard deviations. The study framework was constructed based on the research, theory and practice. Figure 1. Presents the flow chart of the research procedures.

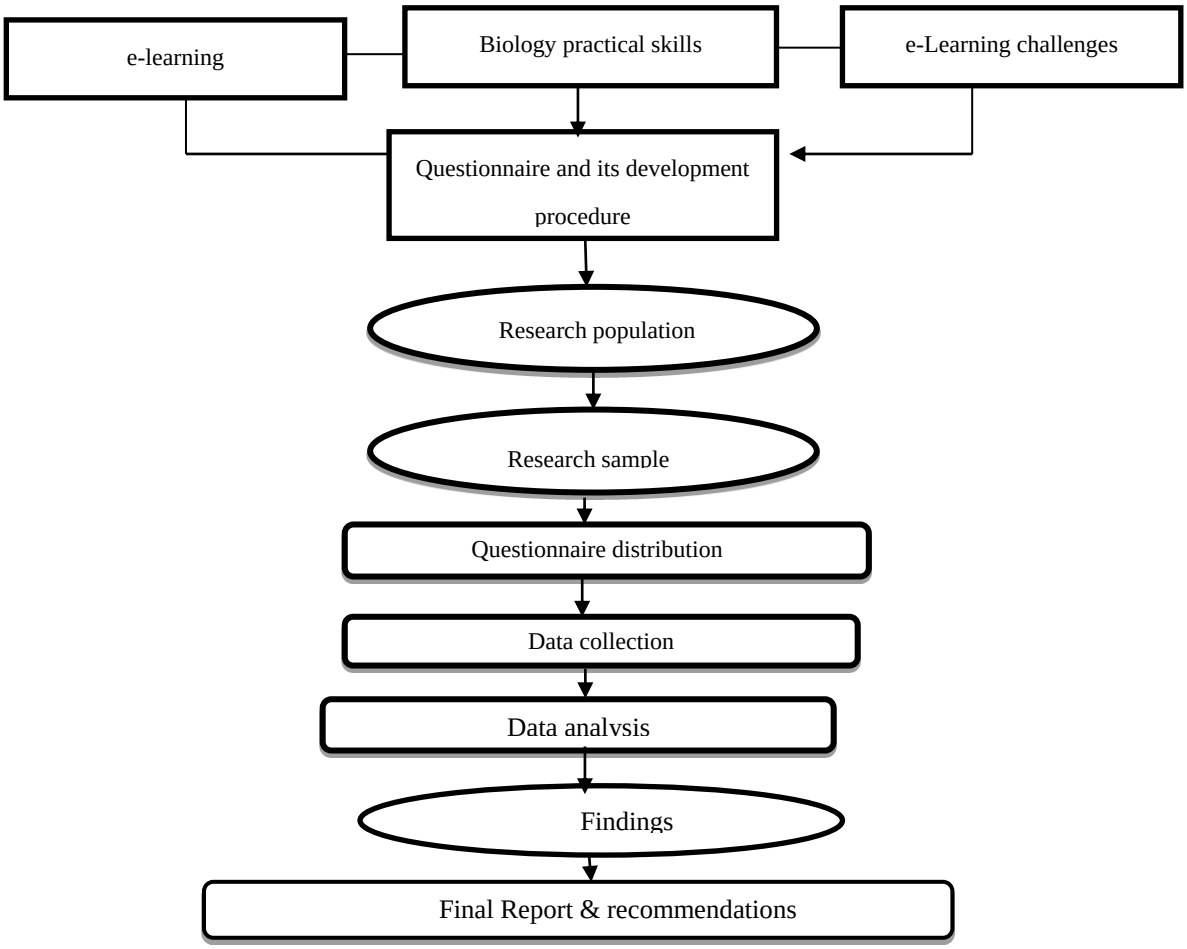

Figure 1. Research Procedure Flow Chart

2.1 Research Population and Sampling

The study was carried out on 226 biology teachers from the public secondary schools in the UAE, distributed across the seven Emirates Education Districts. The research population was composed of the biology teachers in these schools. The stratified random sampling method was applied. Stratified random sampling is a probability sampling technique used in statistics and research to select a

representative sample from a population by dividing it into distinct and homogeneous subgroups called stratum (Krejcie & Morgan, 1970). According to Krejcie Morgan table (1970) for the population 264 the table recommended a sample size of 155. Based on total of the population size 264, the sample size is 85% of the population size which is 226. Due to the small population size this percentage of the study sample size has been determined.

The population was divided into subgroups or stratifications based on school districts and the proportion of secondary schools in them. Each stratum represents a homogeneous population, and the aim is to ensure that the sample is representative of the entire population. To calculate the appropriate sample size for each district, the equation: 85% of the number of teachers in each district was used. For instance, in the Abu Dhabi district, the calculation would be 85% of 90, resulting in approximately 77.

After repeating this equation for all the other districts, the cumulative sample size across all districts was found to be 226, as illustrated in Table 1. Subsequently, the teachers from each district were randomly selected to form the stratified sample. By adhering to these steps, a stratified random sample encompassing 85% of the teachers from all districts was achieved. This sample represents teachers from all seven districts in proportion to their actual distribution in the population, ensuring an unbiased representation. The questionnaires were distributed randomly according to the schools and districts. The total of 226 of the questionnaires were successfully collected and this represented the sample size.

Beforehand, the questionnaire was tested through a pilot study on a sample of 30 biology teachers. The questionnaire was distributed to biology teachers in private secondary schools in Abu Dhabi, which follow the same curriculum as in public schools and under the supervision of the Ministry of Education.

Table 1. The Number and Percentage of Schools and Biology Teachers

District Name	No. of schools	Schools' percent	No. of teachers	Sample Size
Abu Dhabi	30	34%	90	77
Dubai	11	12.5%	33	28
Sharjah	19	21.6%	57	49
Ajman	5	5.7%	15	13
Umm AlQuwain	3	3.4 %	9	8
Al Fujairah	6	6.8%	18	15
Ras-Al-Khaimah	14	16%	42	36
Total	88	100%	264	226

2.2 Research Questionnaire

After a comprehensive review of the existing literature related to the topic of this study, research objectives and consistent hypotheses were established. A questionnaire was modified based on relevant previous studies (Elkhouly, 2021; Mulla, 2019; Alshahrani, 2008; Al-Shammari, 2007) as well as reviewing the previous literature and studies (Al Mahanawi., 2020; Eljack, Alfayez, & Suleman., 2020).

The initial conception of the domains and constructs of the research questionnaire was chosen, based on the objectives and hypotheses of the study. The questionnaire was divided into three variables: The first: represents teachers' perspectives on the e-learning usage in teaching practical skills in biology, the Second variable represents the teachers' perspectives on the impact of e-learning in practical skills in biology. The third one is about the challenges faced biology teachers in implementing e-learning on biology practical skills.

To enhance clarity and accuracy in the responses, a five-point Likert scale was employed. This scale is widely recognized as one of the fundamental psychological measures frequently utilized in educational and social sciences research (Joshi, Kale, Chandel, & Pal, 2015). The questionnaire came out in its current format, following the previous adaptations, to align with the study's objectives and hypotheses. It was specifically adapted to assess teachers' perspectives regarding e-learning usage, particularly as they related to the teaching of practical skills in biology. The questionnaire comprised of three variables, each targeting a specific aspect. In total, there were 54 items distributed across these three constructs.

Then the questionnaire was presented to a panelist of experts and specialists to be validated. Then the questionnaire's items were modified and formulated according to the amendments and comments of the experts and specialists. The questionnaire did not include any questions about sensitive issues such as specific race, religion, income, state of health and marital status. The researcher constructed and modified it based on relevant previous studies that used this approach in the research nearly as in (Elkhouly, 2021; Mulla, 2019; Alshahrani, 2008; Al-Shammari, 2007). In light of this, the questionnaire was expanded to encompass aspects of the learning process and the availability of learning resources. High consideration was given to adapt and refine the items to eliminate bias and redundancy, ensuring that respondents can focus on the questionnaire items without any distractions.

Before the actual study, a pilot study was carried out to identify any defects, barriers or difficulties facing the administration of the questionnaire. Then Cronbach's Alpha was calculated which gave an indication of the questionnaire's reliability.

One of the difficulties arose in the application of the questionnaire was related to the reluctance of some participants to complete the questionnaire, as they were contacted more than once urging them to participate in answering its items.Also, there were challenges related to administrating the questionnaire, in obtaining approvals from the competent authorities that allow the implementation of the questionnaire to the sample as well as the ethical approval from the university, as it takes quite a bit of time.

The survey included questions for each research objectives, revealing teachers' views on the role, impact, and challenges of e-learning in teaching practical skills in biology. A Likert scale from 1 to 5 was used (Mulla, 2019). The responses choices were: Strongly Disagree, Disagree, Neutral, Agree, and strongly agree as illustrated in Table 2. It is important to follow a systematic approach when developing a questionnaire to ensure that it is accurate, reliable, and valid (Mohajan, 2017). Therefore, the questionnaire underwent steps and procedures until it was ready for implementation which are outlined in Figure 2.

Table 2. Likert *Scale for Respond Mode* (Mulla, 2019)

Likert Scale	Response Mode
1	Strongly disagree
2	disagree
3	Neutral
4	Agree
5	Strongly agree

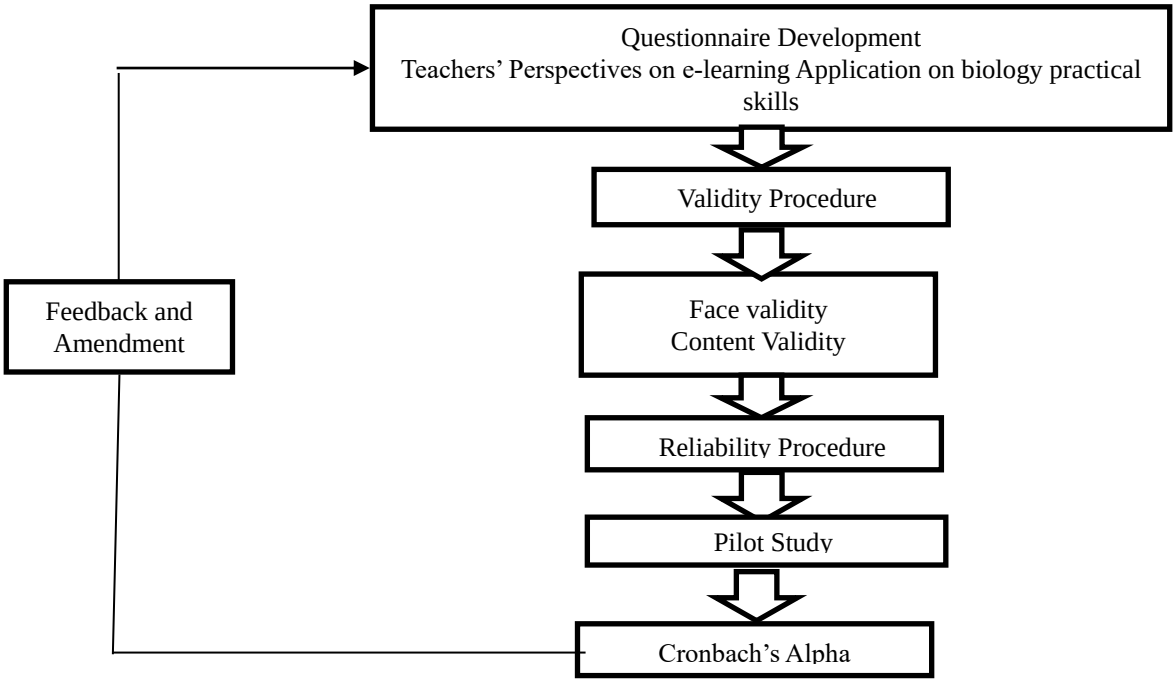

Figure 2. Questionnaire Development Flowchart

The questionnaire began with a concise introduction and research overview, stressing confidentiality. It had two parts: Segment A gathered participant demographics, while Segment B contained variables covering research objectives and questions. Segment B addressed the study's main variables. Table 3 illustrates the research questionnaire's content.

Table 3. Questionnaire Constructs

Variable	Dimension
e-learning Usage	Teachers' perspectives towards e-learning usage in teaching biology practical skills for Grade-12 students.
Impact of e-learning	Teachers' perspectives towards the impact of e-learning on the biology practical skills acquisition of Grade-12 students.
e-learning Challenges	The challenges faced by Grade-12 biology teachers in applying the biology practical skills through e-learning

To ensure questionnaire effectiveness for reliable data collection, steps were taken to enhance item clarity, detailed explanations in the following chapter context.

2.3 Questionnaire Validity

Validity measures how well an instrument reflects its intended measurement. Content Validity Index (CVI) was calculated using Lawshe Method Chart (Taherdoost, 2016) with eight experts, assessing questionnaire item consistency and alignment Table 4. This index was used to ensure that the instrument included all the items that were essential (relevant) and eliminated undesirable items to the particular construct and domain using the following formula Figure 3:

$$\text{CVR}= \frac{ne-(\frac{N}{2})}{(\frac{N}{2})}$$

*n*e = number of experts indicating a measurement item is essential (relevant).

N= total number of experts that answer to that item.

Figure 3. CVR Formula (Taherdoost, 2016)

Table 4. The Lawshe table for Minimum Values of Content Validity Ratio (Taherdoost, 2016)

No. of Panelists	**Minimum Value**	**No. of Panelists**	**Minimum Value**
5	0.99	13	0.54
6	0.99	14	0.51
7	0.99	15	0.49
8	0.75	20	0.42
9	0.78	25	0.37
10	0.62	30	0.33
11	0.59	35	0.31
12	0.56	40	0.29

2.4 Questionnaire Content Validity

After recovering copies from the experts, feedback and ratings were tabulated into spreadsheets. The validity of the total content for each of structure Content Validity Index (Scale) S-(CVI) and the content validity for each of the items I-CVR were calculated. According to the following formulas in Figure 4.

$$\text{Item Content Validity Ratio: I-CVR} = \frac{ne-(\frac{N}{2})}{(\frac{N}{2})}$$

*n*e = number of experts indicating a measurement item is essential.

N= total number of experts that answer to that item.

$$\text{Scale content Validity Index: S-(CVI)} = \frac{\text{Sum of I} - \text{CVR}}{\text{Number of items}}$$

Figure 4. S-CVR Formula Adapted from (Gilbert et al., 2016).

The I-CVR values ≥ 0.78 were acceptable and the values exceeding 0.80 are preferred (Gilbert, etl. 2016). The overall results of the content validity and the face validity of the structures in the questionnaire after deleting the items that obtained values less than the acceptable ≤ 0.8 values were as in the Table 5.

2.5 Questionnaire Face Validity

As for the face validity of the questionnaire, it was calculated after retrieval of the copies from the experts, their evaluations and comments were tabulated, and then the face validity of each item and the face validity of each of the questionnaire's variable were calculated according to the formulas illustrated in Figure 5:

$$\text{I-FVI} = \frac{\text{agreed } items}{\text{number of raters}}$$

I-FVI: item Face validity index

$$\text{S-FVI} = \frac{\text{sum of FVI}}{\text{number of items}}$$

S-FVI: Scale face validity index.

Figure 5. Formula (Yusoff, 2019)

S-FVI values ≥ 0.83 were accepted, considering raters' count; if under 10 raters, this threshold was acceptable (Yusoff, 2019). Calculated S-CVI and S-FVI values were shown in Table 5, after removing items with values below the required. These indices confirm questionnaire validity, reliability, accurate construct measurement, and research suitability.

Table 5. Variable's Face and Content Validity Values

Variable	**Dimension**	**S-CVI Before deleting items**	**S-CVI After deleting items**	**S-FVI Before deleting items**	**S-FVI After deleting items**
e-learning usage	The biology teachers' perspectives towards e-learning usage in teaching biology practical skills for Grade-12 students.	0.97	0.99	0.85	0.99
e-learning impact	Teachers' perspectives towards the impact of e-learning usage on the biology practical skills acquisition of Grade-12 students.	0.55	0.99	0.82	0.99
e-learning challenges	The challenges faced by Grade-12 biology teachers in applying the biology practical skills through e-learning.	0.75	0.99	0.83	0.99

2.6 Questionnaire Reliability

The reliability test was conducted to calculate the stability factor of the research instrument to ensure its suitability for scientific research purposes. Cronbach's Alpha was employed for internal consistency of questionnaire items, yielding suitable stability Table 6. Following the pilot study.

Table 6. The Reliability Test Result of the Pilot Study

Dimensions	**No of Items**	**Cronbach's alpha**
E-learning processes 1: (Teachers' perspectives)	15	0.791
E-learning resources 1: (Teachers' perspectives)	10	0.856
E-learning processes 2: (e-learning impact on the biology practical skills acquisition)	9	0.753
E-learning resources 2: (e-learning impact on the biology practical skills acquisition)	5	0.664
E-learning processes 3: (Challenges in applying biology practical skills through e-learning)	10	0.708
E-learning resources 3: (Challenges in applying biology practical skills through e-learning)	5	0.695
Total	54	0.878

2.7 Data Analysis

The questionnaires were collected; the data was processed using the Statistical Package for Social Sciences program (SPSS). The analysis is divided into three categories as described below:

1. The Reliability Analysis.

The reliability is used to test the overall consistency of the questionnaire used in collecting the primary data from respondents (Aithal, Architha, & Sreeramana, 2020). Reliability coefficient is a measure of the amount of measurement error associated with a test score (Cronbach, 1951).

2. Descriptive statistics.

Initial step for statistical analysis, providing data distribution insight, identifying outliers, and enabling further analysis. Includes response rate, missing data, outliers, multicollinearity, demographic information, and descriptive data like mean, standard deviation, and frequencies.

3. Inferential Analysis.

This analysis comprises the method for estimating what the population characteristics (parameters) might be, given what is known about the sample's characteristics (statistics), or for establishing whether patterns or relationships, both association and influence. In this research Pearson correlation and simple linear regression analyses are used to examine the association between the variables.

This study employed correlation analysis, estimating the Pearson Product Moment correlation coefficient (r), within a correlation matrix to assess associations between predefined research variables before progressing with further analysis. Correlation analysis serves two purposes here: first, exploring natural variables impractical for experimental testing, and second, identifying relationships between variables irrespective of their cause-and-effect direction. The correlation coefficient ranges from -1 to +1, with both positive and negative correlations possible.

3. Results and Discussion

Teachers' perspectives on e -learning to teach practical skills of biology are largely positive, because it saves time, provides opportunities for repeated experience, and provides flexibility in terms of location and time. Teachers prefer to align e -learning with educational strategies and current educational beliefs, which indicates its association with their comprehensive educational view. The benefits of e -learning include students' practice anytime, anywhere, promoting participation, motivation, self -learning, and covering comprehensive curricula through interactive experiences, which ultimately improves the learning process. On the other hand, negative views centered on e-learning it reduces students'

awareness of the tools hazards and chemicals used in practical laboratory experiments, which can pose risks to their health and safety. The absence of some senses such as touch and smell are eliminated during practical laboratory experiments, as is the case in a real laboratory, which may limit sensory experience and the depth of understanding experimental phenomena.

The result revealed that e-learning usage and biology practical skills acquisition are linked to each other in a significant relationship. In other words, the more e-learning usage the better biology practical skills acquisition. The perspectives of teachers on the implementing practical skills challenges in biology through e-learning for Grade-12 students revealed difficulties in considering individual differences, and providing feedback.

It is important to note that the effectiveness of e-learning in acquiring practical skills may depend on various factors, including the quality of e-learning materials, the instructional design of the curriculum, the level of interaction and engagement, and the learners' previous knowledge and skills. Therefore, it would be appropriate to point out that the challenges of e-learning can affect the acquisition of practical skills in biology, but their impact may vary depending on the specific circumstances and the measures taken to address these challenges. e-learning challenges influence biology teachers' usage as issues include technical problems: poor internet, lacking hardware/software. Training gaps for all stakeholders weaken confidence, hinder effective use. Overcoming hurdles is vital for e-learning success in biology teaching. The shift towards e-learning posed a great challenge to the practical component of biology. However, with careful planning and the use of appropriate tools and techniques, it is possible to develop a framework for implementing practical skills in biology through e-learning from methods to students, ultimately leading to meaningful learning outcomes.

4. Conclusion

The findings of this study provide evidence that the experience of teachers in biology e-learning classes is the key for making e-learning a useful strategy in UAE schools, as trained teachers with fair technical skills in e-learning systems will ensure that students in biology classes acquire the necessary knowledge and help them to get good skills in learning this subject. In other words, when teachers have good experience in using e-learning, they can deal with any unexpected obstacles during the class and prepare themselves for all kinds of challenges. To that end, the perspective of biology teachers reveals that developing high-quality e-learning resources boost the experiences and perceptions of students towards the courses and contributed to better practical skills. Although e-learning provides an opportunity to teach practical skills in biology remotely, teachers face several challenges and require appropriate support and resources to ensure successful implementation. This study shed light on the challenges of e-learning in biology classes, such as remote e-learning biology practical skills, difficulties to give feedback during practical experiments while using e-learning. By overcoming these obstacles, e-learning can be better integrated into biology classrooms, enriching the learning experience for students and empowering teachers with innovative teaching strategies. Despite these challenges, courses through e-learning are a significant and growing part of the education landscape, but many biology instructors are sceptical of their effectiveness which need more research on this issue in the future. More research is needed to elucidate specific curricular elements and frameworks that can augment students' online learning of basic biology knowledge and skills.

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