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Analyzing the Opportunities and Challenges of the Use of Virtual Science Lab for Science Teaching and Learning in the College of Science and Arts at Najran University, Saudi Arabia

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ABSTRACT:
The aim of this paper is to analyze the opportunities and challenges of using Virtual Science Lab (VSL) technology in the college of Science and Arts at Najran University, Saudi Arabia. The survey method is utilized to collect data from 56 faculty members and 263 students via electronic questionnaires concerning the use of VSL in the college amidst the pandemic of coronavirus. The survey questionnaires, consist of closed–ended questions linear scale, multiple-choice grid and open-ended questions for comments and suggestions, were administered among the faculty members and students at the college. Data were analyzed using SPSS program, and the results were obtained, analyzed, and interpreted. The results showed that the use of VSL enhances Science teaching and learning environments and fulfills the requirements of science subjects' laboratory experiments. They also indicated that the use of VSL witnesses challenges like lack of motivation, analytical and critical thinking skills, cooperation for group work and negative attitude towards the use of internet and they are due to ethical issues and irregularity of student attendance. The researcher suggests that the teacher and students should be more interactive and cooperative to improve the skills of science laboratory experiments through VSL. This research, hopefully, will help teachers as well as students adapt with the new science learning environments.

Keywords:
opportunities and challenges of VSL technology, science teaching and learning environments etc.

1. INTRODUCTION

Teaching and learning science is a continuous improvement process that can be developed by using the latest tools in science lab. During the pandemic situation, virtual lab technology has proved to be the most effective and important tool for online practical classes in science teaching and learning. It plays an important role to learn science through virtual method. Online classes will remain incomplete without virtual laboratories and virtual laboratories, as the new 'normal', are an effective alternative to face-to-face methods with laboratory practical classes. Mainly the science courses like Physics, Biology, Mathematics, lab classes must be allowed to attend virtually. The development of educational institutions depends on how much they adopt and integrate with the globalization process supported by new technologies. Previously virtual laboratory was optional for science teaching and learning but in fact, Covid-19 pandemic, perhaps, made it mandatory to continue with virtual science teaching and learning.

2. Literature Review

The development of science teaching and learning depends greatly on using modern technologies and tools in educational field. In the field of education, emerging technologies provide opportunities for enhancing and improving the teaching and learning process. The VSL plays an important role in the new educational system through changing the traditional method of lab experiments to electronic lab experiments. Therefore, the use of technological tools in the teaching process provides opportunities to develop teaching and learning method. Science teaching and learning is the key to modern educational process. The use of VSL in science teaching and learning brings effective and significant technological changes in science lab experiments. In Saudi Arabia, online educational system is developing vastly in parallel with

modern technologies and tools in Science lab. So, the use of VSL in the College of Science and Arts at Najran University, Saudi Arabia has created ~~an~~ effective online learning and teaching opportunities for teachers and students. Students are getting better opportunities to learn science easily and effectively. But sometimes traditional science lab is more effective and appropriate for lab experiments. Consequently, the uses of VSL in education face some obstacles and challenges like motivation, developing analytical and critical thinking skills of students, the ability to work in a group and following rules and regulations. Before discussing any details about the opportunities and challenges of using VSL, we should define the term. A VSL is an electronic environment where a student of science interacts with lab experiment or lab activity which is intrinsically remote from the student or which has no immediate physical contact. The whole concept of interactive screen experiment is to bring as close connection to reality as possible, to as many students as possible to the virtual laboratory (Aljuhani et al., 2018). The VSL is a computer-based lab activity that provides big opportunity for student-based learning through communication, collaboration, and cooperation which emphasis the dynamic educational process (Hatherly & Cayless, 2009). The interactive screen experiment in VSL allows students to experiment with a computer interface, which consists of simulation programs, different applications including web-based tools. There are two types of laboratories, the first one is real laboratories (traditional or conventional) and the other is virtual laboratories (simulation or non-traditional). A virtual laboratory provided an interactive environment for creating and conducting simulated experiments.

The current era is witnessing a huge digital revolution, which has resulted in multiple and continuous technological innovations in various fields and education is with no exception. As a result, it was necessary to make a remarkable change in the perception of the educational process. The modern perspective is no longer limited to the traditional pattern, that based on indoctrinating information to the learner. It should go beyond and build on the achievements of the digital age in teaching science through virtual labs which help in overcoming some practical difficulties that the learner may face. The scientific courses are among the most prominent debates that have been affected by the progress in the field of electronic education and its implementation. It is one of the study materials most related to technological techniques, whether from a cognitive point of view, or through the integration of technology (Al-Shemali, & Harsha, 2018). Considering the technical innovations at the present time, VSL has become a reality in the educational process in general, and the science teaching and learning, in particular. The urgency that is in line with the requirements of the twenty-first century; the educational community turned to employ virtual technology in science teaching methods. To overcome the difficulties of using simulation (Al Hazmi, 2016), which resulted in what is known as virtual laboratories (Virtual Laboratories), which (Martinez-Jimenez et al., 2003) referred to as one of the use of computers to advance science-education. In overcoming many problems of education, the real laboratory is in its functionality, in addition to its capabilities for conducting experiments that need equipment. Complex, difficult to provide in traditional laboratories, as confirmed by studies (Alshamrani, 2020; Hazaa & Qutb, 2020; Pramono & Wibawanto, 2019).

The use of virtual reality in the educational process has become an imperative. Due to the wide and rapid spread of modern technological innovations, and to overcome the problems of real reality in the field of science education (Al-Baltan, 2013). The whole world, including the Kingdom of Saudi Arabia, is also experiencing very serious challenges, represented by the spread of the coronavirus pandemic (Covid-19), and so on. It has major impacts in various areas of life in general, and education in particular, and this pandemic has led to all countries of the world taking a set of precautionary measures, in their economic, social, and educational institutions which ensure keenness to achieve social distancing among the members of these institutions, and reduce face-to-face interaction between members of educational institutions to the extent possible; to avoid the transmission of infection, preserving the health of learners and teachers, and all members of these institutions, and this has led to the use of various virtual technologies in the process of science teaching

and learning. One of the most important educational trends, which was confirmed by (Sobhi, 2016), of the urgent need for using the latest educational developments in the field of technology to face the developments and challenges of the current era. Whereas the use of the traditional laboratory in teaching and learning sciences is of great importance, and its integration with the new technology makes it more important. Al-Bayati (2006) stated that the virtual laboratory technology represents one of the fruits of integrating technology in science education, as it helps to compensate the lack of simulation of the real process due to the lack of adequate funding, and for being an effective tool in clarifying the topics and scientific experiments that are difficult to apply in traditional laboratories because of its danger or difficulty for the learner, in addition to the possibility of traders conducting the process for any possible number of times according to the ability of the learner to comprehend, which was confirmed by the (Al Dakin, 2015) and the (Al-Badri, 2016) and the (Bajili, 2019). That Virtual laboratories are a fundamental pillar for developing learners' understanding of scientific concepts and facts in more attractive and interesting ways, and they are good alternatives in the absence of chemical materials and devices and educational supplies in real laboratories. In the same context, virtual laboratories have multiple advantages that qualify them to be used continuously in science education. It was explained (Attia, 2003) that it allows the learner to interact and cooperate with others in conducting the same experience, in addition to the possibility of synchronization between the process of explaining theoretical ideas and practical application, as well as it provides a safe learning environment and various sensory effects, in addition to providing the appropriate time. For the learner, it leads to contemplation, observation, thinking and scientific discovery, and this is confirmed by studies (Hassanein et al., 2019), that the virtual laboratories allow the visual display of data and phenomena that cannot be viewed by real merchants, and also allow the learner to conduct laboratory experiments remotely by himself or in a group of individuals located in different places. Digital science and its replication explain the interactions chemical, structure of particles in three-dimensional form, and visibility of all components of the laboratory, including equipment and measuring devices, and other chemical materials. The use of hypothetical labs is of great importance in undergraduate science education as it gives students the ability to design and assemble parts of experiences themselves to obtain meaningful experimental results, as well as to improve safety measures during operation. This allows dangerous experiments that students cannot do in traditional laboratories and helps them in forming positive attitudes among students about studying science. This helps to give more interest in studying scientific concepts and developing their abilities to think inferential by making hypotheses, testing, and experimenting with unreal environments, as well as training them to collect, analyze and interpret data (Sobhi, 2016). This was confirmed by the study of (Al-Shehri, 2016). A study (Pramono & Wibawanto, 2019) shows that the use of virtual laboratories helps achieve undergraduate goals by overcoming obstacles of using real laboratories in teaching, in addition to that, achieving learning outcomes for areas of science education, such as physics, chemistry, and biology.

3. Research Questions

In this research, the following questions provided the guidance for the study:

1. How do we analyze the opportunities and challenges of the use of VSL technology?
2. Can VSL technology enhance science teaching and learning environments and fulfill the requirements of science subjects' laboratory experiments?

4. Research Methodology

The research method was survey questionnaires consist of closed–end questions linear scale, multiple-choice grid and open-ended questions for comments and suggestions. The statistical data were obtained from 56 faculty members and 250 students at the College of Science and Arts, Najran University, Saudi Arabia. The faculty members and students responses were recorded separately with their comments and suggestions. The above- mentioned questionnaires were in closed ended and the answers were arranged according to 5 linear scale (Strongly agree, agree, neutral, disagree and strongly disagree)

respectively and the scores (5 to 1). The questions of the questionnaires were prepared in ten parts. The first five questions related to opportunities and the other five questions related to challenges of using virtual science Lab. The final stage of the questionnaire was to evaluate more opportunities and challenges of

using VSL with two open ended questions. All questions were mandatory to respond.

5. Results and Analysis

The assessment results of the questionnaire items' reliability are shown in Table 1.

Statistics

Department

N	Valid	319
	Missing	0

Table 5.1: Reliability of questionnaire (α)

Case Processing Summary

		N	%
Cases	Valid	319	100.0
	Excluded[a]	0	.0
	Total	319	100.0

a. Listwise deletion based on all variables in the procedure.

Table 5.2: Frequencies analysis for all departments (Faculty and Students)

Department

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mathematics	79	24.8	24.8	24.8
	Physics	94	29.5	29.5	54.2
	Chemistry	85	26.6	26.6	80.9
	Biology	61	19.1	19.1	100.0
	Total	319	100.0	100.0	

Since the Alpha coefficient value of this questionnaire for both faculty and students is more than 90% as shown in Table 5.1, it can be said that the questionnaire was strongly accepted.

From descriptive frequency analysis of questionnaire as shown in Table 5.2, the Physics department registered the highest number of participations after that Chemistry, Mathematics andBiologyrespectively.

Descriptive Statistics

Table 5.3: Descriptive (Opportunities) analysis

	N	Minimum	Maximum	Mean	Std. Deviation
New and unique online teaching opportunities	319	1.0	5.0	3.937	1.1365
Lab equipment facilities and Scientific tools	319	1.0	5.0	3.674	1.1871
Distance teachers and learners	319	1.0	5.0	3.947	1.0582
Teaching and learning Science easily and effectively	319	1.0	5.0	4.028	1.1057
Availabilty of Lab Technicians and Staff	319	1.0	5.0	3.784	1.2338

Valid N (listwise)	319				

Table 5.4: Descriptive (Challenges) analysis

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Motivation for teaching and learning	319	1.0	5.0	3.887	1.0370
Developing analytical and critical thinking skills	319	1.0	5.0	3.893	1.0497
Encourage to work and practice in a group	319	1.0	5.0	3.859	1.1364
Following rules and regulations related to ethical issues	319	1.0	5.0	4.163	.9929
Irregularity affect students to learn	319	1.0	5.0	3.928	1.0630
Valid N (listwise)	319				

The results of Table 5.3 and Table 5.4 represents descriptive analysis of opportunities variables and challenges variables respectively.

Independent Sample T-Test of opportunities for Faculty and Student

Table 5.5

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
New and unique online teaching opportunities	Equal variances assumed	.596	.441	.713	317	.476	.1194	.1674	-.2100	.4487
	Equal variances not assumed			.762	86.246	.448	.1194	.1566	-.1920	.4308
Lab equipment facilities and Scientific tools	Equal variances assumed	2.450	.119	-3.763	317	.000	-.6442	.1712	-.9810	-.3074
	Equal variances not assumed			-3.505	74.967	.001	-.6442	.1838	-1.0104	-.2780
Distance teachers and	Equal variances assumed	.566	.452	1.391	317	.165	.2163	.1555	-.0897	.5222

learners	Equal variances not assumed			1.576	93.016	.118	.2163	.1372	-.0562	.4887
Teaching and learning Science easily and effectively	Equal variances assumed	3.492	.063	.588	317	.557	.0957	.1629	-.2247	.4162
	Equal variances not assumed			.717	103.812	.475	.0957	.1336	-.1692	.3606
Availabilty of Lab Technicians and Staff	Equal variances assumed	1.555	.213	-4.144	317	.000	-.7340	.1771	-1.0825	-.3855
	Equal variances not assumed			-3.979	77.050	.000	-.7340	.1845	-1.1013	-.3667

An independent sample t-test was used to compare the opportunities of using VSL for faculty and students. Levene's Test also non-significant thus the equal variance can be assumed for both groups. Because of not existing virtual lab, the result of Table 5.5 shows that in case of Lab equipment facilities and scientific tools and availability of lab technicians and staff variables have negative t-value, which indicates a reversal effect and no bearing of the significance of the difference between faculty and students.

Table 5.6

Pearson Correlations

		Distance teachers and learners	Motivation for teaching and learning
Distance teachers and learners	Pearson Correlation	1	.714**
	Sig. (2-tailed)		.000
	N	319	319
Motivation for teaching and learning	Pearson Correlation	.714**	1
	Sig. (2-tailed)	.000	
	N	319	319

**. Correlation is significant at the 0.01 level (2-tailed).

To assess the linear relationship between distance teachers and learners and motivation for teaching and learning of using virtual science lab, a bivariate Pearson's correlation coefficient(r) was calculated. As shown in Table 5.6, the r between the two variables is positive and strong, r (319) = .714, p < .001. One more the r between teaching and learning science easily and effectively and developing analytical and critical thinking skills as shown in Table 5.7 is positive and strong, r (319) = .707, p < .001. Same as the results from Table 5.8, the r between VSL provides a new and unique online teaching opportunities and irregularity in virtual lab affect students to learn is r (319) = .405, p < .001. Therefore, it is confirmed that there is a strong and positive relationship between the opportunities and challenges of using virtual science lab. The relation means that with increasing the opportunities of using virtual science lab, the challenges would be increased and vice versa.

Table 5.7

Pearson Correlations

	Teaching and learning Science easily and effectively	Developing analytical and critical thinking skills

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Teaching and learning Science easily and effectively	Pearson Correlation	1	.707**
	Sig. (2-tailed)		.000
	N	319	319
Developing analytical and critical thinking skills	Pearson Correlation	.707**	1
	Sig. (2-tailed)	.000	
	N	319	319

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.8

Pearson Correlations

		New and unique online teaching opportunities	Irregularity affect students to learn
New and unique online teaching opportunities	Pearson Correlation	1	.405**
	Sig. (2-tailed)		.000
	N	319	319
Irregularity affect students to learn	Pearson Correlation	.405**	1
	Sig. (2-tailed)	.000	
	N	319	319

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.9

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.327	.127		2.582	.010
	Lab equipment facilities and Scientific tools	.197	.032	.226	6.088	.000
	Teaching and learning Science easily and effectively	.391	.038	.416	10.148	.000
	New and unique online teaching opportunities	.321	.036	.351	8.834	.000

a. Dependent Variable: Motivation for teaching and learning

According to the result as shown in Table 5.9, the significance levels were obtained, which are less than 0.05, so the opportunities (independent variables) of using VSL have significance effect in the dependent variable (challenge) like motivation for teaching and learning.

The greater coefficient of beta has more effect it has on independent variable. As mentioned in Table 5.9, VSL makes teaching and learning science easy and effective. (0.416) has the most effect on motivation for teaching and learning science and lab equipment facilities and scientific tools (0.226) has the least effect.

The results as shown in Table 5.10 represent the variance of dependent variable and independent variables regression analysis. Here the coefficient of determination (R square) is 0.727 indicating that the predictors control 73% variance and changes of the motivation for teaching and learning variable. The standard error of estimate (0.544) as shown in Table 5.10 measures the distribution of points around the regression line (in two-dimensional spaces). The larger the value

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of this index, the higher distribution of points around the regression will be and vice versa.

To find the analysis of the certainty of linear relationship between the dependent variable and the independent variables, the ANOVA table is presented as shown in Table 5.11. Since the significance level of test is less than 0.05, the considered test is significant and the relations of variables in regression is linear and significant.

Table 5.10

Model Summary[b]

Model	R	The coefficient of determination (R Square)	The adjusted coefficient of determination (R Square)	Std. Error of the Estimate
1	.853[a]	.727	.725	.5443

a. Predictors: (Constant), New and unique online t b. Dependent Variable: Motivation for teaching equipment facilities and Scientific tools, Teaching and and learning effectively

Table 5.11

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	248.629	3	82.876	279.784	.000[b]
	Residual	93.308	315	.296		
	Total	341.937	318			

a. Dependent Variable: Motivation for teaching and learning
b. Predictors: (Constant), New and unique online teaching opportunities, Lab equipment facilities and Scientific tools, Teaching and learning activities, and effectively

6. CONCLUSION

In a situation like the college of Science and Arts, it is hard to ignore logistics like VSL to conduct lab classes especially in the context of ongoing pandemic. Online method of Science teaching and learning is, in today's context, incomplete without the existence of a virtual science laboratory. After analyzing the comments and suggestions (open ended questions) from both faculty and students, it is highly recommended to enhance the use the VSL in the college of Science and Arts, Najran University. The researcher understands that this research will be a strong evidence for teachers as well as students to adapt with the new science teaching and learning environments.

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