International Journal of Mathematics and
Computer Applications Research (IJMCAR)
ISSN (P): 2249–6955; ISSN (E): 2249–8060
Vol. 13, Issue 1, Jun 2023, 23–38

TRANS STELLAR •Journal Publications •Research Consultancy

IMPLEMENTATION OF VIRTUAL LABS-BASED MATHEMATICAL LEARNING SYSTEM (VLBMLS)

ZAINAB E. AL-JADI

The Higher Institute for Administrative Services-Kuwait

ABSTRACT

This study focused on using virtual labs in mathematics learning for the undergraduate and technical or applied training students' programs at Kuwait state. The effectiveness of such virtual labs in increasing understanding of scientific material and simplifying math concepts is assessed using some appropriate measures like statistical tests of hypotheses stated in this study. The study used a questionnaire tool to assess the effects of using math virtual labs on students and lecturers, and all hypotheses are tested using SPSS package. It was found that math virtual labs are good tool for increasing the understanding for students in math concepts and redesign of their math thinking, also it can simplify the math problems in a way to improve their method in math problem solving and reorder their thinking during solving such problems. Also, math V. Ls can improve students' skills in math thinking and repeat the math problems via simulation tools offered by such labs. In addition, V. Lsincreases the active learning and partnership leaning modules and finally, math V. Ls is a good assessment tool of the educational outcomes of the learning processes. Implementation index of all VLBMLS variables is calculated and it seems to be in a "very good" status with a value of 72.148% as an average which means that math V.Ls can be considered as a good tool in improving math learning system in the studied colleges in Kuwait state.

KEYWORDS: Virtual Labs, Mathematics, Learning, Implementation Index, Education, Kuwait.

Received: May 01, 2022; **Accepted**: May 15, 2023; **Published:** May 26, 2023; Paper Id.: IJMCARJUN20233

Original Article

INTRODUCTION

Experimentation in mathematics learning is enabled by technology, which is critical in the creation of hypotheses and conjectures. The process of experiencing helps the student visualize the situation at hand, allowing them to test multiple options, which is considerably more difficult when simply pencil and paper are used. [1]. School laboratories are very important because they serve several purposes, including: 1) providing a place for students to solve learning problems, 2) providing a good place for students to do experiments, exercises, demonstrations, or other methods, 3) providing a place for students to prove the facts, principles, and concepts of a theory, and 4) providing opportunities for students to work with specific tools and materials, cooperate with friends, be motivated to reveal the truth of a theory, and find solutions[1There are two sorts of laboratories: real laboratories and virtual laboratories. A virtual laboratory depicts experimental procedures using simulations. Virtual learning is fundamentally a learning process that is carried out via technology [2]. Because not all practicums can be completed through experimental activities in real laboratories, virtual laboratories are often used. A system uses genuine laboratory equipment to replicate ideas or notions that are abstract and difficult to explain but nevertheless require real observations.A virtual laboratory is a technology that can enhance a standard practicum system by allowing students to undertake practicum through computer and conduct experiments from anywhere.

The use of a virtual laboratory can alleviate various challenges associated with insufficient laboratory equipment and contribute to the achievement of learning objectives, particularly for abstract concepts [3, 4]. Because of the quick pace of technological advancement, rapid adaptation is essential, particularly in the sector of education. With technological advancements, offering flexible learning requires ingenuity and creativity. Students' primary source of knowledge is increasingly PCs, laptops, and mobile phones with internet connections. Smartphones can also be utilized to generate multimedia and interactive objects. [5-6]. The merging of many types of media into a single computer application that engages pupils by showing visuals, animations, colors, and sounds is known as interactive multimedia. This development is necessary in order to provide trainers with life skills that will allow them to tackle the challenges of social change while also benefiting the greater community. Change in the educational sector needs the inseparable connection of education and technology. The existence of technology must be regarded as an attempt to promote efficacy and efficiency, and technology cannot be divorced from the problem, because it was created and developed to solve human problems. The function of educational labs is changing as the educational world accelerates [5, 7-9]. Mathematics teaching aids are used to assist students with abstraction exercises as well as the discovery of mathematical concepts and principles. Because it is manual, students come into immediate contact with the props when using it, hence a variety of props are needed in the classroom. Additionally, the usage of manual props involves the use of a wide range of materials. On adaptable e-learning platforms, physically studied mathematics teaching aids can be built in multimedia form. This adaptive e-learning platform, especially in the age of digital learning, should be suited to students' developmental and psychological levels. Thus, in order to be more dynamic and practical in their application, mathematical props must be virtualized [7-10]. This adaptive e-learning platform, especially in the age of digital learning, should be suited to students' developmental and psychological levels. [11].

VIRTUAL LABS CONCEPT

Virtual labs employ computer programs to imitate a sequence of tests that would normally be carried out physically. It gives virtual tools, supplies, and laboratory sets to students so they can conduct subjective experiments at any time and from any location [12]. Virtual labs also allow students to practice laboratory tasks that would be impossible to do in real life. Virtual laboratories can help students visualize abstract concepts in science applications [13]. Some of the benefits of a virtual lab are as follows: Allow students to 1) develop alternative experiments due to time and cost efficiency; and 2) obtain comprehension at the macroscopic, submicroscopic, and symbolic levels.3) allows for the dynamic display of submicroscopic particles. 4) aids in chemical compound understanding, and 5) strongly motivates students [14]. Virtual labs can also boost conceptual thinking and research performance. Despite their numerous benefits, virtual labs have several disadvantages, including a) a lack of physical interaction between hardware, equipment, teachers, and students; b) the need for a computer and specific tools; c) the need for technical expert staff, instructors, and curriculum experts to design and produce the lab; and d) virtual labs cannot improve social and psychomotor skills as well as real labs [15]. Regardless of the disadvantages, a virtual lab can engage students in STEM learning through interesting activities and social interaction [16]. Because real-world practice cannot help enhancing STEM skills, while virtual laboratories can. Based on the above logical framework, a STEM virtual lab was created, and its effectiveness in improving students' scientific literacy was evaluated. [17].

MATHEMATICAL VIRTUAL LABS

Virtual Math Lab is a collection of applications that support the teaching and learning of exact sciences. It began as a tool for increasing learning efficiency and making it more appealing to students, assisting them in understanding mathematical concepts and their applications. All applications and visualizations can be used to present educational content either during traditional blackboard-and-chalk classes or as an interactive component of a blended-learning/e-learning course or an internet website. They provide didactic support for students and teachers at all levels of education. Figure 1 depicts some examples of mathematical virtual lab applications.

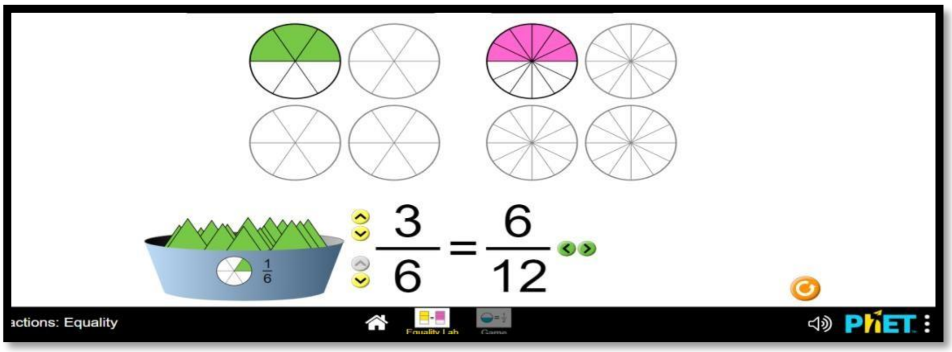

Figure 1: Some Mathematical Virtual Lab Application

Many articles and studies discussed the use of virtual labs in teaching mathematics and science, Dickler et al. (2021) examined data from students who completed Inq-ITS math laboratories while getting remote teaching in order to address the following study questions: (1) Do students find math procedures more difficult than other Inq-ITS inquiry practices? (2) How does the type of math relationship (for example, inverse square) affect the difficulty of a math practice? (3) Which arithmetic sub-practices are the most difficult for children to master? We discovered that students struggled with the math practice of constructing graphs and equations in comparison to other inquiry practices as a result of the fine-grained automated scoring in the Inq-ITS virtual lab, particularly when graphing an inverse square relationship. Furthermore, they discovered that identifying the sort of math relationship in the graph was a particularly difficult sub-practice for pupils. This level of assessment is crucial as we construct auto-scaffolding to guarantee kids get help with these difficult practices [18].

In a blended learning environment complemented by a web-based virtual laboratory, Aboraya (2021) assessed fifth-grade students' grasp of abstract mathematical concepts. The "PhET" simulations site was chosen as a web-based tool since it introduces a research-based mathematics interactive simulation. The purpose of the study was to see how far academic development differed between the experimental group taught about "Fractions" using a flexible blended learning pedagogical model and the control group taught the identical topics using the traditional method. Thirty children were picked at random from a Muscat private school. In order to answer the research questions, both the control and experimental groups were pre-post assessed on learning the targeted abstract mathematical concepts. The data revealed that there is a clear favorable effect in favor of the experimental group in terms of increasing students' achievement in abstract mathematical concepts. In addition, interviews were conducted with members of the experimental group to learn more about their viewpoints on the method used to learn abstract mathematical concepts. Students opted to use the simulation website [19]. This study, conducted by Alneyadi (2019), evaluated science teachers' viewpoints on the nature and frequency of virtual lab implementation by students, as well as its contribution to the growth of science instruction and research in the United Arab Emirates (UAE). The approach of this study was centered on a group that was employed to collect data through structured interviews. 45 science teachers from ten middle schools were included in the study. Two questions were devised to steer the study, enquiring into the goals of virtual practical work and its frequency. According to the findings, virtual labs had a moderate impact on students' knowledge, abilities, attitudes, achievement, and inventiveness. Despite the fact that virtual labs were only employed on a modest scale and on a limited basis, they boosted students' interest, motivation, and achievement. The findings are reviewed in the context of a reevaluation of current methods in terms of implementation, frequency, and country-wide adoption. It is suggested that virtual labs be used to their full potential [20].

Murtianto et al. (2022) discussed the importance of designing an interface (UI) and user experience design (UX) in software development for online mathematics learning. Design Thinking is an innovation-based product design method that focuses on solving problems in a specific product design. Math used design thinking methods to create interface design for V-Lab in five stages: empathize, define, ideate, prototype, and test. The V-Lab Math application's UI / UX design includes material page design, figures, simulation, contact, and evaluation. System testing is accomplished through component testing, which is the testing of system components. The interface components tested in this study are interface components with the black box, single ease question (SEQ) method, which yielded good results while remaining effective and simple to use [21].

METHODOLOGY

In this study the effects of applying virtual labs in mathematical teaching on a group of students in the college is examined and discussed by using an appropriate questionnaire and aims to test the following hypotheses

H10: Math virtual labs have no effect on developing design thinking of students and help on how to solve math problems.

H11: Math virtual labs have a significant effect on developing design thinking of students and help on how to solve math problems.

H20:Mathematical simulations using virtual labs have no effect on covering mathematical problems and increasing understanding of math issues.

H21: Mathematical simulations using virtual labs have a significant effect on covering mathematical problems and increasing understanding of math issues.

H30: Math virtual labs have no effect as a Learner-centered approach which develops math solving problems for students.

H31: Math virtual labs have a significant effect as a Learner-centered approach which develops math solving problems for students.

H40: Math V.L. has no effects on activate Math learning (AML)operations for both students and lecturers.

H41: Math V.L. has a significant effect on activating Math learning (AML) operations for both students and lecturers.

H50: Math V.L.has no effect on developing and activating Partnership Math learning (PML) system.

H51: Math V.L.has a significant effect on developing and activating Partnership Math learning (PML) system.

H60: Math V.L. has no effect on developing an Assessment system of learning outcomes (AOL).

H61: Math V.L. has a significant effect on developing an Assessment system of learning outcomes (AOL).

TOOL OF STUDY

A questionnaire is implemented here to measure the effectiveness of using virtual labs in developing mathematical skills of the students at High Training Colleges in Kuwait, the questionnaire consists of23questions. The population of the study including students, tutors, and managers at two high training colleges in Kuwait. The size of the sample taken is 100 persons. After collecting data, it was found that math virtual labs have been effected by many factors or aspects contributing in implement such Virtual Labs-Based Mathematical Learning System (VLBMLS) which includes the following latents:Design thinking (DT), Simulation of Problems (SoP), Active Math learning (AML), Partnership Math learning (PML) and Assessment of Learning Outcomes (ALO).

Each of these ways contributes to the construction of the VLBMLS, and the contribution of each approach is mathematically represented by implementation index (II). The questionnaire given here-see appendix 1- is used to calculate the contribution of each factor in executing the suggested system using a Likert scale. The statistical criteria for interpreting the arithmetic averages of variants VLBMLS latents is shown in Table 1.

Table1: Statistical Standard for the Interpretation of the Arithmetical Averages of Variants VLBMLS Latents

Implementation index II	0<II≤ 20%	20<II≤60%	60<II≤70%	70<II≤80%	80<II≤100%
Interpretation	Poor	Fair	Good	Very Good	Excellent

RESULTSANDDISCUSSION

The total score average for all received responses was computed and divided by (7 times the number of questions for this variable) to estimate the Implementation Index (II) for each VLBMLS variable or contribution factor, which includes Design thinking (DT), Simulation of Problems (SoP), Active Math learning (AML), Partnership Math learning (PML), and Assessment of Learning Outcomes (ALO), as shown in Equation (1) below. The number "7" refers to the utilized Likert scale, which is "seven points" in this case. Table 1 shows how the results can be interpreted.

$$\text{Implementation Index(II\%)} = \frac{\sum Scoresaverageforeach\ question}{(7)*NumberofQuestions} \times 100 \qquad (1)$$

The firstlatent,design thinking (DT) is chosen as an example tocalculate thescore average andthe level of implementation for this variable. As shown in Table 2, the implementation index for Design Thinking (DT) can be computed as follows:

$$II\%DT = \frac{5.09+6.6+6.12+4.95+4.99+5.0}{7*6} X100\% = 77.98 \qquad (2)$$

The implementation of DT is rated "Very Good" in table 1. Similarly, the implementation index of all VLBMLS Latent, namely Design thinking, Learner-centered approaches (LCA), Simulation of Problems (SoP), Active learning (AL), Partnership learning (PSL), and Assessment for learning outcomes (ALO), was calculated and presented in tables 2, 3, 4, 6, and 7, with the overall results tabulated in table 8. The total average implementation Index for the VLBMLS is 72.148%, indicating that the considered education system is an excellent implementer of such principles.

Table 2: Implementation index for Design Thinking

QUESTION. NO.	ITEM	SCORE AVERAGE
1	I find it difficult to understand some mathematical concepts in real class	5.09
2	Virtual labs can simplify some mathematical concepts using videos and simulations	6.60
3	Virtual labs enable me to repeat the experiment more and more and so more understanding of math problems	6.12
4	After I use math V.L., I can solve more exercises of the textbook	4.95
5	Math V.L. is good tool and it develops my math skills, I find math very simple with V.L.	4.99
6	V.L. help me in design my thinking of math problems and rearrange my steps during solving math problems	5.00
AverageofDT practice		5.46
DTimplementationindex		77.98%
Interpretation		Very good

Table 3: Implementation Index of Simulation of Problems

NO.	ITEM	SCORE AVERAGE
7	V.Ls is a good tool for math problems simulation	5.00
8	V.L. enables me to repeat the problem more than one try to more understanding using simulation tool	4.99
9	I can discover my wrong results in solving math problems using simulation of V.Ls.	5.11
AverageofSoP practice		5.03
SoPimplementationindex		77.90%
Interpretation		Very Good

Table 4: Implementation Index of Learner-Centered Approaches (LCA)

NO.	ITEM	SCORE AVERAGE
10	Virtual Labs in math increases my understanding of math problems and concepts	4.95
11	If I don't understand some basic math problems V.L. forms a reference for more understanding of such problems	4.85
12	V.Ls consider as a good reference of math learning and Knowledge	4.35
13	Most of math problems are explained in simple way by V.Ls.	4.30
Average ofLCA practice		4.61
LCAimplementation index		65.89%
Interpretation		Good

Table 5: Implementation Index for Active Math Learning(AML)

NO.	ITEM	SCOREAVERAGE
14	V.Ls consider as a lab that I can try many experiments and this permit more active learning media	5.15
15	As I repeat the problem using V.Ls I can get new problems with new results	4.60
16	Virtual laboratories in mathematics introduce the factor of suspense and active education for the learner	5.10
Average of AMLpractice		4.95
AMLimplementation index		70.71%
Interpretation		Very Good

Table 6:ImplementationIndexforPartnershipLearning(PSL)

NO.	ITEM	SCOREAVERAGE
17	V.Ls enables me to share math solving problems with other students which causes more understanding	4.95
18	Virtual laboratories in mathematics make it possible for more than one student to participate in the process of solving problems	4.55
19	V.Ls make math learning more active between students themselves and between lecturer and students	4.95
Average ofPSL practice		4.82
PSLimplementation index		68.81%
Interpretation		Good

Table 7: Implementation Index of Assessment of Learning Outcomes (ALO)

NO.	ITEM	SCOREAVERAGE
20	V.Ls enable me to assess my level in solving math problems	4.60
21	I can use V.Ls in self-test and then discover my mistakes easily	5.10
22	V.Ls contain many problems that enables me to assess my level in math before any real class exams	4.85
23	As a lecture of math V.Ls enables me to assess students in more easy and accurate way.	5.50
Average ofALOpractice		5.01
ALOimplementation index		71.6%
Interpretation		Very Good

Table 8: Summary for the Implementation Level Results of Each Constructs Latent Variable

CONSTRUCT LATENT VARIABLE	MEAN ()	VARIANCE (S^2)	IMPLEMENTATION INDEX (%)	INTERPRETATION
Design Thinking	5.46	0.00405	77.98	Very Good
Simulation of Problems	5.03	0.00605	77.90	Very Good
Learner-Centered Approaches	4.61	0.21125	65.89	Good
Active Math Learning	4.95	0.00125	70.71	Very Good
Partnership Learning.	4.82	0.00001	68.81	Good
Assessment of Learning Outcomes	5.01	0.405	71.60	Very Good
OverallVLBMLSimplementationlevel	4.98	0.10647	72.148	Very Good

Table8 also showsthat wecan describe theselected sample ofthe students and lectures as“Very Good”implementers of VLBMLS hence the averageof all latent variables is 72.148%which is equivalentto “VeryGood” depending on table1. Figure 2 illustrates a comparison between implementation indices of all models latent.

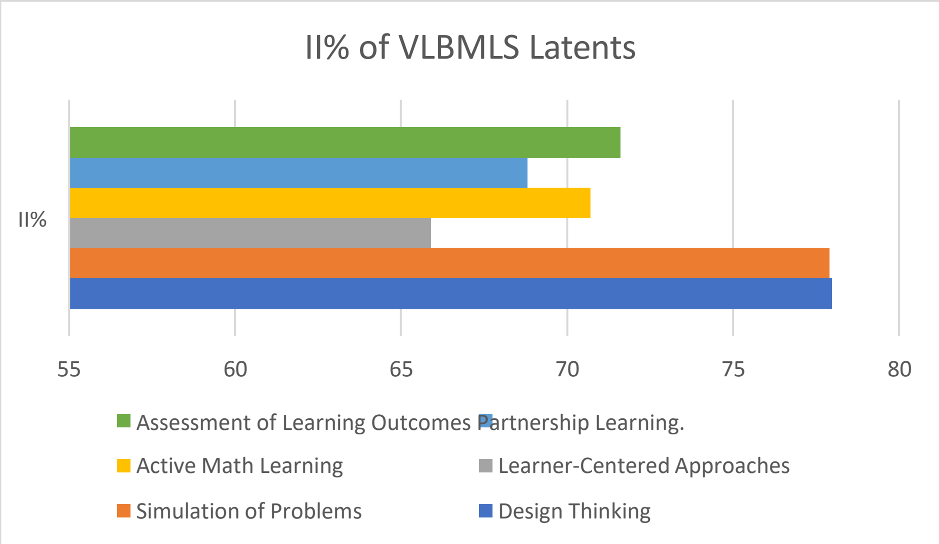

Figure 2: Comparison of Implementation Index between VLBMLS’s Latent Variables

HYPOTHESES TEST AND ANALYSIS

To highlight the hypothesis testing results, the null hypothesis H0 must be mentioned whether it was rejected or not rejected at a defined significance level (-value). The "P-value" is the least significant level of significance. [22] defines the P-value as the likelihood of receiving a statistic test value that is at least as high as that observed when the null hypothesis is accepted. Furthermore, the P-value shows the probability of making a Type I error, or rejecting the null hypothesis while the hypothesis is true. Once a P-value is calculated, a significance level of 0.01 is used in this investigation. Any hypothesis will be rejected if the P-value is less than the significance level of 0.01.A paired sample correlation and a paired sample test are computed using the statistical package for social sciences (SPSS) to conduct the appropriate statistical tests and provide the results of hypothesis testing. The results of the statistical tests are shown in Table 9. As an example, consider hypothesis H1 to explain table 9. The following is hypothesized by Hypothesis H1:

> $H1_0$: Math virtual labs have no effect on developing design thinking of students and help on how to solve math problems.
>
> $H1_1$: Math virtual labs have a significant effect on developing design thinking of students and help on how to solve math problems.

The paired sample correlation and test confirm that H1 has P-values close to zero (i.e., P-value 0.01), implying that H10 is rejected at a significance level of (α=0.01). As a result, the alternative hypothesis H11 is supported (true). Similarly, all of the hypotheses (from H2 to H6) were found to have P-values less than 0.01 indicating that the null hypotheses were rejected, and the proposed alternative hypotheses were supported.

Table 9: Results of the Hypotheses Testing for the VLMBLS model.

Alternative Hypothesis	Relationship	Paired Sample Correlation		Paired Sample Test			Decision
		Pearson	*P*-value	*t*-value	DF	*P*-value	
$H1_1$	DT-VLBMLS	0.988**	0.0001	10.752	99	0.000	Reject $H1_0$
$H2_1$	SoP-VLBMLS	0.975**	0.0001	15.555	99	0.000	Reject $H2_0$
$H3_1$	LCA-VLBMLS	0.980**	0.0010	9.501	99	0.000	Reject $H3_0$
$H4_1$	AML-VLBMLS	0.988**	0.0001	10.618	99	0.001	Reject $H4_0$
$H5_1$	PSL-VLBMLS	0.960**	0.0010	8.156	99	0.000	Reject $H5_0$
$H6_1$	ALO-VLBMLS	0.990**	0.0001	13.222	99	0.000	Reject $H6_0$

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

The results of hypotheses test showed that all alternative hypotheses were accepted while all null hypotheses were rejected depending on paired sampled tests-t-value and p-values, which indicated that the virtual labs of mathematics have a considerable effect on design thinking of students, the problem simulation which is the main tool of V.L.s can support and improve the understanding of students of math problems. Another important result, the V.L.s can be considered as a learning centered approach and active math learning system for math students. Also, V.L.s can be considered as a partnership learning system and a good tool for assessment of learning outcomes for students themselves and for lecturers.

CONCLUSIONS

This study aims to investigate and analyze the effects of using mathematical virtual labs in learning system in Kuwait state in the Applied Education and Training colleges and centers level. The study leads to the following conclusions:

Virtual Labs of math are good tool for increasing the understanding for students in math concepts and redesign of their math thinking, also it can simplify the math problems in a way to improve their method in math problem solving and reorder their thinking during solving such problems.

V.L.S in math can improve students' skills in math thinking and repeat the math problems via simulation tools offered by such labs.

V.L.S increases the active learning and partnership leaning modules.

V.L.Sis a good assessment tool of the educational outcomes of the learning processes.

REFERENCES

[1] *Tarouco L. et al. (2013). Virtual Laboratory for Teaching Calculus: An Immersive Experience. IEEE Global Engineering Education Conference (EDUCON) Page 774-Technische Universität Berlin, Berlin, Germany, March 13-15.*

[2] *J. S. Richardson (1957).Science teaching in secondary schools. New Jersey: Prentice-Hall, Inc.*

[3] *T. Abdjul and N. Ntobuo, "Developing Device of Learning Based on Virtual Laboratory through Phet Simulation for Physics Lesson with Sound Material," vol. 4531, pp. 105–115.*

[4] *Zaturrahmi, Festiyed, and Ellizar. (2020). The Utilization of Virtual Laboratory in Learning: A Meta-Analysis. Indonesian Journal of Science and Mathematics Education.Vol.3 (2), pp:228-236.*

[5] *Gunawan G, Harjono A, Sahidu H, Herayanti L. (2017). Virtual laboratory to improve students' problem-solving skills on*

electricity concept. Jurnal Pendidikan IPA Indonesia. Vol.6(2):257-264.

[6] *Widowati A, Nurohman S, Setyowarno D. (2017). Development of inquiry-based science virtual laboratory for improving student thinking skill of junior high school. Jurnal Pendidikan Matematika dan Sains. 2017;4(2):170-7.*

[7] *Nf. Manikowati and D. Iskandar. (2018). "Engelmann Model Mobile Virtual Laboratories Untuk Pembelajaran Praktikum Siswa SMA.," JournalKwangsan. vol. 6, no. 1, pp. 23–42.*

[8] *Wahyu Y, Suastra IW, Sadia IW, Suarni NK. (2020). The effectiveness of mobile augmented reality assisted stem-based learning on scientific literacy and students' achievement. International Journal of Instruction. Vol.13(3):343-56.*

[9] *Sudiana R. (2020). Progate platform as a virtual laboratory of web-based programming. Prosiding Seminar Nasional Pendidikan FKIP. 2020;3(1):277-282*

[10] *Putri LA, Permanasari A, Winarno N, Ahmad NJ. (2021). Enhancing students' scientific literacy using virtual lab activity with inquiry-based learning. Journal of Science Learning. Vol. 4(2):173-84*

[11] *YanuarHery Murtianto*, M Muhtarom, Bambang Agus Herlambang. (2022). Virtual Mathematics Laboratory Based on Cognitive Load Theory. 4th International Conference on Education and Social Science Research (ICESRE) Volume 2022.*

[12] *Babateen+, H. M. 2011. The Role of Virtual Laboratories in Science Education. IPCSIT, 12(1): 1-2.*

[13] *Baser, M. &Durmus, S. 2010. The Effectiveness of Computer Supported Versus Real Laboratory Inquiry Learning Environments on The Understanding of Direct Current Electricity Among Pre-Service Elementary School Teachers. Eurasia Journal of Mathematics, Science & Technology Education, 6 (1), 47-61.*

[14] *Herga, N. R, Grmek, M. I., Dinevski, D. 2014. Virtual Laboratory asan Element ofVisualization When Teaching Chemical Contents in Science Class. The Turkish Online Journal of Educational Technology,13 (4): 2-3.*

[15] *Carnival, D. 2003. The Virtual Lab experiment Some College Use Computer Do Expand Science Of- ferings Online. The Chronicle of Higher Education, 49(21): 30-32.*

[16] *August, S. E., Neyer, A., Murphy, D. B., Themes, R. Q., Hammer, M., Shoktgozar, D., & Vales, J. 2011. Engaging Student in STEM Education through a Virtual Learning Lab. Conference American Society Engineering Education (ASEE).*

[17] *Ismail, A. Permanasari, W. Setiawan (2016). STEMVirtual Lab: An Alternative Practical Media to Enhance Student's Scientific Literacy.Journal Pendidikan IPA Indonesia.5 (2) (2016) 239-246.*

[18] *Dickler R. et al. (2021). Supporting Students Remotely: Integrating Mathematics and Science in Virtual Labs.ICLS 2021 Proceedings.*

[19] *Aboraya W. (2021).Assessing students' learning of abstract mathematical concepts in a blended learning environment enhanced with a web-based virtual laboratory.Journal Of E-Learning and Knowledge Society Vol. 17, No. 3 (2021), pp. 50-58.*

[20] *Saif Saeed Alneyadi S.S. (2019). Virtual Lab Implementation in Science Literacy: Emirati Science Teachers' Perspectives.EURASIA Journal of Mathematics, Science and Technology Education, 2019, 15(12), em1786.*

[21] *Murtianto Y.H.,Muhtarom, HerlambangB.A., Harjanta A.T. and Sutrisno (2022). Development of User Interface and User Experience in Virtual Lab Mathematics Applications Using Design Thinking Methods.Advances in Dynamical Systems and Applications. Volume 17, Number 1, (2022) pp. 261-272.*

[22] *Montgomery, D. and Runger, G. (2011), Applied Statistics and Probability for Engineers, (5th ed.). Hoboken, NJ: John Wiley & Sons.*

APPENDIX 1.1

Questionnaire and Percentages of Response

QUESTION	VERY STRONGLY DISAGREE (1)	STRONGLY DISAGREE (2)	DISAGREE (3)	UNDECIDED (4)	AGREE (5)	STRONGLY AGREE (6)	VERY STRONGLY AGREE (7)	MEAN
Design Thinking (DT) Latent								
Q1. I find it difficult to understand some mathematical concepts in real class	2%	2%	10%	16%	33%	15%	22%	5.09
Q2. Virtual labs can simplify some mathematical concepts using videos and simulations	4%	4%	10%	10%	32%	16%	24%	6.6
Q3. Virtual labs enable me to repeat the experiment more and more and so more understanding of math problems	4%	6%	8%	10%	28%	24%	20%	6.12
Q4. After I use math V.L., I can solve more exercises of the textbook	5%	5%	10%	10%	30%	20%	20%	4.95
Q.5 Math V.L. is good tool and it develops my math skills I find math very simple with V.L.	4%	5%	10%	15%	26%	15%	25%	4.99

Contd Table : Appendix 1.1

Q6. V.L. help me in design my thinking of math problems and rearrange my steps during solving math problems	5%	5%	10%	10%	30%	15%	25%	5.00
Simulation of Problems (SoP)								
Q.7 V.Ls is a good tool for math problems by simulation	5%	5%	10%	10%	30%	15%	25%	5.00
Q.8 V.Ls enables me to repeat the problem more than one try to more understanding using simulation tool	4%	6%	8%	11%	31%	20%	20%	4.99
Q.9 I can discover my wrong results in solving math problems using simulation of V.Ls.	4%	6%	10%	10%	20%	25%	25%	5.11
Learner-Centered Approaches (LCA)								
Q10. Virtual Labs in math increases my understanding of math problems and concepts	5%	5%	10%	15%	25%	15%	25%	4.95

Contd Table : Appendix 1.1

Q11. If I don't understand some basic math problems V.L. forms a reference for more understanding of such problems	5%	10%	10%	15%	15%	20%	25%	4.85
Q12. V.Ls consider as a good reference of math learning and Knowledge	10%	10%	10%	20%	20%	15%	15%	4.35
Q13. Most of math problems are explained in simple way by V.Ls.	10%	15%	10%	20%	10%	15%	20%	4.30
Active Learning (AL)								
Q14. V.Ls consider as a lab that I can try many experiments and this permit more active learning media	5%	5%	10%	10%	20%	20%	30%	5.15
Q15. As I repeat the problem using V.Ls I can get new problems with new results	10%	10%	10%	10%	20%	20%	20%	4.60

Contd Table : Appendix 1.1

Q16. Virtual laboratories in mathematics introduce the factor of suspense and active education for the learner	5%	5%	10%	10%	20%	25%	25%	5.10
Partnership Learning (PSL)								
Q17. V.Ls enables me to share math solving problems with other students which causes more understanding	5%	10%	10%	10%	15%	25%	25%	4.95
Q18. Virtual laboratories in mathematics make it possible for more than one student to participate in the process of solving problems	10%	10%	10%	15%	15%	20%	20%	4.55
Q19. V.Ls make math learning more active between students themselves and between lecturer and students	10%	5%	5%	10%	15%	20%	35%	4.95

Contd Table : Appendix 1.1

Assessment for Learning (AOL)								
Q20. V.Ls enable me to assess my level in solving math problems	10%	10%	10%	10%	20%	20%	20%	4.60
Q21. I can use V.Ls in self-test and then discover my mistakes easily	5%	5%	10%	10%	20%	25%	25%	5.10
Q22. V.Ls contain many problems that enables me to assess my level in math before any real class exams	5%	10%	5%	15%	20%	20%	25%	4.85
Q23. As a lecture of math V.Ls enables me to assess students in more easy and accurate way.	4%	4%	4%	10%	20%	20%	38%	5.50