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Research Article

Development of Virtual Laboratory Simulation: e-SCILAB on Waves for Grade 7 Science

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ABSTRACT

Virtual Laboratory Simulation (VLS) enhances student understanding, retention of concepts, and promotes active learning through direct visualization and manipulation of computer animations. This study aimed to develop a VLS with complementary manual for Grade 7 physics that can be utilized by the teachers to address the needs of the students in the new normal learning. The developed VLS is composed of a Teacher's Instructional Manual and Student's Learning Manual. The study used Research and Development approach with the ADD (Analysis, Design, and Development) model as the instructional method. These allows the researchers to analyze the need of VLS, identify the design of VLS, and develop the VLS. The VLS was evaluated based on the content quality with a mean of 4.68, technical quality with 4.65, and instructional quality with 4.57. The results for the complementary activity manual in terms of the content quality is a mean of 4.62, the technical quality with 4.54, and the instructional quality with 4.55. The result showed that the developed VLS together with the complementary activity manual satisfied the quality components and attained the intended standards. It is recommended that evaluation of the effectiveness of VLS through pilot tests in public and private schools.

Keywords: *Virtual laboratory simulation, content quality, instructional quality, technical quality, complementary manual*

Introduction

Science is best taught by experiential learning through the use of hands-on activities. Students who are engaged in hands-on activities attained higher science achievement scores compared to those who are not (Stohr-Hunt, 2017). Better learning and attitude towards science are also developed when students

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experience actual science through hands-on activities integrated into classrooms (Carlson and Sullivan, 1999). Apparent problems with the Philippines' science education are the lack of laboratory facilities and equipment and modern instrumentation. This limits the capacity of teachers to guide students learning through experimentation and hands-on activities (Pingol et al., 2015).

In fact, the Programme for International Student Assessment (PISA) states that the Philippines ranked among the lowest in mathematics and science with a score of 353 points and 357 points respectively against a 489 Organization for Economic Co-operation and Development (OECD) average for both categories in the 2018 PISA results (Paris, 2019). Virtual laboratories can be the solution to increase the ranking of the Philippines in the PISA science category. For this reason, computer-aided systems are necessary to assimilate scientific knowledge to the learners (Talis & Ayas, 2012). To improve the science learning of the students, virtual laboratories are necessary to facilitate learning of science concepts.

Currently, these underlying problems in the Philippine education becomes apparent due to COVID-19 pandemic. DepED schools, colleges and universities forced to shift from face to face to online learning. The new paradigm called the learning in the new normal becomes a challenge for the teachers, students and even parents This new way of learning brought by COVID 19 pandemic pervades a way to emphasized online resources for the students to have effective learning. (The New Normal Education in the Philippines, 2020).

With this, the study aims to develop a Virtual Laboratory Simulation, an e-Scilab that will cater to the needs of the students without compromising the pedagogical content of the concepts. It will provide not only learning materials online but also help students to enjoy learning with many possibilities. Virtual Laboratory Simulations not just enhance the conceptual abstraction of the students but also their mathematical comprehension especially in physics subjects (Wästberg et al., 2019).

With the use of ICT advancements in the teaching and learning process, the e-Scilab will provide a simplified and interactive knowledge environment for complex topics through interactive simulations, which will enable students to construct and understand abstract concepts especially in physics (Park, 2019). Karacop and Doymus (2013) have explained that the utilization of animations is more effective than traditional teaching methods as it can aid students in enhancing conceptual understanding of the abstract concepts under study most especially in physics.

Virtual lab simulations may aid students in gaining better comprehension of scientific concepts (Pineda et al., 2015). The e-Scilab contains graphics and dynamic representations and models that display motions or movements and are produced by the different forms of visualizations. These forms of visualization are generated through computer programming. A simulation also contains user interactivity in which learners are interacting by taking control of the series and sequence of animation (Ploetzner et al., 2020).

The COVID-19 pandemic brought an accelerated change in the methods of delivery of the curriculum content. The schools must not only find a new methods of education delivery but also ensure the safety of their stakeholders (United Nations, 2020). The restriction of face-to-face classes brought by the COVID-19 pandemic made this study feasible as it meets the needs of a safe method of education delivery.

In line with this, the researchers developed a virtual laboratory simulation: an e-Scilab on Waves for Grade 7 Science. The developed virtual laboratory simulation was validated in terms of content, technical, and instructional qualities. The result and responses gathered after the validation of the experts were used by the researchers to improve the e-Scilab.

Statement of the Problem

The study aimed to develop an e-Scilab: a virtual laboratory simulation on waves for Grade 7 Science. Specifically, the study did the following:

1. Developed an e-Scilab: a virtual laboratory simulation on waves for Grade 7 Science.
2. Evaluated the quality of the developed e-SciLab activities in terms of:

a. Content Quality
b. Technical Quality
c. Instructional Quality

Methodology

Research Design

This study aimed to develop virtual laboratory simulation (VLS) with a complementary manual for Grade 7 Physics. The study used Research and Development (R & D) approach with the ADD Model as the instructional methods. These allows the researchers to analyze the need of VLS, identify the design of the VLS, development of VLS, and evaluate the VLS based on the content quality, technical quality, and instructional quality.

Needs Analysis of Virtual Laboratory Simulation

The researchers analyzed the need of virtual laboratory simulation through literature review and curriculum review. The curriculum review was done through analysis of the curriculum on the Department of Education, specifically on the Junior High School level. The researchers also made a quick survey tool on the familiarization of teachers on the usage of virtual laboratory simulation prior to the processing of the study. Literature review was done through analysis of existing studies in the Philippines about the usage of virtual laboratory simulation.

Design of Virtual Laboratory Simulation

The design of the virtual laboratory simulation was brainstormed by the researchers and the identified web developer. The researchers identified that the simulation should contain the same features of an interactive simulation, however, the user-friendly quality of the material was given with high emphasis. A complementary activity manual was also added for better learning experience and technical guidance for the students and teachers.

Development of Virtual Laboratory Simulation

During the development phase, the researchers used the DepEd K to 12 Curriculum Guide (CG) for Science particularly in the Grade 7-Force, Motion, and Energy, Third Quarter. The CG was used to identify the content, content standards, performance standards, and learning competency per topic to be included in the VLS. Also, they will utilize the Grade 7 Science Learning Module as a basis for the laboratory procedures in the virtual experiment and for the creation of a complementary activity manual for the teachers and learners.

Validation of Virtual Laboratory Simulation

After the development, the study undergone validation by selected experts particularly Science Teachers. Validation forms are to be adopted by researchers from Alegre (2012) for the Virtual Laboratory and Mercado (2020) for the Activity Manuals, which include assessment of content, technical, and instructional qualities. The participants are coming from the five identified schools in the Region XII.

Participants of the Study

For the evaluation of the developed e-SciLab, the participants came from the five (5) high schools in Region XII, particularly from Notre Dame of Marbel University-Integrated Basic Education Department (NDMU-IBED), Notre Dame Siena School of Marbel (NDSSM), Koronadal National Comprehensive High School (KNCHS), Bambad National High School, and Libertad National High School. The participants will be selected because of their teaching experience in Grade 7 Science.

The participants of the study were chosen purposively. The five (5) Grade 7 Science teachers of each school who were selected as participants of the study followed the criteria set by the researchers. The participant must be a Grade 7 Science teacher, having two (2) years of experience teaching grade 7 science. The researchers also determined the participants based on their availability and connection due to the pandemic.

Research Instruments

The study utilized the following research instruments: DepEd K to 12 curriculum guide for science, Grade 7 science learning module, and evaluation tool for laboratory simulation.

Supplementary material for this study is the Department of Education (DepEd) curriculum guide (CG) for science which was used to design the virtual laboratory simulation. The researchers developed the VLS based on the content, content standards, performance standards, and learning competency. Also, the researcher used the Grade 7 Science Learning Module as bases for the laboratory procedures to be used in the different VLS.

For the evaluation and validation of the developed virtual laboratory simulation, the researchers adapted the evaluation tool rubric from the study of Alegre (2012) to assess the three (3) components of the developed VLS, the content quality, technical quality, and instructional quality. It was made up of a 5-rating scale, where 5 means strongly agree, 4 means agree, 3 means disagree, 2 means strongly disagree, and 1 if the criteria specified in the virtual laboratory simulation is not applicable.

Data Gathering Procedures

The study uses the ADD part of the ADDIE model as a guide in the development of the e-SciLab: a virtual laboratory simulation on waves for Grade 7 science.

Needs Analysis of Virtual Laboratory Simulation

The needs analysis was done to teachers who are instructors of Grade 7 Science. The researchers made a quick needs analysis on the current usage of laboratories (if there is any) through a google form.

Design of the Virtual Laboratory Simulation

In the designing of the virtual laboratory simulation, the researchers created all the materials to be used in the VLS. The researchers hired an animator for the different activities to ensure originality of the creative materials. The materials on the manuals are based on the DepEd Science Learners Manual to ensure alignment.

Development of Virtual Laboratory Simulation

The researchers identified in the CG the content standard, performance standard, and learning competencies at which the teachers find difficult in conducting especially in the laboratory session. Careful planning was made to ensure that the researchers will identify what are to be considered or included in the laboratory simulation, how the e-SciLab addressed the needs of the teachers and how the students be able to conduct the experiments better. After designing the content to be considered in the VLS, the development of the laboratory simulation began. The e-SciLab was developed with the help of a Computer Engineer to ensure the technical quality of the instructional material or VLS. Thus, the ICT component of the VLS was ensured by the researchers.

Validation of Virtual Laboratory Simulation with Complementary Manuals

After the development phase, the selected five (5) evaluators validated the research based on the adapted evaluation tool rubric from the study of Alegre (2012) and Mercado (2020) to assess the three (3) components of the developed VLS, the content quality, technical quality, and instructional quality. It was made up of a 4 rating scale, where 4 means strongly agree, 3 means agree, 2 means disagree, and 1 means strongly disagree. The activities/experiments in the developed e-SciLab was evaluated individually and analyzed differently by the evaluators chosen by the researchers.

In addition, the researchers made clear modifications on the alignment of the validation tool. The researchers removed the item 6 of the Content Quality Assessment because it was found to be misaligned with the content of the VLS prior to the evaluation.

Data Analysis

To determine the validity of the activities/experiments in the research paper, it was validated and evaluated by five science teachers using the weighted mean. The researchers used the 5-point Likert scale below as an interpretation in the evaluation of its content, technical, and instructional quality.

Table 1. Rating Scale for the Developed Laboratory Simulation Validation

Range	Verbal Description	Quality Interpretation
1.00 - 1.80	Strongly Disagree	Very Poor Quality
1.81 - 2.60	Disagree	Poor Quality

Range	Verbal Description	Quality Interpretation
2.61 - 3.40	Neither Agree nor Disagree	Fair Quality
3.41 - 4.20	Agree	High Quality
4.21 – 5.00	Strongly Agree	Very High Quality

Table 1 gives information about the range, verbal description, and quality interpretation of the rating scale. Every range of the 5-point Likert rating scale has a corresponding verbal description from strongly disagree to strongly agree and quality interpretation from very poor quality to very high quality. Values of the weighted mean obtained from the content, technical, and instructional quality assessment are associated with qualitative measures to acquire quality values.

Results and Discussion

Design and Development of the Virtual Laboratory and Activity Manual

Preparation of Teacher's Activity Manual

A component of the e-SciLab was the Teacher's Activity Manual which was intended for the use of the teacher in facilitating the virtual laboratory activity. The activity manual provides the teachers specific instruction on how to operate the virtual laboratory simulation--main material for the virtual experiment. The manual also provides the teacher specific answers for the illustrations, essays and observations of the students, as reflected on the learner's manual.

The teacher's activity manual (Appendix D-1) was prepared with the following activities: Activity 1- Let's Make Waves, Activity 2-Anatomy of the Waves, and Activity 3-Mechanical Waves versus Electromagnetic Waves. Each activity was composed of the following components: (1) Introduction, (2) Objectives, (3) Time Allotment, (4) Procedures, (5) Post-Activities, and (6) References. The content of each activity was aligned with the curriculum guide and the module provided by the Department of Education. The Teacher's Activity Manual was checked and evaluated by selected experts.

Preparation of Learner's Activity Manual

A component of the e-SciLab was the Learner's Activity Manual (Appendix D-2) which was intended for the understanding of the various concepts of Physics-Waves through various virtual simulation activities. The activity manual provides the learner with specific instruction on the utilization of the e-SciLab as stated in Pre-Activity procedures.

The learner's activity manual was prepared with the following activities Activity 1- Let's Make Waves, Activity 2-Anatomy of the Waves, and Activity 3-Mechanical Waves versus Electromagnetic Waves. Each activity was composed of the following components: (1) Introduction, (2) Objectives, (3) Time Allotment, (4) Procedures, (5) Post-Activities, and (6) References. The content of each activity was aligned with the curriculum guide and the module provided by the Department of Education. The Teacher's Activity Manual was checked and evaluated by selected experts.

Preparation of Virtual Laboratory Simulation

The main component of the e-SciLab was the Virtual Laboratory Simulation which was composed of the following parts of the interface: (1) Landing Page, (2) Activity Selection Page, (3) Instructional Video Page, (4) Materials Page, (5) Activity Proper Page, and (6) Credits and References Page. Each activity has its own instructional page until the credits and reference page.

Evaluation of the Content, Technical, and Instructional Qualities of the Activity Manual

To validate the quality of the activity manual, the mean scores of the ratings of the selected experts are determined. The following data are quality components validation in terms of: (1) content quality, (2) technical quality, and (3) instructional quality.

Content Quality Evaluation of the Activity Manual

Table 2 shows the results of the assessment in terms of Content Quality of both teacher's and learner's manual modified by the researchers. It presents the mean responses of the selected experts on the content quality of the activity manual with overall collective mean of 4.62.

Table 2. Result of Content Quality Evaluation of the Activity Manual

Content Quality	Mean	Interpretation
1. The content is scientifically adequate and accurate.	4. 55	Very High Quality
2. Emphasize active learning.	4.75	Very High Quality
3. Contents of each activity is relevant to the objectives.	4.75	Very High Quality
4. It is well organized.	4.45	Very High Quality
5. It evaluates student learning as stated in objectives.	4.7	Very High Quality
6. It allows the development of multiple intelligences.	4.15	Very High Quality
7. Topics are supported by illustrations and tasks suited to students.	4.8	Very High Quality
8. It is aligned to curriculum	4.7	Very High Quality
9. The contents are free of ethnic, gender and other stereotypes.	4.8	Very High Quality
Overall Weighed Mean	4.62	Very High Quality

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

The responses from the evaluator have a total mean of 4.62 which means that they strongly agreed that activity manuals had a very high content quality. The chosen experts emphasized that the content of both the teacher and learner's manuals was supported by illustrations and tasks suited to students and free from stereotypes which both gained a mean of 4.8.

Technical Quality Evaluation of the Activity Manual

The table below shows the mean responses of five (5) selected experts on the Technical Quality of the developed activity manual. After gathering all the responses, the aggregate collective mean is 4.54.

Table 3. Result of Technical Quality Evaluation of the Activity Manual

Technical Quality	Mean	Interpretation
1. The manual is easy to understand.	4.65	Very High Quality
2. The manual allows learner to control pace of learning.	4.60	Very High Quality
3. The graphics are excellent.	4.45	Very High Quality
4. The layout and design are attractive.	4.35	Very High Quality
5. Intend users can easily and independently use the manual.	4.8	Very High Quality
6. The language used is clear, concise, and motivating.	4.7	Very High Quality
7. The manual is aesthetically pleasing.	4.35	Very High Quality
8. The symbol used are well-define.	4.45	Very High Quality
9. Topics are presented in a logical and sequential order.	4.55	Very High Quality
Overall Weighed Mean	4.54	Very High Quality

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

The total mean revealed that the evaluators strongly agreed that the activity manual had a very high technical quality with a collective mean of 4.54. Based from their responses, they confirmed that both manuals were easy to understand, users can easily and independently use the manual and the language used is clear, concise, and motivating with a mean of 4.65, 4.8 and 4.7 respectively. Also, based from their responses, the learner's manual is aesthetically pleasing, understandable and comprehensive.

Instructional Quality Evaluation of the Activity Manual

Table 4 shows the mean responses of five (5) selected experts on the Instructional Quality of the developed teacher's manual. The overall collective mean is 4.55.

Table 4. Result of Instructional Quality Evaluation of the Activity Manual

Instructional Quality	Mean	Interpretation
1. It provides feedback on accuracy of the student's answer.	4.25	Very High Quality
2. It is of high educational value.	4.55	Very High Quality
3. It is good supplement of the curriculum.	4.7	Very High Quality
4. It addresses the needs and concern of the students.	4.7	Very High Quality
5. The manual facilitates collaborative and interactive learning.	4.25	Very High Quality
6. It integrates students' previous experience.	4.7	Very High Quality
7. The manual introduction helps answering test questions.	4.7	Very High Quality
8. It reflects current trend in Physics instruction and experiments.	4.55	Very High Quality
9. The graphics and colors used are appropriate for instructional objectives.	4.55	Very High Quality
Overall Weighed Mean	4.55	Very High Qual-

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

Based on Table 4, the evaluators strongly agreed that the teacher's manual had a very high instructional quality which means that the quality components meet the intended standard. Evaluators noted that it was a good supplement to the curriculum and the manual introduction helped in answering the test questions which both obtained a mean of 4.7.

Summary of Quality Component Evaluation

Table 5 shows the overall responses of the selected experts on the content quality, technical quality, and instructional quality with collective means of 4.62, 4.54 and 4.55 respectively.

Table 5. Overall Mean Response on the Content, Technical, and Instructional Qualities of the Activity Manual

Quality Components	Mean	Description	Interpretation
Content Quality	4.62	Strongly Agree	Very High Quality
Technical Quality	4.54	Strongly Agree	Very High Quality
Instructional Quality	4.55	Strongly Agree	Very High Quality

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

Based from the responses of the evaluators indicated in Table 5, they strongly agreed that the modified activity manual had a very high content quality, technological quality, and instructional quality. All the quality components met the intended standard and pervades motivation among students, show initiative in the learning process and provides opportunities for the learners to improve their competencies holistically.

The modified activity manuals can aid teachers to provide techniques that will better support and enhance the students learning process. Also, the evaluators affirmed that the modified manual contains necessary information that supplements learning and was aligned with the curriculum guide of the DepED.

Evaluation of the Content, Technical, and Instructional Qualities of the Simulation

The mean scores if the ratings of selected experts are calculated to validate the quality of the simulation. The following data are quality component validation in terms of: (1) content quality, (2) technical quality, and (3) instructional quality.

Table 6. Result of Content Quality Evaluation of the Virtual Laboratory Simulation

Content Quality	Mean	Interpretation
1. The content is scientifically adequate and accurate.	4.6	Very High Quality
2. It emphasizes active learning.	4.8	Very High Quality
3. It is well organized.	4.8	Very High Quality
4. It is relevant to learning objectives.	4.6	Very High Quality
5. It helps students build strong ideas.	4.8	Very High Quality
6. It allows the development of multiple intelligences.	4.4	Very High Quality
7. The topics are interesting.	4.6	Very High Quality
8. The contents are free of ethnic, gender and other stereotypes.	4.8	Very High Quality
Overall Weighed Mean	4.68	Very High Quality

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

Table 6 shows the results of the assessment in terms of Content Quality of the simulation made by the researchers. The table presents the mean responses of the selected experts on the content quality of the simulation with overall aggregate mean 4.68.

The descriptor "It evaluates student learning as stated in objectives" was removed from the content quality assessment in virtual laboratory simulation in order to meet the needs of the study. The evaluators strongly agreed that the simulation is scientifically correct, well organized, entertaining, and relevant. Laboratory simulations provides the necessary pedagogical content of the concepts that can meet the needs of the learners (Bogusevschi et al., 2020).

Table 7. Result of Technical Quality Evaluation of the Virtual Laboratory Simulation

Technical Quality	Mean	Interpretation
1. The program is easy to navigate.	4.6	Very High Quality
2. The interactive computer simulation allows the learners to control the pace of learning.	4.8	Very High Quality
3. The graphics is excellent.	4.6	Very High Quality
4. The layout and design are appropriate.	4.6	Very High Quality
5. The manipulative controls are comprehensive and directive.	4.6	Very High Quality
6. The program runs quickly with minimum wait time.	4.6	Very High Quality
7. Intended users can easily and independently use the program.	4.8	Very High Quality
8. The program is aesthetically pleasing.	4.6	Very High Quality
Overall Weighed Mean	4.65	Very High Quality

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

Table 7 presents the mean responses of the selected five science teachers on the Technical Quality of the developed e-SciLab simulation. The overall aggregate mean is 4.65

The evaluators strongly agree that all the developed simulations are easy to navigate, allows learners to control the pace of learning, contains excellent graphics, and contains appropriate layout and design. Virtual laboratories incorporate media design with vivid presentation that increases learners' satisfaction. Interactivity, design influence, and content of the virtual laboratory are geared to meet the needs of the learning performance, satisfaction of the learners, and comprehension of concepts (Vioight & Olbrich, 2016).

Table 8. Result of Instructional Quality Evaluation of the Virtual Laboratory Simulation

Instructional Quality	Mean	Interpretation
1. It provides feedback on correctness of the student's answer.	4.6	Very High Quality
2. It is of high educational value.	4.6	Very High Quality
3. It is good supplement to the curriculum.	4.8	Very High Quality
4. It addresses the needs and concern of the students.	4.6	Very High Quality
5. The instructional material facilitates collaborative and interactive learning.	4.6	Very High Quality
6. It integrates students' previous experience.	4.6	Very High Quality
7. The interactive computer simulation helps in answering the test item questions.	4.6	Very High Quality
8. It reflects current trend in Physics instruction.	4.4	Very High Quality
9. The graphics and colors used are appropriate for instructional objectives.	4.4	Very High Quality
Overall Weighed Mean	4.57	Very High Quality

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

Table 8 shows the mean responses of the selected science teachers on the Technical Quality of the developed e-SCILAB simulation. The overall aggregate mean is 4.57. The table shows that the evaluators strongly agree that the developed simulation has a very high instructional quality. Teaching learners with the aid of simulations promotes "deep learning". The students are able to learn systematically through the use of simulations and they can actively refine their learnings through engaging with the simulation (SERC, 2018).

Summary of Quality Component Evaluation of the Simulation

Table 9. Overall Mean Response on the Content, Technical, and Instructional Qualities of the developed Virtual Laboratory Simulation.

Quality Components	Mean	Description	Interpretation
Content Quality	4.68	Strongly Agree	Very High Quality
Technical Quality	4.65	Strongly Agree	Very High Quality
Instructional Quality	4.57	Strongly Agree	Very High Quality

Rating Scale: 1.00 - 1.80 – Very Poor Quality; 1.81 - 2.60 – Poor Quality; 2.61 - 3.40 – Fair Quality; 3.41 - 4.20– High Quality; 4.21 – 5.00 – Very High Quality

Table 9 shows that the overall mean responses of the selected science teachers under the content quality, technical quality, and instructional quality with means of 4.6, 4.6, and 4.6, respectively.

The overall mean under the content quality, technical quality, and instructional quality response dictates that the evaluators strongly agree that the developed e-SCILAB meets their expectations. The selected evaluators affirmed that the developed e-SCILAB provides adequate materials that supplements learning. The e-SCILAB simulation is a good supplement to the curriculum especially in the 21st century online learning. The evaluators strongly agree that the developed simulation is an appropriate instructional material for teaching grade 7 science and contains accurate information and up-to-date scientific data.

The developed simulation is an appropriate instructional material as it is based on the grade seven DepEd curriculum. Various published sources were used in obtaining the necessary information in the development of the e-SciLab simulation. The evaluators affirmed that the e-SciLab simulation is engaging and supplements learning. Simulations promote instructional effectiveness as a computer-aided instruction. Computer programs are integrated with the teaching and learning process that effectively supplements learning (Owodunni, 2019).

Discussion of the Results of the Activity Manual

Evaluation of Content Quality of the Activity Manual

The content quality of a learning manual is a comprehensive and self-contained unit that comprises of any learning activities arranged to assist students in achieving their unique and clearly stated goals (Nasution, 2011, p. 205).

The modified manuals highlighted interactive learning, aligned to the curriculum, and promote development of multiple intelligences and was stereotype-free. It provides teachers with activities and experiments that can be directly executed through the developed virtual laboratory simulation. Also, it is grounded in a learners-centered approach to education which emphasized that learners are the bearers of their learning process (Hollenweger, 2017).

According to Anggraini & Sukardi (2016), developed learning manual could anticipate the restrictions of available learning time, space, and the power of senses, whether students or teachers. Aside from that, the module can be utilized with pupils to help them learn on their own.

In the classroom, the process of teaching and learning between the teacher and the pupils is still monotonous. This repetitious learning process may have an impact on student learning outcomes. According to Hamid, Nyeneng, & Rosidin (2013), the learning process is not only the transformation of knowledge from teacher to student by memorizing and understanding a number of concepts that appear semi-detached from real life, but it is also emphasized in an effort to assist students in upgrading their life skills from what they have learned, necessitating learning process innovation and creativity. The content quality of the module is a crucial part of the learning process since it can help teachers deliver courses and students learn more readily in the learning process (Pendidikan & Vokasi, 2017).

In the learning process, content quality of a module serves as a springboard of a set of systematic learning activities based on a curriculum that is suited to the competencies that students must acquire. The benefits of having a well-linked content of a learning module enable students to utilized learning since it is self-contained, so students do not need to rely on the teacher to attain the desired competencies through learning activities. This was supported by Anggraini & Sukardi (2015), who stated that learning materials in the form of modules are designed to assist teachers in providing learning experiences that involve mental and physical processes through interaction between students, students with teachers, environment, and other learning resources in the context of achieving the expected competencies. The targeted learning experiences can be fulfilled by using a learning-centered approach to pupils that includes the life skills they'll need to compete in the workforce.

Evaluation of Technical Quality of the Activity Manual

The technical quality of the activity manual contains specific directions to easily navigate the developed laboratory simulation. It contains step by step process, which guided the teachers to facilitate the students in performing the activity in the developed virtual laboratory simulation. Based from the response of the evaluators, they agreed that the technical quality of the teacher's manual was easy to understand, layout and design were attractive and appropriate (Alegre, 2012).

Unlike the module created by the Department of Education, this activity manual is specific to the use of supplementary material thus the technical quality is reflected from the e-SciLab virtual laboratory. The layout and design was found to be appealing by the evaluators because of its simplicity and easy to be comprehended by the students.

On the other hand, according to Mercado (2020), his study was suggested that artistic layout and the over-all look of the manual should be improved. Research literature suggests that the quality of learning material is enhanced if the material is designed to take into account the learners individual preference and learning style.

The design and technical aspect really matters in the manual. Based on one of the evaluator, "*usage of words should be observed all the time because the students are Grade 7 students and unfamiliar words can cause difficulty in learning*." This aspect of the activity manuals was clearly observed by the researchers' although-out the process of making and designing the activity manual.

Evaluation of Instructional Quality of the Activity Manual

The evaluators strongly agree that the activity manual provides feedback on accuracy of the student's answer, has a high educational value, a good supplement to the curriculum, and addresses the needs and concerns of the students. The learning module provides systemic learning activities that are tailored to the learning competencies. A module also provides learning resources that links the learners' needs, aims, and learning outcomes (Jurnal Pendidikan & Vokasi, 2017).

The findings of the evaluation on the instructional activity of the manual dictates that the manual facilitates collaborative and interactive learning, integrates students' previous experience, and the manual introduction helps answering test questions. The modular instruction as an approach in learning promotes instantaneous reinforcement and allows the learners to learn in their own stride. Using modules in instruction maximizes the student's involvement and stimulates their curiosity. Learners use their own effort at their own pace to learn the concepts which stimulates their critical thinking skills (Ambayon, 2020).

The results of the evaluation on instructional quality indicate that the activity manual adheres to the current trends in physics instruction and experiments, and the graphics, and colors used are appropriates for instructional objectives. An enhanced module can bring significant improvement to the students' academic performance. The use of modules in teaching STEM subjects significantly improved the students conceptual understanding and performance level. The learning modules also follows 21st century learning design rubrics which regulates the design and layouts of developed learning modules (Barquilla & Cabili, 2021).

Discussion of the Results of the Virtual Laboratory Simulation

Evaluation of Content Quality of the Simulation

Additionally, all the activities included in the developed e-SCILAB simulation allows the development of multiple intelligences and free from ethnic, gender, and other stereotypes. Virtual laboratories promote inquiry learning that encourages the mastery of skills of the learners (Hermansyah, 2017).

Virtual laboratories are learning environments in which students translate their theoretical knowledge into practical knowledge by doing experiments, simulating a real laboratory atmosphere and processes (Woodfield, 2005).

It allows students to engage in meaningful virtual experiences while also introducing them to fundamental concepts, principles, and procedures. Students can use virtual laboratories to replicate any incorrect experiments or to delve further into the desired experiences. This is further supported by Cakir and Tirezs (2006) research study which indicated that inquiry-based science teaching and learning, with the use of computer simulation and other technology, can be effective. Learners can improve their critical thinking and inquiry abilities by working in groups.

Students become more involved in their learning in an interactive learning environment that uses simulations as the basis for virtual labs for abstract topics. This allows students to develop and understand difficult concepts more easily (Demirci, 2003). In this way, content-appropriate simulations and simulation-based applications might help students learn faster by allowing them to readily communicate their real-life reactions (Karamustafaoglu et al., 2005). Students can express their cognitive style and choose from a variety of options on the computer screen in better designed virtual labs.

Such opportunities enable students to form their own hypotheses about the issues and create their own problem-solving strategies (Windschitl ve Andre, 1998). Furthermore, students who are taught using assisted laboratory content education are more successful than students who are taught using traditional techniques, and laboratory activities are taught alongside theoretical knowledge in physics.

The science teachers affirmed that the content of the simulation help students build strong ideas, evaluates student learning and relevant to the learning objectives. The use of virtual simulations promote a constructivist approach to learning that aids learners in constructing their own ideas about science concepts (Faour and Ayoubi, 2018).

Evaluation of Technical Quality of the Simulation

The science teachers strongly agree that the manipulative controls of the developed simulations are comprehensive and directive, the simulation program runs smoothly, users of the simulation can easily and independently use the program, and the simulation program is aesthetically pleasing. Virtual simulations are designed with a specific tool in recreating a specific set of experiments which gives the users and developers a firm control in when using the simulations. Learners can also use virtual simulations to control their pace of learning as virtual laboratories allows users to repeat the demonstration of the experiment (Wästberg et al., 2019).

Based on Aşıksoy & Islek, (2017), simulations are a technology used with an educational purpose which is to transform theoretical knowledge into skills. They are software programs which replicate the basic components of the real world to provide controlled learning environments. Being an alternative solution for costly laboratories, enabling students to progress at their own pace, providing students with immediate feedback so that they can check their learning.

Virtual laboratories provide students with meaningful virtual experiences and present important concepts, principles, and processes. By means of virtual laboratories, students have the opportunity of repeating any incorrect experiment or to deepen the intended experiences. Research studies have indicated that visualization of phenomena through computer simulations can contribute to student's understanding of physics concepts at the molecular level by attaching mental images to these concepts (Ranjan, 2017).

According to Okoyeigbo, et. al. (2020), the system becomes easier to operate as the simulation's technical quality improves. It also has a user-friendly graphical user interface, and simulation results demonstrate that mistakes may be avoided by employing coding methods, which supports theoretical notions. Students studying Communication Systems courses in higher institutions and other interested parties might benefit from this bundle. This virtual laboratory is also available at the convenience of learners and interested participants.

Virtual laboratories allow working with a wide range of investigated elements and their parameters and provide a wide variety of operating modes of experimental devices. In addition, within virtual laboratories it is possible to create and realize a large number of options for individual tasks in carrying out a laboratory as a practical training for students. This, in its turn, increases the efficiency of the individual approach to students, enhances the effectiveness of learning, as well as develops the spatial visualization ability (Daineko, et. al., 2016).

Evaluation of Instructional Quality of the Simulation

The evaluators strongly agree that the developed simulation provides feedback on correctness of the student's answer. Virtual laboratories is an interactive tool that provides instant feedback procedures that caters the needs of the learners (August et al., 2016). The science teachers strongly agree that the developed simulation has a high educational value, a good supplement to the curriculum, addresses the needs and concerns of the learners, and facilitates collaborative and interactive learning. The virtual laboratory provides an immersive experiment that contains interactive visualizations and simulations that meet the needs of the learners (Jensen, 2015).

The evaluators also affirmed that the developed e-SCILAB simulation integrates the student's previous experience, helps answering test item questions, reflects current trends in Physics, and contains appropriate graphics and color for the instructional objectives. Virtual laboratory simulations guide learners through a series of learning activities and concepts which are related to one another. Interactive elements are also embedded in a virtual laboratory which meets the needs of STEM education and caters the needs of diverse learners (August et al., 2016).

The selected science experts agree that the developed simulation has a high educational value. Virtual simulation provides learners with individualized instruction that promotes self-efficacy. Using virtual simulation as an instructional strategy promotes enthusiasm to the learners and encourages an increase in productivity (Owodunni, 2019).

The result of the evaluation indicates that the developed simulation helps in answering the test item questions found in the module. The use of virtual simulations as a strategy in instruction increases the conceptual understanding of the learners. Instructional needs of the learners are met through the use of simulations that promotes an increase in understanding of key concepts (Darby-White et al., 2019).

Conclusion

Considering the data gathered and organized, the following conclusions were formulated;

1) The developed virtual laboratory simulation met the expected standards and deemed as functional, interactive and aligned to the learning competencies in the curriculum guide for the grade 7 science of the Department of Education (DepEd)
2) The virtual laboratory simulation together with the teacher's and learner's manual supplements learning by promoting interactive animations in the activities and coincides with the needs of the learners
3) The developed E-SciLab was considered by the evaluators to have met the intended standards and satisfied the quality components. The result of the assessment indicate that the developed simulation adheres to all the descriptors under the content quality, technical quality, and instructional quality.

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