The Feasibility Test on Laboratory Based on Virtual Instrument System as Nature of Science Learning Media

Supahar
Faculty of Mathematics and Natural Science
Universitas Negeri Yogyakarta
Yogyakarta, Indonesia
supahar@uny.ac.id

Eko Widodo
Faculty of Mathematics and Natural Science
Universitas Negeri Yogyakarta
Yogyakarta, Indonesia
ekowidodo@uny.ac.id

Abstract—**The disruption era placed the digital industrial world as the paradigm and the new reference in the order of life that caused significant changes known as the Industrial Revolution 4.0. It also affects the laboratory as an integral part of science learning that contains teaching materials, media, facilities, strategies and assessment systems. To optimize the real laboratory as the development of hands-on science, it should be supported by a laboratory based on virtual instrument system (Lab-Vis) model to facilitate various practicums with interactive animation to emphasize the inquiry approach or syntax of "Observing", "Asking", "Testing", "Analyzing" and "Delivering". This study aims at producing the Lab-Vis model as the learning media of the Nature of Science (NOS). The Research and Development (R&D) method in this study employed the Five Phases of the Spiral Teaching Model adapted from the "Five Phases of Instructional Design" by Cennamo and Kalk, [1]. The syntax of this spiral model was done through 5 (five) development phases, i.e. (1) define, (2) design, (3) demonstrate, (4) develop, and (5) deliver. The results of this study were the laboratory model based on virtual instrument system as the learning media for NOS that was feasible based on the assessment results from the material and media experts. This developed product was also considered practical according to junior high school teachers and students who joined science courses.**

Keywords: laboratory, virtual instrument system, learning media, nature of science

I. INTRODUCTION

The Minister of Research, Technology and Higher Education of Indonesia, Mohamad Nasir, in the *'The Education World Forum 2018: Global Summit for Education Minister'* in London, January 22-24, 2018 explained that; "The crucial factors among young human resources to face the industrial revolution 4.0 are determined by the quality of lecturers, teachers, and other educators.

They must be able to adapt to new technologies, global challenges and social entrepreneurship. The adoption in the industrial revolution 4.0 can be seen by the ability of Indonesian people in creating various breakthrough innovations. He added that Indonesia has expanded the IT capability, the internet access and the protection for 'Cyber Security' and it shows the readiness of Indonesia to face the 4.0 era. (http://www.pikiran-rakyat.com/pendidikan/2018/01/25).

The Industrial Revolution 4.0 marked by disruption began to be popular issues from a book called "The Fourth Industrial Revolution", [2] This revolution has fundamentally changed on the way of life and work among people. Unlike the previous industrial revolution, the fourth generation revolution has a wider scale, scope, and complexity. The disruption era placed the digital industrial world as the paradigm and the new reference in the order of life that caused significant changes. This change demands the education world to adjust so that it remains as the integral transformational part. In the education area, the adaptations must be comprehensively done including teaching materials, media, learning tools, and teaching and learning strategies that are oriented to the 21st-century requirements. Science, technology and society approach is suggested because society really needs scientist contribution in science in solving a problem related to using technology in the field in many life activities [3].

This change also affects the laboratory as an integral part of science learning that contains teaching materials, media, facilities, strategies and assessment systems. To optimize the real laboratory as the development of hands-on science, it should be supported by the a laboratory model based on virtual instrument system (Lab-Vis) to facilitate various practices with interactive animation to emphasize the inquiry approach or five syntax of "Observing", "Asking", "Testing", "Analyzing" and "Delivering". This study generally aims at producing the Lab-Vis model as the learning media for Nature of Science (NOS) to improve the students' data and technology literacy to face the disruption era. This model is needed and has a strategic value to develop

students' hands-on and minds-on in order to produce learning based on laboratory activities as well as to improve the processing skills among students .

NOS is an inherent value and assumptions to develop scientific knowledge [4] since the course of Natural Sciences deals with how to learn about nature systematically. It makes science not only in case of mastering the knowledge collection in the form of facts, concepts, or principles but also about the discovery process [5]. The important aspect of NOS is to distinguish between observation and inference as well as to understand theory and sciences law [6]. The students who have better NOS awareness will be ready to become a future leader and to have a high-responsibility. [7]. However, the lack of ICT and android technology use hinders the optimum quality of the learning process. SETS best practice model produces learning that can provide basic skills among students for their development as human beings, community members, and citizens, to be ready for their further education level [8].

One of the important elements in NOS development is the use of local wisdom as the source of science learning. The local wisdom is gained from certain community or ethnicity based on their experiences that may not be owned by other communities. These values are strongly embedded in a particular community or ethnicity in a long period, even its existence is almost equal to those certain community [9]. The efforts made by [10] in designing science learning based on local wisdom showed positive improvements on eleven positive characters among students and the biggest effects were on honesty, discipline, thoroughness, diligence, carefulness, responsibility, and environmental care.

II. RESEARCH METHODS

The research design used Research and Development in which the research flow is described in Figure 1.
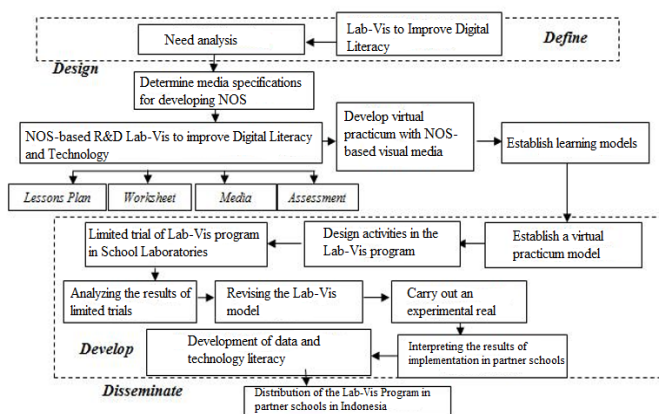

Fig. 1. The research flow

The information collection phase [11] was the initial stage of research and data collection in the form of literature studies, needs analysis and field studies. The design or planning phase was the product design that will be produced including the purpose, description, and components of the Lab-Vis model in NOS-based science learning. The develop or preliminary form of product development phase was the initial product development. Meanwhile, In the disseminate phase, there were four steps of development, namely preliminary field testing including initial field trial, main product revision or revision based on the trial results, main field testing or main field testing and operational product revision [11] or product finalization based on the field trial.

The research procedures were carried out through the model of Research and Development (R&D). The main purpose of this R&D was to develop and validate a virtual laboratory model in NOS-based science learning which was effective and ready to be implemented to realize digital and technology literacy. The R&D stages were formulated into 4-D Models (Four-D Models) [12] with several adjustments [11].

In the define phase, it contained the research and information collection, including; (1) theoretical analysis or literature study on Lab-Vis of NOS-based science learning to realize digital literacy and technology (2) needs assessment to identify the key processing skills and analyze them in the required sub-skills. This analysis guaranteed the comprehensive tasks within Lab-Vis to realize digital and technology literacy involving the approach planning, the learning models selection, and the evaluation designs. The activities of assessment development included information discussion, modeling, assignments, group work, and practice. The evaluation of the Lab-Vis application in science learning incorporated observation, performance and practice tests as well as NOS-based learning models which were conducted collaboratively.

The identification phase of the developed main concepts in compiling Lab-Vis of NOS-based science learning was arranged in a hierarchy and elaborated on the main activities. The activities of Lab-Vis development comprised the whole students' activities in learning, i.e. assessment of learning, assessment for learning and assessment as learning.

Various types of teaching product development models are closely related [13]. The development process was done stage by stage. In reality, the process of product development must pay attention to various supporting details to create a recursive process. By considering that the assessment development cannot be separated from the context

of management and learning organization, the spiral model was chosen that referred to Cennamo and Kalk [1]. In this spiral model, there were 5 (five) development phases, namely: (1) define, (2) design, (3) demonstrate, (4) develop, and (5) deliver.

The development was done from the definition phase (as the starting point of the activity), into the design phases, demonstration, development, and delivery within a spiral process and involved the potential users, the experts from the developed fields (subject matter experts), the team members and the instructors, and the students. At each development phase, the focus will be on the learning elements, namely outcomes, activities, students, assessment and evaluation. The development process was through the iterative cycles from a drafted vision into a concrete product that had been proven its effectiveness, as mentioned by Dorsey, Goodrum, & Schwen, 1997 ([1]] as "the rapid prototyping process".

Fig. 2. The Five Phases of the Spiral Teaching Model Design adapted from 'Five phases of instructional design' by Cennamo and Kalk [1]

Note:

——————— the development phases
·············> the direction of development phases

In each phase of development, it will be continuously faced with the important elements of the teaching design, such as final goal, learning activities, students, assessment and evaluation.

The phases can be described as follows:
1. The define phase was conducted by determining the scope of activities, outcomes, schedules and delivery alternatives. This phase resulted in proposed development activities for needs analysis, objectives formulation, success indicators, final products, strategies for testing the effectiveness of programs and products.

2. The design phase included the planning outline that will produce the teaching design document and assessment.
3. The demonstrate phase was to develop the design specifications and the quality of facilities and media for the initial product development that resulted in the form of detailed documents about the product (storyboards, templates, and prototypes of learning media).
4. The develop phase referred to the stage that was serving and guiding students that resulted in the form of complete teaching materials. Its core activity was the efforts to ensure that all designs can be used by the users and met the objectives.
5. The deliver phase contained a continuation phase to present materials to clients and provide recommendations for future use; the outcome of this phase was the conclusion of the successful product design that was developed for the user benefit and the involved parties.

The spiral model can be used in various development models including the assessments, learning management and the learning content. By referring to the recursive pattern in this spiral model, it can be developed by a peer assessment model in collaborative learning management.

The general objective of this study is to create an integrated geographic information system (Lab-Vis as a learning media of NOS). The most appropriate method to achieve the research objectives was Research and Development (R&D). According to Gay (1990), the R&D approach can be used in situations where the main objective is not testing some theory but developing and validating the tools that are effective and ready to be implemented. Moreover, Borg and Gall [11] mention that "educational research and development (R&D) is a process used to develop and validate educational production". Based on this understanding, it can be seen that the research steps are cyclical series in which each step considering the results of the previous steps until a final new educational product is obtained. The products are developed to meet the needs and based on specified requirements. R&D createD products that had been validated through field tests and revised for its effectiveness. Though the R&D cycle can be considered expensive, it is proven to be able to produce qualified products that meet the learning requirements.

Borg and Gall [11] propose a series of stages that must be taken in the R&D approach, namely "Research and information collecting, developing preliminary forms of product, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing , final product revision, and dissemination and implementation". If these steps are done correctly, it is assumed that the research can produce some
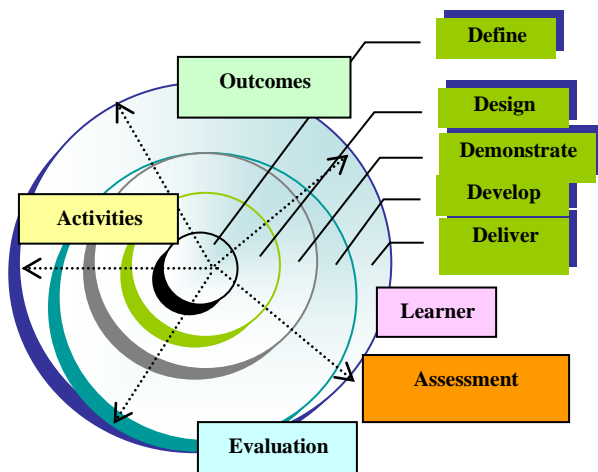
educational products that are ready to use at the school level.

In the research and information collecting or the preliminary study stage, the activities contained library studies that underlined the developed educational products, class observation, and research and development framework for educational products.

In the case of the planning stage, it was implemented after the preliminary study by designing various activities and procedures that will be taken in the study. Those were formulating the specific objetives; estimating the funds, energy, and time for product development; formulating the researcher's ability, work procedures, and forming the participation model during the research; and designing the feasibility test.

The development of the preliminary from the product was the design stage of the initial draft product that was ready for the trial section including the facilities and infrastructure for product testing and validation, evaluation tools and others. The preliminary test and product revision fields aimed at obtaining the setting of the application or product feasibility when the product had been developed. This trial was limited and the results were used as guidance to make revisions on the product. The limited trials can be repeated until the draft product was ready to be tested in a wider scope.

The main field test and product revision were usually referred to the main trial in a wider scope. The purpose of this stage was to determine the extent to which the developed product was ready to be used in schools without the researchers or product developers. Generally, this stage was known as the model validation stage. Meanwhile, the purpose of dissemination was that the developed product can be used by the wider community. The core activity in this stage was to socialize the results of product development.

III. RESULTS AND DISCUSSION

A. Product Characteristics (Lab-Vis as NOS learning media)

Lab-Vis as the nature of science (NOS) learning media is to improve the quality of science learning by utilizing internet-based information and communication technology. It uses various data, information, laboratory facilities and knowledge in science laboratories (schools) in creating virtual learning. This model is different from a number of other applications with similar goals since the concept of Lab-Vis as NOS learning media emphasizes the students' development on their visual, auditory and kinesthetic modalities in integrated science learning.

Firstly, data sourcing was related to the ability of the system to access various data and information from numerous tools and materials as well as the characteristics of Physics subjects. Secondly, data analysis referred to the ability of the system to assist the process of creating knowledge through the assessment of data and information in the science laboratory. Thirdly, the situation awareness focused on the ability of the system to find and provide data and information related to the needs or context of tools and materials in accordance with the practicum to be taught. Fourthly, the risk analysis involved the ability of the system to calculate the risks that will be faced when carrying out its activities in the science laboratory towards various trends or possibilities in certain conditions. Fifthly, the decision support contained the ability of the system to actively assist the policymakers (head of the laboratory) in giving consideration to the decision to implement the qualified science learning, DSS (Decision Support System), based on a number of calculations and consideration from internal or external data or information.

The research that had been carried out in the first year of Higher Education Applied Research was: (1) the compilation of Lab-Vis program of NOS with several integrated topics for science practicum; (2) the content and construct validation that had been carried out on Lab-Vis of NOS by the learning and media experts; (3) the Lab-Vis to develop NOS was tested at the partner schools in the Special Region of Yogyakarta.

The Lab-Vis application to develop NOS was a client-server based system where client computer was only integrated with end-user system and client-requirements. Meanwhile, the computer server can be integrated with database systems and server requirements. Lab-Vis to develop NOS can also be applied to one computer machine that contained the whole part of the system, i.e. end-user system of Lab-Vis of NOS development, servers and client requirements, along with the database system.

In the Lab-Vis application of NOS development, the security and access permission was developed with the User Security Level and User Role. Each user was based on each individual teacher for each school. Only "admin" users acted as Super Users, Administrator user as "default" users were not based on individual teachers. To provide a clearer description, the following program design drawings explain the concept of Lab-Vis of NOS development within science learning.

The limited field trials were done at the partner schools located in Bantul Regency and Sleman, the special region of Yogyakarta. This trial involved 34 students to reveal the practicality and effectiveness of Lab-Vis by using valid and reliable literacy instruments. The data obtained from the field trials included the students' learning outcomes of natural sciences in the form of virtual practicums, observations data on digital literacy through learners'

practicum reports, and data from practicality assessment worksheet.

The digital literacy assessment was carried out by assessing the results of students' practicum in the form of experimental reports. The assessment was done in learning that applied the learning model in the form of virtual practicum. These assessments on the learning implementation of virtual practicum were on the four meetings of the learning activities based on the syntax of virtual experiment activities. Teachers can run learning activities according to the learning plan. The learning syntax on the stage of student practicum reports can be carried out in each meeting for being assessed. The activities of teachers and students during the learning process in the form of virtual practicum is presented in Figure 7.
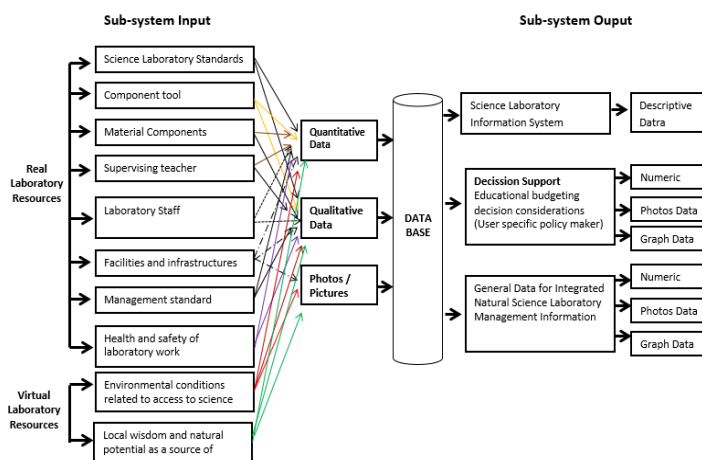

Fig. 3. Lab-Vis Model as a Learning Medium for Nature of Science (NOS)

The following are the type of user roles and their access permission.

1) Administrator

The role Administrator User almost has full access permission to all menus, functions, and modules that existed in the application. The authority and duties of the Administrator are

a. Open and close the learning year
b. Laboratory profiles management
c. User management
d. Teacher management
e. students Management
f. Class management
g. Course Management
h. Tool management
i. Material management
j. Teaching Management
k. Assessment Management

2) Practicum Teachers

The role of practicum teachers has access permission in the form of the authority of individual teachers who also act as practicum

advisers. The authority and duties of the practicum teachers are as follows.

a. Practicum groups Management
b. Overall practicum implementation
c. Learning progress report

3) Laboratory assistant

The role of the laboratory user was in the form of individual authority that only acts as laboratory assistant. The authority and duties of laboratory assistant are:

a. Tools management
b. Material management
c. Infrastructure management
d. Practicum schedule

The application that was designed and tested was Lab-Vis of NOS development for the visual practicum systems in junior high school science subjects, with the following configurations:

4) The Instructions of Lab-Vis Installation to develop NOS

- Minimum Specification
  The minimum hardware specifications to run the Lab-Vis application to develop NOS are a Computer with Intel Core or AMD Processor and 2 GB RAM and Printer.

  The minimum software specifications to run the Lab-Vis application to develop NOS involve:
  1. Windows XP Professional Service Pack 3 (client).
  2. Windows Server 2003 Standard Service Pack 2 (server).
  3. Microsoft .NET Framework 3.5 or Microsoft .NET Framework 4.5.1.
  4. Microsoft SQL Server 2008 Express with Microsoft SQL Server Management Studio.
  5. Crystal Report 2008 Runtime.
  6. Microsoft Office Word dan Excel.
  7. Adobe Reader.
  8. Driver printer.

- Installation

  Before starting the installation process, make sure the Windows user account is the Administrator type and set Windows Control Panel configuration -> Regional and Language, the Formats tab -> the English (United States) format and the Administrative tab -> Current Language for non-Unicode programs.

  The Microsoft .NET Framework 3.5 is installed on the server and the client computer. The installation of the Microsoft

.NET Framework 3.5 for the Windows XP operating system uses the dotnetfx35.exe file and 4.5.1 for the Windows operating system Windows XP, Windows Vista, Windows 7 or Windows 8 using the NDP451 file - KB2858728-x86-x64-AllOS-ENU.exe. If the Microsoft .NET Framework has been already installed on your computer, so there is no need to install it if no problems encountered. Double click on the file to start the installation process.
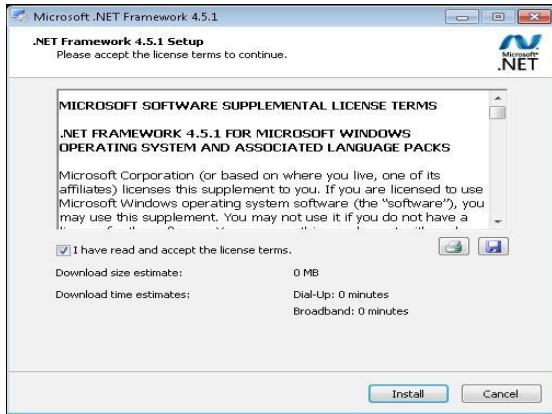

Fig. 4. Lab-Vis Installation

Click on the instruction of "I have read and accept the license terms" option and the Install button to begin the installation process.

- Installation of Microsoft SQL Server 2008 Express With Tool

    Installing Microsoft SQL Server 2008 Express With Tool uses the SQLEXPRWT_x86_ENU.exe file for computers with x86-bit edition and SQLEXPRWT_x64_ENU.exe for computers with x64-bit edition. Double click on the file to start the installation process.
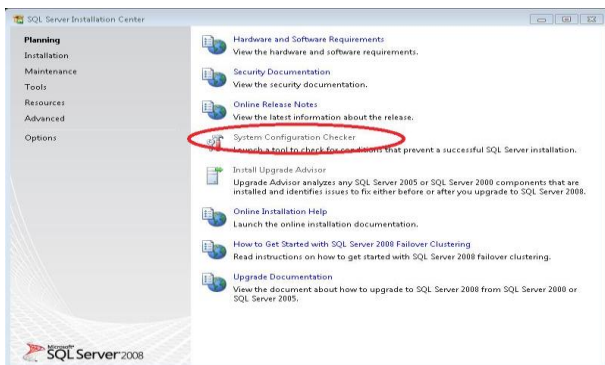

Fig. 5. Microsoft SQL installation

Click on the "System Configuration Checker" to check the configuration of the computer system during pre-installation.

If the "Failed" status appears, the installation cannot proceed. So, the problem must be fixed before continuing the installation process. Click "OK" to proceed to the next step.

In the next stages, the server and client computer machines have different processes and configurations. For server computer, click Select All to choose all options, namely Database Engine Services, SQL Server Replication, Management Tools-Basic, and SQL Client Connectivity, while the client computer only requires to tick the choices of Management Tools-Basic and SQL Client Connectivity.

Crystal Report 2008 Runtime is only installed on the client computer. The Crystal Report 2008 Runtime installation uses the CRRedist2008_x86.msi file for computers with x86-bit edition and CRRedist2008_x64.msi for computers with x64-bit edition. Double-click on the CRRedist2008_x86.msi file to start the installation process.

- Lab-Vis installation to develop NOS

    Lab-Vis to develop NOS is only installed on client computer. The installation of Lab-Vis of NOS development using the setup.exe file or the SetupLab-Vis file to develop NOS.msi. Double-click on the setup.exe file to start the installation process.

    Make sure the installation folder is under "C: \ andihermantyo \ Lab-Vis to develop NOS \". For the Lab-Vis of NOS development, it is only used for one Windows user account, tick "Just Me". For the Lab-Vis application of NOS development that is more than one Windows user account, tick "Everyone" and click Next to continue to the process.

5) *Configuration*

- Database Configuration

    These configuration instructions are only used for server and client systems that are on one computer. For system configuration with server and client systems on different computer machines, please consult the Lab-Vis Application Developer first.

    To start database configuration, double-click the SQL Server Management Studio shortcut on the Windows Start Menu -> Microsoft SQL Server 2008. The main Microsoft SQL Server Management Studio window will appear with the "Connect to Server window". If the "Connect to Server window" does not appear, click "Connect

on the Object Explore"r tab, then click "Database Engine".
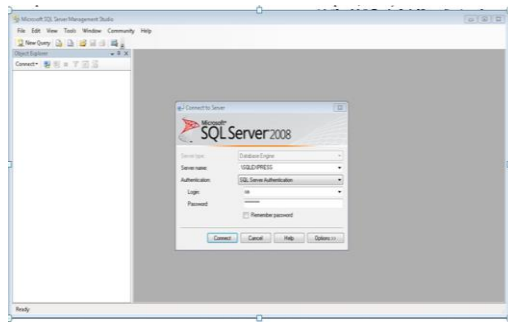

Fig. 6. Microsoft SQL installation

- Lab-Vis Configuration System to develop NOS

These configuration instructions are only used for server and client systems that are on one computer machine. For system configuration with server and client systems that are on different computer machines, please consult with the Lab-Vis Application Developer first.

Make sure in the Windows Control Panel configuration -> Regional and Language, the Formats tab -> English (United States) format and the Administrative tab -> Current Language for non-Unicode programs is the English (United States) format.

To begin configuring Lab-Vis to Develop NOS that has been installed, double-click the Lab-Vis shortcut to develop NOS on the Start Menu -> Lab-Vis to develop NOS or double-click the Lab-Vis shortcut to develop NOS on the desktop. The Lab-Vis application will appear with the Main page and a Dialog window with the message "Error: The ConnectionString property has not been initialized". Click OK to proceed to the next step.

After that, the Server Configuration window will appear. Select LAN CONNECTION (SQL Server Authentication), then fill in the Server Name with ". \ SQLEXPRESS". Login with "sa". Fill in the password with the password that was entered earlier at the Microsoft SQL Server 2008 installation stage. Click the "Simpan" button , the Log In Lab-Vis to Develop NOS page will appear and the Lab-Vis to Develop NOS application is ready to use.

6) Uninstall Process

To uninstall the Lab-Vis application to develop NOS, select and double-click on LAB-Lab-Vis to

develop NOS in the list of programs in Windows Control Panel -> Programs -> Programs and Features (Uninstall or change a program). Click the "Yes" button to confirm.

The limited field trials were done at the partner schools located in Bantul Regency and Sleman, the special region of Yogyakarta. This trial involved 34 students to reveal the practicality and effectiveness of Lab-Vis by using valid and reliable literacy instruments. The data obtained from the field trials included the students' learning outcomes of natural sciences in the form of virtual practicums, observations data on digital literacy through learners' practicum reports, and data from practicality assessment worksheet.

The digital literacy assessment was carried out by assessing the results of students' practicum in the form of experimental reports. The assessment was done in learning that applied the learning model in the form of virtual practicum. These assessments on the learning implementation of virtual practicum were on the four meetings of the learning activities based on the syntax of virtual experiment activities. Teachers can run learning activities according to the learning plan. The learning syntax on the stage of student practicum reports can be carried out in each meeting for being assessed. The activities of teachers and students during the learning process in the form of virtual practicum is presented in Figure 7.
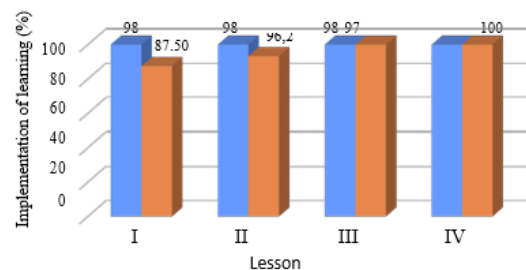

Fig. 7. The implementation of teacher and students activities in using Lab-Vis program

The digital literacy observation sheet in the field trials had been through the validity and reliability test. The measurement of digital literacy among students included the ability to providing simple explanations, generalization, conclusion, further explanations, and strategic steps formulation. The mean digital literacy score obtained by students was converted to the four scale category. The conversion results based on Mardapi [14] that are presented in Table I.

TABLE I.   SCORE CONVERSION IN 4 SCALE SCORE

No	Score range	Scores	Category
1	$X \geq 3,3$	A	Very High
2	$3,3 > X \geq 2,9$	B	High
3	$2,9 > X \geq 2,5$	C	Low
4	$X < 2,5$	D	Very Low

The achievement level of the students' digital literacy aspects in four meetings. The measured aspects consisted of internet searching, hypertextual navigation, content evaluation, and knowledge assembly. In detail, the results of the internet searching aspects at the first, second, third, and fourth meetings can be seen in Table 9. The results of the achievement of students' scores were converted based on Table 1 with the category of "very high", "high", "low", and "very low" [14]. The results of the students' conversion scores consecutively from the first to the fourth meeting were "very low", "low", "high", and "very high". The average achievement level of the internet searching aspect from the first to fourth meeting was 58.24%; 67.50%; 78.38%; and 87.94% respectively. Based on the measurement results, it indicated that the escalation of students' internet searching aspects from each meeting. The highest result was in the second to the third meeting.

The results of the hypertextual navigation aspects at the first, second, third, and fourth meetings can be seen in Table 9. The results of the achievement of students' scores were converted based on Table 8 with the category of "very high", "high", "low", and "very low" [14]. The results of the students' conversion scores consecutively from the first to the fourth meeting were "very low", "low", "high", and "very high". The average achievement level of the internet searching aspect from the first to the fourth meeting was 52.57%; 64.71%; 85.29%; and 90.44% respectively. Based on the measurement results, it indicated that the escalation of students' hypertextual navigation aspects from each meeting. The highest result was in the second to the third meeting.

The results of the content evaluation aspects at the first, second, third, and fourth meetings can be seen in Table 9. The results of the achievement of students' scores were converted based on Table 8 with the category of "very high", "high", "low", and "very low" [15]. The results of the students' conversion scores consecutively from the first to the fourth meeting were "very low", "low", "high", and "very high". The average achievement level of the content evaluation aspect from the first to the fourth meeting was 46,69%; 62,87%; 78,68%; and 82,35% respectively. Based on the measurement results, it indicated that the

escalation of students' content evaluation aspects from each meeting. The highest result was in the first to the second meeting.

The results of the knowledge assembly aspects at the first, second, third, and fourth meetings can be seen in Table 9. The results of the achievement of students' scores were converted based on Table 8 with the category of "very high", "high", "low", and "very low" [14]. The results of the students' conversion scores consecutively from the first to fourth meeting were "very low", "low", "high", and "very high". The average achievement level of the content evaluation aspect from the first to the fourth meeting was 56,00%; 67,65%; 86,03%; dan 93,38% respectively. Based on the measurement results, it indicated that the escalation of students' knowledge assembly aspects from each meeting. The highest result was in the second to the third meeting.

IV. CONCLUSION

This research has succeeded in developing Lab-Vis as the nature of science (NOS) learning media to improve the quality of science learning. It is different from a number of applications with similar goals, the concept of Lab-Vis as NOS learning media emphasizes the use of information for the specific needs to enhance students' visual, auditory and kinesthetic modalities in such integrated science learning. The Lab-Vis products were declared feasible by material experts and media experts and had been tested for developing the students' digital literacy in junior high school. The students' digital literacy aspects involved internet searching, hypertextual navigation, content evaluation, and knowledge assembly.

REFERENCES

[1] K Cennamo and D. Kalk, Real Word Instructional Design. www. amazon. com. Retrieved on 3 August 2018.

[2] "The Fourth Industrial Revolution: what it means and how to respond," World Economic Forum. Retrieved on 2018-03-20.

[3] D. Rosana, N. Kadarisman, A. Maryanto, A. Sugiharsono, "The Evaluation of Science Learning Program, Technology and Society Application of Audio Bio Harmonic System with

Solar Energy to Improve Crop Productivity," Jurnal Pendidikan IPA Indonesia. Volume 6, 2017, pp. 63-70

[4] N.G. Lederman, J.S. Lederman, and A. Antink, "Nature of Science and Scientific Inquiry as Contexts for the Learning of Science and Achievement of Scientific Literacy," International Journal of Education in Mathematics, Science and Technology, 1(3), 2013, pp.138-147.

[5] E., Ö Hacıeminoğlu, Yılmaz-Tüzün, and H Ertepınar, "Development and validation of nature of science instrument for elementary school students. Education Journal" 3-13 42 (3), 2014, pp.258-283.

[6] D.K. Sari and Supahar, "The Content Validity of Assessment Instruments to Measure Analogical-Transfer Ability" International Journal of Sciences: Basic and Applied Research (IJSBAR) 39(2), 2018, pp. 165-172.

[7] S.D. Vitasari and Supahar, "Assessment Instrument of Scientific Literacy Skills on Motion and Simple Machines Learning Based on Nature of Science," International Journal of Sciences: Basic and Applied Research (IJSBAR), 40(1), 2018, pp.108-119.

[8] D. Rosana, N Kadarisman, and IGP Suryadarma, "SETS best practice model: growth optimization and productivity of organic food plants through iasmuspec application. Jurnal Pendidikan IPA Indonesia, 8(2), 2019, pp.267-278

[9] A. Wibowo and Gunawan. "Pendidikan karakter berbasis kearifan lokal di sekolah (konsep, strategi, dan implementasi)," Yogyakarta: Pustaka Pelajar, 2015.

[10] B. Subali, A. Sopyan, and E. Ellianawati, "Developing local wisdom based science learning design to establish positive character in elementary school," Jurnal Pendidikan Fisika Indonesia, 11(1), 2015, pp.1–7. https://doi.org/10.15294/jpfi.v1 1i1.3998.

[11] W. R. Borg, and M. D. Gall, Educational Research: An Introduction, New York: Longman, 1983.

[12] T. Sivasailam, Instructional development for Training Teachers of Exceptional Children, Indiana: Cana University, 1975.

[13] A. Suparman, Desain Instructional, Proyek pengembangan Universitas Terbuka Ditjen Dikti Departemen Pendidikan Nasional, 2001.

[14] D. Mardapi, Teknik Penyusunan Instrumen Tes Dan Non Tes, Yogyakarta: Mitra, 2008.

[15] S.G. Sireci, and K.F. Geisinger, "Using subject-matter experts to asses content representation : an MDS analysis," Applied Psychological Measurement, 19(3), 1995, 241-255.