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Doctoral Dissertation

A Virtual Learning Platform for Developing Skills of Designing and Producing Online Virtual Laboratories

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Research Abstract

The expansion of using new virtual learning applications in educational institutions requires enhancing educators' skills of design and production in such applications. Those skills must be acquired by educational technology students for the future of education because they often lack the above skills in their curriculum. The main purpose of this research is to investigate the effectiveness of virtual learning platform (VLP) in order to cultivate the students' skills in designing and producing online virtual laboratory (OVL) with a standard way. In the context of this research, the OVL is an online practical environment for a specific topic, which makes learners active such as learning by experience and by trial-and-error. On the other hand, the VLP means a web-based learning system including several functions/tools for presenting and managing the OVL.

In order to teach the educational technology students how to design and produce OVL (DPOVL), a new instructional design (ID) model is proposed as standard components for teaching guidelines of DPOVL. Based on the literature review, the model is comprised of the following six phases; OVL pre-design, DPOVL criteria, OVL design, OVL production, OVL experiment-implementation, and OVL evaluation. Moreover, we present a list of practical skills in DPOVL to clarify which kinds of the skills to be cultivated in this research.

We also propose an educational software development process, especially for designing and producing the VLP by integrating some features from software engineering (SE) into the traditional ID framework. The proposed process contains the next five phases; analysis, construction, deployment, implementation, and evaluation, to develop a high-quality product with an iterative process. Based on these model and process, a new VLP software is developed with several innovative tools and special course contents to cultivate the target skills. The developed VLP consists of the following tool groups; a) Learning tools: They support online learning with interactive contents and web activities. b) Management tools: They assist the administration of online learning environment such as user management and content management. c) Communication tools: They facilitate collaboration between the students and the instructors with real-time and/or on-demand style. d) Innovative tools for OVL: They focus on the students' skill cultivation of DPOVL with a template method. e) Evaluation tools: They simplify assessment of the students' performance with various methods like quizzes, questionnaires, and rubric scales. f) Help tool: It guides the students to use the VLP tools through a brief explanation.

Eventually, the empirical experiment was conducted with a quasi-experimental research design

in order to evaluate the effectiveness of the proposed VLP in cultivating the skills of DPOVL. Thirty students, who were the fourth grade of undergraduate students majoring in educational technology, Faculty of Specific Education, South Valley University, Egypt, participated in the experiment. All the students as the participants were assigned to one group as a pre- and post-test design. The data were collected by using online instruments; achievement test, performance observation card, product evaluation card, and usability questionnaire. The results indicated that the VLP had a positive impact on cultivating the following knowledge and skills with significant effectiveness; a) Attaining the knowledge regarding theoretical and practical aspects of DPOVL, b) Acquiring the skills related to a practical aspect of DPOVL, c) Producing the OVL products in the various educational domains. It was also suitable for the educational technology students to learn with the proposed VLP in a comfortable way. From these results, the VLP could provide a significant learning environment to cultivate the specific skills in DPOVL.

In conclusion, there are five main contributions of this research in the educational technology field; firstly, it proposed a new ID framework to teach the educational technology students DPOVL with the fixed format and suitable components. Secondly, it defined the list of 34 practical skills for DPOVL. Thirdly, it adopted the iteration process in designing and producing the VLP to keep the educational software high quality. Fourthly, it provided the novel VLP with the template method to learn the practical skills effectively in DPOVL. Finally, the results of the experiment showed that there was the significant difference with the large effect size between the pre-test mean scores and the post-test mean scores of the experiment group with respect to developing knowledge and skills of DPOVL. In addition, the results indicated that the proposed VLP had a positive impact in producing the OVL products in several educational domains with high mastery level. In the end, the students strongly agreed on the usability of the VLP software.

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List of Abbreviations

ICT	Information and Communication Technology
VLP	Virtual Learning Platform
VLs	Virtual Laboratories
OVLs	Online Virtual Laboratories
DPOVLs	Designing and Producing Online Virtual Laboratories
ID	Instructional Design
ADDIE	Analysis, Design, Development, Implementation, Evaluation
SE	Software Engineering
UML	Unified Modeling Language
LMSs	Learning Management Systems
ACDIE	Analysis, Construction, Deployment, Implementation, Evaluation
MVC	Model-View-Controller
M	Mean
SD	Standard Deviation
DF	Degree of Freedom
SPSS	Statistical Package for the Social Sciences
Min	Minimum
Max	Maximum

Chapter I　Introduction

1.1. Problem Statement

In the twenty-first century, the technological revolution has made a great positive impact on diverse fields including education. Therefore, ICT becomes one of the essential elements of any educational systems/curriculums in recent years. This impact leads to the emergence of the numerous applications of technology in education, such as E-learning, distance learning, virtual learning, and mobile learning. In particular, it is noticeable that some educational systems have expanded using virtual learning applications such as virtual learning systems, virtual classrooms, and virtual laboratories (VLs) in schools and universities. These applications have common advantages about overcoming learning constraints of time and place, enhancing traditional learning, and sufficient and repeatable training.

The VLs are considered as a new ICT application for improving education. This application has many advantages regarding aspects of economic for lower costs and maintenance, rich laboratory equipment, safety for harmful and dangerous experiments, sufficient learning environment, support of real laboratories, motivation for learners, understanding clearly without ambiguity, interactivity in the learning, accessibility via internet remotely, creation by testing new variables, and integration with online courses in the same learning environment. Diverse empirical previous studies also addressed the VL technology in various fields of science (Finkelstein et al., 2005; Yang & Heh, 2007; Zacharia, 2007; Sun, Lin, & Yu, 2008; Tüysüz, 2010; El-Sabagh, 2011; Herga & Dinevski, 2012; Kollöffel & de Jong, 2013; Bajpai, 2013; Lampi, 2013; Cheesman et al., 2014; Mutlu & Şeşen, 2016). These studies confirmed significant and positive impacts of the VL technology like offline and online VLs in enhancing the attainment of knowledge and practical skills for target learners.

In order for educational technology students, who are responsible for next generation education, to apply such technology in actual classroom education, they need to have the skills in designing and producing the OVL (DPOVL) products. In this context, the OVL is considered as a web-based environment which includes virtual experiments for alternatives to real laboratory experiments, invisible phenomenon, and skills or concepts related to the specific educational course. The students have potentials for implementing such technology in the future schools and universities. Moreover, the ideal academic programs at their universities should offer the class of how to design, develop, utilize, combine, and evaluate modern ICT applications for improving education. However, there is no class for learning the DPOVL skills from a technological point of view because it takes long time to update the current academic programs in the educational technology departments, especially in Egypt, with recent ICT

applications like DPOVL. Thus, this kind of the skills becomes one of the weak points of the educational technology students in the era of E-learning.

In response to this problem, an instructional design (ID) model will be proposed to teach the DPOVL skills to the educational technology students in a scientific way. Also, the practical skills for DPOVL will be offered. Moreover, a new virtual learning platform (VLP) as an educational technology solution with specific features and contents will be developed to enhance the students' DPOVL skills in a standard way. In the context of this research, the VLP means a web-based learning system including several functions/tools for presenting and managing the OVL. Furthermore, the developed VLP will be investigated experimentally through practical use by the undergraduate educational technology students to assess its effectiveness and to confirm its usability.

1.2. Research Questions

This research is prompted by the following driving questions:

1. What is an ID model which can guide the educational technology students in DPOVL?

One of the essential points is there is no ID model for DPOVL. Thus, this research focuses on proposing an ID model. In this context, the ID model means an educational framework which includes organized steps in order to guide specific users like the educational technology students to construct specific educational products like the OVL. This research question will be approached by analyzing some previous studies related to the OVL, and ID models to specify main features of the proposed model.

2. What are the suitable practical skills for DPOVL?

The lack of the list of general practical skills for DPOVL makes this research focus on proposing the suitable DPOVL skills for multi-educational domains in a standard way. This research question will be answered by specifying these skills according to researcher's envision and embedding it into the tools and the contents of the VLP system.

3. How to develop the VLP for cultivating the DPOVL skills of the educational technology students?

There is no educational technology solution to cultivate the DPOVL skills. Thus, this research concentrates on developing the VLP with some specific tools and educational contents for DPOVL. The proposed VLP realizes skill learning which needs appropriate experiential training with a fixed form for the novice students. This research question will be accomplished through proposing a blended software development process integrated between ID and

software engineering (SE). Then, the proposed educational software development process will be used in developing the target VLP.

4. How effective is the VLP for the educational technology students?

There is no evidence for the effectiveness of the proposed VLP in cultivating the DPOVL skills of the educational technology students. Thus, this research exams the actual impact of the VLP in improving the target skills. This research question will be conducted by empirical experiments. The finding data of the pre- and post-test of the experimental research group will be collected, analyzed, and compared to answer this research question. Another reason for this question is there is no evidence for the student's usability of the proposed VLP in cultivating the target skills. Thus, this research also focuses on detecting the student's attitude to some usability elements regarding the developed VLP. The finding data of the experimental research group will be collected after learning with the VLP and analyzed to answer this research question.

1.3. Definition of Terms

In this research, there are some specific terms defined as below:

Online Virtual Laboratory (OVL): It is an online environment which includes some tools and virtual experiments for alternatives to real laboratory experiments, invisible phenomenon, skills, and concepts related to the specific educational course. We suggest each virtual experiment in the OVL consists of educational objectives, theoretical explanation, instructions and procedures, simulation, activity, evaluation, and a summary. Thus, it makes learners active through learning by experience and by trial-and-error, participating on not only virtual experiment but also discussion forums and quizzes.

Virtual Learning Platform (VLP): It is a Web-based system that contains several educational tools. Some of them make instructors create, manage and deliver online courses, activities, formative and summative evaluation to teach the students in ICT classroom or online learning at anytime and anywhere. Others enable the students to create and manage their own OVLs.

Skills of Designing and Producing OVL (DPOVL): In this research, the skills mean the practical ability of the educational technology students in DPOVL using the proposed VLP and some software such as Adobe Photoshop and Animate.

The relation among these terms as described in Figure 1 shows that the VLP offers essential services for the students, in particular for establishing and managing the OVL components like virtual experiments, forums, and quizzes.

Virtual Experiment
(Objectives, Theoretical Explanation, Instructions and Procedures, Simulation, Activity, Quiz, Summary)

OVL
(Simple Function Tools, Virtual Experiment, Forum, Quiz)

VLP
(Functions Tools, Educational Content, Management OVL)
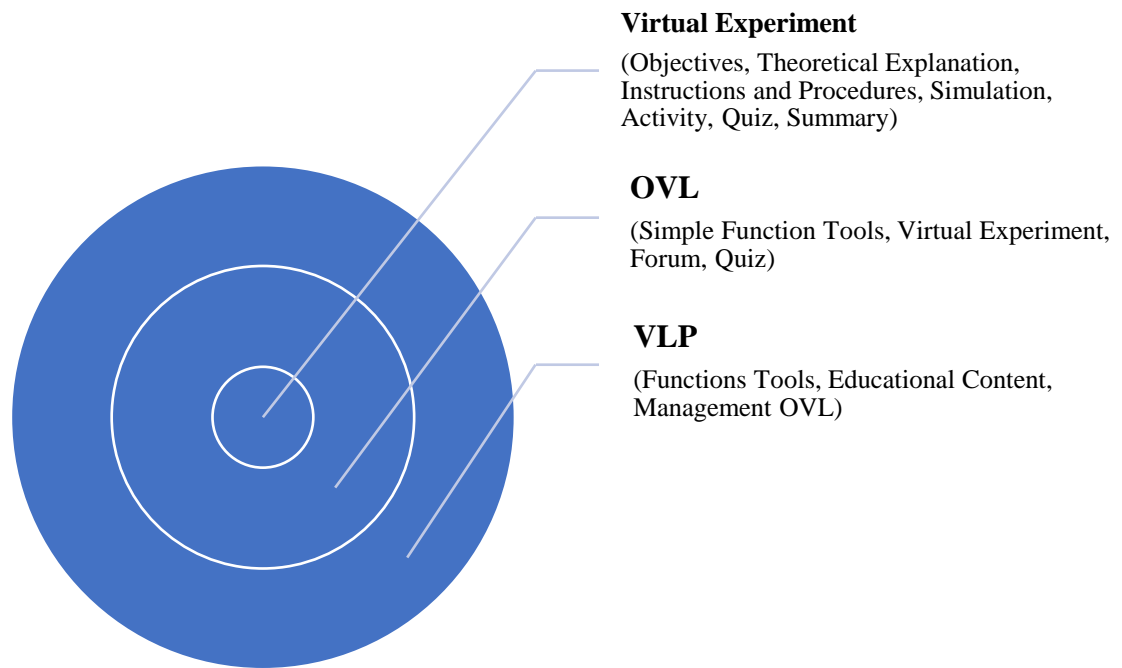
Figure 1. Relationship between main terms of research

1.4. Thesis Outline

This thesis is split into six chapters as follows:

Chapter one, as shown above, presented an introduction of this research. First of all, it described the problem statement of the research in the field of educational technology. Then, it discussed the research questions and explained the main terms of the research. Finally, it stated the whole outline of the dissertation.

Chapter two will focus on presenting viewpoint of the literature and the role of the VL technology in the enhancement of the learning process. Also, it will explain the relationship between the VLs and the specialist students in the educational technology field. Furthermore, it will define target students and VL types. Moreover, it will claim a standard way for DPOVL and the OVL's influence in coming education. Finally, it will present major educational technology paradigm shifts.

Chapter three will focus on providing a guide to the educational technology students for learning DPOVL. It will discuss the proposed ID model for DPOVL. Furthermore, it will claim main practical skills of DPOVL. It will present responses for the first and second research questions; RQ1: What is an ID which can guide the educational technology students in

DPOVL? RQ2: What are the suitable practical skills for DPOVL?

Chapter four will focus on how to design and develop the VLP as an educational technology solution. It will discuss SE technology for developing the VLP, which is combined with traditional ID model with prototyping and iteration. It will present a response for the third research question; RQ3: How to develop the VLP for cultivating the DPOVL skills of the educational technology students?

Chapter five will focus on the implementation and evaluation of the VLP system with the educational technology students. It will describe implementation aspects and main experiment and present the results and discussion of the evaluation. It will present a response for the fourth research question; RQ4: How effective is the VLP for the educational technology students?

Chapter six will describe a conclusion for overall research findings according to the research questions, research contributions to knowledge and recommendations, research limitations, and future work.

Chapter II   Research Background and Literature Review

2.1. Chapter Overview

This chapter aims to present research background and related work of VL technology. The chapter presents discussion for VLs as a modern technology for improving the learning process, especially the OVL. It explains the significance of the OVL for the students in the educational technology field. It claims the standard way for DPOVL and the OVL influence in coming education. Finally, it presents some of the major paradigm shifts in educational technology related to ICT evolution.

2.2. Significant Impact of VLs in Enhancement of Knowledge and Practical Skills

The VLs are one of the important learning applications in developing modern education. The VLs work as an alternative solution for real laboratories since the VLs overcome several restrictions about equipment, cost, and risks of experiments. In addition, the VLs provide the students with sufficient training opportunity for the experiments because of time and economic efficiency. In recent studies, the VLs have gained considerable attention in improving education, especially in supporting practical learning. (Chu, 1999) claimed that the VL provided simulations of complicated scientific processes that were less likely to be demonstrated in the real laboratory. Furthermore, (Tatli & Ayas, 2012) confirmed the VLs enriched the students' experiences as a supportive factor to the real laboratories.

On the other hand, recent empirical studies which addressed VLs have confirmed the major impact in enhancing the practical skills and achievement of students in various fields of science across educational stages. For example, physics academic achievement and process skills of tenth graders (Yang & Heh, 2007), conceptual understanding for electric circuits of undergraduate students (Zacharia, 2007), conceptual knowledge for electric circuits and procedural skills of secondary vocational engineering education (Kollöffel & de Jong, 2013), concepts of photoelectric of undergraduate students (Bajpai, 2013), science learning for elementary school students (Sun, Lin, & Yu, 2008), conceptual understanding and science process skills of fourth grade primary school students (El-Sabagh, 2011), achievement level and attitudes towards chemistry of high school students (Tüysüz, 2010), knowledge in chemical topics of seventh grade elementary pupils (Herga & Dinevski, 2012), chemistry scientific process skills of first grade pre-service science teachers'(Mutlu & Şeşen, 2016).

As outside fields of science, there are diverse studies such as computer networking skills (Lampi, 2013), pharmacology education regarding student's confidence and skills in the real laboratory in addition to decreasing experimental accomplishment times (Cheesman et al.,

2014). Based on this analysis of the previous studies, the VLs have been approved that it has a valuable impact on learning process.

2.3. Advantages of OVL in Improvement of Education

The OVLs are characterized by many advantages as modern methods in developing educational process. Some previous studies presented several advantages of the VLs such as (Herga & Dinevski, 2012), (Rajendran, Veilumuthu, & Divya, 2010), and (Chan & Fok, 2009). Now, we have organized and added these advantages from the improvement of learning point of view as follows:

1. Economic: The OVLs are low in costs of equipment and tools because preparation and maintenance of equipment in the virtual form are easier than the real laboratories.

2. Richness: The OVLs offer rich environments with the kits and tools with information through linking to particular websites.

3. Safety: The OVLs provide safe environments, particularly regarding the danger and harmful experiments.

4. Sufficiency: The OVLs supply sufficient and repeatable training environments for experiments like "learning by doing," which lead to mastery in learning.

5. Enhancement: The OVLs help the learners in improving their performance regarding experiments, equipment, and tools in the real laboratories.

6. Motivation: The OVLs cause excitement in learning to the learners by interactive simulation about reality and theoretical ideas, which encourage to continue their learning process.

7. Understanding: The OVLs facilitate the learners to reach a high level of understanding especially in practical experiments, concepts, laws, rules, relationships, processes, and ideas in various courses.

8. Interactivity: The OVLs serve interactive environments to the learners with not only the OVL contents but also the instructors and other learners.

9. Accessibility: The OVLs provide diverse contents to the learners anytime and anywhere.

10. Creation: The OVLs offer the possibility of original experiments by testing new variables on the virtual representation of some theoretical ideas, which conduce to creativity in learning.

11. Integration: The OVLs work to enhance the online courses through offering practical part of the course.

2.4. Current Situation of VLs Regarding Educational Technology Students

Despite the valuable impact in multi-domains and the advantages of the OVL technology for the learning process, the current students who study in educational technology departments do not have skills in DPOVL as a new ICT application in education. There are a couple of barriers to teach such skills as follows; at first, there are no suitable educational contents for standard skills in DPOVL without dependence on educational domains. Secondly, there are also no online tools which help the students learn the skills without technical and programming difficulties. The ideal situation is to move the VL technology, especially, the OVLs to be designed and produced by specialists in educational technology to become an ICT tool in future schools and universities as shown in Figure 2.
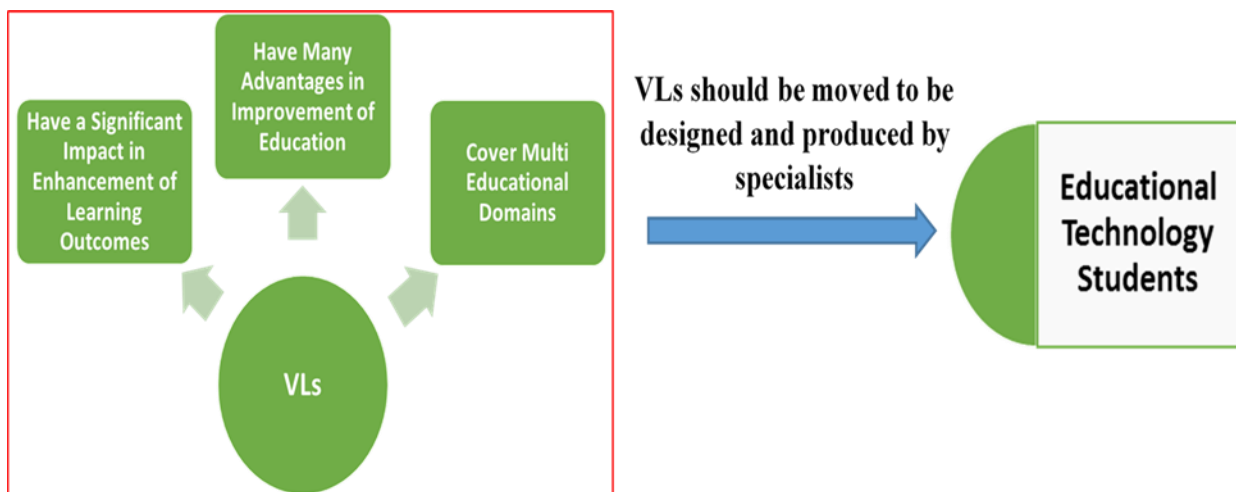
Figure 2. VLs technology transition to specialists of educational technology

One of the major difference from the traditional learning is mainly to target not knowledge but cognitive/technical skills. In this context of the research, the knowledge-based learning means achievement of knowledge about both of theoretical information and practical skills regarding specific learning topics of DPOVL. On the other hand, skill based learning intends to provide sufficient training materials for cultivating the target skills in DPOVL of the educational technology students. Furthermore, these skills should be performed practically by the students.

2.5. Target Students

The target students of this research are the educational technology students as the next generation of specialists and responsible persons for ICT in education. The main aim of educational technology field is to enhance and support education by ICT. The students in the

department of educational technology typically learn how to integrate ICT in education, according to educational theories and principles, instructional design, and other perceptions of educational sciences. The academic programs in their universities usually include learning how to design, develop, utilize, combine, and evaluate the modern applications of ICT in order to improve education. Therefore, these students have potentials to be responsible for implementing such technology in the future schools and universities after graduation as instructional designers, content developers, computer and information technology instructors, and specialists for educational technology.

2.6. Types of VLs

2.6.1. Online VLs (OVLs)

This kind of the VLs provides virtual environments in the form of the website via the internet. Therefore, the learners can learn skills, real experiments, and theoretical ideas about the courses practically anytime and anywhere. Also, they interact with not only the contents through interactive simulation but also the instructor and their colleagues through some communication tools. Such OVLs also provide them with many information offered by external website links.

2.6.2. Offline VLs

This type of the VLs is available in the form of specialized software which contains menus and tools in a specific field. After setting up the VL program on the computer, the learners can conduct experiments to obtain practical skills. This type sometimes needs much time in designing and producing the program package and is now limited to specific practical fields, for example, ChemLab ("Model science software products - model ChemLab," n.d.).

2.7. Proposed General Design for the OVLs

In this section, we discuss the general elements of the VLs such as their shape and components to reach to one uniform of the OVLs suitable for multi- domains. The OVLs become one of the new ICT tools for developing learning in the schools and universities. Therefore, such uniform would help the educational technology students in DPOVL with a standard way. In order to consider the uniform of the OVLs, we have made an analysis of many fields of the previous studies which proposed not only online but also offline VLs in many areas (Yang & Heh, 2007), (Sun et al., 2008), (Tüysüz, 2010), (El-Sabagh, 2011), (Herga & Dinevski, 2012), (Tatli & Ayas, 2013), (Bajpai, 2013), (Lampi, 2013), (Cheesman et al., 2014), (Mutlu & Şeşen, 2016).

After analyzing these previous studies, we summarized the following findings:

1. The significant impact of the VL technology was to increase learning skills and educational attainment of the learners in the various fields.

2. The VL technology can be used in the teaching courses which have the real laboratory experiments and also courses which have no laboratory experiments in reality such as an invisible phenomenon and concepts.

3. There was no fixed form in designing of the VLs, especially the OVLs. Also, its components and way of organizing contents differ on each previous studies according to each field and the researchers' suggestion.

From the results of the analysis, we decide to suggest a unique and general form of the OVL suitable to any courses/domain (not only practical but also theoretical) in educational institutions as shown in Figure 3. The suggestion is divided into the following two parts:

Fixed part: We call it OVL platform. This part is stable in any OVL. It consists of common functions such as basic user interfaces to display the OVL contents and add virtual experiments from any courses, management tools like quizzes, reports, and communications tools such as forums.

Variable part: We call it OVL contents. This part is variable according to the contents of the courses. In this section, we suggest how to organize the contents inside the OVL to become segments. Each segment should belong to one real experiment, invisible phenomenon, skill, and concept which consists of educational objectives, theoretical explanation, instructions and procedures, simulation, activity, evaluation, and summary. Such form of the general OVL would help the students for designing and producing the high-quality OVLs with a stable/standard way.
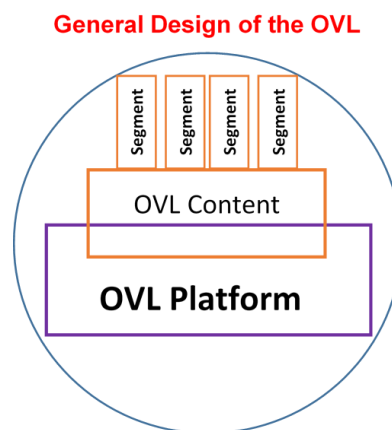
Figure 3. Suggestion to realize general design for the OVL

2.8. OVLs Support Factors for Learning Process

2.8.1. OVLs as supportive tools for online courses

The OVLs and online courses are similar in presenting something to the learners via the internet in an easy and interactive way. However, the types of these contents are quite different. The online courses typically provide e-contents with multimedia in a static form. On the other hand, the OVLs mainly serve interactive simulations for practical experiments. It means the OVLs would enhance the online courses from a practical point of view. In order to expand the availability and reusability, we sometimes implement both materials independently. The OVL environment can also integrate into the online courses as complementary learning resources.

2.8.2. The OVLs as supportive tools for learning in the real laboratories

Another role of the OVLs is to increase levels of learning in the real laboratories. The OVLs are sometimes used in blended learning where the learners can conduct training before and after experience in a real laboratory. On the other hand, they may be able to learn new simulation which has no real laboratory. In both ways of learning on the OVLs, they have to pass the following several steps to learn the contents deeply. Firstly, the learners should identify general and specific objectives in the OVLs and know the theoretical background about simulations through brief text information and instructions about how to perform the practical simulation in the OVLs without mistakes. Moreover, they begin to conduct simulation practically through many actions such as dragging and dropping items, changing values and shapes, collecting, arranging, and classifying items. They may also communicate with other learners with asynchronous tools to confirm their achievement and skills like forums. Finally, they have to make a self-evaluation through answering electronic questions and read a summary of main information of the target simulations to conclude the contents. Figure 4 shows these cyclic steps of the idealistic learning process inside the OVLs. If the learners do not acquire the target skills, they can repeat learning from the objectives step. As a result of the learning process, they would reach to the following outcomes:

1. Sufficient training about practical skills.
2. Learner's experience related to the real laboratories' equipment.
3. Learner's experience related to the virtual learning environment tools.
4. Mastery of learning by training and experiencing difficult theories practically.
5. Implementation of new ideas during learning.
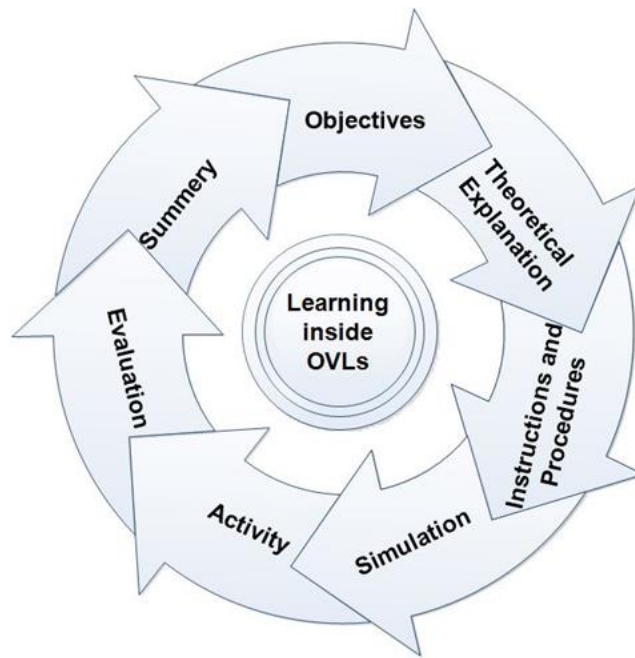
Figure 4. Idealistic learning process inside the OVLs

2.9. Paradigm Shifts in Educational Technology Field

The paradigm shifts in educational technology are linked to technological evolution. This research focuses only on major historical aspects of educational technology paradigm shifts. These paradigm shifts are related to use a computer in education such as computer-assisted instruction (CAI), intelligent tutoring system (ITS), and the internet and web application.

2.9.1. Computer-assisted instruction paradigm shift

The emergence of computer devices and use it in the education field led to the beginning the computer-assisted instruction (CAI) as a new educational technology paradigm shift. The main theme of the CAI is to develop and utilize courseware to enhance learning in the classroom. the CAI has emerged since the early 1960's (Teichert, 1985). By the early 1980s, the vital technological advancements had occurred that would make manner for improved and endure the CAI (Michel, 2001). According to Nazimuddin (2015), the CAI has several advantages regarding offers program can adapt to the abilities and preference of the individual learner, provides to learners the instant responsiveness of computer interactions, motivating learners to learn, and boosting independence and individual responsibility for instruction. On the other hand, the CAI has some disadvantages related to programs are costly to develop and require considerable preparation time (Zhang, Watson, & Banfield, 2007).

2.9.2. Intelligent tutoring system paradigm shift

Intelligent tutoring system (ITS) paradigm shift represents the subsequent development of the CAI. The ITS pointing to "any computer program that can be used in learning and that contains intelligence" (Freedman, Ali, & McRoy, 2000).

ITS have many advantages in improve education regarding individualized instruction delivery through adapt itself to becomes suitable for different categories of learners, Also using this system teaching can be accomplished with low intervention from the instructors which make it truly effective in regions where there is lack of trained instructors (Chakraborty, Roy, & Basu, 2010, p.75).

2.9.3. Interactive learning environment paradigm shift

This paradigm shift is considered as the significant change in educational technology field because it led to the emergence of several applications in education like distance learning, virtual learning, and mobile learning. Furthermore, it made an essential change for traditional teaching methods. The main features are instructional websites, Learning Management Systems (LMSs), web 2.0 applications, designing and developing new specialized VLP system to solve specific educational problems.

2.10.   Summary

This chapter presented the importance of the VL technology as a new ICT tool in improving education. Also, it stated why this research suggested learning of designing and producing such technology, especially the OVLs for the specialists in the educational technology field. Then, it proposed a general design for the OVLs and presented how the OVLs support the learning process with a standard way suitable for DPOVL in multi domains. Finally, it introduced some of the major paradigm shifts in educational technology related to ICT evolution.

Chapter III   Proposition of Modeling for DPOVLs

3.1. Chapter Overview

This chapter aims to propose an instructional design (ID) model as an educational framework to teach undergraduate students in the educational technology field how to design and produce the OVL. Thus, the proposed model makes the students learn the DPOVL process in a systematic way. The chapter presents discussion for modeling of DPOVL and claims the practical skills of DPOVL. It represents the responses for the first and second research questions; RQ1: What is an ID model which can guide the educational technology students in DPOVL? RQ2: What are the suitable practical skills for DPOVL?

This chapter is an updated version of work previously published in

1- Ahmed, M. E., & Hasegawa, S.: An Instructional Design Model and Criteria for Designing and Developing Online Virtual Labs. *International Journal of Digital Information and Wireless Communications (IJDIWC)*, *4*(3), 355-371, (2014).

2- Ahmed, M. E., & Hasegawa, S.: An Instructional Design Model for Designing and Producing Online Virtual Labs for Educational Technology Students. In *The Third International Conference on E-Learning and E-Technologies in Education (ICEEE2014)* (pp. 191-205). The Society of Digital Information and Wireless Communication, (2014).

3.2. Tasks of Instructors and Target Learners in OVL

3.2.1. Tasks of instructors in designing process

In actual education systems, the instructors would have many duties in the designing process of the OVL as the course content experts. In this part, we illustrate two types of the tasks by the instructors' responsibility.

Some educational systems focus on qualifying the instructors to specialize in one subject. These systems also produce specialists in educational technology to collaborate with the instructors in implementing technology in the schools. In these cases, the instructors play a major role in designing the OVL regarding their teaching courses. Therefore, they must have technological skills and awareness of teaching methods using ICT. The fundamental point of their role is to participate with the specialists of educational technology in the following design steps:

1. They must decide target learners and courses.

2. They must specify teaching topics from the subjects/courses.

3. They must define the general and specific objectives and formulate the objectives

accurately.

4. They must recognize the importance and necessity of the OVL.

5. They must prepare the appropriate contents and activities for the OVL to achieve the target objectives.

6. They should consider how to organize the OVL topics logically.

7. They should select the suitable evaluation style for each topic.

The instructors in other educational systems may also have additional tasks in the designing process to combine ICT into the classroom in the absence of the specialists of educational technology in their schools. In these cases, they have to be responsible for not only designing but also producing the OVL besides teaching courses. The additional tasks are summarized as follows:

1. They must study and apply criteria for DPOVL with high quality.

2. They must design and implement the OVL platform.

3. They must design and implement the OVL contents.

4. They must publish the OVL via the internet and conduct technical tests.

5. They should perform the improvement of the OVL based on the technical tests results.

6. They should carry out training to other instructors about how to use the OVL.

3.2.2. Tasks of the instructors in teaching with the OVL

When using the OVL in teaching, the instructors also face several tasks as follows:

1. They must plan online teaching methods to reach best practice.

2. They should enhance and motivate self-learning for the learners.

3. They should do training to the learners about how to use the OVL.

4. They should plan to integrate the OVL in the real laboratory environment.

5. They should interact with the learners via the internet in synchronous or asynchronous manners.

6. They should evaluate and track the performance of the learners to continue for improvement of education.

7. They should provide enrichment activities like additional internet websites to get related information easily.

3.2.3. Tasks of learners in the OVL

In using the OVL in learning, the learners are required to fulfill the following duties:

1. They must have the ability for self-learning to the OVL contents according to their intentions and attitudes.

2. They must conduct the required activities and assignments and send them to the instructors via an electronic form.

3. They should contact the instructors and other learners through electronic learning tools such as e-mail, discussion forums.

4. They should extend creative thinking during their learning process to reach new relationships among the variables.

3.3. Proposed ID Model to Teach DPOVL for Educational Technology Students

Based on previous researches, the VL leads to promote learning by providing interactive virtual environments, which makes the learners repeat diverse activities for cultivating their skills and for accomplishing their experiments with saving costs and controlling experiment variables. Also, the VL can apply to theoretical fields that have no real laboratories by experiencing a new simulation to understand difficult or invisible phenomena, concepts, and theories. If we intend to teach the geography of climate and weather practically, for example, we can use a VL including a simulation regarding change in weather on the map. In order to improve education by using such new technology, we should pay attention to the students in the department of educational technology as described in section 2.5. However, now they may have no ID models which guide how to design and produce the OVL because most of the previous studies about the VL focused on establishing the impact of the VL in specific fields as new ICT tools in education. In this research, an ID model is suggested to teach DPOVL to the students through a uniform shape and components. This model would guide them to reach suitable skills for DPOVL at diverse courses and fields in the future schools and universities.

In order to reach to our suggestion model, several previous studies were analyzed. Some of them confirmed the positive impact of the proposed OVL (Sun et al., 2008), (El-Sabagh, 2011), (Cheesman et al., 2014), (Yang & Heh, 2007). Others discussed some of the previous ID models such as ASSURE model (Smaldino, Russel, Heinich, & Molenda, 2005, pp. 47-73), ADDIE model (Forest, 2014), Morrison, Ross, Kalman, and Kemp model (2011), Dick and Carey systems approach model (Dick, W., Carey, L., & Carey, 2009, pp. 1-8), Alessi and Trollip design and development instructional model (2001, p.410), Gerlach and Ely systematic

approach model (1980, pp. 10-29). The results of the analysis showed the OVL had no specific and suitable ID model in teaching DPOVL as a new instructional technology product for the specialists in ICT education, especially for the students in the department of educational technology.

In light of these previous studies and literature, an ID model was proposed for DPOVL. The proposed model contains six phases, OVL pre-design, DPOVL criteria, OVL design, OVL production, OVL experiment-implementation, and OVL evaluation which lead to DPOVL step by step as described in Figure 5. We believe it is important to become widespread of teaching DPOVL in various educational institutions. The main phases of the proposed model were explained as below:

3.3.1. OVL pre-design phase

OVL pre-design is the first phase of the DPOVL model. In this phase, the educational technology students would conduct the following steps:

1. Determining the target learners of the OVL: The students would specify the target learners by defining the educational level and grade like "3rd grade of elementary schools" or "freshman year of universities level."

2. Defining the subject for the OVL: The students would specify one course/subject which intends to be made for the OVL. The course should be selected from same grade courses/subjects of the target learners like science, mathematics, chemistry, biology.

3. Specifying the topics for the OVL: The students would choose main course topics related to real experiment or theoretical idea, theories, concept, and law.

4. Deciding the overall objectives for the OVL: The students would specify general objectives for the OVL.

3.3.2. DPOVL criteria phase

The criteria are commonly used to provide the guidelines for the students in designing and producing any ICT tools for education. The students should learn and apply the DPOVL criteria to reach to acceptable educational and technological OVL products. Therefore, the instructors of educational technology can prepare a list of criteria of DPOVL or select the available lists of the criteria prepared previously and teach it to the students.
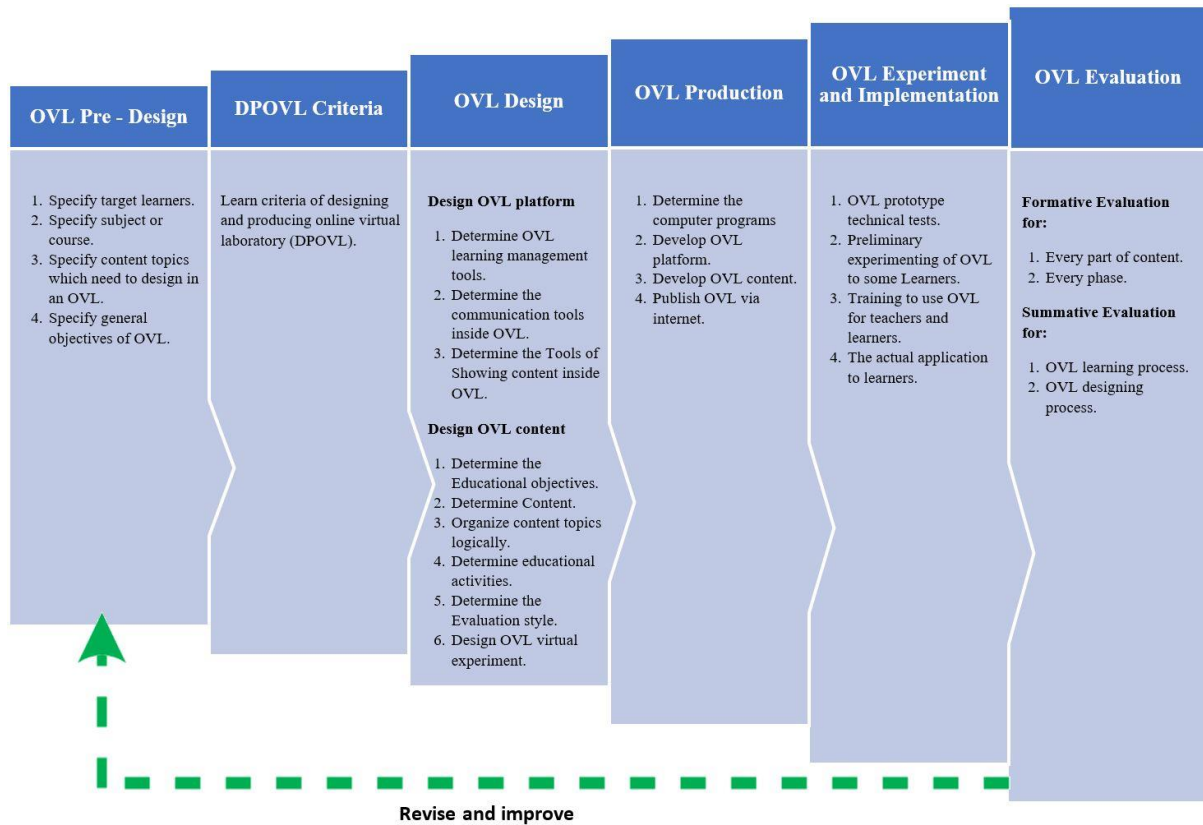
Figure 5. Instructional design model for DPOVL

3.3.3. OVL design phase

The fundamental role of the OVL design phase is to provide the students with the sequential steps in order to reach general design of the OVL suitable for the multi-educational domain. As described in Section 2.7, this research was proposed a new standard form of the OVL by dividing into the following two parts.

3.3.3.1. Designing OVL platform

This part is stable in any OVL, which contains skills for determining the OVL platform tools in light of the proposed tools of the VLP system. These skills consist of the following steps as below:

1. Determining tools of management learning in the OVL: The students determine some tools for management the OVL like report tool, and quiz tool.

2. Defining tools of communication in the OVL: The students determine some tools for communication in the OVL like forums.

3. Deciding content display tools in the OVL: The students determine some tools for

adding virtual experiments and displaying all the OVL contents.

3.3.3.2. Designing OVL contents

This part is variable according to the contents of the courses. In this section, we suggest how to organize the contents inside the OVL to become segments. The educational technology students may need to cooperate with a content expert in the case of difficult experiments. The students would apply the criteria of DPOVL as much as possible to the OVL contents. Such skills consist of the following steps as below:

1. Determining instructional objectives: The students would divide the general objectives of the OVL to a subgroup of educational objectives according to each topic.

2. Determining actual contents: The students would specify actual contents for the OVL topics according to selected course. The OVL contents should achieve the OVL objectives. The actual contents might include texts, digital images, computer graphics, and videos. They could use and modify existing contents to achieve the OVL objectives.

3. Organizing topics logically: The students would arrange the list of the collected topics of the OVL logically from simple to complex according to the course.

4. Determining educational activities: The students would specify the OVL activities which help the target learners to confirm their learning such as discussion forums, search on the web.

5. Determining evaluation style: The students would specify the appropriate evaluation style like electronic quizzes for the OVL contents and each virtual experiment.

6. Designing OVL virtual experiment: The students would design the OVL contents through conversion of the OVL topics into segments as virtual experiments. Each virtual experiment represents one real experiment, skill, theory, or law as described in Figure 6. Each virtual experiment should have an obvious title and following seven tabs: educational objectives, theoretical explanation, instructions and procedures, simulation, activity, evaluation, and summary as follows.

   a) Educational objectives: At first, the students would specify the educational objectives that the learners should acquire at the end of learning for each virtual experiment.

   b) Theoretical explanation: The student would specify theoretical backgrounds for each virtual experiment such as scientific laws, rules, applications, information, and description.

c) Instructions and procedures: The students would explain the correct sequences to conduct the simulation of each virtual experiment in practice.

d) Interactive simulation: It is a vital part contained in the virtual experiment. In this step, the students specify the components of the virtual experiments such as experiment objects (images, graphics) and the aim of each object.

e) Activity: The students would specify activity for each virtual experiment such as group discussion to enhance the learners' performance and conduct the improvement of learning outcomes and mastery of skills.

f) Evaluation: The students would specify assessment methods for each virtual experiment like a small quiz for self-assessment.

g) Summary: The students would include a summary of each virtual experiment. It makes the learners summarize the main points in the OVL virtual experiment.
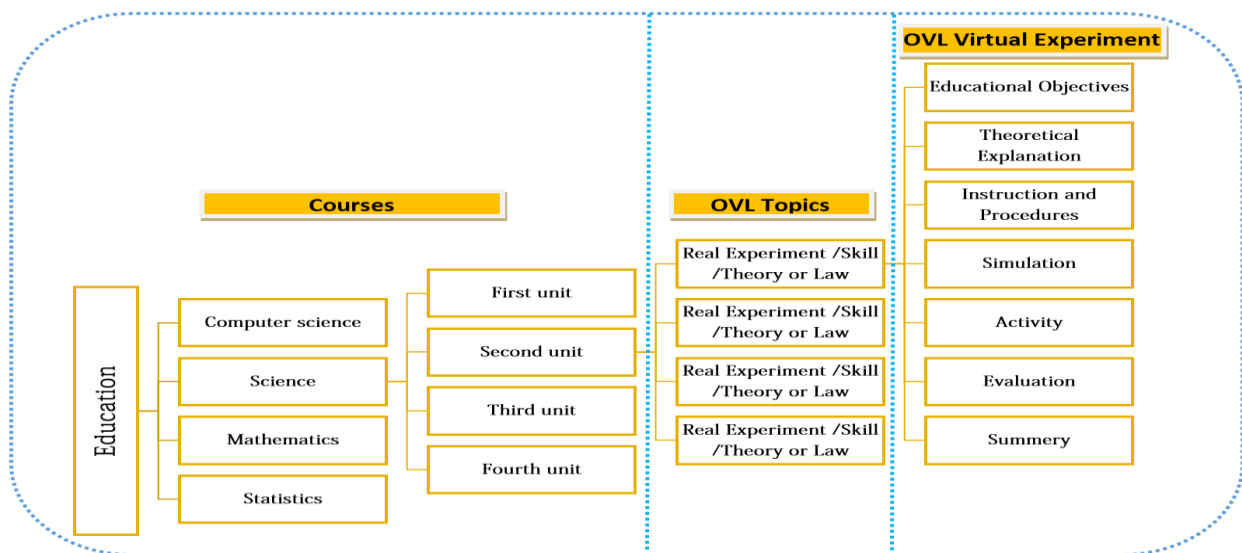
Figure 6. Organization of OVL contents

3.3.4. OVL production phase

In this phase, the educational technology students begin to produce the OVL as the following steps:

1. Determining computer programs: The students first select application development environments to realize the designed OVL with high quality. The environments may support ASP, PHP, JAVA, MySQL, Adobe Animate, Cinema 4d Studio, and Unity. They can also consider ready-made web systems if available like the VLP system.

2. Developing OVL platform: After determining the environments, the students implement the OVL platform by programming or using the ready-made system to create some learning management tools and the content displaying tools inside the OVL. Also, they develop some synchronous and asynchronous communication tools.

3. Developing OVL contents: The students also produce the segments or the virtual experiments of the OVL contents such as texts, animations, images, graphics, videos, simulations, electronic questions, and activities according to the DPOVL criteria as much as possible. They should keep the segment production to harmonize with the OVL platform.

4. Publishing OVL via the internet: The students publish the OVL in the VLP system according to the course name and uploaded simulation files in the OVL via the internet.

3.3.5. OVL experiment and implementation phase

In this phase, the educational technology students begin to check the OVL and conduct actual implementation in schools and universities as the following steps:

1. Conducting technical tests for the OVL: After publishing, the OVL becomes an initial instructional product. Therefore, the students should carry out technical testing such as user interface and accessibility, navigation, robustness, database connection, and performance. Based on these results, they should fix the technical errors of the initial OVL.

2. Making preliminary OVL experiments with some target learners: The students perform a preliminary experiment of the OVL to a few target learners to receive early feedbacks regarding easy handling, difficulties, notes, and mistakes. In light of the results, they can make necessary reforms, and it becomes a final version of the OVL.

3. Making training of the OVL: Training on how to use such new technological resources contributes to increasing the OVL efficiency. Thus, they conduct training for the instructors about how to use the OVL tools as online teaching skills, to perform training for the learners about how to access, navigate, use the OVL tools, and to conduct their assignments electronically.

4. Applying actual target learners: In this step, the instructors can use the OVL actually in teaching in the classrooms as an instructional technology tool to start an online teaching session with the target learners, to make discussion, to present replies for the learners' inquiries, to receive assignments from the learners, and to offer feedbacks from the

performance of the learners.

3.3.6. OVL evaluation phase

OVL evaluation phase presents the learners' main indicators about learning inside the OVL and quality of the designing process as a whole of the OVL. The students need to make improvements permanently in the systematic process based on the results of the evaluation. At this phase, they would use two types of evaluation.

3.3.6.1. Formative evaluation

Formative evaluation for every part of contents: The instructors conduct a formative evaluation during the actual learning process with the OVL final product. Therefore, they should implement it as electronic questions or questionnaires in every segment (virtual experiment) of the OVL contents. The results of this evaluation provide the following feedbacks about revisions and modifications of the OVL contents to the target learners, the learners' progress in achieving the objectives inside the OVL to the instructors, and the level of performance to the learners in order to motivate them in continuing in their learning process.

Formative evaluation for every phase: The students also perform a formative evaluation after each phase during the design process under the supervision of the teaching staff in educational technology department to improve the DPOVL model. They can use some tools such as evaluation forms, reports, and checklists.

3.3.6.2. Summative evaluation

Summative evaluation for the OVL learning process: The summative evaluation would be conducted at the end of the learning with OVL final product. This evaluation provides one of the main indicators of the learning process, the learners' level, and instructors' performance inside the OVL. The students can use some evaluation tools such as interviews, quizzes, and questionnaires.

Summative evaluation for the OVL designing process: The students need to detect the negative and positive aspects of the whole of the DPOVL model at the conclusion of the project. They use some evaluation tools like evaluation forms, questionnaires, and interviews with the instructors and the target learners. They carry on such evaluation under the supervision of the teaching staff in educational technology departments. The results would improve the OVL design process continuously.

3.3.7. Features of DPOVL model

In the proposed DPOVL model, we skip the analysis phase since the students do not need to make analysis before DPOVL. First of all, the analysis is a difficult phase since they need some experience in the actual classroom. Also, the target learner's characteristics are defined by the usual courses in the schools and universities. Our model also provides the instructors and the learners with enough technological training for using the OVL. Thus, they do not need to focus on the learner and instructor analysis. The instructional designer and the actual instructor can specify the content parts like real experiment, skill, concept, and idea directly according to their experience in teaching the courses on the OVL. It means they do not need course analysis, too. On the other hand, we add the OVL pre-design phase as the first one. Thus, it would make useful inputs for the OVL designing phase. Our model also focuses on the DPOVL criteria phase because the criteria are vital to guide them for DPOVL with high efficiency. The professors of the educational technology can prepare or select any criteria in this phase. We divide the OVL design phase into two parts. The OVL platform is a fixed part in any OVL, which contains a group of tools to make management of learning and to provide the learners with multi-communications with the instructors and the contents. On the other hand, the OVL contents are variable parts according to the courses, which are divided into the segments. Each segment represents a virtual experiment which belongs to one real experiment, skill, concept, or idea to improve learning. Such segments also have the possibility for reuse in another OVL, especially simulation. These parts would make the model general and suitable for diverse domains. In the OVL production phase, we do not specify application development environments to produce the OVL so that they can select anything freely. In OVL experiment and implementation phase, we claim two ways of the experiment as the technical and the preliminary test. The results of the OVL evaluation phase would make the students improve the OVL in a systematic process. The model components in all phases offer the students the sequential steps to make them simple and efficient. Finally, the main original aspect of the DPOVL model is to present a new standard design form suitable for DPOVL in multi-educational domains.

3.4. Suggestion Criteria for DPOVL

This research also presented the latest version of the criteria list for DPOVL to be easier in teaching the model directly to the students. The criteria aim to reach modern educational and technical principles by providing guidelines. Consequently, we make a derivation of some

elements for the criteria from the previous studies regarding to the VL (Cagiltay, Aydin, Aydin, Kara, & Alexandru, 2011), (Padman & Memon, 2002), (Hristov, Zahariev, Bencheva, & Ivanov, 2013), (Li, Zheng, & Zhong, 2010), (Darrah, Humbert, Finstein, Simon, & Hopkins, 2014), and criteria for e-learning technologies, qualification, and evaluation (Shee & Wang, 2008), (Hsu, Yeh, & Yen, 2009), (Ardito et al., 2004), (Holt & Segrave, 2003), (Jung, 2011), (Wu & Chen, 2013), (Pike & Huddlestone, 2006), (Thomas, 2001). In addition, other elements of the criteria are picked up from designing online electronic courses, developing e-contents, evaluating instructional websites (Büyüközkan, Arsenyan, & Ertek, 2010), (Ghirardini, 2011), (Çelik, 2012), (Teng et al., 2004), (Wright, 2003), (Hasan, 2014), and (Eristi, Sahin-Izmirli, Izmirli, Firat, & Haseski, 2010), and general aspects of educational technology (Southern Regional Education Board [SREB], 2009), (SREB, 2008).

Although there are diverse types of the previous studies, the elements of the criteria were divided into two parts; educational criteria of DPOVL and technological criteria of DPOVL. The one part is mainly related to educational rules and theories. Another part is technical standards related to the computer software. The criteria contain diverse specific elements related to the OVL.

3.4.1. Educational criteria of DPOVL

The educational criteria of DPOVL have some instructional items that may guide the educational technology students to design the acceptable OVL environment. In this aspect, there are five main sections.

The first aspect is related to design the OVL objectives as follows.

1. It should be specified clearly.
2. It should be linked to the OVL contents.
3. It should be formulated in the behavioral form.
4. It should be measurable and appropriate for the OVL target learners.
5. It should be shown at the beginning of each OVL content.
6. It should be described as not learning activity but learning outcomes.
7. It should be arranged in a sequence according to expectations of the learning outcomes.

The second aspect is related to E-contents of the OVL. It mainly helps to provide acceptable design contents of the OVL as follows.

1. It should be directly related to the educational objectives.

2. It should be sufficient for achieving objectives.

3. It should be up to date.

4. It should be objective.

5. It should be easily understood, clear and brief.

6. It should be accurate in scientific and linguistic.

7. It should be organized logically and sequentially.

8. It should be designed according to self-learning strategy.

9. It should be divided into small and gradual learning steps.

10. It should be included summaries which describe the main ideas of each part.

11. It should be classified according to the types of the contents like practical or theoretical ones.

12. It should be reviewed by instructor or used directly if reviewed courses are available.

13. It should be rich with appropriate multimedia.

14. It should be displayed in various forms, such as animations, simulations, figures, pictures, and videos.

15. It should be supported linear and nonlinear presentation styles.

16. It should be clearly specified by additional information linked to other websites.

17. OVL content copyrights should be clarified.

The third aspect is E-activities of the OVL. This section describes guidelines for activities which support learning the process in the OVL as follows.

1. It should be related to the OVL objectives.

2. It should be suitable for the OVL contents.

3. It should be defined clearly.

4. It should be designed in a learner-centered way.

5. It should send feedbacks to the learners.

6. It should provide the learners with the time plan about online and offline learning activity such as starting time, duration, and end time.

7. It should be included in each content's part.

8. It should support collaboration among the learners in a synchronous or asynchronous way.

The fourth aspect is E-evaluation of the OVL. This aspect is aimed to design efficient and

objective evaluation for the OVL as follows.

1. It should be related to the educational aims of the OVL contents.

2. The evaluation style should be appropriate to the OVL objectives.

3. It should be covered all the OVL contents.

4. The question meaning should be clear.

5. Its questions should be ordered by difficulty level.

6. Its question template should contain texts, images/graphics, and sounds/videos to prepare an effective evaluation for the OVL contents.

7. It should provide formative evaluation for each virtual experiment during learning.

8. It should provide the OVL summative evaluation after learning.

The final criteria aspect is E-feedback of the OVL. This aspect aimed to design good feedback for the OVL evaluation as follows.

1. It should be provided immediately.

2. It should not be general but specific for the question.

3. It should be suitable for the learners' level.

4. It should be connected to the objective of the questions.

5. It should be suitable shapes such as texts, images, graphics, sounds, videos, and animations.

6. It should guide the learners to the correct answer in the case of a mistake.

7. It should support the learners with extra information to the right answer.

8. It should give the learners overall information about their responses in OVL evaluation quizzes.

3.4.2. Technological criteria for DPOVL

The educational criteria of DPOVL have some instructional items that may be guided the educational technology students to produce the acceptable OVL environment. For this type, there are tenth most important aspects.

The first aspect is related to the OVL platform. It assists in DPOVL, especially in user interface with high effectiveness by the following criteria.

1. The OVL platform tools should be easy and clear to use and understand.

2. It should be consistent and provide the learners with stabilized operation.

3. Its hyperlinks should use clear anchor words to identify the learners where to lead.

4. It should provide sufficient contrast between the texts or images and the page background.

5. Its design should be artistic and creative.

6. It should be divided into appropriate categories.

7. It should provide multiple channels of communication.

8. It should provide learning management tools.

9. It should provide a display function for the contents.

10. Updating the contents should be easy.

The second aspect is related to texts and explanation of the OVL as follows.

1. Text-based contents should be limited.

2. It should be clear and readable.

3. Its font should be selected in appropriate patterns and sizes.

4. Its headlines should be structured by the font size hierarchically.

5. Its titles should be straightforward and expressive.

6. It should be formulated in short sentences and simple structure.

7. It should be formulated in active forms not passive and interrogative forms.

8. Its color should be suitable compared to the OVL background.

The third aspect is the OVL digital images and graphics. This aspect aims to present some elements for the quality of images and graphics used in the OVL as follows.

1. It should be relevant to the OVL contents.

2. It should be clear and not be crowded.

3. Its color should be relevant to reality.

4. It is high-resolution quality.

5. Its digital effects should be related to actual fact.

6. It should be highlighted to emphasize the meaning.

7. It should show real dimensions.

8. Its design should be suitable to ask the questions.

9. Its quality should be facilitated perception.

The fourth aspect is the OVL digital sound. This aspect aims to confirm the powerful sound for the OVL if used as follows.

1. The number of it should be limited.

2. It should be used to make obvious the meaning.

3. It should serve a clear purpose.

4. It should be pure and not contain echo or noise.

5. The audio commentary should be concurrent with the display.

6. It should be properly pronunciations.

7. It digital effects should be realistic and related to the OVL contents.

8. It should be high quality as much as possible.

The fifth aspect is the OVL digital video for real experiments. This aspect aims to reach quality for target video which may be used in the OVL to explain real laboratories experiments as follows.

1. It should serve a clear purpose.

2. It should show same real environment of experiment clearly.

3. It should be concurrent with audio commentary if needed.

4. It should display with some control tools such as play/stop video, volume, and screen size.

5. Its design should be suitable to ask the questions.

6. It should be related to the accomplishment of the objective of the OVL contents.

7. The digital effects of the OVL video should help to achieve the objective with high quality.

8. It should provide an interactive environment for the OVL experiment if needed.

9. It should work to upgrade the level of critical thinking.

10. It should boost to continue learning in the OVL environment.

The sixth aspect is the OVL navigation. This aspect aims to reach flexible navigation in the OVL as follows.

1. It should be easy to move.

2. Its labels should be easy to understand and express what they contain.

3. Broken links should be avoided.

4. Exit links should be provided at any time.

5. Backlinks to the OVL main page should be made available from every page.

6. Its links should use graphic buttons.

7. Main navigation should be stable.

8. Its links should be consistent and not crowded.

9. Its structure should be organized logically by the appropriate labels such as categories, main links, and sub-links.

10. Its links should be classified by category, color, providing links in a new page or using on the same page.

11. It should avoid orphan pages.

12. It should provide the learners with enough orientation by diagram, mind map, flow chart, instructional image, and graphics.

The seventh aspect is the OVL simulation. This aspect aims to reach interactive simulations for virtual experiments in the OVL as follows.

1. It should be related to the contents' objectives.

2. It should provide a virtual environment similar to the practical real objects.

3. It should represent the theoretical idea easier to understand.

4. Its images, graphics, and the theoretical ideas should show the meaning as far as possible.

5. It should be creative.

6. It should provide the interactive environment.

7. It should harmonize with computer software and web system used in the producing OVL.

The eighth aspect is the OVL Interactivity. This aspect aims to provide an interactive learning environment for the OVL as follows.

1. Its multiple forms should be provided such as the instructor to the learners, the student to the students, and the student to the OVL contents.

2. It should be provided in synchronous and asynchronous ways if possible.

3. It should provide the students with full control for the OVL learning environment.

The ninth aspect is the OVL learning administration. This aspect aims to provide a guide for the proper management for the OVL as follows.

1. It should provide a direct login to the OVL.

2. It should include information about the OVL subject or courses.

3. It should provide tools for assessing performance in the OVL.

4. It should offer functions to upload and download files.

5. It should be balanced between cost and learning outcomes.

6. It should provide tracking function for learning.

The tenth aspect is the OVL publishing and technical support. This aspect aims to provide a guide for making satisfaction about the OVL deployment as follows.

1. The OVL requirements about software and hardware should be specified.

2. The specified capacity of the OVL in the server should be enough.

3. The OVL website address via the internet should be simple.

4. The OVL pages should be downloaded quickly.

5. The OVL should be controlled remotely from the host institution.

6. The testing of the OVL should be validated.

7. The OVL should be robust.

8. The OVL should be easy to maintain regarding routine tasks like a back-up.

9. The OVL should provide accessibility in anytime and anywhere.

10. The OVL should supply technical supports for the learners.

11. The OVL should have information about copyrights of educational institutions.

3.4.3. Features of criteria DPOVL

The DPOVL criteria were suggested to provide modern guidelines for the students for DPOVL. The criteria contain some new areas of elements related to the OVL and virtual learning environments. First of all, the elements related to simulation represent the vital components of the OVL about real experiments, skills, relationships, concepts, laws, and ideas during the designing process. Secondly, the OVL platform criteria provide the framework about communication opportunities and display of the OVL contents. Also, the criteria related to the OVL learning administration are standard elements to provide the students with proper management functions for learning inside the OVL.

On the other hand, new elements are added suitable to the OVL to grow the main elements referred to the educational criteria such as objectives, E- contents of OVL, E-activities of OVL, E-evaluation of OVL, and E-feedback of OVL. These items would make a good guideline for designing the OVL contents. Furthermore, we pick up the criteria elements which belong to diverse types of multimedia such as texts and explanation, OVL digital images and graphics, OVL digital sound, and OVL digital video to become more suitable to DPOVL. We also suggest the criteria for publishing the OVL to guide the students without technical errors.

3.5. The Proposed Practical Skills for DPOVL

The target skills of DPOVL were specified in light of the VLP system and some of the computer software like Adobe Photoshop and Adobe Animate CC and ActionScript 3.0. These skills will be learned by the educational technology students in the VLP. The following is the proposed list of the practical skills in DPOVL:

A) Main skills in designing OVL by the VLP system

1. Defining OVL target learners, course, topics, and general objectives as the OVL framework.

2. Determining management tools, communication tools, and content tools as the OVL Platform.

3. Specifying virtual experiment objectives, theoretical explanation, instruction and procedure, simulation, activity, evaluation style, and summary as the virtual experiment design.

4. Fixing evaluation style, description of evaluation contents as the overall assessment.

B) Skills in producing OVL

I. Skills in producing OVL by the VLP

1. Creating an OVL framework.

2. Creating a virtual experiment in the OVL.

3. Creating an educational forum in the OVL.

4. Creating a quiz for OVL.

5. Creating a quiz for the virtual experiment.

6. Adding a true/false question to the quiz.

7. Adding a single choice question to the quiz.

II. Skills in producing interactive simulation of the virtual experiment

a) Skills in preparing simulation by Adobe Photoshop.

1. Creating new file suitable for the simulation of the virtual experiment.

2. Collecting simulation images/objects of the virtual experiment in one file. Each images/objects should be put on an independent layer.

3. Arranging the simulation images/objects of the virtual experiment by the logic form in the file.

4. Designing reset button for virtual experiment simulation.

5. Writing the name of simulation images/objects.

6. Resizing the simulation images/objects to become appreciated with keeping the resolution.

7. Selecting and removing non-essential elements from the simulation images/objects.

8. Recoloring the required parts of the simulated images/objects.

9. Drawing some shapes used in the simulation by drawing tools in Photoshop.

10. Saving the simulation file of the virtual experiment as a PSD or PDD format.

b) Skills in producing a simulation of the virtual experiment by Adobe Animate CC and ActionScript 3.0.

1. Creating a new ActionScript 3.0 project file for the simulation in Adobe Animate CC.

2. Saving the new file as an Adobe Animate CC file format.

3. Importing the simulation file of the virtual experiment as Adobe Photoshop format to Adobe Animate CC.

4. Converting the simulation elements to symbols.

5. Adding action code to the simulation element related to drag and drop.

6. Adding function code to reset simulation related to click to position the object.

7. Adding action code to the simulation element related to click to hiding the object.

8. Adding action code to the simulation element related to show the object.

9. Adding motion to the simulation element associated with the type of motion tween.

10. Adding motion to the simulation element associated with the type of shape tween.

11. Adding motion to the simulation element associated with the type of classic tween.

12. Adding action code to stop motion of the simulation element.

13. Publishing the simulation file of the virtual experiment as a SWF format.

The proposed skills are divided into two main sections; the first section is for the skills in DPOVL by the VLP system. These skills are determined so that the students can learn DPOVL without obstacles and programming difficulties.

The second section is for the skills in producing interactive simulation by some computer applications like Adobe Photoshop and Animate. These skills are selected to realize an interactive simulation of the virtual experiment. At first, the skills in designing simulation are chosen based on the Adobe Photoshop application because this application has the potential for designing the simulation objects through several tools and commands. In this research, these skills are important because they enable the target students to:

- Organize and order the simulation objects in a real design environment.

- Make treatment of the simulation objects to remove unwanted parts.

- Prepare the simulation objects to facilitate developing interactive environment.

- Design new object graphics for the target simulation.

The skills in producing simulation are determined based on Adobe Animate CC and ActionScript 3.0. These applications have the capability of generating the OVL simulation through several actions and commands. In this research, these skills are essential because they allow the target students to:

- Make an interactive simulation environment with reality as much as possible.

- Realize repeatable and sufficient training for simulation.

- Produce interactive simulation compatible with the VLP system.

3.6. Summary

This chapter proposed a model as a framework for DPOVL. Also, it presented the main skills of DPOVL to enhance the practical skills of the educational technology students. Thus, this chapter offered a response to the first research question through the proposition of the ID model as a new framework by analyzing related work regarding the OVL and ID models to specify main features of the proposed model. It also presented the list of practical skills to be embedded into the VLP tools and the contents with a standard way as a response to the second research question.

Chapter IV   Design and Development of Virtual Learning Platform

4.1. Chapter Overview

The aim of this chapter is to discuss the development of the VLP for teaching DPOVL. It explains how to design and develop the target VLP based on a proposed software development process. It also states main features of the VLP tools and contents. This chapter represents a response for the third research question; RQ3: How to develop the VLP for cultivating the DPOVL skills of the educational technology students?

This chapter is an updated and extended version of our work previously published in

1- Ahmed, M. E., & Hasegawa, S.: An Integration between Instructional Design and Software Engineering for Developing Virtual Learning Platforms, Proceedings of SIG-ALST-B402, The Japanese Society for Artificial Intelligence, pp.10-13, (2014).

2- Ahmed, M. E., & Hasegawa, S.: A Proposed Model Combining Instructional Design and Software Engineering for Developing Virtual Learning Platforms. Proceedings of Global Learn 2015, pp.654-663, (2015).

3- Ahmed, M. E., & Hasegawa, S.: A Prototype Virtual Learning Platform for Teaching Skills of Designing and Producing Online Virtual Labs in Classrooms. Research report on Japanese Society for Information and Systems in Education, Vol.31, No.4, pp.21-24, (2016).

4.2. A Blended Model Embedding ID and SE for Developing VLP

4.2.1. Basic concept of VLP

VLPs are online environments, which contain educational functionalities and interactive contents in order to manage and deliver learning to the students through synchronized and asynchronized communication manner. The VLPs are considered one of the modern applications of ICT in education as an alternative solution to education through distance learning and a part of blended learning with traditional face-to-face classrooms. In both ways, the VLPs have a good impact on learning process since they enable instructors to control learning in classrooms electronically in comparison with traditional ways. Furthermore, they provide the instructors with tracking data of the students' performance. Moreover, they work to increase the student interactivity in learning and raise the students' technological skills. Therefore, we claim the VLPs are one of the main important environments to enhance mastering of learning at present and future in schools and universities.

In order to design and develop VLP system for DPOVL, there is no process which provides a

framework for design and development of the VLP in a scientific way. We found the traditional ID process does not provide enough guidance to produce the VLP. The core of the ID process consists of five elements such as analyze, design, develop, implement, and evaluate (Gustafson & Branch, 2002, p.2). They are usually called an ADDIE model. However, we saw this process had some deficiencies in methodology for designing and developing the virtual learning products, especially the VLP. Generally speaking, the traditional ID process only focused on educational contents. Also, it did not contain a development methodology for the VLP functions and interfaces with enough detail. Thus, educational technology specialists (researchers, instructional developers/designers, postgraduate students and undergraduate students) who not have SE background need a new methodology with clear steps for designing and developing such instructional products like the VLP because they have potentials for integrating and implementing such modern technology into teaching and learning the process in the future schools and universities. On the other hand, most of the virtual learning applications are implemented on the web-based platform. In this context, the functions enable the instructors and the students to conduct specific educational tasks according to specific requirements. However, the contents are just intended to teach the students inside the VLP. Therefore, it is very important for them to identify how to develop the VLP by themselves based on the ID way. We consequently need to provide the chance to create and develop various VLPs with innovative functions, which will lead to improving the learning process in schools and universities in coming education.

In order to improve the ID process for VLP development, we suggest a new blended model which integrates the SE approach with the ADDIE process. We have conducted an analytical approach to detect insufficiency of the ADDIE process in developing the VLPs as instructional products and to gather suitable SE features and techniques. In the beginning, we suggest a simple SE process which consists of three phases as "analysis," "construction," and "deployment." Then, we embed the SE process into the ADDIE process as the blended ID model to the specialists in the domain of educational technology through clear and organized steps.

Nowadays, there are various open source learning management systems (LMSs) related to the VLPs like Moodle and Sakai. In this research, we developed a new VLP from zero and did not adopt any existing open source projects. Consequently, it provides to the specialists learn the general process of designing and developing the VLPs for other solutions in the future situations.

4.2.2. Methods

4.2.2.1. Analytical approach

In this research, we have used the analytical approach by making analyses for related studies which focused on the ID, SE for solving our problem regarding the ID process for the VLPs. Although there were a number of the ID processes proposed, we mainly paid attention to the ADDIE model in this research because (Molenda, 2003) claimed the ADDIE process was one of the generic ID processes.

We collected and analyzed diverse previous studies which explained and used ADDIE process (Molenda, 2003), (Peterson, 2003), (Wang & Hsu, 2009), (Davis, 2013), (Hsu, Lee-Hsieh, Turton, & Cheng, 2014), (Cheung, 2016), and (Wiphasith, Narumol, & Sumalee, 2016) according to this main question: Is the traditional ADDIE process suitable for developing the VLPs? We found the ADDIE process was used in the design process for only curriculum or course contents and did not cover new educational technology products like the VLPs. Also, the ADDIE framework did not include a scientific way for designing and developing the VLP tools. In summary, the analyses showed that the current ADDIE process is not suitable for designing and developing the VLPs as the instructional products for the specialists.

4.2.2.2. SE as a methodology for solution

Firstly, we have paid attention to the SE process which focuses on developing a software system. It is expected to overcome the discussed deficiencies of the ADDIE process as a methodology for designing and developing the VLPs by means of the following reasons: The VLP requires an architecture design for diverse complicated functions. Conveniently, SE provides the specialists with a good way for designing the VLP through Unified Modeling Language (UML) such as a use case diagram, a class diagram, and other diagram representations. According to (Rumbaugh, Jacobson, & Booch, 2005, p. 3), "the UML is a general visual modeling language to specify, visualize, construct, and document the artifact of the software systems." Secondly, the VLP is considered as a wide instructional project compared with other educational projects. Integration between the ADDIE and SE provides an incremental development approach by dividing the VLP project into small parts as iterations. That enables the specialists to develop and update the VLP at a short time with low costs and high quality. Finally, according to our findings from the previous studies, we concluded design and development of the VLP functions were out of range in the ADDIE process. On the other hand, SE provided enough processes and methods for developing software projects. Therefore, we could apply the SE approach to

modify designing and developing phases of the VLP in more suitable way.

4.2.2.3. Proposed simple SE process for VLP functions

In order to reach to our suggested approach, we first made an analysis of some literature review in the field of SE (Bell, 2005), (Pressman, 2010), (Sommerville, 2011) and (Abrahamsson, Salo, Ronkainen, & Warsta, 2002), especially main SE features, processes, and models used in developing software systems such as waterfall model, prototyping process, incremental development process, spiral model, and agile methods. The main aim of this analysis is to gather suitable SE features and techniques which can help in modifying the traditional ADDIE process to become suitable for developing the VLPs. Based on the analysis, we proposed a simple SE process as described in Figure 7. This process contains some SE features and techniques like system requirements specification, UML as a design approach, and incremental development. Although some the SE approaches imply team development, the initial proposition of this research mainly focuses on a single or few researchers project. By following such kind of the process, it would provide good quality during the developing process of the VLPs by using some SE testing techniques like integration testing, system testing, and acceptance testing. The simple SE process consists of three phases; analysis phase, construction phase, and deployment phase.
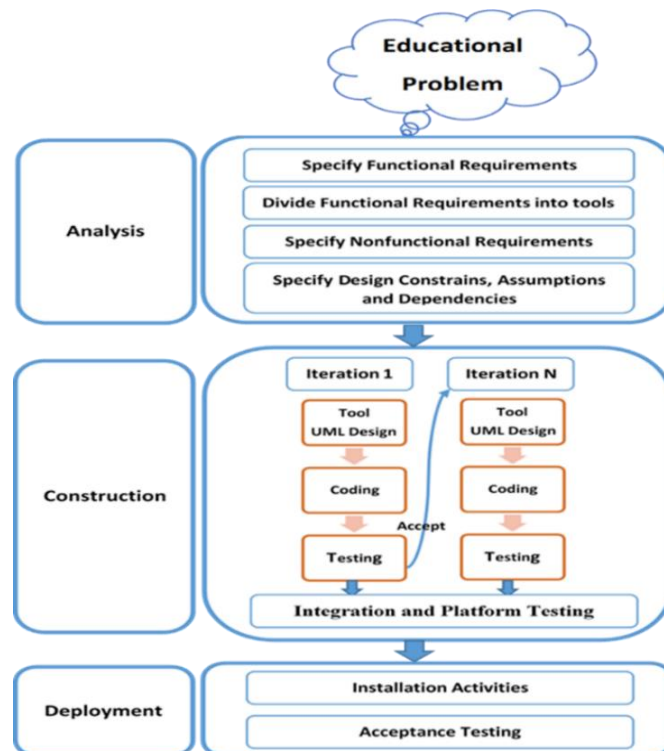
Figure 7. Proposed SE process for VLP as a system

4.2.3. Discussion of ACDIE model

The main outcome of this step of the research is to propose a blended model which combines the proposed SE process into the ADDIE process to become suitable for developing the VLP as an instructional product. We call it ACDIE model as described in Figure 8. This model is suitable only for the educational technology specialists who do not have SE background in their academic programs. For instance, the specialists of educational technology departments, South Valley University in Egypt does not include software engineering courses about how to design and develop web application system. The main features of the proposed process are as follows:

4.2.3.1. Analysis phase

We merge the analysis phase of the SE process into the ADDIE analysis phase. It includes some features for analysis requirements of the VLP functionality and technical aspects. The new analysis phase in the ACDIE process is based on educational research problems and the domain of educational materials. This phase includes new aspects about the SE approach and learning content aspects of the analysis. First of all, the researcher would specify the VLP target users and characteristics, define the VLP functional requirements, and then divide the requirements into specific functions with a use case scenario. They should also specify nonfunctional requirements such as system performance, safety, security, system design constraints, assumptions for overall use cases and dependencies for the VLP. Besides, they would be required to analyze the learning content aspects that they intend to teach the students inside the VLP, such as course requirements like course name, course description, prerequisites, and general objectives of the course. Finally, they must decide to determine course topics and evaluation instruments and to divide the topics into segments which are small parts of the contents.

4.2.3.2. Construction phase

We replace the design and development phases in the traditional ADDIE model by the construction phase of the proposed SE process to guide the specialists the SE approach. The construction phase includes two parts: the VLP functions and the VLP contents as described in Figure 8. An SE incremental approach was adopted in developing not only in the VLP functions but also in the VLP contents in a scientific way because this approach provides many advantages for developing the VLP with regard to speed, cost, and quality.

Construction of VLP functions. In this part, the researchers begin to build the system incrementally. They develop diverse functions step by step through iterations. Each iteration typically represents one development process of a certain function. The following is detail steps of the construction phase:

1. Making up design for each function with UML such as class diagrams.

2. Implementing the function through actual coding in programming languages such as PHP, C++, HTML, CSS, and JavaScript with database applications like MySQL.

3. Conducting verification and validation for each developed function. If the function is accepted, they would move to the next iteration. If the function has code errors or does not meet the functional requirements, on the other hand, they might make a modification and revision.

4. Integrating the developed function to the whole VLP system and test the system to confirm it works together without any problems under the analyzed system scope and system requirements.

Construction of VLP contents. As explained the construction process of the VLP functions in the previous section, here we explain the steps of construction for the VLP contents as follows:

1. Making up segment design of course content lesson (specifying behavioral objectives, actual contents, educational media...) or evaluation instrument contents.

2. Implementing the lesson design by computer programs and the VLP course tool or evaluation instrument by the quiz, questionnaire, observation card, and performance/product evaluation card tools.

3. Conducting educational and technical testing for each developed lesson or content of the evaluation instrument. If the segment is accepted, moving to the next iteration. If not so, making modifications and revisions.

4.2.3.3. Deployment phase

Deployment is a new phase added to the traditional ADDIE model, which aims to reach good quality before starting formal operation of the VLP. The researchers should perform installation activity based on the requirements for the server, such as providing enough capacity and installing required software. After installation, they would also make a backup and secure the data. Furthermore, they have to ensure good performance and to stabilize the VLP system in assuming an environment without any problems. Also, this phase includes an acceptance testing for the VLP by the target users. In addition, the researchers would conduct a pilot study

of the whole VLP system as a learning environment by the small sample of the target users to gather early feedbacks about any implementation problems related to research design, evaluation instrument's reliability, and the VLP system errors. Finally, they can make a necessary modification for all main detected problems, and then the system becomes ready for operational use.

4.2.3.4. Implementation phase

In this phase, the researchers would apply the VLP into actual education in the classroom. Firstly, the instructors make an orientation for the target students about the VLP course description (course title, main aims and topics outline, evaluation methods), the VLP course study timetable, and how to use the VLP tools. Then, they conduct pre-evaluation instruments for the VLP course. Finally, they would implement actual teaching by the proposed VLP according to the study timetable.

4.2.3.5. Evaluation phase

The evaluation phase is renewed by adding usability evaluation methods for the VLP to test the effectiveness and efficiency. The main role of this phase is to detect the successful range in developing the VLP by the researchers. The evaluation results would improve not only the VLP developing process but also learning process inside the VLP continuously in a systematic process. We divide the process according to the construction phase as below:

Formative evaluation for the VLP: This kind of evaluation is conducted during the developing process to refine the VLP functions and contents. a) Formative evaluation for the VLP functions includes an evaluation by the expert review to detect usability problems of the VLP functions in an early stage. It also has an evaluation by following a small sample of the VLP target users to detect usability problems which will face the students in a real learning situation. b) Formative evaluation for the VLP contents improves the VLP contents design. To conduct this kind of evaluation, they could use expert review and trail on a small sample of the VLP target users.

Summative evaluation for the VLP: The researchers would conduct a summative evaluation at the end of the development process to detect the effectiveness of the proposed VLP functions and contents. a) Summative Evaluation of the VLP functions to check their usability. They could also use usability evaluation instruments like questionnaire and survey with the actual VLP users to gather feedbacks about the VLP usability in the classroom. b) Summative Evaluation of the VLP contents to check the effectiveness of the proposed VLP in developing

target outcomes. They could also use some online evaluation instruments like quizzes, performance observation card, and evaluation card of the final product.

4.2.4. The proposed ACDIE model characteristics

The proposed ACDIE model has some features as an educational software development process. First of all, it aims to design and develop functions and educational contents. Also, it is considered as a specific process for developing the VLPs depending on some SE features and techniques, especially the incremental approach and educational principles together as an essential element in this process. Finally, the researchers who do not have SE background can follow it in developing new web-based educational products, especially the VLPs.
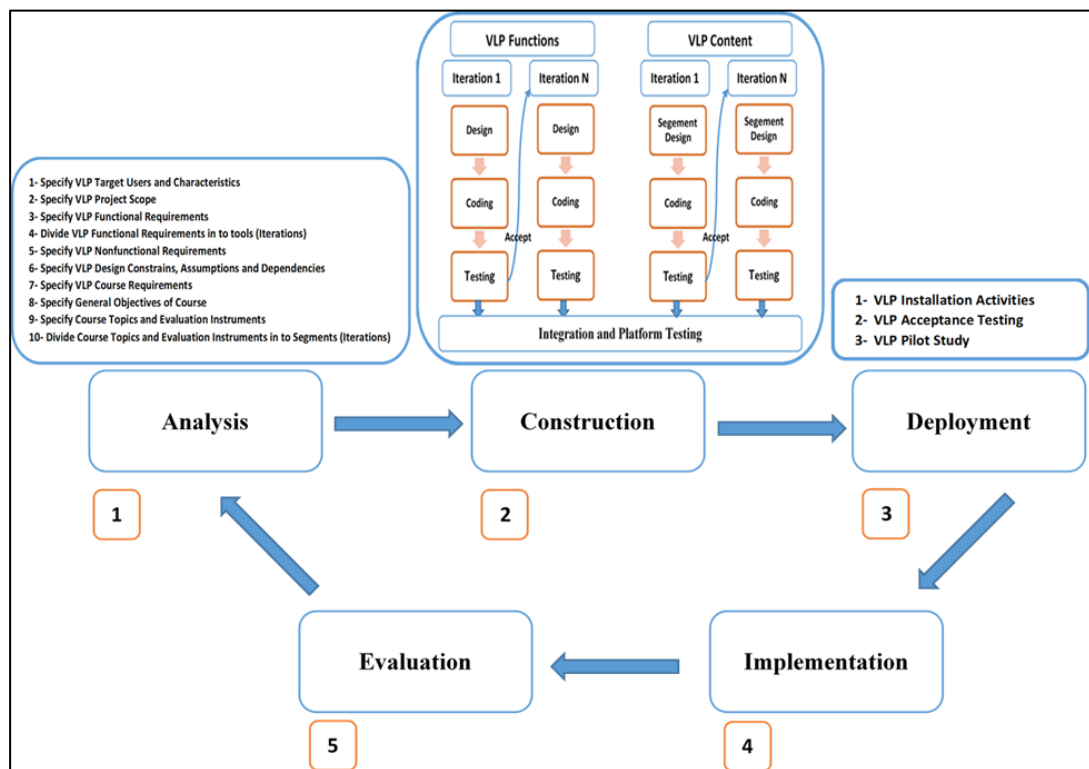
Figure 8. ACDIE Model for Development VLP

4.3. Case Study: Developing VLP Prototype for DPOVL

Based on the proposed ACDIE model, the prototype VLP system was developed for university level to teach the educational technology students how to design and produce the OVL. The motivations for developing new VLP system from zero and not using existing LMS were to apply the proposed ACDIE model as an educational development process. Also, it is important for me to learn new experiences about how to design and develop web application platform, to

apply the UML design methods for the VLP functions, to implement the functions by CakePHP framework, to conduct testing for the VLP system, to understand how the VLP tools work together, to deploy and remotely manage the VLP on the server. In this section, the ACDIE model phases were applied to develop the target VLP system, especially in the analysis, construction, and deployment phases as below.

4.3.1. Analysis of the VLP project

The purpose of this analysis phase is to provide a description of the VLP system as an instructional product. This description contains an outline of the requirement for the VLP system such as the VLP project scope, the VLP target users and characteristics, the functional and non-functional requirements, the design constraints, the VLP assumptions for overall use cases, the dependencies, and the VLP course content requirements. The details of the initial analysis phase are described in Appendix A. The description of the analysis would become a guideline for instructional designers and developers to develop the VLP system.

4.3.2. Construction of the VLP project

4.3.2.1. Constructed VLP function tools

This section explains how to construct actual VLP functions according to the ACDIE model with the user management tool and the cloud storage tool as an example of the iteration process. First of all, all functions which inside the VLP have an educational background to achieve the learning objectives. For instance, the user management tool provides user authentication for the target students and makes the instructor track the learning performance of the students. On the other hand, the cloud storage tool enables the instructors and the students to store their files related to the learning process in the VLP and to manage the files at anytime and anywhere. We applied a Model-View-Controller (MVC) pattern as a software architectural pattern in designing and developing the VLP project. This pattern is considered as an economical and flexible about saving time in revising and modifying the VLP functions. Actual examples of the iteration process are constructed according to the blended model typically as follows:

a) Iteration 1 (User Management)

- Design: The design for the VLP user management tool was made based on the applied MVC software architectural pattern. We used a class diagram as the UML method to design classes for the model, controller, and view of the tool.

- Coding: In this step, the actual code for all the design was implemented based on the class diagram by using the CakePHP framework, PHP, CSS, MYSQL database application.

- Testing: The verification and validation testing for the tool were conducted. In the verification testing, the tool was reviewed to confirm its design and behavior. In the validation testing, the test cases for the tool were implemented to confirm the tool was harmonized with the requirements and to achieve the intended purpose. The test cases for the tool was prepared based on the template headline presented by (Guru99, 2014). Finally, we fixed errors to reach the final version of the tool.

b) Iteration 2 (Cloud Storage)

Another tool was developed after moving to the next iteration by using the same steps: The design for the cloud storage tool was made based on the applied MVC pattern as described in Figure 9. Then the coding for the cloud storage tool was implemented, and the testing was conducted. See the final test cases of this iteration as described in Appendix B. The similar test cases were prepared to fix the errors.

By same construction steps, all of the VLP functions were developed as shown in Table 1. The current prototype version of the VLP system supports two languages; English and Arabic.
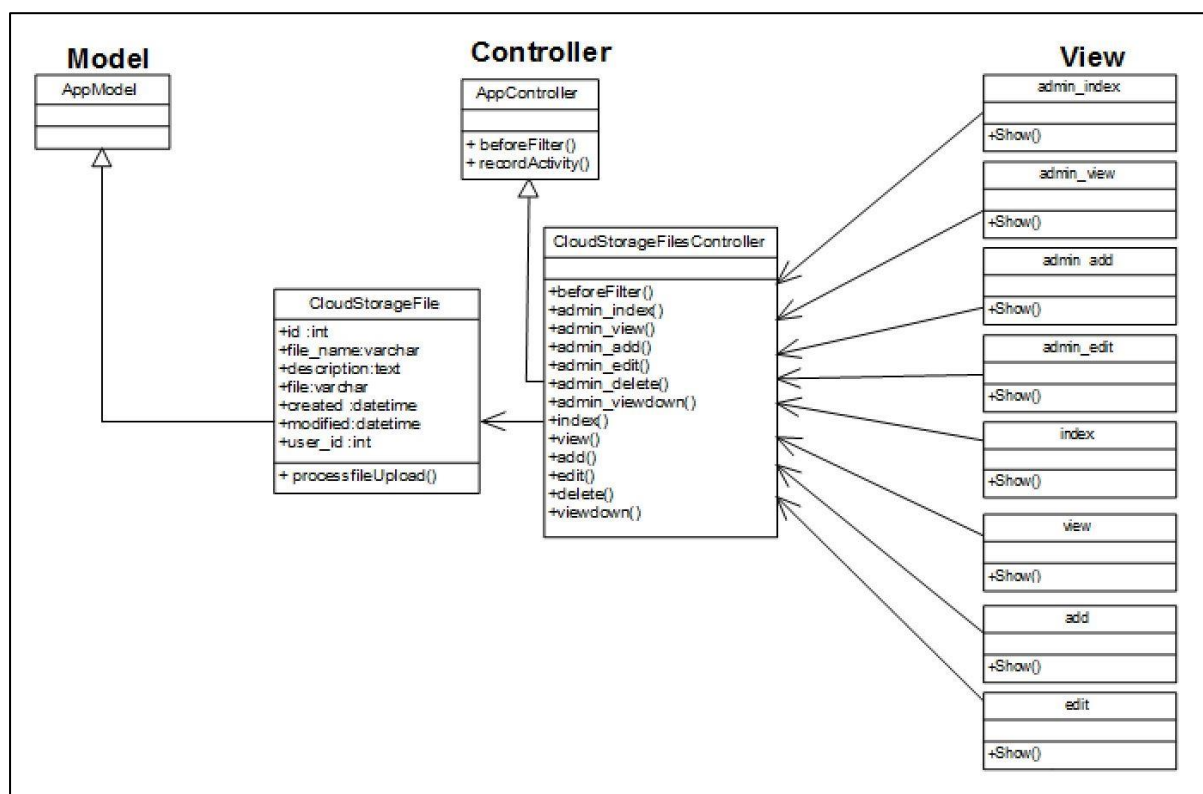
Figure 9. Description of UML design of the cloud storage tool

Table 1. The VLP administration tools

Role of Learning	Tool Name
Learning tools	Course tool
	Online Response tool
	Glossary tool
	WebQuest tool
	Assignment tool
Management tools	User management tool
	Announcement tool
	Teacher information page tool
	Learning download center tool
	Cloud storage tool
	Report tool
Communication tools	Forum tool
	Video conference tool
	Message tool
Innovative tools for the OVL	OVL designer tool
	OVL creator tool
	Educational image library tool
Evaluation tools	Quiz tool
	Questionnaire tool
	Performance observation card/product evaluation card tool
Help tool	VLP help tool

4.3.2.2. Constructed VLP course contents

In order for the educational technology students to know how to design and produce the OVL practically, the special course contents were developed and presented by the VLP course function. The course lessons were designed at first, then developed by the VLP course tool and some computer software. Finally, each lesson was tested to confirm it worked without problems. The evaluation instrument was also designed, developed, and tested in the similar steps. The course contents were included some multimedia elements like text explanation, video, instructional drawing and images about DPOVL. The courses consisted of three units involved

11 lessons as described in Table 2. The first unit provided some information and knowledge about VL as a modern technology for improving the learning process, especially an OVL concept, advantages, and general design. The second and third units involved how to design and produce the OVL, respectively.

4.3.3. Deployment of the VLP project

In this phase, the VLP prototype version was installed in a LAMP (Linux-Apache-MySQL-PHP) server. Then, we conducted a system testing for the VLP system in the real environment. Some technical problems were found and fixed successfully. The following pilot study in the next chapter and an acceptance test for the VLP were conducted by the target users. Early feedbacks about implementation problems were gathered with regarding research design, evaluation instruments, and the VLP system errors and usability problems.

Table 2. Description for the OVL course contents

Course General Objectives		
At the end of learning the OVL course, the student should be able to:		
1	Acquiring knowledge about the OVL and the skills in DPOVL.	
2	Performing the DPOVL skills practically.	
3	Making a design for OVL in one of the subjects.	
4	Producing an OVL in one of the subjects.	
Course Units	Lessons	
1 VL in education	1	Concept, types, and advantages of OVL
	2	General design of OVL
2 Designing OVL	1	Pre-design phase of OVL
	2	Criteria of DPOVL
	3	Skills in designing OVL
	4	Skills in designing OVL electronically by the VLP system
3 Producing OVL	1	Producing phase of OVL
	2	Skills in creating OVL by the VLP system
	3	Skills in preparing the simulation of a virtual experiment by Adobe Photoshop
	4	Skills in producing interactive simulation of a virtual experiment by Adobe Animate CC and ActionScript 3.0
	5	Skills in creating and publishing virtual experiment in the OVL by the VLP system

4.4. The Relationship between VLP Development and Required Skills of DPOVL

There is a robust relationship between VLP system development and required skills of DPOVL as follows; The VLP system embeds some of the DPOVL model features to establish new

online software tools for the DPOVL skills. The main tools for the VLP are "OVL designer tool" and "OVL creator tool." The aim of these tools is to cultivate the main required skills of DPOVL practically without coding difficulties. In addition, the VLP system includes several tools to realize teaching and evaluating the necessary skills of DPOVL. For example, the VLP system offers the course tool for developing and presenting the online course contents specialized in how to design and produce the OVL. The course introduces theoretical information and practical skills related to the required DPOVL skills. In conclusion, the VLP system provides the innovative tools for DPOVL as the required skills and also realized multi-tools to teach and assess the students' skills.

4.5. The VLP System Overview

The VLP system consists of two modes; an instructor mode for system administrator and a student mode. In the instructor mode, as shown in Figure 10, the instructor has full authority for administration of the VLP tools. The student mode provides the students with the interactive contents and the specialized tools for DPOVL.

Figure 10. Instructor mode GUI of the VLP system

4.6. The VLP Tool Description

The aim of this section is to present the main features and services of the developed VLP as a prototype web application system for teaching the DPOVL skills in the classroom.

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4.6.1. Innovative tools for the OVL

The educational background of the innovative tools of the OVL is based on the proposed DPOVL model phases like OVL pre-design, OVL design, OVL production, as ready-made templates. Thus, it facilitates the DPOVL skills of the educational technology students without any difficulties and technical problems.

1. OVL designer tool: It enables the students to design their own OVL with a group of ready-made templates as shown in Figure 11. The detail of the templates are as follows:

   − Template for designing OVL framework: It makes the students specify OVL name, target users, domain of course, topics, and general objectives.

   − Template for designing OVL platform: It specifies management tools, communication tools, and content display tools to be used in the learning session. This design is limited to the proposed tools in the current VLP.

   − Template for designing virtual experiment: It describes seven components of the virtual experiment, i.e. educational objectives, theoretical explanation, instructions and procedures for the experiment, simulation components and objects, activity, evaluation, and experiment summary.

   − Template for overall design evaluation: It defines the type of evaluation tools like quiz and description of the tools.

This tool provides the instructor with management function which gathers all the OVLs designed by the students as learning outcomes.

Figure 11. OVL designer tool screenshot for displaying OVL design and some ready-made templates

2. OVL creator tool: It provides the students with a template-based production function for the OVL without any code programming. It also has a management function for the instructor to assess the produced learning outcomes. The tool automatically creates the OVL after filling information in the template. The detail of the tool templates are as follows:

− Template for OVL framework: It includes a ready-made template to input main information of the OVL final product such as OVL name, target users, the domain of course, topics, and general objectives as shown in Figure 12.

− Template for virtual experiment: It imports all components of the virtual experiment. For simulation, the contents made by Adobe Photoshop and Adobe Animate CC with ActionScript 3.0 are uploaded and published.

− Template for quiz: It has a template for quiz generation which arranges question items and options.

− Template for forum: It provides a template for forum generation which adds topics and posts comments.

Figure 12. Template for OVL framework screenshot

3. Educational image library tool: It enables the instructors to manage image categories and educational images, which helps the students in preparing simulation on several domains without copyright problem. The students can download these images and embed them to their simulation objects.

4.6.2. Learning tools

The learning tools are considered as a group of tools focuses on delivering online learning contents and formative and summative evaluation activities to the target students.

1. Course tool: It enables the instructors to manage course contents, information of units and lessons using ready-made templates without coding as shown in Figure 13. It also displays such contents to the students.

2. Online response tool: It enables the instructor to make online responses with two types of questions; true and false and single choice. It also displays such online responses to the students who input a feedback about their progress during learning session in the classroom. Moreover, it provides the instructors with statistical results about the students' responses. This gives the instructors an indicator about their teaching method efficacy in the classroom.

Figure 13. Ready-made template for adding contents to the lesson

3. WebQuest tool: The concept of WebQuest is "an inquiry-oriented activity in which some or all of the information that students interact with comes from resources on the internet." introduced by Bernie Dodge at San Diego State University (Dodge, 1997). It provides the instructors with a ready-made template including six essential parts; introduction, task, process, resources, evaluation, and conclusion (Educational

Broadcasting Corporation, 2004). It also displays such WebQuest to the students.

4. Assignment tool: It enables the instructors to manage assignments. It also displays such assignments to the students and accepts to submit their answer files to the instructors. Furthermore, it enables the instructor to download the students' answer files.

5. Glossary tool: It provides two ready-made templates for glossary and terms. The first one includes the glossary name and descriptions. The second one contains a text explanation and instructional image/drawing, video/audio clips for each term. These tools also display such online glossaries/terms to the students.

4.6.3. Communication tools

1. Video conference tool: It enables the instructors to manage video conference sessions. It also displays such video conference sessions to the students. This tool is realized by BigBlueButton open source system.

2. Message tool: It supports communication between the instructors and a specific student with a direct message.

3. Forum tool: It provides the instructors and the students with a discussion forum for diverse topics with ready-made templates for forums, topics, and posts. It provides the students to publish the posts with attachments.

4.6.4. Evaluation tools

1. Quiz tool: This tool provides the instructor with ready-made templates to create quizzes with two types i.e. true or false and single choice questions including instructional image/drawing and video/audio. It also displays such quizzes to the students.

2. Questionnaire tool: It enables the instructors to manage online questionnaires with closed questions according to 5-Likert scale grade (1 to 5). Moreover, it enables the instructor to ask open questions. It also displays such questionnaires to the students.

3. Performance observation card/product evaluation card tool: The performance observation card is considered as an evaluation tool which focuses on assessing the practical skills of the target learning. On the other hand, the product evaluation card tool is regarded as an evaluation tool which concentrates on assessing the final product according to the specific criteria. It enables the instructors to manage these cards containing closed questions with rubric subscale in three scores (0 to 2) for the VLP students. It also displays such cards to the students.

4.6.5. Management tools

1. User management tool: It enables the instructors to manage the target student account. It also allows them to log in the VLP system. This tool contains ready-made templates for registration of their data.

2. Teacher information tool: It enables the instructors to manage their information such as academic data and contact. It also displays such information to the students.

3. Announcements tool: It enables the instructors to manage educational announcements. It also displays such announcements to the students.

4. Learning download center tool: It enables the instructors to manage learning files that help the students facilitate learning like extra explanation files and presentation files. The students can download them in their learning session.

5. Cloud storage tool: It enables the instructors and the students to store and manage their files on the server. It also displays such files to them at anytime and anywhere.

6. Report tool: It enables the instructors to generate reports about all students' activities in the VLP system such as login activity reports, quiz reports, questionnaire reports, and performance observation card /product evaluation reports.

4.6.6. Help tool

It enables the instructors to manage the help cases about how to use the VLP system. It provides a ready-made template for adding support cases including help title, help text explanation, and video/audio clips. It also displays such help cases to the students.

4.7. VLP System Online Course Contents for DPOVL

The developed VLP as a web application system presents online course contents explained the proposed skills in DPOVL. The course contents were produced by some tools like the VLP course tool and a screen recording software with text explanation, video, and instructional image/drawing. These lessons are classified according to theoretical and practical lessons as follows:

4.7.1. Unit one: VL in education

This unit presents the general overview of the VL technology in education. There are two theoretical lessons in this unit as shown below:

The first lesson is related to the concept, types, and advantages of the VL. This lesson focuses on; identifying the concept of the OVL, determining the types of the VL, and explaining the advantages of the OVL.

The second lesson is about the general design of the OVL. This lesson covers identifying the components of general design for the OVL, recognize the OVL platform and contents, and determining the model of DPOVL.

4.7.2. Unit two: Designing the OVL

This unit presents how to design the OVL according to the steps of the DPOVL model practically for the educational technology students. There are four lessons in this unit; three are theoretical lessons, and the remaining is a practical one as follows:

4.7.2.1. Theoretical lessons

The first lesson is relevant to a pre-design phase of the OVL. This lesson focuses on determining the target users, the course, the topics, and the general objective of the OVL.

The second lesson is about the criteria of DPOVL, which covers how to identify the educational and technological criteria of DPOVL.

The third lesson is related to the skills in designing the OVL, which provides how to cultivate the skills in designing the OVL platform and contents.

4.7.2.2. Practical lesson

The fourth lesson describes the practical skills in designing the OVL by the VLP system (specialized tool "OVL designer"). Figure 14 shows an example of the content explanation. This lesson gives the ways of designing the OVL, the OVL platform, and the virtual experiments and the overall evaluation in the OVL.

4.7.3. Unit three: Producing the OVL

This unit presents how to produce the OVL according to the steps of the DPOVL model practically for the educational technology students. There are five lessons in this unit; one lesson is a theoretical lesson and the others are practical ones as shown below:

Figure 14. Screenshot as example for lesson four content in unit two

4.7.3.1. Theoretical lesson

The first lesson is about the OVL production phase according to the steps of the DPOVL model. This lesson focuses on; identifying information about computer language, software, and specialized web system of producing the OVL, and identifying information about producing the OVL platform, the OVL contents, and publication.

4.7.3.2. Practical lessons

The second lesson is related to the creation of the OVL according to the "OVL creator" tool. This lesson introduces; generating the OVL by the "OVL creator" and identifying production of the OVL platform in an automatic way.

The third lesson is about the skills of preparing simulation of the virtual experiments by using Adobe Photoshop. This lesson focuses on; creating new file suitable for the simulation of the virtual experiment, collecting each simulation images/objects in one file with an independent layer, arranging the simulation images/objects, designing reset button for simulation, writing the name and resizing of the simulation images/objects, selecting and removing non-essential elements from the simulation images/objects, recoloring the required parts of the simulated images/objects, drawing some shapes used in the simulation, and saving the simulation file of the virtual experiment as a PSD or PDD format.

The fourth lesson is relevant to the skills in producing the simulation of the virtual experiment by Adobe Animate CC and ActionScript 3.0. This lesson consists of; creating and saving a new ActionScript 3.0 project file for the simulation in Adobe Animate CC, importing the PSD simulation file of the virtual experiment to Adobe Animate CC, converting the simulation elements to symbols, adding action code to the simulation element related to drag and drop, adding function code to reset simulation related to click to position an object, adding action code to the simulation element related to click to hiding an object and show an object, adding motion to simulation element, adding action code to stop motion of simulation element, and publishing the simulation file of the virtual experiment as a SWF format.

The fifth lesson discusses the skills in creating the OVL virtual experiment, electronic quiz, and forum. The skill content of how to create the OVL forum was delivered to students by learning download center tool. Figure 15 shows an example of the contents for creating the virtual experiment in the OVL.

Figure 15. Content explanation for skill of creating a virtual experiment in the OVL

The instructors encourage the novice students to use diverse VLP tools through an orientation session about the importance of the VLP system and task of each tool. During learning with the VLP system, the instructors also ask the students to use the VLP tools, for example, when the instructors create a discussion forum in which the students join. Furthermore, the instructors explain the students the necessity of the course tool contents in learning how to design and

develop the OVL. Thus, these tools make the students keep motivation for learning and applying the DPOVL skills.

4.8. Summary

In summary, our suggested ACDIE model in this research attempted to focus on developing both educational functions and contents of the virtual learning products like the VLP. In this attempt, we made the integration between the SE field and the ID field. There were some previous research to improve the traditional ID process through the SE approach. (Tripp & Bichelmeyer, 1990) argued that rapid prototyping could be applied as an alternative ID model, especially for computer-based instruction. Also, (Rawsthorne, 2005) presented another attempt through agile instructional design which concentrated on the development of the curriculum process. We found these attempts did not provide enough ID process for developing the VLP. In addition, this chapter presented the educational software process for developing the VLP. The VLP prototype was developed based on our suggested ACDIE model. The development mainly traced the analysis, construction, and deployment phases for both of the tools and contents of DPOVL. Moreover, it offered the VLP system overview, tools features, and description for OVL course contents.

**Chapter V   Implementation and Evaluation of Virtual
Learning Platform**

5.1. Chapter Overview

This chapter discusses the pilot implementation and final evaluation of the developed VLP. The main aim of this chapter is to evaluate the effectiveness of the VLP prototype in developing the target skills of the educational technology students. It explains the pilot implementation through a small trial to detect vital problems and refine the VLP. It also states the final experiment of the VLP and its findings. This chapter represents a response of the fourth research question; RQ4: How effective is the VLP for the educational technology students? This chapter is an updated and included version of the work previously published in

1- Ahmed, M. E., & Hasegawa, S.: A Prototype Virtual Learning Platform for Teaching Skills of Designing and Producing Online Virtual Labs in Classrooms. Research report on Japanese Society for Information and Systems in Education, Vol.31, No.4, pp.21-24, (2016).

2- Ahmed, M. E., & Hasegawa, S.: The Effectiveness of Virtual Learning Platform in Developing Skills of Designing and Producing Online Virtual Laboratories of Educational Technology Students, (2017), (submitted).

5.2. Implementation Design

In order to achieve the purpose of this research, we investigated the effectiveness of the VLP in developing the skills in how to design and produce the OVL by the educational technology students. The one group pre- and post-test was adopted as an experiment design in this research because this was frequently applied as reports regarding to the value of a novel teaching method or an interest aroused by some curriculum innovations (Cohen, Manion, & Morrison, 2007, p 282).

Table 3. Implementation design of research

Pre - test measurement(O_1)	X (Treatment)	Post - test measurement(O_2)
The Achievement Test	Experiment Practice by (VLP)	The Achievement Test
Performance Observation Card		Performance Observation Card
		Product Evaluation Card
		Usability Test

Table 3 shows the experiment design that an achievement test and a performance observation card were conducted as the pre-test evaluation instruments. Then, same test and card were

performed again in the post-test evaluation. Also, a product evaluation card of the final OVL product and a usability test of the VLP were carried out in the post-test evaluation.

5.3. Variables of Implementation

The current research design consists of one independent variable with the VLP and two main dependent variables with the DPOVL skills and usability of the VLP as described in Table 4.

Table 4. Variables of the research

Independent Variable	Dependent Variables
VLP	**1. DPOVL Skills** This variable divided into – Knowledge aspect of the DPOVL skills: This variable measured the degree of the participants' achievement for theoretical and practical information regarding DPOVL by the achievement test instrument. – The performative aspect of the DPOVL skills: This variable measured the participants' performance for the DPOVL skills by the performance observation card instrument. – The OVL products: This variable measured the participants' ability in producing the OVL in multi-domains by the product evaluation card instrument for the final product. **2. Usability of the VLP** This variable evaluated the VLP system usability from the participants' point of view by the usability questionnaire instrument.

5.4. Evaluation Instruments

There were four types of the evaluation instruments used to collect data during the empirical experiment: The online achievement test was used to evaluate the attainment of knowledge regarding DPOVL. The performance observation card was a direct and indirect observation to estimate the performance level of how the students performed the DPOVL skills. The production evaluation card was adopted to detect the mastery level of the OVL products produced by the students. The usability questionnaire was used to detect the VLP usage from the students' perspective. All evaluation instruments were reviewed by one external specialist in the educational technology field as validity. The detail of each instrument was described as follows:

5.4.1. Online achievement test

The main purpose of the achievement test was to measure the impact of the VLP in developing an attainment of knowledge aspect related to DPOVL. The achievement test was proposed by the researcher and designed in an electronic form. It was contained 20 questions with a total score 20. It allowed the students to choose the answer from three options. The results of the test were calculated by a VLP electronic scoring system. The electronic scoring system showed and stored a report for each student after submitting the test response. This report was showed each question of the test and the selected response, true or false case and question score. Moreover, it showed the student's name and score. The preparation of the achievement test question was taken into consideration the relative weights of the content topics. The goal of the test was assigned to reach 80% of knowledge regarding DPOVL as the mastery level.

5.4.2. Online performance observation card

The online performance observation card was prepared by the researcher to measure the effects of the VLP in cultivating the performance skills of DPOVL and designed in an electronic form. The card included 34 skills and the total score was 68. The goal of the card was to reach 80% as the mastery skills. Each skill had a three rubric subscale (Performing skill with high level = 2, Performing skill with moderate level = 1, No performing skill = 0). All calculation was automatically done by the system. The real procedure of the evaluation was the researcher observed and estimated each skill based on the rubric scale before and after learning.

5.4.3. Online product evaluation card

The aim of the product evaluation card was to measure the effects of the VLP in mastering the level of the OVL production. The card was prepared by the researcher and designed in an electronic form. The card included 23 criteria related to DPOVL, and a total score was 46. Each criterion had a three rubric level (Available = 2, Somewhat Available = 1, Not available = 0). The goal of the card was to reach 80% as the mastery criteria. The researcher filled the student's score for each criterion in the online card, and the system automatically calculated the total score. The preparation of the product evaluation card criteria was taken into consideration relevant to the OVL skills and components.

5.4.4. Online usability questionnaire

The aim of the usability questionnaire was to measure the attitude of the educational technology students towards the proposed VLP. The questionnaire was designed in an electronic form. The usability questionnaire items for the VLP were proposed and derived based on some previous scales of usability (Lund, 2001), (Nielsen, 2013). The questionnaire included 9 closed items. Each item was answered by a five-point Likert scale. The ranging of Likert scale started from 1 (strongly disagree) to 5 (strongly agree). The usability questionnaire as described in Appendix C.

5.5. Review and Pilot Implementation of the VLP System

5.5.1. Expert reviews for the VLP system

The initial review for the VLP system was conducted by four specialists in the two fields; educational technology, and curriculum and instruction. The purpose of this review by the experts was to validate the developed VLP was acceptable as a learning system in general. The evaluation instrument was closed/opened electronic questionnaire to know their opinion about the developed VLP. The questionnaire included ten closed items, each of which was estimated

Table 5. Experts' evaluation questionnaire results for the VLP based on item per number of the experts

	Evaluation Items	Response (number of experts)				
		SA	A	N	D	SD
Q1	The aim of the VLP is clear and understandable	4	0	0	0	0
Q2	The user interface of the VLP is attractive and consistent	3	1	0	0	0
Q3	The VLP provides innovative function tools specialized in DPOVLs	4	0	0	0	0
Q4	The VLP tools have an educational background.	4	0	0	0	0
Q5	The tools work well without any kind of error	4	0	0	0	0
Q6	The VLP navigation is flexible and easy to use	3	1	0	0	0
Q7	The contents of the course are appropriate to achieve the goal of the VLP	3	1	0	0	0
Q8	The proposed VLP contains sufficient communication tools to achieve interactivity in learning process	2	2	0	0	0
Q9	The proposed VLP provides adequate assistance for students with modern form	3	1	0	0	0
Q10	The proposed VLP takes into account the educational and technological principles of e-learning	4	0	0	0	0

Note: SA (5) = Strongly Agree, A (4) = Agree, N (3) = Neutral, D (2) = Disagree, SD (1) = Strongly Disagree

by a five-point Likert scale. The range of the scale was from 1 (strongly disagree) to 5 (strongly agree). All items were asked in a positive scoring direction. Also, it included two open items, about the description of the VLP educational/technical problems and suggestion for improvement of the VLP.

The results showed the experts were satisfied with the current version of the VLP (see Table 5). Moreover, according to the results of the two open items, minor suggestions to be improved were received. For example, a text hint should be added to the language icons in the GUI. It would be taken into account to improve this suggestion in the VLP user interface in future.

5.5.2. Pilot study for the VLP system

A pilot experiment was conducted before the main experiment. The pilot study aimed to detect about; a technical error of the VLP functionality, any mistakes in the course contents of the VLP, and the reliability of some online evaluation instruments i.e. the achievement test, the performance observation card, and the product evaluation card. The participants of the pilot study were ten undergraduate students (5 males and 5 females) from the fourth grade on the college of specific education at South Valley University, Egypt. Their major was educational technology and their age ranged from 21 to 25 (M= 22.8, SD=1.23). All participants were assigned in one group pre- and post-test design. The participants took part in a class using the VLP to learn how to design and produce the OVL. The pilot study was conducted in the second term of the academic year 2015-2016 and was taught by the same instructor. A computer lab with internet connection at the college was provided to them as the place to join the pilot study. At first, an orientation session was conducted to share the purpose of the study. The participants were registered as users in the VLP system and carried out the achievement test and the performance observation card as the pre-test instruments. In the intervention phase, they took a class with the VLP system. Finally, the post-test instruments; the achievement test, the performance observation card, the product evaluation card, and the usability questionnaire, were conducted respectively. Also, the achievement re-test was performed two weeks later of the pilot study.

Results of a pilot study. Firstly, we found some unexpected technical errors for the VLP functions and mistakes in the VLP contents. Such errors and mistakes were fixed during the class.

Secondly, the participants' scores on the achievement test were analyzed by using SPSS v20 to confirm the reliability of the instrument. The test-retest reliability method was applied to the achievement test scores in post-test – retest for the same participants of the pilot study. The

results showed the Pearson correlation was 0.705. This value means acceptable reliability of achievement test instrument for collecting data. The achievement test instrument as described in Appendix D. The inter-rater reliability was used to evaluate the reliability of the performance observation card. The percent agreement between two raters was calculated by dividing the number of actual agreements by the number of possible agreements and multiplying it by 100 (Cohen, Manion, & Morrison, 2007, p. 147). The two raters observed and estimated the 34 DPOVL skills for each student of the pilot study at the same time with three rubric subscales. The percent agreement between two raters for the ten participants ranged from 79 % to 100% and the mean for all observed cases was 96 % (see Table 6). This value indicates the acceptable reliability of the performance observation card instrument. The performance observation card instrument as described in Appendix E.

Table 6. Percent agreement for pilot study participants performance

Student No	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Percent Agreement	100%	91%	88 %	100%	79 %	100%	100%	100%	100%	100%

The inter-rater reliability was also used to evaluate the reliability of the product evaluation card in the similar way of the performance observation card. The pair raters evaluated and estimated the 23 criteria of the OVL product for each student in the pilot study at the same time with three rubric subscales. The percent agreement between two raters for the ten OVL products ranged from 91 % to 100% and the mean for all evaluated products was around 99% (see Table 7). This value indicates the acceptable reliability of the product evaluation card instrument. The product evaluation card instrument as described in Appendix F.

Table 7. Percent agreement for pilot study participants products

Product No	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Percent Agreement	100%	100%	100%	100%	100%	100%	91 %	100%	100%	100%

5.5.3. Acceptance testing for the developed VLP

The acceptance testing was conducted to validate the acceptance of the developed VLP as an educational technology solution for cultivating the DPOVL skills of the educational technology students. After learning with the VLP in the pilot study, the online acceptance-testing questionnaire was deployed to the participants. The questionnaire included six closed items

with a five-point Likert scale. Five items asked them in a positive scoring direction, and 1 item asked them in a negative scoring direction. The ranging of Likert scale started from 1 (strongly disagree) to 5 (strongly agree) for positive items and inversion for negative items. Also, it included two open items for a description of the VLP educational/technical problems and suggestion for improvement of the VLP.

Results of the acceptance testing for the developed VLP. Table 8 shows the results of the acceptance-testing questionnaire. From Q1 to Q5, the results represent almost of the participants accepted the developed VLP system as a solution for cultivating the target skills. On the other hand, from Q6, there were some, not vital problems observed in using the VLP. For instance, a delete function error was occurred in some components of the OVL creator tool. Based on these results, we have already fixed such errors.

Table 8. Acceptance testing questionnaire results for the VLP

	Question	Response (number of participants)				
		SA	A	N	D	SD
Q1	The user interface of the VLP system is acceptable and attractant	8	2	0	0	0
Q2	The aim of the design and development of the VLP system is clear and understandable	9	1	0	0	0
Q3	The VLP system provides you with a good electronic environment for learning	10	0	0	0	0
Q4	The aim of each function in the VLP system is clear and understandable	9	1	0	0	0
Q5	The VLP system provides you with specialized tools and is easy to use for DPOVLs	7	3	0	0	0
Q6	You have faced some problems with using the VLP system	2	1	1	1	5

Note: SA (5) = Strongly Agree, A (4) = Agree, N (3) = Neutral, D (2) = Disagree, SD (1) = Strongly Disagree

From the results of this pilot study, we concluded several main outcomes. Firstly, it was indicated that the experts had a positive attitude for the current developed VLP as an educational web-based system. Also, the educational technology students as the participants of the pilot study accepted the current version of the VLP as a learning environment. Secondly, it was helped to refine and fix several technical errors of the VLP functionality during the practical use. Thirdly, it was also helped to modify and correct some mistakes of the VLP course contents related to the DPOVL skills. Finally, it was assisted to detect the reliability range of some evaluation instruments.

5.6. Main Experiment

In order to overcome lacking the skills of the educational technology students regarding DPOVL, the main experiment was performed to exam the actual impact of the proposed VLP in cultivating the target skills. The experiment was implemented several functions and contents of the VLP with thirty participants who learned by the VLP system in an ICT classroom. Also, the experiment included usability evaluation of the VLP system. In this research, the Arabic version of the VLP system was used.

5.7. Participants and Ethical Considerations

The participants of this research were thirty undergraduate students (4 males and 26 females) who were the fourth grade in the faculty of specific education at South Valley University, Egypt. The participants were majoring in educational technology. The participants ranged in age from 21 to 24 (Mean = 21.7, SD = 0.65). All of them were assigned to one experimental group. They took part in a class with the VLP in the second term of the academic year 2015-2016 and were taught by the same instructor. This research took into account the ethical consideration during this implementation. The formal permission to conduct the experiment was taken from the head of the educational technology department and dean of the faculty of specific education. Moreover, it was obtained a prior oral consent from the students in participating in the experiment. Also, the experiment focused on an educational domain and did not have any harmful effects.

5.8. Evaluation Procedure

A computer lab with internet connection at the university was provided to the participants as a place to attend the experiment. At first, an orientation session was conducted to share the purpose of the research. The participants were registered as users in the VLP system. Each of them accessed the tools and the contents on the VLP website (http://dlc-vm09.jaist.ac.jp:30080/users/login) with username and password as shown in Figure 16. Next, the pre-test instruments; online achievement test, performance observation card was applied to assess the initial level of the DPOVL skills of the experimental group according to the evaluation procedure of the research as shown in Figure 17. Then, the participants were asked to learn by the proposed VLP with the instructor in the computer lab. The several functions and contents of the VLP were used except for the video conference and educational image library tools as the following steps; a) The learning process by the VLP contained the learning course

contents of how to design and produce the OVL. b) The participants joined in discussion forums for the topics created by the instructor to enhance the knowledge regarding the contents. c) The participants performed online responses as a formative evaluation to receive immediate feedback of their performance during their learning. d) They downloaded the assignment and submitted their response by the assignment tool. e) They received simple web quests related to the topics and submitted their responses via the assignment tool. f) They conducted the practical training for the target designing skills by using the OVL designer tool. g) They applied the target skills in making one OVL design for one course or subject selected from a specific grade at any educational stage. Also, they sent the results of their design to the instructor as a part of the assignment. h) They performed the training for the producing skills of the OVL by using the OVL creator tool, Adobe Photoshop, and Adobe Animate CC. i) They applied the target skills in making one OVL product for the designed OVL formerly. j) Finally, after finishing their learning with the VLP, they were asked to conduct the post-test instruments such as the achievement test, the performance observation card, the product evaluation card, and the usability questionnaire. Some screenshots from the Arabic version of the VLP system were shown in Appendix G.

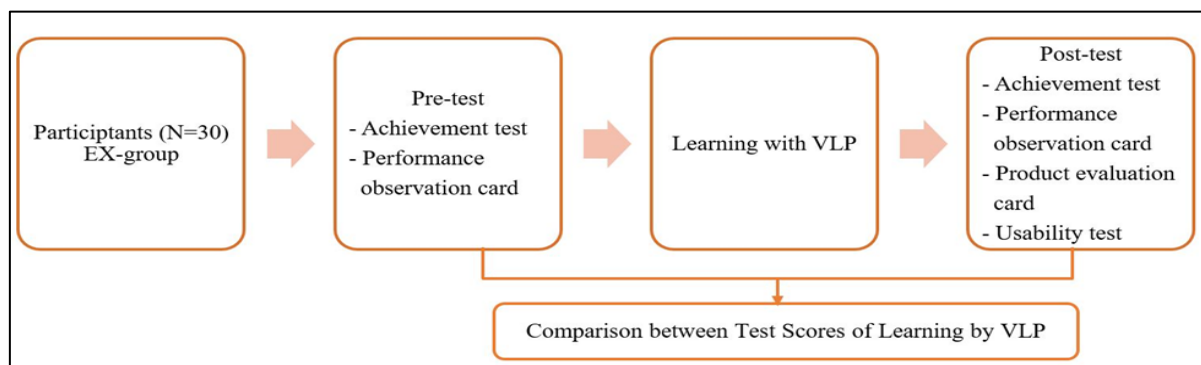Figure 16. System login for students

Figure 17. Evaluation procedure

5.9. Data Collection

In order to achieve the main objective of this research, there are four types of the data collection instrument used as follows; a) Achievement test was used to collect data of the participant's knowledge regarding the DPOVL skills. b) Performance observation card was used to gather data about the participants' DPOVL skills. c) Product evaluation card was used to collect data for the OVL products. d) Usability Questionnaire was used to collect the participant's opinions about the usage of the VLP.

5.10. Data Analysis

The paired sample t-test was adopted as the statistics analysis of the main experiment to detect the difference between the pre- and post-test scores of the research group in the achievement test and the performance observation card. Furthermore, the effect size was used to ascertain the magnitude of the effect of the proposed VLP in cultivating the knowledge and skills of DPOVL of the educational technology students. Moreover, descriptive statistics like means, median, standard deviations, and range were reported for the following research variables: the participants' age, the participants' scores in the product evaluation card, and the participants' usability attitude questionnaire. All statistical procedures were conducted at α=0.01 level (2-tailed statistics).

5.11. Results and Discussion

5.11.1. Attaining knowledge of DPOVL

A paired-samples t-test was performed to compare the scores of the thirty participants in the achievement test before and after learning with the proposed VLP. As shown in Table 9 and Figure 18, the results indicated that the scores on the post-test (M = 18.73, SD = 1.55) were higher than the scores on the pre-test (M = 12.37, SD = 4.27), t (29) = 7.832, $p < 0.01$, Cohen's d = 1.43.

These results showed a significant difference at 0.01 level with the effect size exceed Cohen's convention for a large effect (d = .80). Thus, these results suggested the VLP treatment had a large effect on developing knowledge of DPOVL of the educational technology students. The proposed VLP delivered the interactive learning environment to the participants through some possibilities. Firstly, it provided the participants with the special online course contents with multimedia like video, instructional image/drawing which covered almost knowledge of DPOVL. Secondly, the VLP provided them with the discussion forums for the topics relevant

to DPOVL. Thirdly, it enabled them to receive immediate feedback about their performance through the online responses as the formative evaluation. Fourthly, it supported diverse types of web form such as the assignments and the simple web quests to make them deep understanding of the learning topics. Finally, it gave them to perform sufficient training opportunities for the skills in designing the OVL by the "OVL designer tool" and for the skills in producing the OVL by the "OVL creator tool." Moreover, the results in Figure 18 showed that the mean percentage ratio of post-test results in the achievement test 93.65%. That indicates that the proposed VLP has enhanced mastery of learning knowledge for the participants at the level of over 80%.

5.11.2. Performing skills of DPOVL

A paired-samples t-test was performed to compare the scores of the thirty participants in the performance observation card before and after learning with the proposed VLP. As shown in Table 9 and Figure 18, the results indicated that there was a significant increase in the scores on the post-test (M=60, SD=9.38) than the scores on the pre-test (M = 7.33, SD = 7.17), t (29) = 24.640, $p < 0.01$, Cohen's d = 4.50.

These results showed a significant difference at 0.01 level with the effect size exceed Cohen's convention for a large effect (d = .80). Thus, these results illustrated the VLP treatment had a large effect on developing the performance of the DPOVL skills of the educational technology students. The VLP supported the participants with the course contents which showed the DPOVL skills. Especially, the contents included the following instructional videos for the skills; in creating the OVL, in preparing simulation design of the virtual experiment by Adobe Photoshop, in producing the interactive simulation of the virtual experiment by using Adobe Animate CC and ActionScript 3.0, and in creating and publishing the virtual experiment in the OVL by the VLP system. The VLP also provided two specialized innovation tools with the ready-made templates for learning the DPOVL skills without programming difficulties. The first one was the "OVL designer tool" which included a ready-made template for the skills of designing the OVL. Also, the VLP provided the participants with another specific tool under the name of the "OVL creator tool." It helped them learn the skills in producing the OVL with a ready-made template for the skills in producing the OVLs. We expected 80% was mastery level of the target skills. The results in Figure 18 showed that the mean percentage of the post-test of the performance observation card was over 88%. It means the VLP helped the participants conducted suitable training.

Table 9. Comparison between the mean of pre-and post-test for the experimental group in the achievement test and the performance observation card.

Evaluation Instrument	Group	N	M	SD	DF	T-Value	p	Significance level	Effect size (Cohen's d)
Achievement test	Pre-test	30	12.37	4.27	29	7.832	.000*	0.01	1.43
	Post-test	30	18.73	1.55					
Performance observation card	Pre-test	30	7.33	7.17	29	24.640	.000*	0.01	4.50
	Post-test	30	60	9.38					

$p < 0.01$ Achievement test full mark score =20   Performance observation card full mark score =68
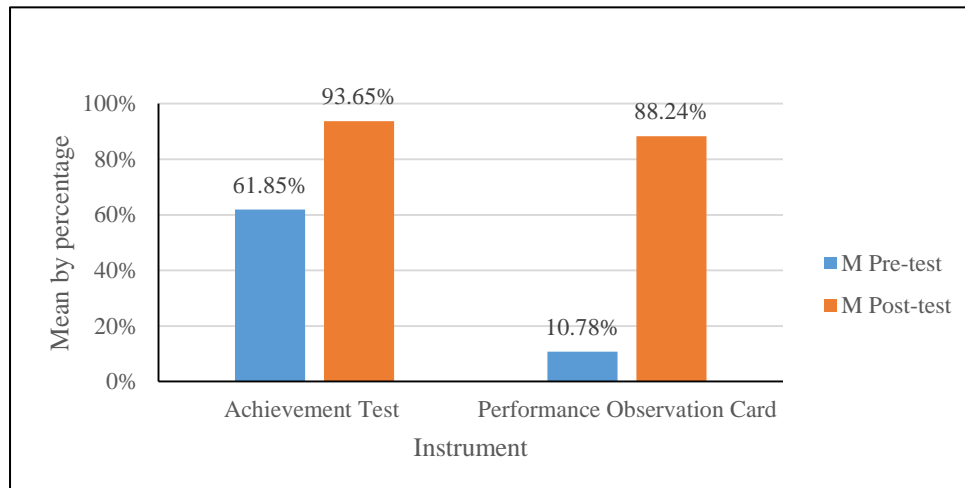
Figure 18. Comparison between mean of pre-test and post-test for experimental group in achievement test and performance observation card

5.11.3. Producing the OVL products

A criterion of the mastery level 80% was applied to the scores of the thirty participants in the product evaluation card after learning with the proposed VLP. As shown in Table 10 and Figure 19, the results of the post-test were ranged from 40 to 46 (the full mark was 46). Thus, we confirmed that all the participants' scores were higher than the assumed criterion 80%. Moreover, the mean of the correct percentage of the product evaluation was over 95% which was higher than the original mastery level. That indicates that the proposed VLP has a positive effect to reach the mastery level in producing the OVL.

Table 10. Comparison between participant's scores on the product evaluation card and criterion score of the mastery level

Research Instrument	N	Min	Max	M	SD	Criterion Score of mastery level 80%
Product Evaluation Card	30	40	46	43.97	1.43	36.8

The results inferred the effectiveness of the VLP was caused by the interactive learning contents and the ready-made templates. The VLP provide them with discussion forums to enhance the learning of the OVL producing skills. In addition, it assisted them to receive and download learning files related to learning content of producing OVL like a file of how to create OVL forum. Furthermore, it provided to them with an online formative evaluation which led to support the learning of the target contents. Moreover, it enabled them carried out enough training for producing the OVL and managing of their OVLs products by the "OVL creator tool." Finally, the "OVL creator tool" provided the participants with the common ready-made template for establishing and publishing an OVL framework as shown in Figure 20 and automatically deployed a simple platform with enough guidance. This tool also included several OVL function tools with common design ready-made templates such as add virtual experiment, add a forum, add a quiz, and OVL reports. Thus, it provided the participants with specialized OVL tools for creating and displaying OVL components which assisted them in producing the OVL products in multi-domains through easy way without coding problems.
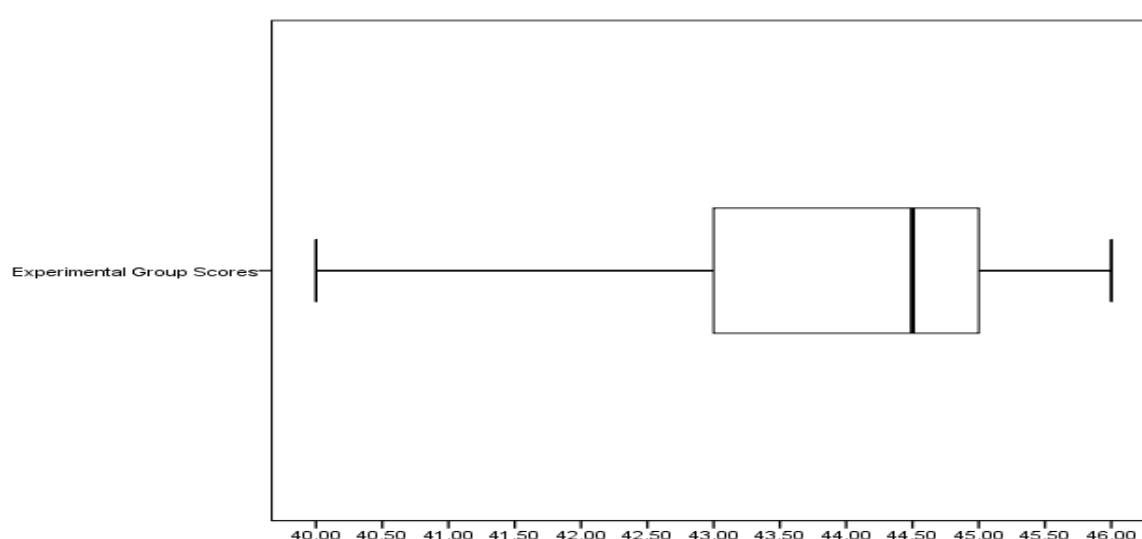
Figure 19. Boxplot for distribution of the participants' scores in the product evaluation card

Figure 20. Framework of the ready-made template

The domain classification of the produced OVL is described in Table 11 which shows a number of the products for each domain. It can be obviously seen that the number of the OVLs as final products were distributed to the eight domains (subjects). Although 21 (70%) products were related to science fields such as science, biology, chemistry, geology and environmental sciences, the remaining 9 (30%) products were in other theoretical issues like social studies, computer network, mathematics, and Arabic language. This diversity indicated the proposed methodology was acceptable not only science fields instead of real laboratories but also the conceptualized subjects.

Table 11. Classification of the number of the OVL products by subject domain.

Domain name	Science	Social Studies	Arabic Language	Biology	Chemistry	Computer Network	Geology and Environmental Sciences	Mathematics
Number of the OVLs products	14	2	1	5	1	4	1	2

Table 12 shows the number of the produced OVL products per each educational stage. We can also know that the products were covered all of the educational stages from kindergarten to university. In summary, we concluded that the proposed VLP led to various OVL products

covered with several domains and educational stages with proper contents and functions. Due to the limitation of the experiment, it is difficult to show actual coverage for our proposal. We will continue the research to investigate this point.

Table 12. Classification of the OVL products by educational stage.

Educational stage	Kindergarten stage	Elementary stage	Preparatory stage	Secondary stage	University stage
Number of the OVLs	1	10	8	5	6

In order to detect the common insufficiency of the OVL products, we picked up the 9 products in order from the low score of the product evaluation card. As a result, we found these products often lacked some educational activities for each virtual experiment and included intermediate quality of the simulation and DPOVL criteria.

The future treatment to overcome these deficiencies were as follows; the next version will enhance the ready-made templates with automatic hints based on the students' learning process to apply the DPOVL criteria effectively, it will arrange some new features regarding the skills of the OVL activities, it will present extra videos or more explanation regarding how to develop the simulation and add the web activities.

On the other hand, we picked up the 3 high-level OVL products to know their strong points. Each of them had a high quality simulation which contained interactive actions, a reset function, and good quality of images/graphics in common. These products would be useful for practical learning with a sufficient training environment to reach mastery level in the actual classroom because they provide target learners with not only the interactive simulation but also the assessment and the communication tools. The following are examples of the high-level OVL products;

Computer Network OVL: This OVL product will use as an ICT tool to support the traditional teaching of computer network course. It will provide the target learners with interactive simulations for invisible tasks of computer network devices like the switches and hubs to enhance understanding some theoretical aspects in the computer network domain. Figure 21 shows the OVL product.

Mathematic OVL: This product will provide an interactive simulation for some mathematic topics like theory of Pythagoras and superposition "first case." This OVL product will enhance the learners with motivation in learning some mathematic aspects. Figure 22 shows the OVL product.
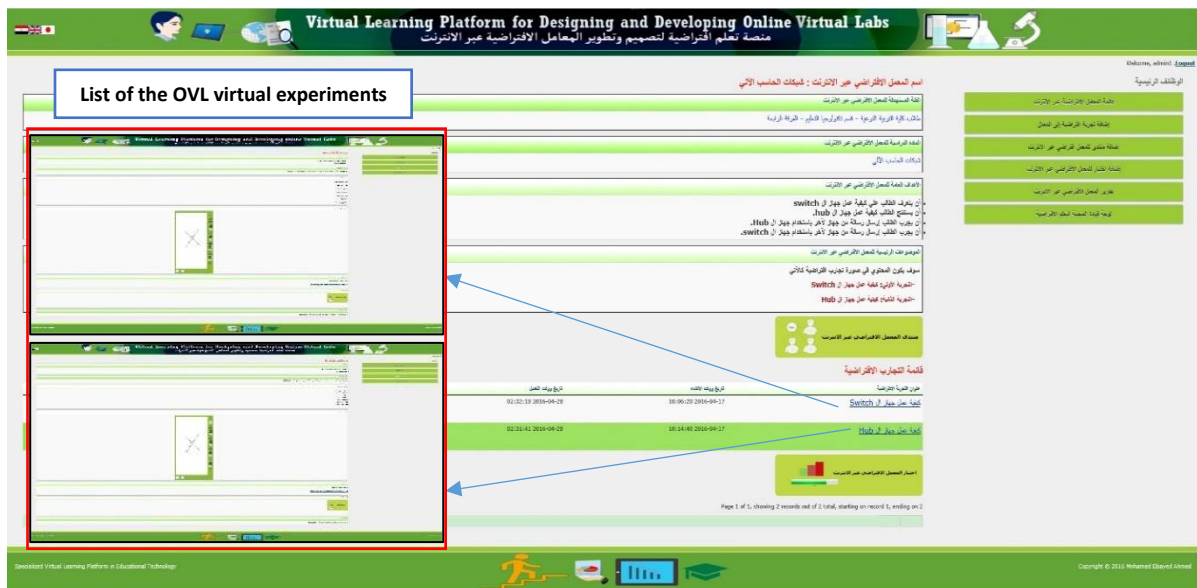
Figure 21. Computer Network OVL product for one of the students who participated in the research experiment
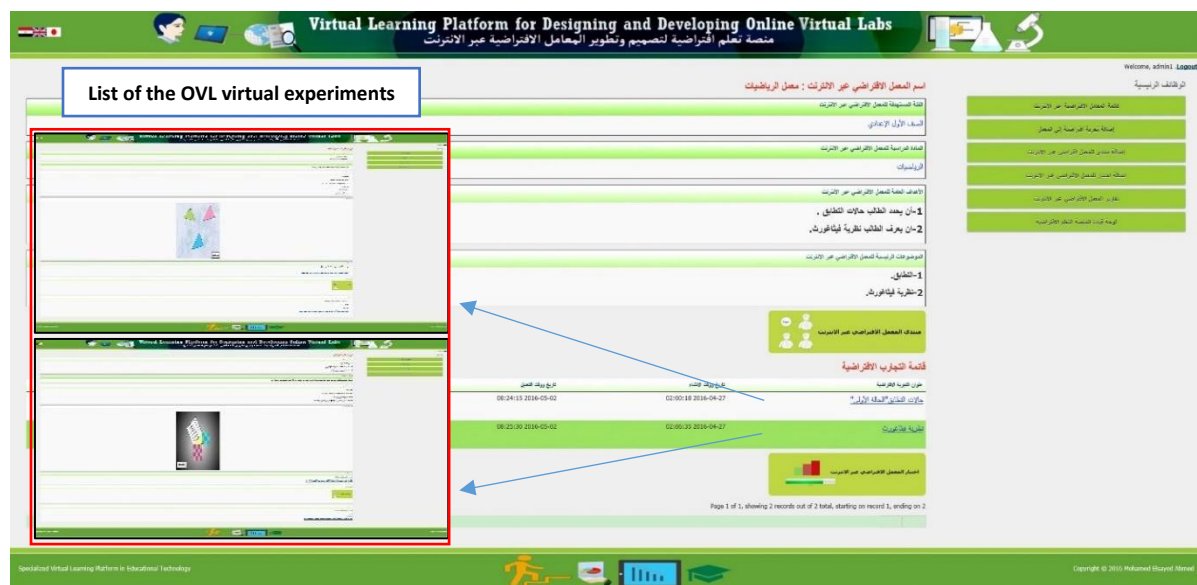
Figure 22. Mathematic OVL product for one of the students who participated in the research experiment

Biology OVL: The OVL product will be useful for teaching some biology topics because it provides interactive simulations for an alternative to real laboratory experiments. This OVL will be used as an ICT tool in enhancing teaching biology with real laboratories so that the learners can conduct enough training for the practical skills in an economical way. Figure 23 shows the biology OVL product.

Figure 23. Biology OVL product for one of the students who participated in the research experiment

5.11.4. Usability of the VLP

Table 13. Usability testing questionnaire results for the VLP based on item per the number of the participants

	Question	Response (Number of Students)					Median
		SA	A	N	D	SD	
Q1	The user interface of the VLP is acceptable and attractant	22	6	1	1	0	5
Q2	Ease of design, produce, and publish the OVLs by using the VLP	22	6	1	1	0	5
Q3	The VLP provides to me good electronic environment for learning which makes me use it in learning other courses in the future	20	8	2	0	0	5
Q4	The VLP has a flexible navigation so you can refer to the homepage of the platform from any page	23	4	3	0	0	5
Q5	The VLP showed to you error message to fix any problems during dealing with the VLP system	23	6	1	0	0	5
Q6	The VLP provides to you help and guidance	17	9	4	0	0	5
Q7	A performance of the VLP is speed and efficiency	20	8	2	0	0	5
Q8	The VLP provides to you the possibility of modification and deletion when dealing with a student's functional tool	23	4	3	0	0	5
Q9	The aim of use each function tool in the VLP system is clear and understandable to me	19	10	1	0	0	5
	Overall Median						5

Note: SA (5) = Strongly Agree, A (4) = Agree, N (3) = Neutral, D (2) = Disagree, SD (1) = Strongly Disagree

Table 13 shows the results of the 5-point Likert-scale questionnaire with 9 question items. Almost of the participants were strongly agreed for usability of the VLP software with Median = 5.

5.12. Summary

The prototype version of the VLP was reviewed by the experts and experimented through the pilot implementation by the small target students. The results showed that the VLP was well designed and accepted. However, there were some educational and technical errors and suggestions for improvement. Based on the results of the pilot study, we claimed that the ACDIE framework might help in constructing and deploying the acceptable version of the VLP as a web system. The ACDIE framework adopted the MVC pattern in constructing the VLP tools, which helped to understand its design and implementation. The gradually developing process contributed to focus on constructing each tool individually and providing the possibility of modification and improvement at any time. Also, the validation process was useful to meet its requirements and to decrease programming errors. In addition, system testing after deployment to the real environment improved the quality of service. The developing VLP contents in the ACDIE framework based on the proposed ready-made templates of the VLP tools contributed to easy content construction with good management and without code errors. Also, designing and constructing the contents according to educational aspects maybe support the experts and the target participants in accepting current version. Finally, we could claim there were no vital programming obstructions in the pilot implementation of the VLP.

The main experiment pointed out that the developed VLP gave a positive impact for cultivating the target skills of the DPOVL of the educational technology students. Moreover, they felt comfort about the VLP system services. Furthermore, they were asked to respond one open question via the forum tool about "what is your opinion on the VLP system for DPOVL?" 27 of the participants sent a feedback about their views on learning from the VLP system, how to design and produce the OVL. Almost of the participants' opinions indicated that the VLP had a good solution for teaching the DPOVL skills. The students' opinions were concluded as below.

The participants stated that the VLP was easy to use, clearness, attractive, good color of design, simple, flexible, and multi-lingual user interface. The VLP organization was easy to navigate by the students. It did not require their experience in the use of computers since it was easy and simple platform structure. It did not also require their expertise in the field of programming. They only focused on the tasks that the VLP performed. Also, they stated that the VLP was

considered as an economic tool and it could be used without the guidance of the instructor. It provided enough explanation with suitably grouped tools, which helped the students to learn by themselves. They tried it several times and communicated with the instructor by the forums and the messages. Finally, they reported that the VLP helped them in DPOVL with theoretical explanation and videos of all the basic skills and professionalism. Such system was useful in learning gradually step by step from novice to advanced level in the creation of the OVL. The platform provided tools, which assists in creating the OVL in diverse domains. It was possible to make the design of virtual experiments with the simplest way. It provided a ready-made template to create quizzes and forums.

The results showed that the VLP prototype version had many advantages. However, two students reported some problems. One student referred to inconvenience in creating quiz through many steps and pages. Also, the student stated the GUI of the student mode was nice design, but the other pages of the VLP were not satisfied with its design. Another student stated that the videos explanation did not include sound in the developed VLP.

Thus, this chapter presented the positive impact of the developed VLP in cultivating the target skills and showed positive attitude of the students regarding the developed VLP services as an answer to the fourth research question.

Chapter VI   Conclusion, Contributions, Recommendations, Limitations, and Future Work

6.1. Chapter Overview

This chapter describes a conclusion, contributions and limitations, recommendations and future work of the research. First of all, it mentions the conclusion of the research based on the finding of the research questions. And then, it presents the main contributions to the educational technology field, limitations, and recommendations. Finally, it states the future work related to improvement the development of the VLP and future vision to change Egyptian educational system.

6.2. Conclusion

This research proposed the new ID framework to teach the educational technology students the DPOVL with fixed shape and components. Also, it proposed the software development approach for developing the VLP as a web educational software. Moreover, it presented the VLP for developing the DPOVL skills of the educational technology students. Furthermore, this research examined the actual effect of the developed VLP in cultivating the target skills and some usability aspects by conducting an empirical experiment. Finally, it showed the findings and discussion of the experiment.

The answers to the research questions were put in a sequential and associated manner as described in Figure 24.
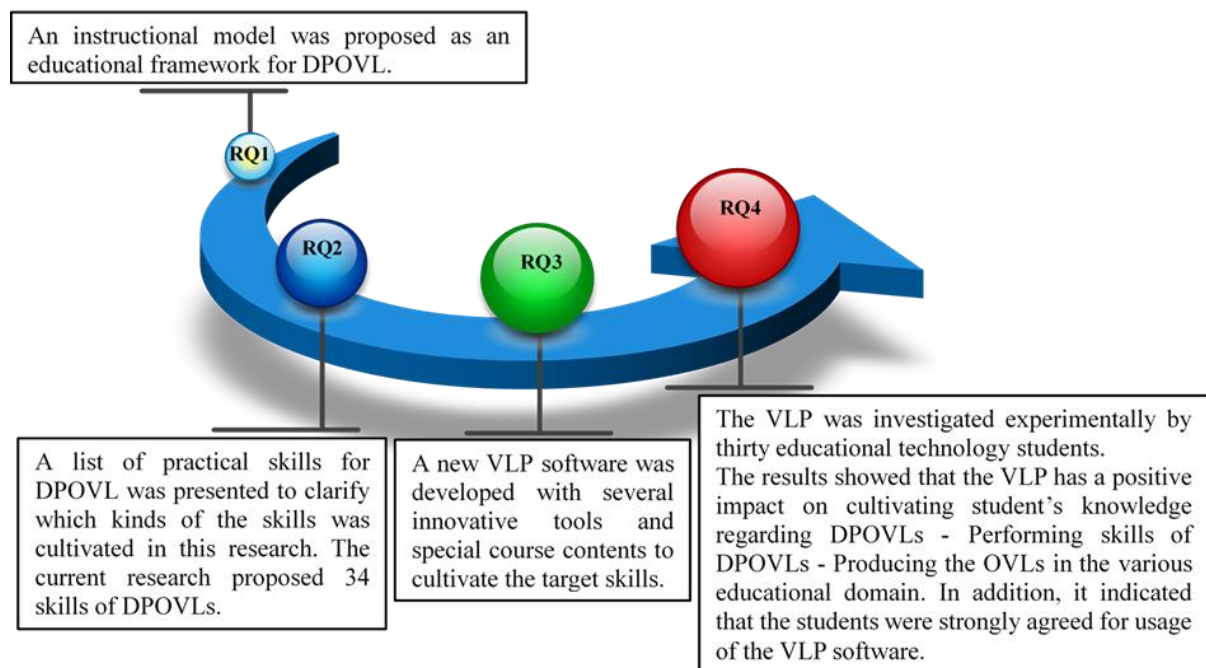

Figure 24. Conclusion of the answers of the research questions

1. What is an ID model which can guide the educational technology students in DPOVL?

Firstly, a general ID model was proposed to teach the students in the department of educational technology how to design and produce the OVL in a standard way. This model was attempted to improve their DPOVL skills with stable form and components. The previous studies of the OVL in some fields and the previous ID models were analyzed. Based on the results of the analyses, the ID model of DPOVL was proposed. This model focused on e-learning and virtual learning components suitable in modern educational systems. The proposed model contains six phases, OVL pre-design, DPOVL criteria, OVL design, OVL production, OVL experiment-implementation, and OVL evaluation, which leads to producing the OVL step by step. Also, the list of criteria for DPOVL was suggested to provide the guidelines for the students. We had done the literature reviews related to VLs, e-learning, online technological resources, online courses and instructional websites besides different aspects of educational technology. Depending on the reviews, we made a derivation of the DPOVL criteria and organized them under two parts: educational criteria and technological criteria. These criteria would be used by the instructors of educational technology in the criteria phase when teaching the DPOVL model to the students. These criteria would provide the students with educational and technological guidelines to DPOVL with the acceptable high level of efficiency.

2. What are the suitable practical skills for DPOVL?

Secondly, the list of the practical skills for DPOVL was proposed. These skills were specified in light of the ID model of DPOVL, VLP system, and some of the computer software like Adobe Photoshop and Adobe Animate CC and ActionScript 3.0. The current research proposed the 34 skills of DPOVL. The main skills include; designing OVL by the OVL designer tool and producing the OVL by using the OVL creator tool. These skills were learned through the VLP course contents.

3. How to develop the VLP for cultivating the DPOVL skills of the educational technology students?

Thirdly, the blended ID model called ACDIE was proposed. This model was integrated the traditional ADDIE model and some SE features and process for designing and developing the VLP for the specialists in educational technology. The VLP contains specific functions for improving learning in future schools and universities. The previous studies regarding the ADDIE model, main SE features, and processes were analyzed. The analysis results showed deficiencies of the traditional ADDIE model in developing the VLP since it focused on the learning contents only and the VLP functions were out of the range of it. Findings of the

analysis showed the proposed ACDIE blended model would be able to overcome the insufficiency of the traditional ADDIE model in designing and developing the VLP for modern educational systems. The proposed model has contained five phases, analysis, construction, deployment, implementation, and evaluation. Based on the ACDIE process phases, the VLP prototype system was developed. The main features of the VLP system include some different kinds of functional tools to support teaching process; a) Learning tools: They stimulate the learning environment by delivering interactive course contents, web quest activities, and assignments to the students besides active teaching by online formative evaluation during learning. b) Management tools: They facilitate administration of learning process through managing students, publishing announcements, presenting teacher information, uploading learning files, storing files, and tracking the progress of student activities. c) Communication tools: They enhance the sharing of the students in learning process by discussion forums and exchanging message with instructors. d) Innovative tools for the OVL: They enable the students to create OVL designs and OVL actual products. e) Evaluation tools: They help the instructors to conduct the online evaluation with several kinds of evaluation methods and to present immediate feedbacks to the students. f) Help tool: It supports the students with an overview of the VLP tools. Also, the VLP system contains the learning contents in order for the students to know the skills of how to design and produce the OVL. The VLP course contents were developed and presented by the VLP course tool. The course contents included some multimedia elements like text explanation, video, instructional drawing, and images. In addition, the evaluation instrument contents were developed and presented by the VLP evaluation tools.

4. How effective is the VLP for the educational technology students?

Finally, The VLP prototype system was reviewed by some experts and implemented as the pilot study to the educational technology students. Based on the expert review and the pilot study results, the refinements of the VLP system were successfully implemented. The practical experiment was conducted to evaluate the effectiveness of the proposed VLP. In this investigation, the proposed VLP software with several innovative tools and special course contents were used to enhance the DPOVL skills except for the video conference and educational image library tools. A quasi-experimental research design with one group pre- and post-test was adopted. The proposed VLP was conducted with thirty participants from the fourth grade of undergraduate majoring in educational technology. All participant students were assigned to one group pre- and post-test design. The data were collected by using online

instruments; achievement test, performance observation card, product evaluation card, and usability questionnaire.

The results of the current research showed a significant effectiveness of the proposed VLP regarding in increasing the knowledge level of the educational technology students regarding DPOVL. The results also showed a significant effectiveness of the proposed VLP regarding in increasing practical skills of the students in DPOVL. Also, it demonstrated that the proposed VLP had a positive impact in producing the OVL for multi-educational domains at the level of more than 80%. Moreover, the results indicated that the educational technology students strongly were agreed for usage of the VLP software. This VLP as a solution could be applied to boost educational technology departments.

6.3. Contributions

The current research presents some beneficial and original contributions in two fields; information science and educational technology as follows. Firstly, it contributes to knowledge through the proposed VLP for DPOVL in several domains with easy way. Another contribution of the VLP system is to provide a new tool for developing online courses directly without dependence on code programming and other software, which helps the instructors to use ICT in the classroom. An additional contribution is to provide a tool for conducting an online formative evaluation and to gather students' feedback during learning with the system in the classroom. Secondly, due to lack of the research in this field, this research results present benefits for establishing a new course for DPOVL in the educational technology departments. Also, this research results present benefits for the future researches which focus on developing new web systems like the OVL with new features. Thirdly, it contributes to propose a model which combines some SE features and traditional ADDIE framework to develop the VLP for the specialists in educational technology who do not have SE background in their academic programs. This approach helps us to develop the target VLP system for DPOVL with systematic way. Fourthly, it contributes to propose the new ID model for DPOVL in the multi-domains. This model helps us to reach the general design for the OVL with a standard way suitable for several educational domains, to construct the VLP system, and to guide the students in DPOVLs. Fifthly, it presents some practical DPOVL skills suitable for several educational spheres. These skills help us to acquire the students' DPOVL skills in general. Sixthly, it works to enhance the educational technology department's programs shortly by teaching students how to design and produce the OVL for improving the learning in schools and universities. Seventhly, the previous studies showed the impact of VLs as a new ICT tool in improving the

learning in several domains. This research shifts it focus to DPOVL by the specialists in educational technology rather than test the impact of the OVL. Thus, it shifts the OVL from the experimental stage to become an essential ICT tool in improving education. Moreover, it works to develop the OVL itself as an educational technology product in future. Eighthly, it proposes the original ready-made templates for creating OVL suitable for multi-educational domains. Finally, it proposes a standard way of skill learning of DPOVL as an educational technology product.

6.4. Recommendations

Based on this research finding, some recommendations were suggested. At first, the ACDIE model is considered as an acceptable framework for developing VLPs since it includes a systematic way for developing not only the tools but also the educational contents of the VLP. It enables the instructional developers who do not have SE background to apply incremental developing and testing for the tools and contents one by one. Thus, it helps to develop an acceptable system and decrease errors. Therefore, it would be regarded as a development framework for developing other VLPs in the future.

Secondly, the proposed VLP would be used for teaching DPOVL in the educational technology departments and faculties of education because the empirical experiment for the VLP has approved the positive impact in developing DPOVL in several domains. Thirdly, the proposed VLP would be utilized for online teaching as a distance learning system or ICT in classroom. Thus, the instructors would be used the VLP as an ICT application tool in teaching other courses in schools and universities. The VLP might help to raise the efficiency of the learning environment in classrooms. Finally, the VLP system would be used as a tool for conducting training in educational institutions, especially by ICT centers in schools and universities. Because it has a potential in acquiring skills with masterly level. Therefore, the researcher expects the VLP would present a valuable training with high efficiency.

6.5. Research Limitations

The present research had some limitations as follows: First of all, the research sample was limited to the thirty participants from fourth grade in Educational Technology Department, Faculty of Specific Education at South Valley University, Egypt. The accesses to VLP system was limited to the closed experiment for the participants. It means the current system does not support open access like MOOC because the aim of this research was to evaluate the system with the specific target users. It was limited to the proposed DPOVL skills according to the

researcher's envision and might not cover some technological skills of all educational domains. The learning process of DPOVL model was limited on OVL pre-design, DPOVL criteria, OVL design, and OVL production phases and did not cover all phases. The domain of the OVL products focus on practical and theoretical courses. However, the students' products did not cover all educational domains beside the theoretical issues, and the invisible phenomenon was limited. The time of semester and students of the research experiment was limited. Thus, if the students take much time, they may produce higher-quality OVL. Finally, the research results depend on the participant's honesty in the answer for all evaluation instruments.

6.6. Future Work

6.6.1. Improvement of the VLP system

In the future, the VLP will be improved by issued Japanese version besides Arabic and English versions. Also, some improvements will be conducted for some tools like the OVL design tool and OVL creator tool by improving the ready-made template for designing and producing virtual experiment not only simulation but also video function for the virtual experiment. Moreover, the GUI of the VLP system will be re-designed by grouping similar tools in one category. Furthermore, some new features will be added. Finally, the improving version of VLP will be examined again in developing the DPOVL skills of postgraduate students.

6.6.2. Future vision for Egyptian educational system

Recently, the VLs technology achieved the high effectiveness in developing learning outcomes, especially regarding attainment of knowledge and practical skills in several subjects and courses. The future vision is to implement the OVL as an ICT tool in the Egyptian educational system especially for courses which have real laboratories. The OVL will provide an interactive virtual environment for real experiments, invisible phenomena, concepts, and theories of courses in the Egyptian schools and universities. Thus, it would overcome the deficiencies of the Egyptian educational system that almost of the real laboratories lack kits or equipment, little economic budget of purchase and maintenance, and weak learning practical outcomes of learners.

In order to change the Egyptian educational system in the future, several research projects of OVLs projects will be designed, developed, and implemented in cooperation with course content instructors in schools and universities. Thus, it would lead to expanding in integrating such new technology in the Egyptian educational system.

The main feature of this future vision is to support schools and universities which have limitations regarding real laboratories by using the OVLs, especially in science domain subjects. Also, enhance the learning inside real laboratories or classrooms by designing and producing several OVLs in varied educational domains. In addition, provide sufficient training for learners by OVLs anytime anywhere. Furthermore, support active learning in the ICT classroom by providing OVL in tablet PC of learners. At the end, support mastery learning in schools and universities.

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Appendices

Appendix A: Conclusion of the VLP analysis phase

VLP Project Scope	This project is a VLP to focus on educational technology field. It is designed for teaching staff in educational technology departments and faculty of education who are looking for enabling their students from DPOVLs. This system will provide instructors interactive tools for teaching via the internet and enough content about how to produce OVL. In addition, it will provide a specialized tools for design, creating, publish the OVLs in various educational domains via the internet.

VLP Target Users and characteristics	Instructors in university stage whose teach in faculties of education or educational technology departments.	Students in university stage whose students in faculties of education or educational technology departments.
	Instructor characteristics: − The instructor should have enough knowledge and skills about using ICT in education. − The instructor should be familiar with teaching by virtual learning and E-learning tools like LMS and virtual classrooms.	Students characteristics: − The student must have the enough ability to deal with computers and internet browsing. − The student must have the ability to study online and self-learning. − The student must have the ability to work duties electronically.

VLP Functional requirements	User management tool: this tool will provide the login system for VLP. It will allow for instructors and students who have registered in system database to login into VLP system and use system functionality ant anytime anywhere. Instructors have management responsibilities for full control of VLP system.
	Teacher information tool: this tool will provide to instructors create their information such as academic data, contact data. Moreover, enable instructors to control their information through a view, modify and delete it. Also, this feature will display instructor's information to VLP students.
	Announcement tool: this tool will provide for instructors to create educational announcements and publish it, also modify, and delete it. Also, it will display announcements to VLP students.
	Forum tool: this tool will provide for instructors to create discussion forums and enable them for control of this forum through a view, modify and delete it. Moreover, it will show forums to VLP students. Furthermore, it will enable student for search in forums. Furthermore, this tool will provide to instructor control in hidden/displaying the online responses to VLP students.
	Learning download center tool: this tool will provide for instructors to upload files which help to facilitate learning for VLP students and also enable them for control of

	this uploaded files through a view, modify and delete it. In addition to showing and download uploaded files by VLP students.
	Course tool: this feature will provide to instructors create course content, units and lessons and also enable them for control of this course through a view, modify and delete it. Also, this feature will control in displaying course content to VLP students
	Online Response tool: this tool will provide for instructors to create online formative evaluation questions and enable them for control of this online response and its questions through a view, modify, and delete it. Moreover, this tool will control in hidden/displaying online response to VLP students.
	WebQuest tool: this feature will provide for instructors to create a web quest and enable them for control of this web quest through a view, modify, and delete it. Moreover, this tool will control in hidden/displaying web quests to VLP students.
	Assignment tool: this feature will provide to instructors create educational assignments and also enable them for control of this assignments through view, modify and delete it. Moreover, this tool will provide to VLP students download the assignments and submit answers to their educational assignments to instructors. Furthermore, it will enable instructors for downloading student answers files.
	Cloud Storage tool: this tool will provide to instructors and students to store their files on the system server, and enable them for control of this storage files through a view, modify, download and delete it.
	Video conference tool: this tool will provide to instructors create video conference session for visual contact with their students. Moreover, enable instructors for control of this Video conference session through view, modify, and delete it. Furthermore, this tool will provide to instructor control in hidden/displaying the video conference session to VLP students. This tool will depend on BigBlueButton open source system.
	Message tool: this tool will provide to instructors send messages to a specific student. Moreover, enable instructors for control of this message through view and delete it. It will provide to instructors send messages to a specific instructor.
	Educational image library tool: this tool will provide to instructors add an educational image in many fields and organize it into categories and also it will enable them for control of this educational image and categories through view, modify, and delete it. Moreover, it will enable students for search in library images. Furthermore it will enable students for downloading image files.
	OVL designer tool: this feature will provide templates for the educational technology students to create design for OVL suitable for all domains contains: 1. Design for OVL framework 2. Design for OVL platform 3. Design for virtual experiments of OVL 4. Design for overall evaluation of OVL

	Also, this tool will provide to student control on his OVL design through a view, modify and delete functionality.	
	OVL Creator: this tool will provide templates for the educational technology students to create and publish the OVL in any educational domain : 1. Create and publish OVL framework 2. Add automatically the OVL platform 3. Create and publish virtual experiments of OVL 4. Create and publish quizzes for virtual experiments and OVL 5. Create and publish forums for OVL Also this tool will provide to student control on his OVL product through view, modify and delete functionality.	
	Glossary tool: this tool will provide to instructors create an online glossary of terms with multimedia for course content to VLP students. Moreover, enable instructors for control of this glossary and terms through a view, modify and delete it. Also, this feature will display number of terms to VLP students	
	Quiz tool: this tool will provide to instructors create an online quiz for evaluating their students and store test results in the system. Moreover, enable instructors for control of this quiz through a view, modify, and delete it. Also, this feature will display quiz content to VLP students.	
	Questionnaire tool: this tool will provide to instructors create an online 5-point Likert-scale questionnaire for evaluating their students and store questionnaire result in the system. Moreover, enable instructors for control of this questionnaire through a view, modify, and delete it. Furthermore, this tool will provide the control of hidden/display questionnaire content to VLP students.	
	Performance observation card/product evaluation card tool: this tool will provide to instructors create 3-point scale questionnaire for evaluating their students, and store questionnaire results in the system. Moreover, enable instructors for control of this questionnaire through a view, modify, and delete it. Furthermore, this tool will provide the control of hidden/display questionnaire content to VLP students.	
	Report tool: this tool will provide reports to the instructor about all students' activities in the VLP system like login activities reports, quizzes reports, questionnaires reports, and Performance observation card /product evaluation reports.	
	VLP Help tool: this tool will provide to instructors and students guide for using VLP system tools.	
VLP design Constrains	− This system is developed using PHP, HTML, and JavaScript as a web-based programming language, CSS, and MYSQL. − Systems users must have a correct username and passwords to access	− Users can access anytime anywhere. − Course limit to one course "OVL course".

	to a VLP system and dealing with functions.	
VLP assumptions for overall use cases and dependencies	Using the VLP final System assumes the following overall use cases: – Internet connection with high bandwidth – Modernistic Web–browser – Instructor and students registration will limit to one course at one university.	The VLP System needs the following dependencies: – Server enough capacity to store OVL which will create by students. – Video conference system (BigBlueButton) to conduct a video session between instructors and students. – The user has a basic knowledge of computer science.

VLP Nonfunctional requirements	Performance requirements
	– Downloading VLP system files are speed.
	– The VLP system will display data for users speedily.
		Safety and security requirements
		– VLP System users accounts are protected and Secured database
		– VLP System secured against viruses and malware.
		– VLP System has two modes admin instructor mode and student mode, so access to VLP system tools and content is different according to the user role.
		– Students have not ability for creating, modifying and deleting VLP system content except for tools as below:
		  1. Cloud storage files tool.
		  2. OVLs designer tool.
		  3. OVLs creator tool.
		  4. Student profile (modify only).

VLP course content	Course name: The OVLs course.
	Course Description: This course will provide to the educational technology students a specific knowledge and skills for DPOVLs.
	Prerequisites: Students would have basic knowledge about ICT in education.
	General objectives of OVL course are to enable students for developing OVLs for any domain in schools and universities.
		OVLs main topics (units)
		  1. VL in education.
		  2. Designing OVL.
		  3. Producing OVL.
		
		Topics segments (lessons)
		  1. VL in education:
		– *Segment 1:* Concept, types, and advantages of OVL.
		– *Segment 2:* General design of OVL.
		  2. Designing OVL:
		– *Segment 1:* Pre-design phase of OVL.
		– *Segment 2:* Criteria of DPOVL.

| | This main general objective is divided into the following sub-general objectives:

At the end of learning the OVL course, the student should be able to:

1. Acquiring knowledge about the OVL and the skills in DPOVL.
2. Performing the DPOVL skills practically.
3. Making a design for OVL in one of the subjects.
4. Producing an OVL in one of the subjects. | – *Segment 3:* Skills in designing OVL.
– *Segment 4:* Skills in designing OVL electronically by VLP system.

3. Producing OVL
– *Segment 1:* Producing phase of OVL.
– *Segment 2:* Skills in creating OVL by VLP system.
– *Segment 3:* Skills in preparing simulation of a virtual experiment by Adobe Photoshop.
– *Segment 4:* Skills in producing an interactive simulation of a virtual experiment by Adobe Animate CC and ActionScript 3.0.
– *Segment 5:* Skills in creating and publishing virtual experiment in the OVL by VLP system. |

Appendix B: Test cases for the cloud storage tool as example

Test scenario	1. Validation for storing and downloading files in VLP cloud storage for instructor mode		
Test cases	Test VLP system response to add cloud storage file in VLP	Test VLP system response to input empty add cloud storage file in VLP	Test VLP system response to download cloud storage files from the VLP website to instructor computer
Preconditions	Instructor Logged in	Instructor Logged in	Instructor Logged in
Test steps	1. Click on the "Cloud storage" tool 2. Click on the " Create new cloud storage file " functionality 3. Enter file name 4. Enter a description 5. Select the file from your computer 6. Click on submit storage file button	1. Click on the "Cloud storage" tool 2. Click on the "Create new cloud storage file " functionality 3. Enter empty file name 4. Enter an empty description 5. Select an empty file from your computer 6. Click on submit storage file button	1. Click on the "Cloud storage" tool 2. Click on the "download " functionality of a file 3. The file will be saved automatically in the default download folder in the computer
Test Data	File name: Instructor file 1 Description: This a test file File: c->desktop-> instructor file 1	Empty file name Empty description Empty File	
Expected results	The file must be stored on VLP system, and the VLP system displayed message "The cloud storage file has been saved."	The file must be failed to store on VLP, and the VLP system displayed message "The cloud storage file could not be saved. Please, try again." In addition, the VLP system displayed text hint for all fields	The file must be downloaded from VLP system to instructor computer
Actual results	Instructor file is stored on VLP successfully, and the VLP system displayed "The cloud storage file has been saved."	The File storage failed, and the VLP system displayed message "The cloud storage file could not be saved. Please, try again." with text hint for all fields	Cloud storage file downloaded successfully
Status	Pass	Pass	Pass
Comments			

Test scenario	2. Validation for storing and downloading files in VLP cloud storage for student mode		
Test cases	Test VLP system response to add cloud storage file in VLP	Test VLP system response to input empty add cloud storage file in VLP	Test VLP system response to download cloud storage files from the VLP website to student computer
Preconditions	Student Logged in	Student Logged in	Student Logged in
Test steps	1. Click on the "Cloud storage" tool 2. Click on the "Create new cloud storage file" functionality 3. Enter file name 4. Enter a description 5. Select the file from the computer 6. Click on submit storage file button	1. Click on the "Cloud storage" tool 2. Click on the "Create new cloud storage file" functionality 3. Enter empty file name 4. Enter an empty description 5. Select an empty file from the computer 6. Click on submit storage file button	1. Click on the "Cloud storage" tool 2. Click on the "download" functionality of a file 3. The file will be saved automatically in the default download folder in the computer
Test Data	File name: Student file 1 Description: This a test file File: c->desktop->student file 1	Empty file name Empty description Empty File	
Expected results	The file must be stored on VLP system, and the VLP system displayed message "The cloud storage file has been saved."	The file must be failed to store on VLP, and the VLP system displayed message "The cloud storage file could not be saved. Please, try again." In addition, the VLP system displayed text hint for all fields	The file must be downloaded from VLP system to student computer
Actual results	Student file is stored on VLP successfully, and the VLP system displayed "The cloud storage file has been saved."	The File storage failed, and the VLP system displayed message "The cloud storage file could not be saved. Please, try again." with text hint for all fields	Cloud storage file downloaded successfully
Status	Pass	Pass	Pass
Comments			

Appendix C: Usability test Questionnaire for the VLP

	Question	5	4	3	2	1
Q1	The user interface of VLP is acceptable and attractant					
Q2	Ease of design, produce, and publish the OVLs by using VLP					
Q3	The VLP provides to me good electronic environment for learning which makes me use it in learning other courses in the future					
Q4	The VLP has a flexible navigation so you can refer to the homepage of the platform from any page					
Q5	The VLP showed to you error message to fix any problems during dealing with the VLP system					
Q6	The VLP provides to you help and guidance					
Q7	A performance of the VLP is speed and efficiency					
Q8	The VLP provides to you the possibility of modification and deletion when dealing with a student's functional tool					
Q9	The aim of use each function tool in VLP system is clear and understandable to me					

Note: (5) = Strongly Agree, (4) = Agree, (3) = Neutral, (2) = Disagree, (1) = Strongly Disagree

Appendix D: Achievement test for knowledge of DPOVLs

1. The name of the fixed portion in the general design of the OVL is………..

   - OVL platform

   - OVL content

   - OVL content and platform

2. The OVLs work for mastery learning because of its excellence………..

   - Economic

   - Sufficient training

   - Accessibility

3. Virtual experiment in the OVL consists of………..

   - Six components

   - Five components

   - Seven components

4. Determine the target learners and subject which the OVLs depend on it in ……….. of the DPOVL model

   - Design phase

   - Production phase

   - Pre-design phase

5. Which of the following criteria must be applied when the production of interactive simulation for virtual experiment

   - Provide learning management tools within the OVL

   - Provide tools to download and upload files

   - The virtual environment provides similar training in the practical reality

6. Can be resized image of a virtual experiment while maintaining a degree of clarity in Adobe Photoshop by………..

   - Ctrl + N

   - Ctrl + R

   - Ctrl + T

7. When preparing and assembling simulation images of a virtual experiment together in a single file in Adobe Photoshop program must be………..

   - Each image / elements of simulation in a single layer

   - Each image or element of the simulation in a separate layer

- Each image / elements of simulation in a single duplicate layer

8. To make a reset button for virtual experiment simulation for sufficient training that's required to use action code………..in ActionScript 3.0 language in Adobe Animate CC
   - Actions -> Click to Position an Object
   - Actions -> Drag and Drop
   - Actions -> Show an Object

9. Can used action code………..to hide elements / objects of interactive simulation of a virtual experiment in Adobe Animate CC program
   - Actions -> Drag and Drop
   - Actions -> Click to Position an Object
   - Actions -> Click to Hide an Object

10. To stop classic tween motion for an interactive simulation object of a virtual experiment in a specific position on the stage can use action code………..
    - Actions -> Stop Movie Clip
    - Timeline Navigation -> Stop at this Frame
    - Actions -> Show an Object

11. To import Adobe Photoshop design file of a virtual experiment from inside Adobe Animate CC file by used command………..
    - File -> Import -> Import to Stage
    - File-> Open
    - Insert -> Scene

12. To convert interactive simulation objects of a virtual experiment to symbols So that it can handle programmatically in the ActionScript 3.0 language in Adobe Animate CC can use the command………..
    - File -> Export - > Export Image
    - Modify -> Convert to Symbol
    - Insert -> New Symbol

13. Can used action code………..to add drag and drop for simulation objects of a virtual experiment with the Adobe Animate CC program
    - Actions -> Click to Hide an Object
    - Actions -> Click to Position an Object
    - Actions -> Drag and Drop

14. To upload interactive simulation file of the virtual experiment in VLP system, the file extension format must be………..

- PSD
- fla
- SWF

15. To make design of OVL can use the tool………..in VLP system

- OVL designer tool
- Instructional image library tool
- OVL creator tool

16. The VLP system provides create an electronic question contain………..

- Text, images, graphics, video, and sound
- Text, images and graphics
- Only texts

17. To add virtual experiment for OVL in the VLP system by used command………..

- Create the design of virtual experiment
- Create a virtual experiment
- Create design of the OVL platform

18. To add electronic questions for summative quiz of OVL in the VLP system by used command………..

- Click on the OVL quiz icon, then chooses edit command
- Click the virtual experiment quiz icon, then chooses command of edit and create questions for the quiz
- Click on the OVL quiz icon, then chooses command of edit and create questions for the quiz

19. To make production of OVL can use the tool………..in VLP system

- OVL designer tool
- Instructional image library tool
- OVL creator tool

20. To publish an interactive simulation file of a virtual experiment in Adobe Animate CC can use the command………..

- Control -> Test
- File -> Publish
- File -> Save as

Appendix E: Performance observation card skills instrument

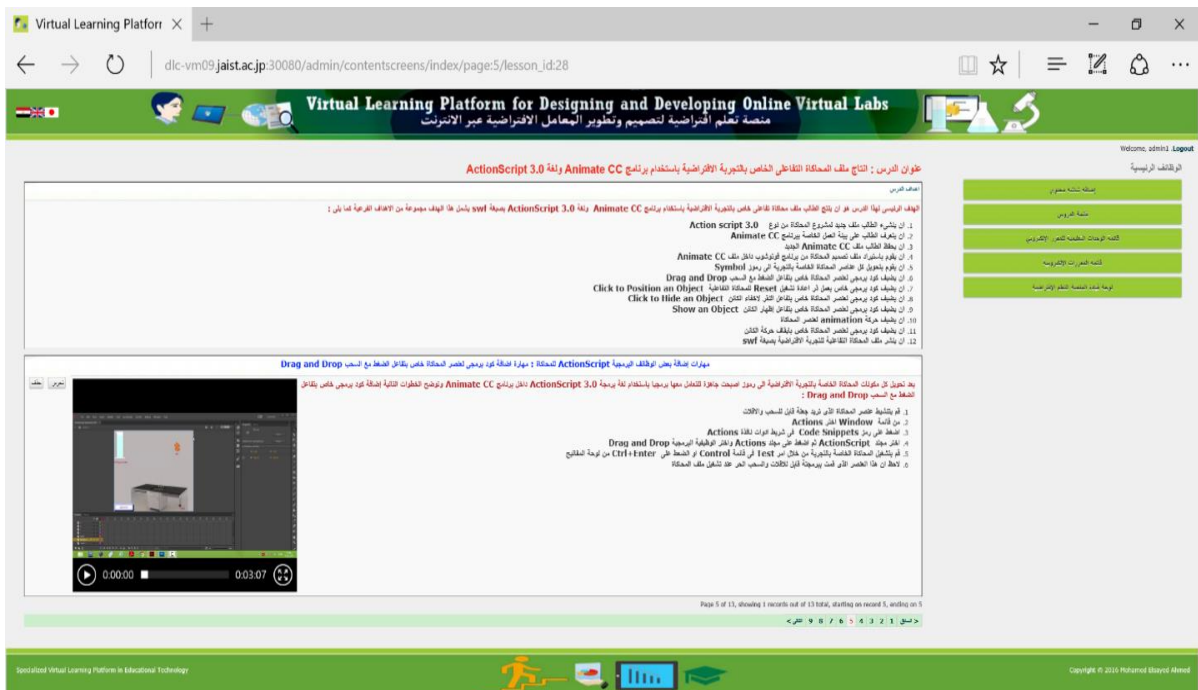| Skill Items	performing skill with high level (2)	performing skill with moderate level (1)	No performing skill (0)
Performance level			
Firstly: Main skills of designing OVL by VLP system			
1 Creating design for OVL by the VLP			
2 Creating design for the OVL Platform			
3 Creating design for a virtual experiment in OVL design			
4 Creating a design of the overall evaluation of the OVL			
Secondly: Skills of producing OVL			
1. Skills of producing OVL by VLP system			
5 Creating an OVL framework			
6 Creating a virtual experiment in the OVL.			
7 Creating an educational forum in the OVL.			
8 Creating a quiz for OVL.			
9 Creating a quiz for the virtual experiment.			
10 Adding a true/false question to the quiz.			
11 Adding a single choice question to the quiz.			
2. Skill of producing interactive simulation of virtual experiment			
a) Skills of preparing simulation by Adobe Photoshop			
12 Creating new file suitable for the simulation of the virtual experiment.			
13 Collecting simulation images of the virtual experiment in one file. Each image should be put on an independent layer.			
14 Arranging the simulation images of the virtual experiment by the logic form in the file.			
15 Designing reset button for virtual experiment simulation.			
16 Writing the name of simulation images			
17 Resizing the simulation images to become appreciated with keeping the resolution.			
18 Selecting and removing non-essential elements from the simulation images.			
19 Recoloring the required parts of the simulated images.			

20	Drawing some shapes used in the simulation by drawing tools in Photoshop.			
21	Saving the simulation file of the virtual experiment as a PSD or PDD format.			
	b) Skills of producing simulation of a virtual experiment by Adobe Animate CC and ActionScript 3.0			
22	Creating a new ActionScript 3.0 project file for the simulation in Adobe Animate CC.			
23	Saving the new file as an Adobe Animate CC file format.			
24	Importing the simulation file of the virtual experiment as Adobe Photoshop format to Adobe Animate CC.			
25	Converting the simulation elements to symbols.			
26	Adding action code to the simulation element related to drag and drop.			
27	Adding function code to reset simulation related to click to position the object.			
28	Adding action code to the simulation element related to click to hiding the object.			
29	Adding action code to the simulation element related to show the object.			
30	Adding motion to the simulation element associated with the type of motion tween.			
31	Adding motion to the simulation element associated with the type of shape tween.			
32	Adding motion to the simulation element associated with the type of classic tween.			
33	Adding action code to stop motion of the simulation element.			
34	Publishing the simulation file of the virtual experiment as a SWF format.			

Appendix F: Product evaluation card for OVL product instrument

Evaluation Items		Criteria Level		
		Available (2)	Somewhat Available (1)	Not available (0)
1	The OVL published via the internet			
2	The OVL showed target users			
3	The OVL specialized in one subject			
4	The OVL showed the included topics			
5	The OVL showed the general objectives			
6	Function tools OVL platform was worked with fix form and efficiency			
7	The OVL platform was provided some tools for learning management in the lab			
8	The OVL platform was provided some tools for educational communication with students			
9	The OVL platform was provided some tools for uploaded and displayed learning content in the lab			
10	The OVL was easy to update the content			
11	The design of the OVL was attractive and consistency			
12	The hyperlinks of the OVL platform were used clear words to lead it			
13	The OVL content was divided to independent virtual experiments			
14	The OVL was included a list of virtual experiments arranged logically			
15	The OVL was included educational objectives for each virtual experiment			
16	The OVL was included a theoretical explanation for each virtual experiment			
17	The OVL was included instructions and procedures for each virtual experiment			
18	Simulation of each virtual experiment in the OVL was working interactively			
19	The OVL was included educational activity for each virtual experiment			
20	The OVL was included a summary of the main ideas for each virtual experiment			
21	The OVL was included formative evaluation for each virtual experiment			
22	The OVL was provided a summative evaluation of all virtual experiments in the lab			
23	The OVL product was applied educational and technological principles of design and produce the OVLs			

Appendix G: The VLP system screenshot

dlc-vm09.**jaist.ac.jp**:30080/admin/labs/view/91

Virtual Learning Platform for Designing and Developing Online Virtual Labs
منصة تعلم افتراضية لتصميم وتطوير المعامل الافتراضية عبر الانترنت

Welcome, admin1 . **Logout**

الوظائف الرئيسية

تصميم المعمل الافتراضي عبر الانترنت : معمل العلوم

انشاء تصميم منصة معمل افتراضي عبر الانترنت

الفئة المستهدفة للمعمل الافتراضي عبر الانترنت

انشاء تصميم التجربة الافتراضية

الصف الثاني الإعدادي

انشاء تصميم التقويم العام للمعمل

المادة الدراسية للمعمل الافتراضي عبر الانترنت

قائمة خدمات المعامل الافتراضية عبر الانترنت

العلوم

لوحة قيادة المنصة التعلم الافتراضية

الموضوعات الرئيسية للمعمل الافتراضي عبر الانترنت

1-ظاهرة الاحتباس الحراري

2-ثبات اختلاف الضغط الجوي باختلاف الارتفاع عن سطح البحر

الأهداف العامة للمعمل الافتراضي عبر الانترنت

1-أن يتعرف الطالب على ظاهرة الاحتباس الحراري

2-أن يتدرب الطالب على تجربة توضح ظاهرة الاحتباس الحراري

3-أن يتدرب الطالب على ثبات اختلاف الضغط الجوي باختلاف الارتفاع عن سطح البحر

تصميم منصة المعمل الافتراضي عبر الانترنت

تصميم التجربة الافتراضية

تصميم التقويم الحتامي

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Virtual Learning Platform × +

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Virtual Learning Platform for Designing and Developing Online Virtual Labs
منصة تعلم افتراضية لتصميم وتطوير المعامل الافتراضية عبر الانترنت

Welcome, admin1 . **Logout**

الوظائف الرئيسية

الاستجابات عبر الانترنت

إضافة استجابة عبر الانترنت جديدة

قائمة بإجابات الاستجابات عبر الانترنت

لوحة قيادة المنصة التعلم الافتراضية

				الرؤية	الوظائف الرئيسية	تاريخ ووقت الانشاء	العنوان	رقم
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			08:54:02 2016-03-03	استجابة عبر الانترنت	3
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			18:51:05 2016-03-22	استجابة عبر الانترنت 2	4
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			23:59:33 2016-04-06	استجابة عبر الانترنت	5
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			18:27:40 2016-04-07	استجابة عبر الانترنت الوحدة الثانية	9
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			00:41:58 2016-04-10	استجابة عبر الانترنت . الوحدة الثانية 2	10
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			22:48:48 2016-04-26	استجابة رقم 4	11
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			22:57:03 2016-04-26	استجابة رقم 5	12
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			22:59:31 2016-04-26	استجابة رقم 6	13
نتائج	بدا الإجابة على الاستجابة على الانترنت	حذف	تحرير			01:28:57 2016-04-27	استجابة رقم 7	14

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