



activities for improving skills and for conducting experiments with saving costs and full control in experiment variables. In addition, we can now create the VLs for theoretical fields that have no labs in the reality by creating a new simulation to understand difficult relationships, rules, laws, concepts, and ideas. If we want to teach geography of climate and weather practically, for example, we can use the VLs including simulation in regard to changes in temperature on the map.

In order to improve modern education using such new technology, who should be responsible persons? We believe one of the candidates is educational technology students who specialize in developing education with technology. They typically learn how to integrate ICT in education according to pedagogical background, such as educational theories, instructional design, and educational sciences. The range of their learning usually covers designing, producing, utilizing, and evaluating technological resources, such as e-courses, instructional websites, interactive videos, digital images and graphics, and educational software. Therefore, these students have potentials to be responsible for implementing technology in future schools and universities after graduation as instructional designers, content developers, ICT teachers, and specialists for educational technology.

Consequently, they should develop their skills in designing and producing the online virtual labs, we call it DPOVLs, for the era of e-learning and virtual learning. However, now they have no instructional design models which guide how to design and produce the VLs because most of the previous studies about the VLs focused to establish the effectiveness of the VLs in specific fields as new technology tools in education.

In this paper, we suggest an instructional design model to teach DPOVLs to the educational technology students through uniform shape and components. This model would enable them to reach suitable skills for DPOVLs at any courses and fields in the future schools and universities. In addition, we propose a list of criteria to provide guidelines of DPOVLs for the students. Our criteria are based on an analysis of the recent previous studies in regard to the VLs and e-learning, previous criteria of designing online courses and websites. Then, we pick up the DPOVLs criteria related to instructional

design of VL components such as objectives, contents, learning activities, evaluation and feedback, and technological design of VL like online VLs platform, multimedia, simulation, administration, navigation, interactivity, publishing and technical support.

## **2. GENERAL VLS**

### **2.1 General Definition of VLs**

In an effort to teach the VLs to the educational technology students, we first need to consider about a general definition of the VLs because they should learn basic concept of the VLs without any domain restrictions.

Some literatures have been limited in their definition of the VLs as a substitute for the real lab. Babateen [7] stated the VL is “a virtual studying and learning environment that stimulates the real lab. It provides the students with tools, materials and lab sets on computer so as to perform experiments subjectively or within a group at anywhere and anytime”. Harms [8] also defined the VL as “a computer simulation which enables essential functions of laboratory experiments to be carried out on a computer”. In addition, Carnevali and Buttazzo [9] referred to the VL as “a computing system that allows to share the physical resources available in a laboratory with remote users connected on the internet”. On the other hand, it was clear the difference of the VLs’ form in the previous studies. Harms [8] focused on “a computer simulation”, Carnevali and Buttazzo [9] represented “a computing system”, and Prieto-Blázquez et al. [10] referred to “virtual learning environment”.

In this research, we define a VLs are virtual learning and teaching environments based on a designing and producing VLs model, where the learner interacts with diverse kinds of learning methods such as excises, practices, activities and simulations to reach learner’s goals such as mastery of a specific skills and understanding of relationships among concepts anytime and anywhere.

### **2.2 General Design of Online VLs**

In this section, we discuss about the general elements of the VLs such as their shape and components to reach to one uniform of the “online” VLs (OVLs). The OVLs become now one of new

technology tools in developing education to enhance online courses in any schools and universities. Therefore, such uniform would be suitable for teaching the present virtual contents in diverse practical and theoretical courses to the educational technology students.

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 computer-based VLs such as science [11], chemistry [3], [12], biology [13], physics [14], medicine [5], psychology [15], mathematics [6], calculus [16], computer science [17], automatics and robotics [18], computer network [4], [19], software engineering [20], computer interface technology [21], linguistic [22], studio [23], history and cultural dynamics [24], statistics [25] and others. After analyzing these previous studies, we summarized the following results:

1. The significant impact of the VLs technology was to increase learning skills and educational attainment of the learners in the various fields.
2. Some VLs were used to teach practical courses as substitutes for the real labs in the fields of science, chemistry, biology, and physics.
3. Other VLs were used to teach theoretical courses which have no lab in the reality in the fields of psychology, mathematics and statistics.
4. There was no fixed form in designing of the VLs.
5. Components and way of organizing contents in the VLs differed on each previous study.
6. The VLs were divided into two types, OVLs and computer-based VLs.

As we focus on the OVLs in this research, we first make clear the differences between the two types as follows.

**OVLs:** This type of the VLs provides virtual environments in the form of the website via internet and are sometimes integrated with electronic courses. Therefore, the learners can learn skills, experiments and theoretical ideas of courses practically anytime and anywhere. In addition, they interact with not only the contents through interactive simulation but also the teacher and their colleagues. Such OVLs also provide them with many information offered by external website links.

**Computer Based 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 carry out experiments to obtain practical skills. This type needs a lot of time in designing and producing program package and is now limited to specific practical fields, for example, ChemLab [26], Crocodile Physics [27], and Virtual Chemistry Lab Program [28].

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

**Fixed part:** We call it OVL Platform. This part is stable in any OVLs. It consists of common functions such as basic user interfaces to display any virtual experiments, skills, and ideas from any courses, management tools like login, tracking, and communications tools such as e-mail, forum, chat, and video conference.

**Variable part:** We call it OVL content. This part is variable according to contents of the courses. In this part, we suggest how to organize the content inside the OVLs to become segments. Each segment should belong to one experiment, skill, or idea. This segment consists of aims, theoretical side, instructions and procedures, simulation, activity, and summary.

Our suggestion form of the general OVLs will help the students and instructional designers design and produce the high quality OVLs in a stable way.

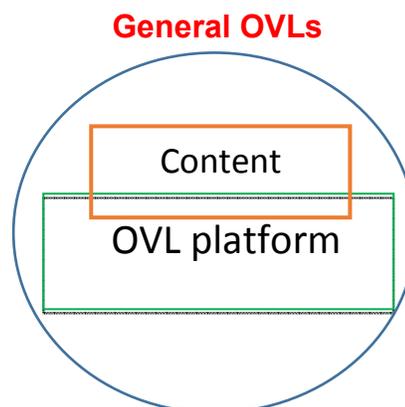


Figure 1: Suggestion form of general OVLs

### 3. ADVANTAGES OF OVLs

The OVLs are characterized by many advantages as modern educational methods in developing educational process. Some previous studies presented diverse advantages of the VLs such as [3], [29], and [30]. Now we have organized and added these advantages from improvement of learning point of view as follows:

1. **Economic:** The OVLs are low in costs of virtual equipment, tools, and maintenance, compared with the real labs.
2. **Richness:** The OVLs have rich environments with the kits and tools, furthermore with information through linking to especial websites.
3. **Safety:** The OVLs provide safe experimental environments, especially with respect to 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. **Consolidation:** The OVLs support the learners to improve their performance in real labs in terms of experiments, equipment, and tools.
6. **Motivation:** The OVLs causes excitement in learning to the learners by interactive simulation about reality and theoretical ideas, which encourages to continue their learning process.
7. **Ease of understanding:** The OVLs are easy to follow for the learners to overcome difficulty in understanding of practical experiments, concepts, laws, rules, relationships, processes, and ideas in various courses, which steer to improve learning itself.
8. **Interactivity:** The OVLs offer interactive environments to the learners with not only the experimental contents, but also the teacher and their colleagues.
9. **Accessibility:** The OVLs provide diverse contents to the learners anytime and anywhere.
10. **Creation:** The OVLs offer possibility of original experiments by testing new variables on the virtual representation about some theoretical ideas, which conduce to creativity in learning.
11. **Support online courses:** The OVLs work to support online courses through offering practical part of a course, which presents the

learners an integrated e-learning environment for the course with theoretical part.

### 4. HOW TO LEARN IN OVLs

The OVLs are sometimes used in blended learning where the learners can make training before and after learning in real lab. In another case, they may be able to learn new simulation which has no real lab. In both ways of learning on the OVLs, they have to pass the following several sequential steps in order to reach to mastery of learning:

**Objectives:** The learners should first identify general and specific objectives in the OVLs.

**Theoretical side:** The learners then need to know the theoretical background about simulation through briefly text information related to virtual experiment.

**Procedures and instructions:** The learners should take the right steps how they can implement practical simulation in the OVLs without mistakes.

**Simulation:** The learners begin with practice by dragging and dropping items, changing values and shapes, collecting, arranging, and classifying items.

**Activity:** The OVLs provide the learners with interactivity in regard to virtual actions to confirm achievement of the learning. The functions support synchronous and/or asynchronous activities.

**Evaluation:** In this step, the learners make self-evaluation through answering electronic questions or writing a report about the objectives.

**Summary:** The learners finally read the summary about main information of the target simulation to conclude it.

The following figure shows several sequential steps of the learning process inside the OVLs. If the learners do not acquire the skills, they can repeat from the Objective stage. As a result of the learning process, outcomes inside the OVLs reach to:

1. Mastery learning by understanding and implementing difficult theories, rules and laws practically.
2. Sufficient training about practical parts in the course.
3. Implementation of new ideas during learning.
4. Learner's experience related to the virtual learning environment tools such as virtual classrooms, virtual teaching, and learning in a virtual university.

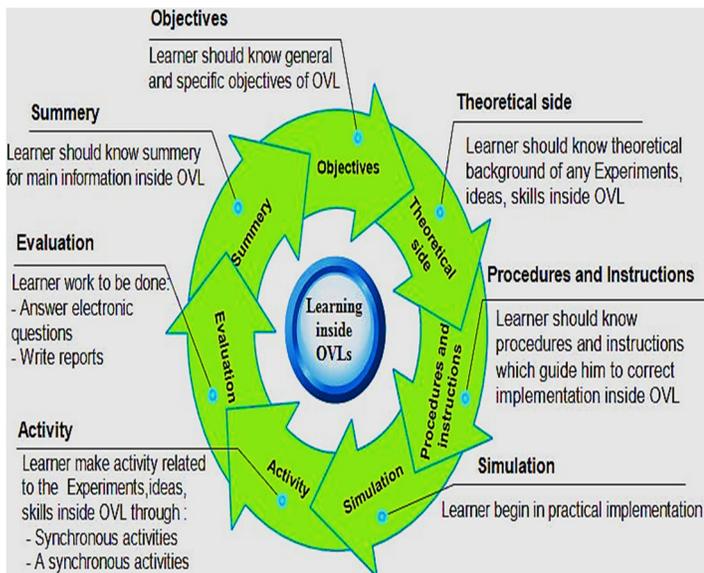


Figure 2: Learning process inside OVLs

## 5. ROLES OF TEACHER AND LEARNER IN OVLs

### 5.1 Role of Teacher in Designing OVLs

The teacher plays an important role in designing the OVLs regarding to his/her teaching course. Therefore, he/she must be familiar with teaching strategies for e-learning and the technological ability. The main point of the role is to participate with instructional designers in the following design steps:

1. The teacher must identify importance and necessity of the OVLs for the target learners and the target fields.
2. The teacher must decide the topics and appropriate contents and activities for each simulation to achieve these objectives.
3. The teacher should determine the general and specific objectives and formulates them accurately.
4. The teacher should consider how to organize the contents.
5. The teacher should select the suitable evaluation style for each simulation.

### 5.2 Role of Teacher in Teaching with OVLs

When using the OVLs in teaching, the teacher also faces several tasks as follows:

1. The teacher must plan online teaching to reach best practice.

2. The teacher should encourage and motivate self-learning.
3. The teacher should make training to the learners about how to use OVLs.
4. The teacher should plan to integrate the OVLs in the real labs.
5. The teacher should interact with the learners via internet in a synchronous or asynchronous manner.
6. The teacher should evaluate and monitor the performance of the learners in order to continue for improvement and development of education.
7. The teacher should provide enrichment activities with additional internet sites to get related information easily.

### 5.3 Role of Learner in OVLs

In using the OVLs technology in learning, the learners are required to have the following abilities:

1. Application skill for activities and assignments electronically.
2. Basic skills for e-learning technology such as e-mail, forums, search, chat, using audio and video.
3. Self-learning skill according to their intentions and attitude.
4. Exploratory and creative thinking skill to reach new relationships among variables.

## 6. INSTRUCTIONAL DESIGN MODEL FOR DPOVLs

We suggest an instructional design model for DPOVLs to teach the educational technology students how to design and produce the general OVLs suitable to any field. The model would guide the students to good practitioners of the OVLs to improve education.

In order to reach to our suggestion model, we have made an analysis of diverse previous studies. Some of them confirmed the effectiveness of the proposed OVLs [5], [6], [11], [12], [13], [14], [15], [17], [18]. Others discussed the previous models of the instructional design such as ASSURE model [31], ADDIE model [32], Kemp model [33], Dik and Carey model [34], Stephen & Staley model [35],

Gerlach and Ely model [36]. The results of the analysis are summarized as follows:

- The OVLs had no instructional design model specific in teaching how to design and produce them for the specialists in developing education such as the educational technology students.
- All previous models focused on the components of phases of the traditional education and computer-aided education. For example, educational software was not mentioned as the e-learning and virtual learning components,

which now becomes an essential element of modern educational systems.

- Most of previous models consisted of analysis phase, design phase, development phase, and evaluation phase.

Consequently, we have decided to propose our original instructional design models for DPOVLs as described in Figure 3 because we believe it is necessary to become widespread use of e-learning and virtual learning in various educational institutions.

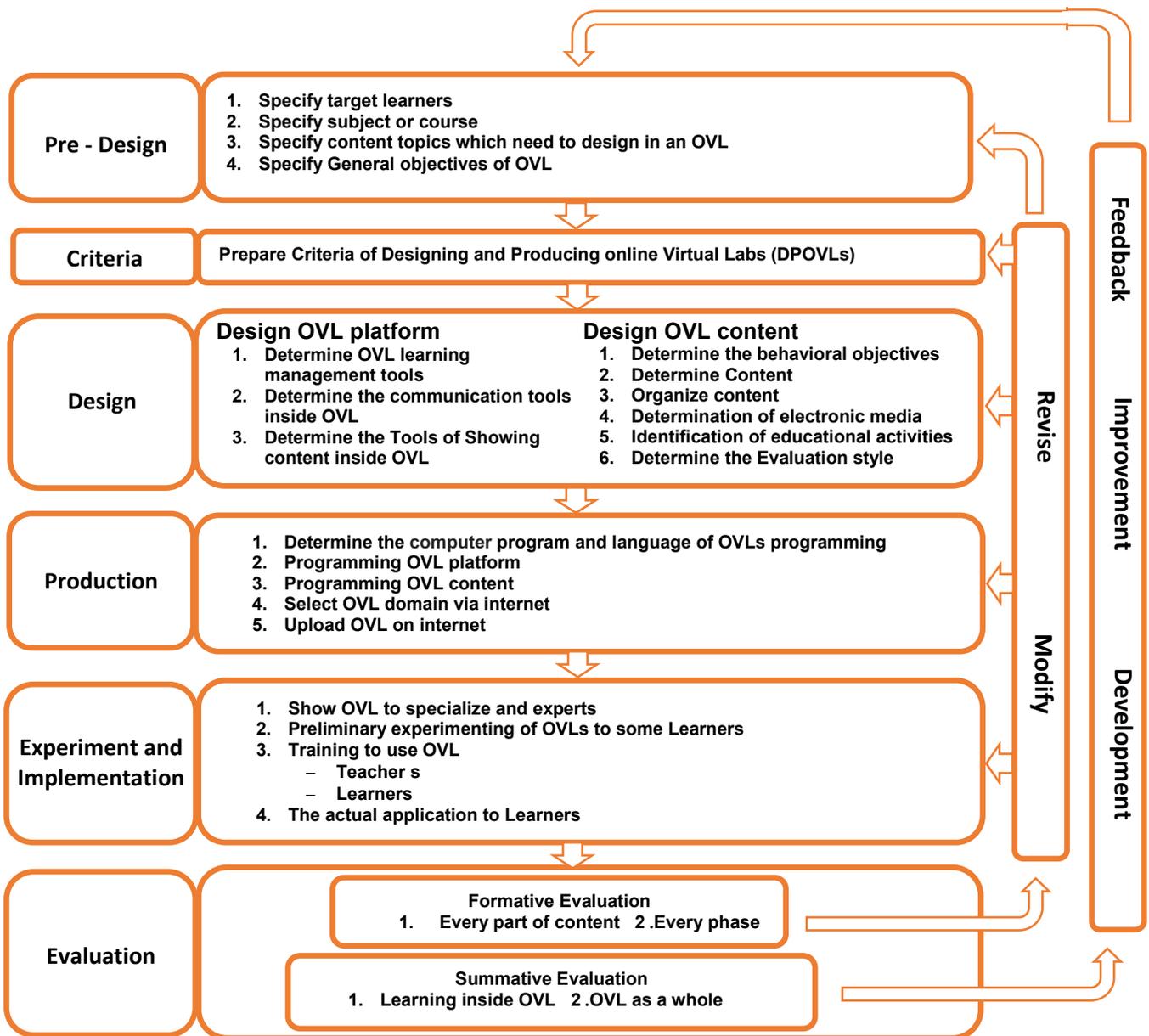


Figure 3: Instructional design model for DPOVLs

## 6.1 Pre-Design Phase

Pre-design is the first phase of the DPOVLs model where the educational technology students specify target learners by determining the educational stage and grade, for example, 3rd grade of elementary schools or freshman year of universities. Then, they select a target course and specify content's topics that they want to teach in the OVLs. Typically, they would pick up the parts regarding to not only recurrent training but also difficulty in understanding such as concepts, rules laws, relationships and ideas. Finally, they decide general objectives of OVLs.

## 6.2 Criteria for DPOVLs Phase

The criteria are usually used to provide guidelines for the educational technology students when designing any instructional tools. Therefore, we confirm which criteria they would use at this phase. Although these criteria can be prepared by selecting from the any criteria for DPOVLs, we propose a list of the criteria in order to make it easier for the users of our model according to the following steps:

### Aim of the criteria is:

- To reach modern educational and technical principles by providing guidelines for the educational technology students easy to implement the OVLs clearly.

### Previous studies for derivation of criteria are:

- Regarding to the VLs [37], [38], [39], [40], [41], [42], and [43].
- Related to the criteria for e-learning technologies, qualification, and evaluation [44], [45], [46], [47], [48], [49], [50], [51], and [52].
- Focused on the criteria for designing online electronic courses, developing e-contents, and evaluating instructional websites [53], [54], [55], [56], [57], [58], and [59].
  - About educational technology [60], [61], [62], [63], [64], and [65].

Through such diverse types of the previous studies, we divide the elements of criteria into two parts as described in Table 1 so that they can understand the criteria easily. The one part is mainly related to educational rules and theories. Another part is technical rules related with computer software. Our

criteria contains diverse specific elements related to the OVL. Thus, such elements are underlined in the following sections.

### 6.2.1 Educational Criteria for DPOVLs

#### a) Objectives

- They should be specified clearly.
- They should be related to the contents.
- They should be formulated in behavioral form.
- They should be measurable.
- They should be appropriate for the target learners.
- They should be shown at the beginning of each content.
- They should describe not learning activity but learning outcomes.
- They should be arranged in sequence according to expectations of learning outcomes.

Table 1. Elements of criteria for DPOVLs

DPOVLs Criteria	
Educational Criteria	Technological Criteria
a) Objectives	a) Virtual lab platform/interface
b) Contents	b) Text
c) Learning activities	c) Image and graphics
d) Evaluation	d) Sound
e) Feedback	e) Video and animation
	f) Navigation
	g) Simulation
	h) Interactivity
	i) Learning administration
	j) Publishing and technical support

#### b) Contents

- They should be directly related to the educational objectives.
- They should be sufficient.
- They should be up to date.
- They should be objective.
- They should be easily understood, clearness and succinctness.
- They should be accurate in scientific and linguistic.
- They should be organized logically and sequentially.
- They should be designed according to self-learning strategy.
- They should be divided into small and gradual learning steps.

- They should be involved in summaries which describe the main ideas.
- They should be classified according to the types of content like practical or theoretical ones.
- They should be reviewed by subject-matter experts such as teachers or staffs.
- They should be rich with appropriate multimedia.
- They should be displayed in various forms, such as animations, simulations, figures, pictures, and videos.
- They should be supported both linear and nonlinear presentation styles.
- They should be clearly specified by enrich information linked to other websites.
- They should specify their copyrights.

### c) Activities

- They should be related to the OVL objectives.
- They should be suitable to the OVL contents.
- They should be defined clearly.
- They should be designed in learner-centered way.
- They should send feedbacks to the learners.
- They should provide the learner with time plan about online and offline learning such as starting time, duration, and deadline.
- They should be included in each contents' part.
- They should support cooperation among the learners in a synchronous and asynchronous way.

### d) Evaluation

- It should be related to the educational objectives in the OVL contents.
- Its styles should be appropriate with the OVL objectives.
- It should be covered all the OVL contents.
- It should be clearly stated and understandable.
- It should have variety in question types.
- Its questions should be ordered in difficulty level.
- Its questions should contain pictures, videos or animations related to the simulation.
- It should provide continuously formative evaluation during learning.
- It should provide summative evaluation after learning.

### e) Feedback

- It should be provided immediately.
- It should be not general but specific.
- It should be suitable for learner's level.

- It should be linked to the objective of the questions.
- It should be provided in several shapes such as text, photos, graphics, voice, video, and animation.
- It should guide the learners to the correct answer in the case of failure.
- It should support the learners with additional information to the correct answer.
- It should give the learners prioritized information about how their performances do or do not meet the objectives so that they can understand how to improve their future performance.
- It should be balanced in terms of amount and timing to make it most effective.

## 6.2.2 Technological Criteria for DPOVLs

### a) OVL platform/interface

- Its tools should be easy and clear to use and understand.
- It should provide the learners with stable operation.
- Its style should be consistent.
- It should provide search functions.
- Its hyperlinks must use the words that clearly identify where to lead.
- It should provide sufficient contrast between the text or images and the background.
- Its design should be artistic and creative.
- It should be divided into appropriate categories, for example, all management tools under name "OVLs management" category.
- It should provide multiple channels of communication (e-mail - forums –video/audio conference....etc.)
- It should provide learning management tools.
- It should provide a display for the contents.
- It should be easy to update the contents.

### b) Text

- Text-based content should be limited.
- It should be clear and readable.
- It should be structured by diversity of the font size of headlines hierarchically.
- It should select appropriate font's styles and sizes.
- Its titles should be simple and expressive.
- It should be formulated in short sentences and simple composition.

- It should be formulated in not passive but active forms and not contain interrogative forms.
  - Its background should be suitable for colorful words in the OVLs.
- c) Image and graphics**
- They must be original and relevant to the contents.
  - They should be clear and not be crowded.
  - Their color should be appropriate to reality.
  - Their contrast and brightness should be balanced.
  - Their digital effects should be related to real and do not use visual tricks to hide from the truth.
  - They should be highlighted to emphasize the meaning.
  - They should show real dimensions.
  - Their design should be suitable to ask the questions.
  - Their quality should be facilitated perception.
- d) Sound**
- The number of it should be limited.
  - It should be used to make clear the meaning.
  - It should serve a clear purpose.
  - It should be pure and not contain echo and noise.
  - It should be a synchronize audio commentary with the display.
  - It should be properly pronunciations.
  - Its digital effects should be realistic and related to the contents.
  - It should be high quality as much as possible.
- e) Video and animation**
- They should serve a clear purpose.
  - They should use in the necessary time.
  - Their design should be suitable to ask the questions.
  - They should synchronize with audio commentary if needed.
  - They should be related to the achievement of the objective of the OVL content.
  - They should display with some control tools such as stop, repeat, sound, pause, and screen size.
  - They should be high quality as much as possible.
  - They should work to upgrade the level of critical thinking.
  - Their speed should be designed according to specific tasks.
  - They should increase learning desire.
- f) Navigation**
- It should be easy to move.
- Its labels should be easy to understand and express what they contain.
  - Broken links should be avoided.
  - Exit links should be provided at any time.
  - Back links to the OVL platform should be provided from every page.
  - Its links should use graphic buttons.
  - Main navigation should be stable.
  - Its links should be consistent and not crowded.
  - Its structure should be organized logically by the appropriate labels such as categories, main links, and sub-links.
  - Its links should be classified by category, color, providing links in a new page or using in the same page.
  - It should avoid orphan pages.
  - It should provide the learners with enough orientation by diagram, mind map, flow chart, instructional image and graphics.
- g) Simulation**
- It should be related to the contents objectives.
  - It should provide a virtual environment similar to practical real objects.
  - It should represent the theoretical idea easier to understand.
  - Its images, graphics and theoretical idea should illustrate the meaning as far as possible.
  - It should be creative.
  - It should be provide interactive environment.
  - It should harmonize with computer software used in the producing.
- h) Interactivity**
- Its multiple forms should be provided such as teacher to learner, learner to learners, and learner to content.
  - It should be provided in both synchronous and asynchronous ways.
  - It should provide the learners with full of control.
- i) Learning administration**
- It should provide a direct login to the OVLs.
  - It should provide information about OVLs' subject and course.
  - It should provide announcements such as next skills, encouragement for participation, time of contact, guides, results, and award, etc.
  - It should provide information about new and emerging technologies such as Wikis, blogs,

collaborative contents development software, and video conferencing software, etc.

- It should offer functions to upload and download files.
- It should be fitted between cost and learning outcomes.
- It should provide tools for assessing performance in the OVLs.
- It should provide tracking function for learning.

#### **j) Publishing, and technical support**

- The OVLs requirements about software and hardware should be specified.
- The server of the OVLs should have enough space in consideration of future expansion.
- The OVLs domain via the internet should be simple and suitable content types.
- The OVLs pages should be downloaded quickly.
- The OVLs should be controlled remotely from the host institution.
- The testing of the OVLs should be validated.
- The OVLs should be robust and sustainable to handle inadvertent damage by the students or malicious programs.
- The OVLs should be easy to maintain in terms of routine tasks like back-up.
- The OVLs should provide accessibility in anytime and anywhere.
- The OVLs should supply technical supports for the learners.
- The OVLs should have information about copyrights of educational institutions.

### **6.3 Design Phase**

The main role of design phase is to provide the educational technology students with the sequential steps in order to reach general design suitable to any courses. As described in Section 2.2, we propose in this paper a new shape of the OVLs by dividing into the following two parts in the design phase.

#### **6.3.1 Designing OVL platform**

The OVL platform is the fixed part and essential in any OVL. This part contains a group of tools which provides the learners with high interactivity during learning inside the OVL. It also supports the teacher to control learning and contents. It consists of the following elements:

#### **a) Determine the tools for management of learning inside the OVLs**

In this step, the students specify some tools to be controlled in management learning inside the OVLs. The following tools are typically used in the OVLs:

- Registration tool which controls the learners' entrance in the OVL.
- Tracking tool which tracks performance of the learners in the OVL.
- Download files tool which presents the learners important files for learning inside the OVL.
- Announcement tool which provides the learners with important dates for discussions, sending duties, etc.
- Search engine tool which supports the learners to find additional information.
- Evaluation tool which presents the learners different types of evaluation.

#### **b) Determine the tools of communication within the OVLs**

Communication is one of the important parts in learning on the OVLs because the learners are able to obtain actual usage of the knowledge by communicating with their colleagues and teacher. Thus, the educational technology students should be determined suitable communication tools whether synchronized such as chat rooms or video/audio conferencing, and asynchronous such as forums and email.

#### **c) Determine the tools for displaying the contents inside the OVLs**

The contents are main components in the OVL. Thus, they should be presented easy to understand. The students have to specify some tools to display the OVL contents such as upload tool, glossary tool, and content update tool.

#### **6.3.2 Designing OVL contents**

The OVL contents is a variable part in any OVL. This part is changeable according to the courses or the fields. In this part, the educational technology students need to cooperate with some experts like teachers. Consequently, we present how to design the OVL contents in design phase through the following sequential steps:

### a) Identify behavioral objectives:

The students should divide the general objectives of the OVLs into sub-objectives called behavioral objectives. These objectives cover all content parts inside the OVLs to be easily observed and measured.

### b) Determine contents:

In this step, the students should specify sufficient contents for the topics that they want to teach so as to achieve the learning objectives inside the OVLs.

### c) Organize contents:

It is well known that the course is divided into modules in schools and universities. The students and teachers want to teach some parts from their course on the OVLs to improve learning skills and achievement at the learners. Thus, we propose how to organize contents inside the OVLs through dividing the content into parts or segments as described in figure 4. Each part/segment belongs to one experiment, skill, or idea. It consists of a group of tabs as follows: aims, theoretical side, instructions and procedures, simulation, activity, summary. We explain these components in the following:

**Educational objectives:** At first, the learners recognize the educational objectives that they should acquire in the end of learning for any actions inside the OVLs.

**Theoretical side:** In this part, the OVLs present the learners' theoretical backgrounds for any actions such as scientific laws, rules, applications in life, information, and description.

**Instructions and procedures:** This part explains the correct sequences to implement the experiment in practice.

**Simulation:** It contains the components for the actions in virtual form, the learners conduct practical implementation by dealing with several actions.

**Activity:** Each segment of the contents should include educational activities. They support the learners' performance and confirm on improvement learning outcomes and mastery of skills.

**Evaluation:** Each action must contain the questions for self-assessment inside the OVLs. Such questions would confirm mastery of the contents and achieve the objectives for the learners.

**Summary:** It must be put in the end of each action. It makes the learners summarize the main points in the actions.

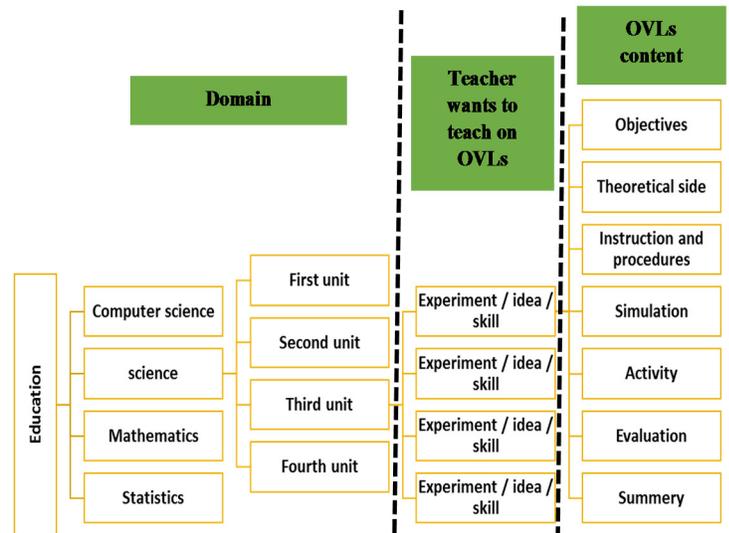


Figure 4: Organization of OVL contents

### d) Identify electronic media:

In this step, the students should determine the electronic media for the content parts such as texts, images, graphics, and voices. They should also clarify and simplify the contents and then achieve the objectives of the OVLs for the learners.

### e) Identify educational activities:

Every action should contain educational activities. The students should specify activities which enable the learners to confirm information and skills during learning and to increase their motivation in addition to activities which support critical thinking and problem solving.

### f) Determine evaluation style:

The students must determine appropriate evaluation style with the teachers. The style should be suitable to each action. They have also to determine the evaluation style for the whole OVL contents.

## 6.4 Production Phase

In this phase, the educational technology students begin to implement the design by using computer programs and languages. After this phase, the OVLs became an instructional product. This phase includes several steps as follows:

### a) Determine the computer program and language of OVLs programming:

The students first select computer program and language which realize the design of the OVL with high quality like MySQL, PHP, and Adobe Flash.

### **b) Programming OVL platform:**

After determining the computer program and language, the students implement the OVL platform by programming the OVLs learning administration tools and display content tools inside the OVLs. In addition, they develop the synchronous and asynchronous communications tools.

### **c) Programming OVLs content:**

The students also produce the elements of the OVL contents using text, animation, image, graphics, video, simulation, electronic questions and activities based on the OVL criteria. According to the manner of organizing the contents, they would prepare the contents so as to harmonize with the OVL platform.

### **d) Select domain and upload OVLs via internet:**

Finally, the students specify name of OVLs website according to the instructional institutions and the topics. They also provide the necessary capacity on the server to publish the OVLs on internet.

## **6.5 Evaluation Phase**

Evaluation phase presents the educational technology students main indicators about learning inside the OVLs and quality of the design for the OVLs at whole. They need to make improvements and developments permanently in systematic process. At this stage, they would use two types of evaluation.

**Formative Evaluation:** They perform in every part of the contents during learning process inside the OVLs, and carry out it after every phase during the designing model phase. The results of this evaluation provide the feedbacks to:

- The teacher to improve online teaching skills to achieve the objectives.
- The instructional designer to make revisions and modifications on model phases to improve the model designing process.

**Summative Evaluation:** They should make it to evaluate the learners' level at the end of learning inside the OVLs by making electronic tests for all OVL contents. They also make it for the whole OVL design by using questionnaire and interview. These results would:

- Help the teacher improve online teaching methodology.
- Enable the learners to know the level of their learning.

- Help the instructional designer to develop the OVL design at whole continuously.

## **6.6 Features of DPOVL model**

In the proposed DPOVL model, we skip the analyses phase since the educational technology students do not need to make analyses before DPOVLs. First of all, analyses is a difficult phase where they need some experience. In addition, the target learners' characteristics are actually defined by the usual courses in schools and universities. Our model also provides the teacher and the learners with enough technological training for using the OVLs. Thus, they do not need the learner and teacher analyses. The instructional designer and the teacher specify the content parts like skill, idea, and experiment directly according to their experience in teaching the course on the OVLs. It means they do not need course analyses.

On the other hand, we add the pre-design phase as the first one. This would make good inputs for the designing phase. Our model also focuses on the criteria phase because the criteria are very important to guide them for DPOVLs with high efficiency. Although the professors of the educational technology can prepare any criteria in this phase, we have suggested the list of criteria for DPOVLs to be easier in teaching our model directly to the students.

We divide the design phase into two parts. The OVLs platform is a fixed part in any OVLs, which contains a group of tools to make management of learning in the OVL and to provide the learners with multi communications with the teacher and the contents. On the other hand, the OVLs contents are variable parts according to the courses. The OVLs contents are divided into the segments, each of which segment belongs to one experiment, skill, or idea to improve learning. Such segment also have possibility for reuse in another OVLs. These parts make the model general and suitable to diverse fields.

In production phase, we do not specify computer software and language to produce the OVLs so that they can select anything freely. The results of the evaluation phase would make the students improve the OVLs in systematic process. Our model components in all phases offer the students the sequential steps to make them simple.

## 7. Conclusion

In this paper, we presented an instructional design model for designing and producing the online virtual labs in order for the educational technology students to improve skills regarding the OVLs in various courses with stable form and components in schools and universities. We made the analyses of the previous studies about the online virtual labs in many fields and the previous instructional design models. Based on the results of the analyses, we proposed the instructional design model of DPOVLs focused on e-learning and virtual learning components suitable in modern educational systems. The proposed model contains six phases, pre-design, criteria, design, production, experiment and implementation, and evaluation which lead to produce the OVLs step by step.

Our model focuses on the criteria for DPOVLs as 2 parts, 15 categories, and 139 items by specifying independent phases where the professors in the educational technology department would leave from preparation of the criteria.

The proposed model will be performed in the near future at the students and tested in actual educational institute. In addition, we will develop the OVL template to reach a pilot system for the OVLs.

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