Development of a Ubiquitous Learning System with Scaffolding and Problem-Based Learning Model to Enhance Problem-Solving Skills and ICT Literacy

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***Abstract*—The purpose of this research is to 1) design of an Ubiquitous Learning System with Scaffolding and Problem-based Learning (USPBL) model to enhance problem-solving skills and information and communications technology literacy, and 2) evaluate the USPBL model. The research procedures divide into two phases. The first phase is to design of USPBL, and the second phase is to evaluate the USPBL model. The sample group in this study consists of five experts selected by purposive sampling method. Data were analyzed by arithmetic mean and standard deviation. The research findings are as follows: 1. The USPBL model consist of three components is 1) principles of ubiquitous learning environment (ULE), problem-based learning with scaffolding in ULE, problem solving skill and ICT literacy 2) objectives of the model are to enhance problem solving skill and ICT literacy and 3) learning process 2. The experts agree USPBL model is highest level of appropriateness.**

***Index Terms*—Problem-based learning, ubiquitous learning, Scaffolding, problem-solving skills, information and communications technology literacy.**

I. Introduction

Development of problem-solving skills is essential and considered an important goal of the present education management because the skills are vital for lifelong learning. The development also corresponds to the framework of the Partnership for 21st Century Skills declaring that it is mandatory that learners develop problem-solving skills, a component of the Learning and Innovation Skills [1]. As a result of the expanding application of information and communications technology (ICT) in the field of education, it becomes inevitable for learners to improve their ICT literacy in order to foster capability in making use of ICT as a learning tool, effectively. Therefore, the learning environment should be managed to facilitate an improvement of the aforementioned skills [2].

The development of problem-solving skills can be achieved by employing a problem-based learning model or PBL. It is a form of learning that stimulates learners to obtain new knowledge through a study of problems in real world. The learners are the centre of this learning model. Instructors are facilitators and use problems as learning stimuli. There may be many solutions to a problem. The learners solve a problem by acquiring new information and evaluating results based on a real situation [3].

In the course of learning where the learners undertake the problem-based learning, the instructors must possess skills to stimulate, give guidance, and prepare sources of related information in order to support the learners. The mentioned assistance for the learners is called scaffolding. It means a provision of assistance in form of supports for learners to accomplish tasks, which cannot be achieved merely by them. When they start to show competency to fulfill the tasks, the assistance will be gradually lessened until they could assume full responsibility for or complete the tasks independently [4].

The term "u-learning" stands for ubiquitous learning. The word 'ubiquitous' means everywhere. The combination of that with the word 'learning' denotes a learning model that allows learners to gain knowledge anywhere by using mobile computer technology and wireless communication as tools. The learning recognizes learner's context. The so-called ubiquitous learning environment (ULE) [5] is a setting that encourages pervasive study. Learning can happen anytime with a mobile computer mediating an access to knowledge sources. The right learning theory for ubiquitous learning environment is constructivism. It complies with the current learning model and contributes to ICT literacy improvement as learners have the chance to practice various skills e.g. utilization of mobile devices to access information sources as well as information management, integration, evaluation, creation and communication with others. Furthermore, the scaffolding using the context-awareness attribute of the ubiquitous learning environment and therefore provides assistance based on learners' context, e.g. examination score, duration, and status of an activity, etc [6].

Consequently, the researcher proposes an initiative to develop a learning model based on the principles of problem-based education with the scaffolding employing the attribute of ubiquitous learning environment. It enables learners to acquire knowledge anywhere and anytime with the scaffolding provided in accordance to their individual context in order that they could achieve the learning goals.

II. Purpose of Study

1) To develop a Ubiquitous Learning System with Scaffolding and Problem-based Learning (USPBL) model to enhance problem-solving skills and information and communications technology.
2) To evaluate the developed Ubiquitous Learning System with Scaffolding and Problem-based Learning (USPBL) model to enhance problem-solving skills and

Manuscript received March 10, 2013 revised May 30, 2013.

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information and communications technology.

III. Scope of Study

A. Population and Sampling Group

Population of study is experts in the field of instructional design, problem-based learning, ubiquitous learning, information and communication technology, problem solving skills and ICT literacy.

The sample groups are five experts in the field of instructional design, problem-based learning, ubiquitous learning, information and communication technology, problem solving skills and ICT literacy, selected by purposive sampling method.

B. Research Variables

Independent variable is Ubiquitous Learning System with Scaffolding and Problem-based Learning (USPBL) model to enhance problem-solving skills and information and communications technology.

Dependent variable is evaluation of the model.

IV. Methodology

A. The First Phase

The development of Ubiquitous Learning System with Scaffolding and Problem-based Learning (USPBL) model .

1) Analyze and synthesize former researches relevant to the elements of problem-based learning, ubiquitous learning environment, scaffolding, problem-solving skills and ICT literacy
2) Study about learning process by interviewing the instructors in order to synthesize the data of learning activity; and by interviewing the students about their ability to use ICT tools for learning, their learning and cognitive style
3) Design the Ubiquitous Learning System with Scaffolding and Problem-based Learning (USPBL) model to enhance problem-solving skills and information and communications technology.
4) Present the model to the advisors for consideration and revision.
5) Present the model to the experts for consideration by in-depth interview.
6) Create the evaluation tools for evaluate the model's suitability.

B. The Second Phase

This phase was to evaluating the Ubiquitous Learning System with Scaffolding and Problem-based Learning (USPBL) model.

1) Present the designed model to the 5 experts in the field of instructional design, problem-based learning, ubiquitous learning, information and communication technology, problem solving skills and ICT literacy for review and evaluate the suitability.
2) The model is modified according to the experts' suggestions.
3) After modification, presenting the model in the form of diagram with report.
4) Analyze the results of evaluation of the model by mean ($\overline{X}$) and standard deviation ($S.D.$) consisting of 5 criteria for evaluation according to the idea of Likert scale.

V. Result

A. Ubiquitous Learning System with Scaffolding and Problem-Based Learning (USPBL) Model to Enhance Problem-Solving Skills and Information and Communications Technology

The learning model consists of three key elements, namely 1) components and principles of learning; 2) objectives of the learning model; and 3) learning process, steps, and activities, the details thereof are shown in Fig. 1.

1) Components and principles of learning are composed of

a) Ubiquitous learning environment (ULE)

The ubiquitous learning means a form of study encouraging pervasive education using mobile computer technology and wireless communication as a tool. The learning recognizes learners' context. A management of environment for u-Learning is commonly known as ubiquitous learning environment (ULE). It is an adaptation of learning situation to stimulate pervasive study. Learning can happen anytime with a mobile computer mediating an access to learning sources. The right learning theory for ubiquitous learning environment is constructivism as it conforms to the problem-based learning model. The ubiquitous learning environment in this research is referred to as an adaptation of a setting that encourages the problem-based study. It incorporates four components: 1) mobile device; 2) wireless communication; 3) ubiquitous learning management system (u-LMS); and 4) context-aware system. The learning in this environment will permit learners to develop their ICT literacy through practical use of devices with facilitation from instructors.

b) Problem-based learning with scaffolding in the ubiquitous learning environment

Problem-based learning with scaffolding in the ubiquitous learning environment is actually an internal process within ULE. Learners will receive and solve a problem situation as assigned by the system. They could work on it anywhere and anytime. The problem-based learning comprises seven steps as follows [3], [7]:

1) present a problem; 2) clarify concept and definition of the problem; 3) develop hypotheses and their sequence; 4) formulate learning objectives; 5) collect additional information; 6) synthesize and test newly acquired information; and 7) reflect and evaluate. Through all these steps, the scaffolding is automatically adjusted and provided in accordance with learners' context by referring to the context awareness attribute of Ubiquitous Learning Environment so that learners could solve the problem. Assistance will be given considering individual learner's context that is 1) Identity e.g. knowledge, background, attitude, academic score; 2) Activity e.g. events taking place

during the course of learning; and 3) Time e.g. start time or duration of attendance. The context is detected by Learner' Context-Aware Module so that a decision could be made on giving appropriate assistance. The assistance can come in any of these forms: 1) Coaching; 2) Eliciting articulation; and 3) Task Support.

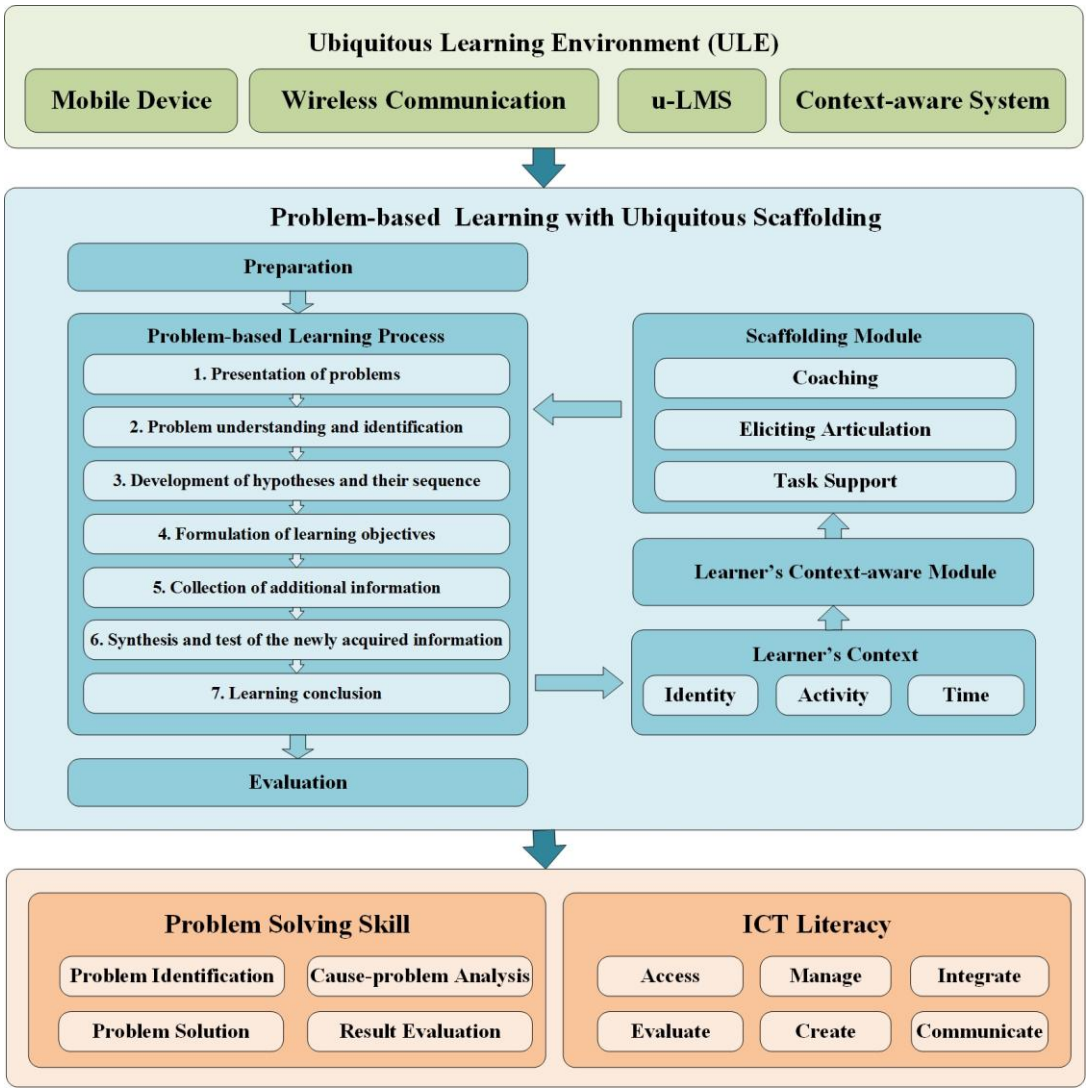

Fig. 1. The ubiquitous learning system with Scaffolding and problem-based learning (USPBL) model.

c) Problem solving skill

Problem Solving Skill. Means the ability to reflect, collect, analyzes and assesses information for making a decision to suggest a method by which obstacles or undesired situation are eliminated or diminished. According to Weir [8], it comprises four sub skills: 1) problem identifying skill; 2) cause-problem analyzing skill; 3) solution suggesting skill; and 4) result assessing skill.

d) Information and communications technology literacy (ICT literacy)

ICT literacy signifies competency in the use of digital technology, and communication devices or network to access, manage, integrate, evaluate, create information, and communicate with others [2]. It is an essential skill and needed to be enhanced among learners at present time.

2) The objective of the learning model is to enhance problem-solving skill and information and communications technology literacy

3) Learning process, steps, and activities can be divided in three stages

a) Preparation stage

1) Orientation. Instructors explain details and provide guidance about the ubiquitous learning.
2) Registration and workshop. Instructors distribute tablet computers to all learners for basic use workshop. Learners register, test the system access, and practice using the learning management system for each subjects, discussion board, and assignment submission.
3) Learner grouping. Groups of five members are formed on voluntary basis and each member's role is identified. The information about each group is then posted via u-LMS interface.
4) Evaluation of Problem-solving skill and ICT literacy. It is executed before learners commence the learning.

b) Learning stage

Learners will study online at any place with WiFi internet connection such as home, university, as well as public areas offering WiFi internet connection service, and do not need to attend traditional classrooms. The problem-based learning is employed as a key model and has a system to provide

scaffolding at every step of problem solving. The system will define learners' context taking into account the weekly scores and time spent at each learning steps. In the first week of study, learners are provided with scaffolding in order to be able to achieve a learning goal of individual step. In the subsequent weeks, the assistance will be given based on the scores obtained at every step in prior weeks. If the scores are below a set standard, the system will continue to assist duly. However, if the scores meet the standard, no assistance will be given. In case where learners spend too much time than a standard time allotted for each step, it demonstrates that they encounter difficulty and the system will consider providing aid to them automatically. Details of each learning steps are described as follows:

1) Presentation of problems. When a study time comes, learners receive a reminder message from the system sent to their tablet computer so they get ready for the forthcoming learning. The system then sends a problem situation to learners automatically.
2) Problem understanding and identification. Learners study and understand the problem situation received from the system through discussion and brainstorming among their group members via u-LMS interface on the tablet computer. Then learners submit the result of problem identification to the system. Group work enhances interpersonal communication skills.
3) Development of hypotheses and their sequence. Group members undertake discussion and brainstorming to analyze causes of the problem and develop hypotheses. Members can express their views freely. Learners sequence the hypotheses, write them down and submit to the system.
4) Formulation of learning objectives. Group discussion and brainstorming are undertaken to formulate learning objectives that give direction for the search of additional information to prove the selected hypotheses. Learners summarize the result of learning objective formulation and submit it to the system.
5) Collection of additional information. Members divide tasks of additional data research from knowledge sources. The sought data shall correspond with the formulated learning objectives and be looked up on the tablet computer. In this step, learners can exercise the use of ICT, particularly to get to information. After that, learners summarize the acquired information and input in the system.
6) Synthesis and test of the newly acquired information. Members jointly produce a summary of the research and separate the hypothesis-supporting information from that non-hypothesis-supporting. Together they make a conclusion of the supporting information and test if it is sufficient to prove the hypothesis. Learners submit the result of the information synthesis and test. In this step, they practice skills to integrate and evaluate the information.
7) Learning conclusion. Group members discuss and brainstorm via chat room and produce a conclusion on the learning, principles, and ideas obtained through the problem-based study. Learners input the result reflecting their own view in the system. In this step, they practice skills to create and manage the information by writing a learning conclusion.

c) Evaluation stage

1) Evaluation of problem-solving skill. After finishing the study, learners' problem-solving skill is evaluated by using closed form questionnaire about the problem-solving skill. Four aspects of the skill are evaluated: 1) problem identification; 2) cause-problem analysis; 3) problem solution; and 4) result evaluation.
2) Evaluation of ICT literacy. This study used the authentic assessment to evaluate the ICT literacy. Actual performance is assessed so learning records and achievements are taken into consideration to evaluate the learners' skill. The skills being evaluated are information accessibility, management, integration, evaluation, creation, and communication with others.

B. Evaluation Result of the Ubiquitous Learning System with Scaffolding and Problem-Based Learning (USPBL) Model

TABLE I: THE EVALUATION RESULTS OF THE USPBL MODEL

Evaluation Lists	Results		Appropriateness
	$\overline{X}$	*S.D.*	
1. Components and principles of the model.	5.00	0.00	Highest
2. Objectives of the learning model.	4.20	1.10	High
3. Learning process.	4.80	0.45	Highest
Summary	4.67	0.51	Highest

From Table I, shows that the experts agree that a USPBL learning model was appropriateness in highest level. ($\overline{X}$ = 4.67, *S.D.* = 0.51)

TABLE II: THE EVALUATION RESULTS OF LEARNING PROCESS

Evaluation Lists	Results		Appropriateness
	$\overline{X}$	*S.D.*	
1. Preparation stage.	4.65	0.52	Highest
2. Learning stage	4.71	0.57	Highest
3. Evaluation stage	4.63	0.54	Highest
Summary	4.66	0.54	Highest

TABLE III: THE EVALUATION RESULTS OF USPBL MODEL FOR USING

Evaluation Lists	Results		Appropriateness
	$\overline{X}$	*S.D.*	
1. USPBL model is appropriate to enhance problem-solving skill.	4.40	0.55	High
2. USPBL model is appropriate to enhance ICT literacy.	4.60	0.55	Highest
3. USPBL model is possible for using.	4.60	0.55	Highest
Summary	4.53	0.55	Highest

From Table II shows that the experts agree that the learning process was appropriateness in highest level. ($\overline{X}$ = 4.66, *S.D.* = 0.54)

From Table III shows that the experts agree that the USPBL for using was appropriateness in highest level.($\overline{X}$ = 4.53, *S.D.* = 0.55)

VI. Discussion

According to the assessment by experts, it was found that the USPBL model were in highest level of appropriateness. The results were in accordance with the research of Jones and Jo [5] who found that u-Learning helped facilitate the learners to study everywhere and anytime, and it complied with the theories of Constructivism. Moreover, the results were in compliance with Hung [9], who found out that the integration of problem-based learning activities and the scaffolding increased the problem-solving skills because the activities encouraged the learners to confront with the problems and think strategically in order to solve the said problems.

Also, the results conformed to Ku and Chang [7], who found that the problem-based learning with mobile device in Ubiquitous Learning Environment would facilitate the learners in solving the problems and communicating with the team members. This also enhanced the efficiency of the learners because there was no limitation of time and place.

To set up the USPBL, any education institutes that desire to apply this learning model should be well prepared in terms of infrastructure, instructors, and learners.

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