Development of a Constructivist Web-based Learning System with Student Personalized Conceptual Profile

Niwat SRISAWASDI[a*], Sattarat SRIKASEE[a] & Patcharin PANJABUREE[b]
[a]*Faculty of Education, Khon Khean University, Thailand*
[b]*Institute for Innovative Learning, Mahidol University, Thailand*
*niwsri@kku.ac.th

Abstract: This paper describes the use of student personalized conceptual profile, which is learning problem of the concept, in a constructivist web-based learning system. Such learning problems, which are diagnosed by basing upon a Fuzzy membership function, serve as a guideline to planning learning suggestions to individual students. Based on such learning suggestions, the constructivist web-based learning system handled the learning material in a useful, flexible and individualized way to students. The students, therefore, are provided meaningful personalized learning material, encouraged in searching conceptual knowledge, opened an opportunity in constructing the conceptual knowledge by oneself and collaboration in group learning resulting in improvement of learning achievement.

Keywords: Web-based learning environment, constructivist learning, diagnostic system, testing, learning problem

1. Introduction

With the rapid growth of computer and communication technology used in education, much research in this area has been developed Computer-Based Training (CBT), Computer Aided Instruction (CAI), Intelligent Tutoring Systems (ITSs) and in recent years in Web-based learning system. Regarding to the IEEE Learning Technology Standard Committee, Web-based learning environment utilizes the Internet as the primary method of communication between Web-browsers and students. Web-based learning environment has been taken advantages over traditional classroom-based learning environment in which the students are guided to follow textbooks and fixed learning process without awareness students' different personalized information. Such that web-based learning environment with the use of powerful personalized mechanism could provide adaptively an appropriate way to individual learning [1], which called web-based learning system in this study. Moreover, it can incorporate multiple media such as text, audio, graphics, video and animation to encourage and reduce cognitive load for students' learning [3].

In the recent years, several researchers have been study on constructivist web-based learning environment [4-5]. This existing research focused on promotion students to learn actively for constructing new knowledge by themselves. However, more focus should be placed on concerning their own personalized conceptual profile which is conceptual learning problems within the learning environment. Therefore, this study was designed to employ student conceptual learning problems as an important factor for developing a constructivist web-based learning system. Such learning problems, which are diagnosed by basing upon a Fuzzy membership function, serve as a guideline to planning conceptual learning suggestions to individual students. Based on such learning suggestions, the constructivist web-based learning system handled the learning material in a useful, flexible and individualized way to students. The students, therefore, are provided meaningful personalized learning material within the developed constructivist web-based learning system. This study was intended to show that, through their personalized conceptual learning material fitted with their own conceptual learning problem, the students would be alert in searching conceptual knowledge, constructing the knowledge by oneself, collaboration in group learning, and improvement of their learning achievement.

2. Diagnosing Conceptual Learning Problems based on a Fuzzy Membership Function

This study aims to diagnose students' conceptual learning problem by applying the concept of a Fuzzy membership function. The testing and diagnostic conceptual learning problem systems, built from the previous study [6-8], are applied to serve the needs of the current study. A conceptual test sheet of subject is needed to be constructed by teachers before the course begins. When developing the conceptual items for the test which cover all concepts that students need to learn in a topic, the intensity of association concepts (C_k) for each test item (Q_i) need to be determined. Without loss of generality, the intensity values range from 0 to 5, with 0 indicating no relationship and 1-5 representing the intensity of the relationship, with 5 the most intense (as shown in Table 1).

Table 1. Illustrative example of determining the intensity of association concepts for each test item

C_k / Q_i	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Q_1	2	0	5	0	0	0	0	0	0
Q_2	1	0	5	0	0	1	0	0	0
Q_3	4	4	5	1	1	0	0	0	0
Q_4	4	4	5	2	1	1	0	0	0
Q_5	2	5	5	1	4	1	0	0	0
Q_6	1	5	3	5	5	0	5	0	0
Q_7	0	0	1	0	0	0	0	5	0
Q_8	5	3	2	5	1	2	0	0	0
Q_9	0	1	0	0	0	0	0	0	5
Q_{10}	5	0	0	0	0	0	0	0	5
SUM(C_k)	24	22	31	14	12	5	5	5	10
ERROR(S_j, C_k)	9	8	16	3	2	2	0	5	0
IAD(S_j, C_k)	0.38	0.36	0.52	0.21	0.17	0.8	0	1.00	0

The summary steps in the diagnosing students' learning problems consist of the following:

- **Step1:** Finding concepts related to the test items that the students failed to correctly answer, assuming that a student (S_j) failed to correctly answer Q_2, Q_3, Q_4, and Q_7.
- **Step2:** Calculating incorrect answer degree IAD(S_j, C_k) of each concept for individual students. IAD is the ration of the ratio of incorrect answers to the total intensity values of concept C_k; that is IAD(S_j, C_k) = ERROR(S_j, C_k)/SUM(C_k). ERROR(S_j, C_k) is the total intensity values of the incorrect answers which are related to Ck for each student. As indicated in Table 1, then we have IAD(S_j, C_1) = 0.38, IAD(S_j, C_2) = 0.36, IAD(S_j, C_3) = 0.52, etc., indicating that the student failed to answer 38% of the test items

related to C_1, 36% of the test items related to C_2, 52% of the test items related to C_3, and so on.

- **Step3:** Finding the learning problems of the student by applying the Fuzzy membership function. Since the IAD serves as the fuzzy input values in generating the level of learning ability; therefore, with the widely use of the technique of fuzzy inference in expert systems, the fuzzification operations are used to combine IAD values with membership functions to produce the level of learning ability. Assuming that x = IAD(S_j, C_k). There are three parameters (i.e., a, b, and c) used to define the curve of the functions by assuming that a = 0, b = 0.5, c = 1. Therefore, the membership function of LOW(x), MEDIUM(x), and HIGH(x) are following:

$$\text{LOW}(x) = \begin{cases} 1 & \text{for } x \le a, \\ 1 - 2\left(\dfrac{x-a}{c-a}\right)^2 & \text{for } a \le x \le b, \\ 2\left(\dfrac{x-c}{c-a}\right)^2 & \text{for } b \le x \le c, \\ 0 & \text{for } x \ge c. \end{cases}$$

$$\text{MEDIUM}(x) = \begin{cases} 0 & \text{for } x \le a, \\ 2\left(\dfrac{x-a}{b-a}\right)^2 & \text{for } a \le x \le \dfrac{a+b}{2}, \\ 1 - 2\left(\dfrac{x-b}{b-a}\right)^2 & \text{for } \dfrac{a+b}{2} \le x \le b, \\ 1 - 2\left(\dfrac{x-b}{c-b}\right)^2 & \text{for } b \le x \le \dfrac{b+c}{2}, \\ 2\left(\dfrac{x-c}{c-b}\right)^2 & \text{for } \dfrac{b+c}{2} \le x \le c, \\ 0 & \text{for } x \ge c. \end{cases}$$

$$\text{HIGH}(x) = \begin{cases} 0 & \text{for } x \le a, \\ 2\left(\dfrac{x-a}{c-a}\right)^2 & \text{for } a \le x \le b, \\ 1 - 2\left(\dfrac{x-c}{c-a}\right)^2 & \text{for } b \le x \le c, \\ 1 & \text{for } x \ge c. \end{cases}$$

The corresponding fuzzy membership function for determining Performance_Level(S_j, C_k) of each student (Sj) for each concept (Ck) as given as follows:

- If x is HIGH Then Performance_Level(S_j, C_k) is Poorly-Learned with degree D_H,
- If x is MEDIUM Then Performance_Level(S_j, C_k) is Partially-Learned with degree D_M,
- If x is LOW Then Performance_Level(S_j, C_k) is Well-Learned with degree D_L.

For example, IAD(Sj, C6) = 0.8, by applying the fuzzification operation, the following fuzzy input values will be produced: Fact 1: IAD(Sj, C6) = 0.8 is HIGH with D_H = 0.92; Fact 2: IAD(Sj, C6) = 0.8 is MEDIUM with D_M = 0.32; Fact 3: IAD(Sj, C6) = 0.8 is LOW with D_L = 0.08. With the maximum degree MAX(0.92, 0.32, 0.08) = 0.92, the Performance_Level(Sj, C6) is poorly-learned, implying that the student has learning problem of concept C_6; therefore, the student need to re-learn this concept. If Performance_Level(S_j, C_k) is Partially-Learned, implying that the student has some problem of concept C_k; therefore, the student need to do more practice in the concept C_k. In addition, If Performance_Level(S_j, C_k) is Well-Learned, implying that the student completely learn in the concept C_k; therefore, the student do not need to do anything in the concept C_k.

3. An Implementation of a Constructivist Web-based Learning System

Based on diagnosing student conceptual learning problem procedure, a constructivist web-based learning system has been developed using the PHP programming language and the Microsoft®.NET Framework. To evaluate the effectiveness of the developed constructivist web-based learning system, an experiment on Basic Computer course on topic “video creating with Window Movie Maker program” of thirty-seven senior high school students was conducted. The students were assigned to undertake learning with the system anytime during two weeks.

3.1 Teachers’ Mode

In the developed constructivist web-based learning system, the teachers are asked to develop the conceptual test sheet which covers ten concepts studied on topic “video creating with Window Movie Maker program”. Moreover, they are asked to determine the intensity value of association concepts for each test item before the topic begins (Figure 1).

3.2 Students’ Mode

In the developed constructivist web-based learning system, the students are asked to take the on-line conceptual test on topic “video creating with Window Movie Maker program”. There were 30 items on ten concepts studied of the topic. When the teachers determined the intensity value of association concepts for each test item and the student submitted his/her answers of the conceptual test sheet, the diagnosing conceptual learning problems in the developed constructivist web-based learning system can work effectively. The developed constructivist web-based learning system will diagnose his/her conceptual learning problems and provide the learning performance of each concept (Figure 2). Moreover, the student is given the personalized learning material corresponding to his/her conceptual learning problems with the constructivist web-based learning environment as shown in Figure 3.

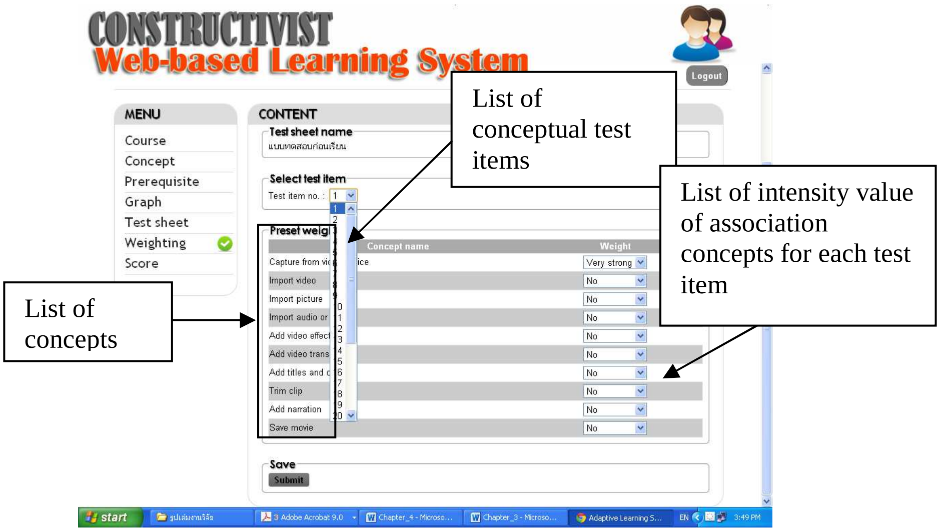

Figure 1. Illustrative interface example of the determining the intensity value of association concepts for each test item

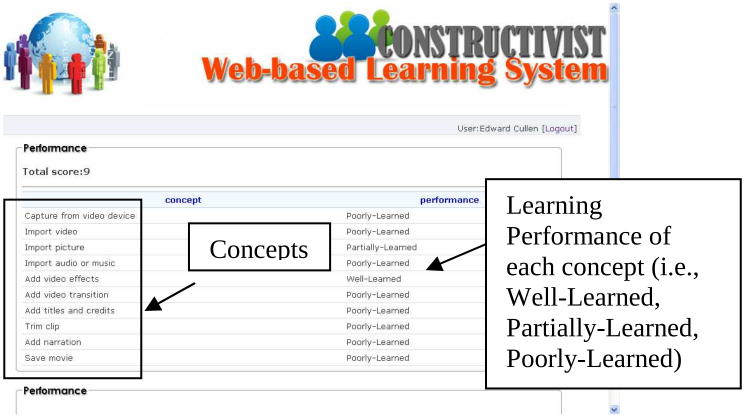

Figure 2. Illustrative interface example of the personalized learning performance of each concept studied

Figure 3. Illustrative interface example of constructivist web-based learning environment

4. Results

To evaluate the effectiveness of the developed construcivist web-based learning system on students' conceptual learning of video creating with Window Movie Maker program, the students' conceptual scores on the topic were examined both before and after their undertaken with the system. In addition, the students' perception toward the developed construcivist web-based learning system was investigated.

4.1 Conceptual Knowledge Score

The result of the students' conceptual knowledge score is taken to be the average normalized gain <g> by analyzing the conceptual pre-test and post-test. Hake (1998) defined the <g> as "High gain, <g> ≥ 0.7", "Medium gain, 0.7 > <g> ≤ 0.3", and "Low gain, <g> < 0.3" [2]. As shown in Table 2, the conceptual score of pre- and post-test, the <g> is 0.42 indicating that the students have progression of their learning by gaining better conceptual knowledge after participating with the developed constructivist web-based learning system, and the progression of their conceptual knowledge has medium gain size. According to Table 2 result, this evidence suggests that learning with the developed constructivist web-based learning system impacted moderately on improving the students' conceptual understanding of video creating with Window Movie Maker program.

Table 2. Learning progression of conceptual score by the average normalized gain <g>

Conceptual test (Total score = 30)	N	Mean	S.D.
Pre-test	37	8.73	3.18
Post-test	37	17.65	3.86
<g>	0.42		

4.2 Students' Perceptions toward the Constructivist Web-based Learning System

A questionnaire was administered to the students to explore their perceptions toward the constructivist web-based learning system after their participating with the system. There were 27 items on three constructs including media attributes, learning content attributes, and theoretical attributes of constructivist web-based learning system, and each item rated students' perceptions using a five-point scale. Higher scores on this instrument indicated more positive perceptions toward the system. A statistics description of the questionnaire is provided in Table 3.

Table 3. Overall mean and S.D. of students' perception scores on each construct

Perception questionnaire (Maximum score = 5)	Mean	S.D.	Description
Media attributes	4.08	0.72	Satisfactory
Learning content attributes	3.96	0.79	Satisfactory
Theoretical attributes	3.95	0.79	Satisfactory

The results in Table 3 shows the means of the items on media, learning content, and theoretical constructs were 4.08, 3.96, and 3.95 respectively which imply that the students are satisfied in learning and engaging with the constructivist web-based learning system. This result suggests that they positively perceived attributes of the constructivist web-based learning system for their conceptual learning of conceptual learning of video creating with Window Movie Maker program.

5. Conclusions

This study investigated an impact of a constructivist web-based learning system, which is an integration of testing and diagnostic conceptual learning problem system and constructivist web-based learning environment, on students' conceptual knowledge. The results showed that the constructivist web-based learning system affected the students gaining conceptual learning progression in a medium grain size. In addition, they prevalently expressed positive perceptions toward media attributes, learning content attributes, and theoretical attributes of constructivist web-based learning system. This finding indicated that constructivist web-based learning system could be involved in order to enhance students' conceptual learning. As the finding, the way of integration personalized conceptual profile into making student learning process within constructivist-designed web-based learning environment could be used to provide more flexible phenomenon of individual learning for students and more suitable conceptual learning in domain-specific concepts.

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