Using Problem-Based Learning Approach to Facilitate Learning of Science

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Abstract: This paper illustrates the integration of the hybrid Problem-Based Learning (PBL) approach in the development of the prototype C^{2}HADAM, a multimedia courseware that is intended for the teaching and learning of the Science subject for form two students in Malaysian secondary schools. The discussion begins with the Constructivist theory and conceptual frameworks underlying C^{2}HADAM. The learning concepts of inquiry learning, contextual education, simulation, exploratory learning, self-directed learning, and student-centered learning are also incorporated into C^{2}HADAM. Next, this paper details the development of the project using a popular development life cycle namely ADDIE. ADDIE life cycle consists of the analysis, design, development, implementation, and evaluation phases. This paper also highlights some of the screen snapshots taken from C^{2}HADAM prototype. The final part of this paper presents some of the findings from the Effectiveness construct. The results show positive feedback on the use of the courseware, and the courseware proves to enhance learners' performance. The integration of the PBL principles in the development of the courseware, thus, promises more of its application in the teaching and learning of other scientific disciplines.

Keywords: Problem based learning, Science, Constructivism

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Introduction

This paper discusses the design and development of a multimedia courseware package, namely C^{2}HADAM, for the teaching and learning of the Science subject, particularly on the topic of Nutrition. The whole development of the package is using Problem Based Learning (PBL) approach. The PBL approach, which is gaining popularity nowadays, is viewed as a new paradigm shift in the teaching and learning process. Concurrently, the robust growth of the Internet and multimedia technology has acted as the catalyst for the development of the education system in our country. The use of ICT allows the learners to be exposed to various learning environments and authentic hands-on learning experiences (Zumbach et al. 2006). This paper begins with a discussion of Constructivist learning theory adopted in the development of the C^{2}HADAM multimedia package. The second section of the paper deals with all five working phases involved in developing the package. Following this is the third section, which presents the module and some screenshots taken from the courseware. The fourth section, also the last section of the paper, discusses the findings from a case study conducted with a number of selected schools.

Theoretical Framework of C^{2}HADAM

This paper elaborates on the design and structure of C^{2}HADAM, developed based on the hybrid PBL approach, which evolves from Constructivist learning theory. According to Reigeluth (1999), there have been numerous learning techniques adopting the Constructivism Theory model, such as the project-based approach, situational learning, cooperative learning, and PBL. Nevertheless, Savery and Duffy (1995), and Jonassen (1999), declare that out of all these learning techniques, the PBL approach is regarded as a true manifestation of the Constructivism Learning model. For this reason, the PBL approach has been determined as the learning approach adopted in this attempt of developing multimedia courseware. The constructivist learning approach promotes learning strategies such as exploratory, experiments, and problem-solving, which prove to be effective in the teaching and learning of the science domain (Neale & Smith 1990; Su 2008).

According to Bonk dan Wisher (2000), some learning features of the constructivism model are as follows:

(i) Meaningful learning takes place with regard to learners' past experiences and current knowledge
(ii) Interpretation of meaning is personalized and depends on the learner's background
(iii) Learning is a dynamic process, where experiences are transformed into knowledge and skills.
(iv) Assessments are integrated into every task.

According to Kolmos and Graaff (2007), and Mohd Ali et al. (2007), the PBL methodology is receiving more attention as a teaching and learning strategy, especially for global education. Savery and Duffy (1995), and Gulsecen and Kubat (2006) assert that PBL is defined based on the constructivism principles, which comprise three important aspects:

(i) Learners build up their understanding from their interaction with their surroundings

(ii) Cognitive conflicts serve as a stimulus in a learning process.

(iii) Knowledge is gathered from social interaction and an individual's motivation level.

Barrows and Tamblyn (1980) define PBL as learning activities that take place as a result of working out or solving a problem. In addition, Liu (2005) asserts that PBL is a learning process that presents the learners with sets of problems, which they have to work out critically and creatively. The situations or problems presented should emulate authentic scenarios. This feature makes up the most important component of the PBL approach. The situations are constructed to cater to the intended learning outcomes and required skills (Kearsley & Shneiderman 1999; Tse & Chan 2003). Identifying a problem is the first move in the learning process; thus, learners are introduced to real problems at the early stage of their learning course (Duch et al. 2001; He et al. 2002). The problems, in consequence, will prompt the learners to focus on the application of their problem-solving skills, logical thinking, and knowledge to resolve the problems. These sets of problems also serve as the appetizer to the whole learning topics (Scot et al. 2007).

The C^{2}HADAM Multimedia Prototype

The C^{2}HADAM multimedia prototype is designed based on ADDIE Model stand for analysis, design, development, implementation, and evaluation. This model takes into account various aspects of development: (i) the analysis of PBL teaching and learning methodology; (ii) the design of learning outcomes that suit the ID model and C^{2}HADAM multimedia courseware modules; (iii) the preparation of teaching plan inventory; and (iv) the implementation of assessment and improvement of the system based on the Life Cycle Model of C^{2}HADAM (KH C^{2}HADAM). The C^{2}HADAM multimedia prototype include PBL features, learning activities, ID model construction, courseware modules development, teaching content inventory. There are six (6) modules available as follows:

- The Introduction Module

This module is divided into four submodules - montage, about PBL, about C^{2}HADAM, and users' registration. The Introduction module provides a brief explanation of the C^{2}HADAM courseware, which is developed based on the PBL approach. The montage is created to gauge the attention of its users.

- The Scenario Module

This module consists of several problem-based scenarios on topics related to digestion. It serves as a trigger to the learning and problem-solving process. The module is developed based on the concept of the Contructivist Approach, which reflects real-life scenarios. The scenarios require the learners to take a role of a dietician in a private health center, who is responsible to handle issues of an imbalanced diet. Student need to record the

results in the learning journal available in the courseware, to be shared with and viewed by other learners.

- The Teacher Module

This module consists of three submodules: learning outcomes, explanations and examples, and exercises. The contents of this module are derived from a few Science reference books (Choo & Low 2003; Deve et al. 2006; Tee 2006; Yeap & Sopia 2006) and a book titled "Panduan Diet Malaysia" (Jawatankuasa Penyelaras Makanan dan Pemakanan Kebangsaan, Kementerian Kesihatan Malaysia 1999). The submodule Learning Outcomes provides the introduction to all the subtopics with the expected learning outcomes; among the topics are Food Classification, Digestion Process, and Balanced Diet. This is an outstanding feature of PBL because the knowledge gained can be activated before the learning topics are presented. Explanations provided are prepared as scaffolding to facilitate the learners' understanding of the topics discussed. The use of the 3D animation technique is also integrated into this module, for instance, the use of the animation to describe a normal digestion process versus one with a problem to enhance learners' comprehension.

- The Test Module

This module includes several sets of sample examinations questions aims to guide the learners with the questions and answers. The questions are constructed with the assistance of teachers who have been teaching the Science topics for Form Two, and also with reference to Science revision books recommended by the school administration (Ooi 2004; Ooi et al. 2004; Hasroni & Daisy 2006). This Test module supplies a few sets of question forms including MCQs, labeling, and fill-in-the-gaps.

- The Problem Solving Module

This module is designed to display explanation and problem-solving exercises aimed to reinforce learning. Several sets of scenarios are prepared for the learners to solve. The learners need to work in groups of 6-7 to finish the tasks. The purpose of this module is to provide drilling practices to boost learners' competence, as well as their problem-solving skills; thus, aiding them to structure their thoughts systematically.

- The Exploration Module

The learners are given the option to access the websites to search for topics related to nutrition and to use the email facilities and online forums to exchange ideas on the topics. There is also a component named Ask the Experts, which features questions on topics related to nutrition, especially on the process of digestion. Learners may select the 'expert' and ask questions.

Method

This section presents the method and results from the evaluation on the effectiveness construct of the courseware application. The results are gathered from a study case with 64 Form Two students from Secondary School Seksyen 24 (2), Shah Alam, Selangor, Malaysia. The evaluation on the effectiveness construct of the C^2HADAM courseware application is conducted based on the following research questions:

Q1 Does the use of the C^2HADAM multimedia package, with the Hybrid PBL approach, enhance the performance of the Form Two students in comparison with the conventional teaching and learning methodology on the same topic Nutrition?

(a) Pre and Post Tests

This issue was addressed with the quasi-experiment method carried out on two groups of Form Two students: the Experiment Group (X1), who received the treatment by using the C^2HADAM multimedia package based on the Hybrid PBL approach, and the Control Group (X2), who received the conventional teaching and learning methodology on the same topic. To measure the performance in terms of the pre and post-tests scores between the two respondent groups, the Experiment Group (X1) and the Control Group (X2), the Dependant T-Test was applied.

Table 1. Demographic Distribution Of Samples

Group	Girls	Boys	Total
Experiment (X_1)	16	18	34
Controlled (X_2)	16	14	30
Total	**32**	**32**	**64**

The measurement adopted to assess the effectiveness construct of the courseware is from the scores of pre and post-tests taken by both groups on the topic of Nutrition. The students from the Experiment Group (X1) were exposed to teaching using the courseware, and they are labeled with the letter E, followed by the numbers 1 – 34; on the other hand, the Control Group (X2) was taught using the conventional method, and are labeled with the letter K, followed by the numbers 1-30.

Table 2 shows the average scores from the pre and post-tests, together with the improvement scores, for the Experiment Group (X1). Likewise, Table 3 shows the scores for the Control Group (X2). From both tables, there are improvements in the student's performance on the topic of Nutrition for both groups. However, the improvement for the group using the C^2HADAM multimedia package is higher than the group using the

conventional method. The Experiment Group (X1) had an increase of 28.60%, while the Control Group (X2) 14.75%.

Table 2. Pre And Post Test Scores For Experımental Group (X1)

Students	Pre Test Scores (%)	Post Test Scores (%)	Improvements (%)
E1	27.5	60	32.5
E2	27.5	37.5	10
E3	25	62.5	37.5
E4	35	60	25
E5	55	95	40
E6	35	50	15
E7	30	40	10
E8	32.5	65	32.5
E9	25	52.5	27.5
E10	32.5	55	22.5
E11	30	80	50
E12	30	65	35
E13	20	35	15
E14	35	50	15
E15	30	65	35
E16	15	50	35
E17	20	50	30
E18	25	80	55
E19	35	50	15
E20	25	37.5	12.5
E21	22.5	30	7.5
E22	27.5	50	22.5
E23	37.5	50	12.5
E24	32.5	40	7.5
E25	52.5	70	17.5
E26	30	70	40
E27	30	65	35
E28	30	80	50
E29	22.5	75	52.5
E30	20	45	25
E31	15	55	40
E32	27.5	65	37.5
E33	0	37.5	37.5
E34	0	37.5	37.5
Average	**27.6**	**56.176**	**28.602**

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Table 3. Pre And Post Test Scores For Control Group (X2)

Students	Pre Test Scores (%)	Post Test Scores (%)	Improvements (%)
K1	30	32.5	2.5
K2	32.5	32.5	0
K3	30	35	5
K4	27.5	32.5	5
K5	25	30	5
K6	17.5	17.5	0
K7	27.5	35	7.5
K8	45	67.5	22.5
K9	40	67.5	27.5
K10	37.5	67.5	30
K11	30	62.5	32.5
K12	35	62.5	27.5
K13	37.5	70	32.5
K14	35	70	35

K15	32.5	50	17.5
K16	45	47.5	2.5
K17	27.5	30	2.5
K18	17.5	20	2.5
K19	22.5	30	7.5
K20	15	32.5	17.5
K21	20	27.5	7.5
K22	27.5	45	17.5
K23	30	45	15
K24	22.5	37.5	15
K25	35	40	5
K26	35	60	25
K27	27.5	45	17.5
K28	32.5	50	17.5
K29	20	35	15
K30	35	60	25
Average	**29.8**	**42.6**	**12.8**

Results Discussion

Tables 2 and 3 show that the average score in the pre-test for the Experiment Group (X1) is 27.6%, and the Control Group (X2) is 29.8%. Therefore, the difference in the pre-test scores between both groups is 2.2%. On the same tables, the average score in the post-test for the Experiment Group (X1) is comparatively higher at 56.17%, than the Control Group (X2) at 42.6%. Thus, the difference in the post-test scores between both groups is 13.58%

The analysis from both tables also reveals that there is a difference in the lowest pre-test scores for both groups of respondents. The lowest pre-test score from the Experiment Group (X1) is 0%, while the Control Group (X2) is 15%. Meanwhile, the highest pre-test score from the Experiment Group (X1) is 55%, and from the Control Group (X2) is 45%. Yet, the analysis brings to light another finding that the lowest post-test score for the students of the Experiment Group (X1) is 30%, and for the students of the Control Group (X2) is 17.5%. The highest post-test score for the Experiment Group (X1) is higher, which is 95%, than the highest post-test score for the Control Group (X2), which is 70%.

The passing mark for the tests was set at 40%. The analysis shows that the students from the Experiment Group (X1) have a higher passing rate (85%) than the students from the Control Group (X2) (53.4%). Table 4 displays the distribution of post-test scores for both groups. It reveals that 14 students (46.6%) from the Control Group (X2) failed the test, and only 6 students (17.6%) from the Experiment Group (X1) obtained lower than the passing mark. Another noticeable difference in the student's performance is that none from the Control Group (X2) obtained excellent scores (80-100%); however, 4 students (11.8%) from the Experiment Group (X1) managed to be in the excellent score range.

Table 2 also shows that students E18 and E29 from the Experiment Group (X1) obtained the highest

improvement in scores, which are 55% and 52.5% respectively. On the other hand, students E21 and E24 gained the lowest improvement in scores which is 7.5%. Similarly, Table 3 displays student K14 from the Control Group (X2) had shown the highest improvement in the score with 35%, as students, K2 and K6 attained the lowest improvement which is 0%. Therefore, it can be observed that the Experiment Group (X1) obtains higher scores, in its highest and lowest improvement than its equivalent from the Control Group (X2). The finding reveals that the majority of students from the Control Group (X2) were not able to show a good grasp of the topic (14 out of 30 students obtained scores between 0-34). Conversely, the students from the Experiment Group (X1), who adopted the teaching and learning using the C^{2}HADAM multimedia courseware, display a rather even distribution of performance.

Table 4. Ranges of Scores in The Post Test

Scores	Experiment Group (X_1)		Control Group (X_2)		Total	
	No.	Percentage	No.	Percentage	No.	Percentage
0-39	6	17.6	14	46.6	20	31.3
40-49	3	8.8	5	16.7	8	12.5
50-59	10	29.4	2	6.7	12	18.7
60-69	8	23.5	7	23.3	15	23.4
70-79	3	8.8	2	6.7	5	7.8
80-100	4	11.8	0	0	4	6.3
Total	**34**	**100.0**	**30**	**100.0**	**64**	**100.0**

Conclusion

This paper discusses selected learning theory, namely constructivist that incorporated into the development of the C^{2}HADAM multimedia courseware. This courseware focuses on the topic of Nutrition for selected Form Two students, who were tested using the PBL approach for their Science subject. The features of PBL including simulations, problem scenario sets, collaboration, and scaffolding play important roles in aiding the learners to comprehend the scientific concept of the topic of Nutrition. A few series of interviews, checklists, and question sets were administered to evaluate the application of the courseware. In short, respondents provided positive feedback on the use of the courseware, and the courseware proves to enhance learners' performance. The integration of the PBL principles in the development of the courseware, thus, promises more of its application in the teaching and learning of other scientific disciplines.

Recommendations

The current study revealed that Problem Based Learning approach is an important method for enhancing teaching and learning of Science subject. However, the results of this study should be treated with caution due to the small sample size. On this basis, future research should further examine the differences in learning styles

among students and personalized learning according to their preferences. It could also contribute to a deeper understanding of the teaching and learning approach suitable for learning Science course.

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