IMPLEMENTING PROBLEM-BASED LEARNING IN SCIENCE CLASSROOM

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Abstract

This paper reports on how the popular learning theory, the Problem-Based Learning (PBL) approach, was incorporated into the Form Two science curriculum of Malaysian secondary education. The evidence suggests that PBL is an instructional approach that has the potential to help students develop understanding and lifelong learning skills. A common feature of problem-based learning is to provide students with a range of resources that assist them in solving various problems. The focus of this paper is to discuss the development cycle and methodology involved in developing the multimedia courseware called C²HADAM. This paper will also include some screenshots of the C²HADAM courseware. Finally, it will provide the discussion of the research findings. These findings are potentially useful for the multimedia courseware developer and also science teachers who intend to incorporate PBL into their work. This study is a part of the first author’s on-going PhD work which aims to test the implementation of hybrid PBL approach at a selected secondary school in Malaysia. The multimedia courseware focuses on the topic of ‘Nutrition’, which is included in the Form Two Science curriculum for Malaysia secondary schools.

Keywords: Courseware, Hybrid Problem-Based Learning, and Science.

Introduction

This paper emphasizes the design and development of an interactive multimedia courseware for ‘Nutrition’, a topic covered in the Form Two Science subject. A Problem-Based Learning (PBL) was used as this particular approach has become a popular teaching and learning paradigm. With the advancement of Information Communication Technology (ICT), innovative use of multimedia technology has been a major factor in impacting the current trend of education worldwide. No doubt that ICT can improve the way Sciences should be taught and enhances students understanding of basic nutrition knowledge, particularly on the human digestion process.

This paper starts with a discussion on some of the development life cycle adopted in producing multimedia courseware packages namely C²HADAM. The development cycle is known as Kitar Hayat C²HADAM (KHC²HADAM). The second section describes all the five phases involved in developing the courseware. The third section of this paper explains the modules and screenshots taken from C²HADAM Packages. The forth and final part of this paper presents some of the findings from the test conducted at one of the smart schools in Shah Alam, Selangor, Malaysia.

Development Cycle of C²HADAM Packages

C²HADAM is developed in a cycle of five phases namely Analysis, Design, Development, Implementation and Evaluation. This development cycle is called Model Kitar Hayat C²HADAM (KHC²HADAM) which has been developed in an integrated way by looking at various learning theories such as Problem Based Learning, Contextual, Collaborative and Constructivist.
approaches. The teaching and learning strategies for science field are also incorporated in producing C²HADAM package. There are five phases involved in developing C²HADAM as shows in Table 1 below:

<table>
<thead>
<tr>
<th>Process</th>
<th>Methods</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1: Analysis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Problem analysis – study why student hard to understand nutrition topics.</td>
<td>• Interview and questionnaires for 15 Science teachers asking about teaching and learning techniques uses in school.</td>
<td>• The topic of Nutrition, with the sub-topic of digestion system, has been identified as one of the difficult topic (<em>Lembaga Peperiksaan Malaysia 1993, 1994, 1995, 1996 &amp; 2004)</em>.</td>
</tr>
<tr>
<td>• Student background analysis</td>
<td>• Questionnaires given to 350 Form Two students from some selected secondary schools in Negeri Sembilan (Sekolah Menengah Kebangsaan (SMK) Mantin, SMK Taman Tuanku Jaafar, Seremban, SMK Taman Semarak, Nilai and one of the smart schools in Selangor, SMK TDDI Jaya, Shah Alam.</td>
<td>• List of teaching content, learning outcomes, and syllabus for the topic of Nutrition</td>
</tr>
<tr>
<td>• Science teaching and learning objectives</td>
<td>• For student, they are given a 40 multiple choices test question pertaining to nutrition topic</td>
<td>• Teaching and learning methodology for Science subject</td>
</tr>
<tr>
<td>• User requirement and technical constraint</td>
<td>• Identify the suitability of PBL approach in teaching science</td>
<td></td>
</tr>
<tr>
<td>• Identify the suitability of PBL approach in teaching science</td>
<td>• Analyze problem solving techniques</td>
<td></td>
</tr>
<tr>
<td>• Phase 2: Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Building the inventories for the content of the teaching</td>
<td>• Discussions with some experts in the PBL approach have helped complete the designing phase of the courseware</td>
<td>• List of inventories for the teaching content and syllabus for the topic of Nutrition</td>
</tr>
<tr>
<td>• Mapping of the curriculum</td>
<td>• Extensive review of literature on PBL approach, science teaching strategy has been done.</td>
<td>• Programming tools and media</td>
</tr>
<tr>
<td>• Choosing the media and techniques</td>
<td></td>
<td>• Storyboards and flowcharts</td>
</tr>
<tr>
<td>• Instructional design</td>
<td></td>
<td>• Modules</td>
</tr>
<tr>
<td>• Designing of flowcharts and storyboards</td>
<td></td>
<td>• Databases</td>
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<tr>
<td></td>
<td></td>
<td>• Curriculum mapping on Nutrition</td>
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</tbody>
</table>

**Phase 3: Development**

<table>
<thead>
<tr>
<th>Process</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>• Creation of problem</td>
<td>• This phase requires</td>
<td>• Constructive</td>
</tr>
</tbody>
</table>

*Table 1: C²HADAM Packages development cycle*
**Phase 4: Implementation**

- Application testing.
- Pre test Experiment

- This phase requires the researcher to test the C²HADAM package in terms of its usability, effectiveness and student’s problem solving skills.

- Preliminary test on C²HADAM
- Testing data
- Modification

**Phase 5: Evaluation**

- Testing Data compiled from all the research instruments (questionnaires and check list)
- Modification

- This phase requires the researcher to evaluate all the elements found in the C²HADAM packages based on research construct and prove the hypothesis.

- Evaluation of C²HADAM Package in terms of effectiveness, usability and problem solving skills.
- Evaluation of the C²HADAM development cycle and the C²HADAM Instructional Design (ID) model

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**C²HADAM PACKAGES**

C²HADAM is an acronym for constructive courseware for nutrition topic. It has been developed using Macromedia Director and Flash 8.0, the commercially available multimedia programming tools. This hybrid C²HADAM is available in digital, web-based and paper-based formats. A web-based format is particularly suitable for the learning of applied science subject. However, web-based learning has also been widely applied to the life science to reinforce whatever the students have acquired in the classroom, laboratory, or class activities (Chan, Huang, & Chi, 2003). With emphasis on learning the concept of nutrition, the use of visual representation is critical in creating real-life experience that allows students to relate the materials with their daily food intake. Faaiizah (2006) highlighted the use of ill-structured problem such as human digestion problem and constipation problem act as a trigger to start the learning process that will help students appreciate and better understand the learning topics.

In addition to learning content, the access to digital resources such as online nutrition courses also allows the exploration of different information resources. C²HADAM has been developed as menu-driven, which allows students to enter the information stream at a variety of points, rather than being forced to follow a predetermined path. With the help of various multimedia development tools, the visual representations of nutritional topic aim to foster potential learning interest and stimulate student’s attention. The use of animation, simulation, clickable diagrams and pictures are used to clarify concepts that a static textbook image simply cannot clarify. The
use of images, motions, video and problem scenarios as a trigger make a scientific phenomenon easily comprehended by students.

The C²HADAM Package comprises six modules

- Module 1: Introduction
- Module 2: Scenarios
- Module 3: Teacher
- Module 4: Exploration
- Module 5: Problem Solving
- Module 6: Test

The ‘Introduction’ module functions to introduce student to the C²HADAM courseware. It starts with a montage, followed by information about PBL and a short description of C²HADAM courseware. The last part of this module is the registration screen for students to register as the legal user of the courseware. After successful registration process, the main menu screen for the courseware will be displayed as shown in Figure 1.

![Diagram of the stomach and some internal organs that relate to the concept being taught](image)

**Figure 1: C²HADAM main menu**

The ‘Scenarios’ module functions to help students understand the problem, which has been presented using simulation techniques as shown in Figure 2. Tong de Jong et al (2002) stated that computer simulation is a program that is used to emulate an approach similar to the real world. With this kind of learning approach, the different parameters are given as the input and the system conducts the simulation and results are analyzed. Computer simulation can occur as a physical simulation (based on object); procedure simulation (having certain expertise to run it); situation simulation (based on current situation) or just based on a simulation process. In other words, simulations can generally be defined as a model to show the real system. It has been proven to be a more effective strategy than classroom teaching (Norazah Nordin 2002; Nor Azan 2005). In using C²HADAM courseware, the students have to act as a dietician to help solving a dietary problem. Students are given access to the on-line Learning Journal and Forum to discuss and share their findings. After meeting the real world problem scenario, students will be guided to use the problem solving chart called the FILAS tables. FILAS is an acronym Facts, Ideas, Learning Issues, Actions, and Solutions. Students need to identify what they know from the scenario and how to go about solving the problem and document the information on a FILAS tables. In the ‘Learning Issues’ stage, students need to document what critical issues are to
finding out more about the problem. The purpose of developing the ‘Scenarios’ module is to present a problem which acts as a trigger for the topic of discussion as shown in Figure 3.

Figure 2: Simulation screen (Student receives an offer letter as a dietitian)

Figure 3: Problem scenarios screen

The ‘Teacher’ module is to scaffold or guide students’ understanding of the topic. This module acts as a tutorial for the students. There are three components in this module, namely Learning Outcome, Explanation, and Exercise. This module can motivate students because of the multimedia approach and the scaffolding, self-explanation, and hyper-linking tutoring strategies it provides. The integration of various media elements such as graphics, audio, video and animation in this module adds more value to this courseware. Students are provided with content materials in the form of a resources collection that enables them to explore the content. The content materials are presented in some depth as the students need a comprehensive knowledge of the subject area. One of the 3D animation examples taken from this module shows how the digestion process takes place in the human body.
The ‘Exploration’ module is to help or guide students to get more information by clicking the Learning Resource button created in the courseware. Some of the features available in this module are ‘Ask Expert’, Forum, Nutrition notes and web sites, E-mail capability, Glossary and Multimedia Gallery. Students are required to work in a small group consisted of 4 to 6 student to gather information, learn primary concepts and principles necessary to solve the problem, and contact with real dietitian and food expert to acquire thinking process for solving nutrition and diet problem. An important part of each learning task is the online discussion known as C²HADAM Forum. Students are advised that they need to use this feature while they are solving on each of the problem scenario listed in the Problem Solving Module. The online discussion can be used by the teacher to facilitate sharing of information among the students, and encourage sharing of ideas through comparison of experiences of the different problem scenarios in which the students work.

The ‘Problem Solving’ module aims at enriching the learner’s understanding through problem solving activities. In this module, students can improve their problem solving skill using inquiry technique known as FILAS Chart. The FILAS Chart also enables the teacher to see the level of understanding the students attain, and to provide additional guidance on how to improve their levels of understanding of the nutrition topic. The course materials are designed to enable the problem solving activities and the online discussion available at C²HADAM Forum to complement each other to provide an engaging and challenging learning environment. Since the approach used in developing C²HADAM courseware is PBL which is quite new to Malaysian secondary school students, the researcher has decided to use hybrid PBL by combining paper-based and digital forms. Some groups of students will work using the courseware and some others will use paper-based worksheet called C²HADAM Sheet. In this prototype, only four samples of problem are available. Students come up with alternative solutions to the problem after analyzing the “facts”, “ideas”, “learning issues” and “action” as shown in Figure 4. Students need to recommend “solution” to be shared among all group members in a class. Each student can review other student’ tentative answer and send comments or feedback. According to Kowalczyk & Leggett (2005), the collaborative learning is very important in PBL learning environment. This fact is also supported by other research (Wiersema 2000) to study the effect of collaborative design in the courseware. The design of the samples problem available in this package is quite simples and relevance to student life. The contextual approach is being applied here to produce a more realistic courseware which is important to be considered in courseware creation process (Shana and Bettye 2006).

![Figure 4: FILAS Chart (online)](image-url)
The ‘Test’ module is to test the learner’s understanding through the set of multiple-choice questions, Fill in the blank, and Labelling. Some of the questions in this module are sample Penilaian Menengah Rendah (PMR) test taken from reference book recommended by teacher so that students can get used to the questions during their real examinations (Tee, 2006).

RESEARCH FINDINGS AND DISCUSSION
This section focuses its discussion on the effectiveness of the C²HADAM packages and the analysis of its overall performance. The evaluation was a case study done on samples selected based on purposive sampling among Form Two students of Sekolah Menengah Kebangsaan Seksyen 24 (2), Shah Alam, Selangor, Malaysia. The demographic distribution is as tabulated in Table 2 and the research instruments are tabulated in Table 3.

Table 2: Demographic Tabulation

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group (X₁)</td>
<td>34</td>
</tr>
<tr>
<td>Control Group (X₂)</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
</tr>
</tbody>
</table>

Table 3: Research Instruments

<table>
<thead>
<tr>
<th>Quantitative Data</th>
<th>Qualitative Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soal Selidik Keberkesanan C²HADAM Pelajar (SPHP)</td>
<td>Senarai Semak Perkembangan Pelajar (SSPP)</td>
</tr>
<tr>
<td>Soal Selidik Penilaian C²HADAM Guru(SPHG)</td>
<td>Maklumat Temu Bual (STB)</td>
</tr>
<tr>
<td>Soal Selidik Kemahiran C²HADAM (SKHF)</td>
<td>Prosedur Maklumat Dalaman (PMD)</td>
</tr>
<tr>
<td>Pre test &amp; Post test</td>
<td></td>
</tr>
</tbody>
</table>

Five hypotheses will be tested in this research. However, as for this paper, only one of the hypotheses will be highlighted:

Hypotesis Null 1 (H₀₁):
There is no significance difference in terms of students’ achievement in the Nutrition test between those using C²HADAM package and those using the conventional approach.

Pre-test and post-test were conducted to evaluate students’ performance. Each test comprised 40 multiple choice questions pertaining to the Nutrition topic. A quasi-experimental approach was conducted on two groups of samples consisting of Form 2 students at the Sekolah Menengah Kebangsaan Seksyen 24 (2), Shah Alam, Selangor, Malaysia. The Experimental (E) group underwent a learning process on the topic ‘Nutrition’ through C²HADAM packages designed based on the hybrid Problem Based Learning approach. The Control (C) group on the other hand, underwent the learning process on the same topic through the conventional approach. Evaluation was done based on the marks obtained by both groups in both pre-test and post-test.

Statistical Analysis of Students’ Achievement
To analyse the difference in achievement between both groups, the couple t-test was applied. Data was analyzed using SPSS version 14.0. Paired t-test was used to show students’
achievement on nutrition topic for the experimental group. They underwent learning the topic ‘nutrition’ through C²HADAM package.

Statistik Analisis Model 1 atau SAM 1: Students’ Achievement is shown in Figure 5 here to explain the step taken to answer research hypotheses. Results shows that t value = 2.849, with significant values for the both end, p = 0.000. As the p value was less than 0.05, statistically, this showed that there was an increased achievement by students from the experimental group in terms of marks based on the pre and post-tests conducted. Thus, the hypothesis nol Ho1 was rejected. Statistically, there is a significance difference in terms of achievement for those groups using C²HADAM package based on hybrid PBL compared to those using a conventional approach.

CONCLUSIONS
We have presented a development life cycle model adopted in developing the prototype C²HADAM package. The prototype, which focuses on the topic of Nutrition for Form Two secondary school, has been developed to test the effectiveness of PBL in the learning of Science subject. The use of simulations and problem scenarios as a trigger for discussions, play a major role in the understanding of a scientific concept, which in this case is nutrition. Interviews and questionnaires were used to obtain the feedback on the overall effectiveness and the reliability of the courseware design. Generally, the respondents have given positive feedback on the courseware and it is hoped that the principles used in C²HADAM can be applied to any other scientific concepts.
REFERENCES


http://www.city.londonmet.ac.uk/deliberations/collab .learning/wiersema.html