PRELIMINARY ANALYSIS FOR DEVELOPMENT OF INTERACTIVE MULTIMEDIA COURSEWARE USING PROBLEM BASED LEARNING FOR MATHEMATICS FORM 4 (PBL MATHS-SET)

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ABSTRAK

Interactive Multimedia PBL MathS-Set courseware is based on Problem Based Learning (PBL) for the topic Set in form 4 mathematics syllabus. This courseware illustrates authentic scenarios which often faced by practitioners. The problems illustrated are ill-structured, hence, are more challenging and demand students to come out with a project apart from learning about the concepts of Set. This early stage of research includes Preliminary Analysis, Teaching Analysis, Lawson Scientific and Reasoning Test (LSRT) and Designing Analysis. For this first stage analysis, research instruments that include interviews, questionings, and tests, are utilized in order to identify problematic subtopics in the topic mathematical set for form 4. All data have been analyzed using SPSS version 12.0. Apart from that, documents from the Ministry of Education, Malaysia were also analyzed to identify students’ progress in answering the tests in that particular topic. LSRT on the other hand, is used to identify students’ level of reasoning for the sole purpose of cooperative learning. The pilot test was carried out and the results of the test was 0.92 using the Kuder Richardson 20 (KR20) formula. Researcher hopes that the results obtained from the data would be able to be of assistance to researcher in designing this courseware.

INTRODUCTION

PBL is learning that results from the process of working toward understanding or resolution of a problem (Barrows & Tamblyn, 1980). According to Bridges (1992), PBL is an instructional strategy that has the following characteristics:

1. The starting point for learning is a problem.
2. The problem is a real world problem that has no structure. The problem is one that the students are apt to face as future professionals.
3. Students can work individually or in groups and are responsible to their own process of learning.
4. Assessment will include the process of getting the answer to the problem.

Savery dan Duffy (1995) stress that the problems in PBL must be challenging for the students and the level of difficulty must be the same level as it occurs in real life. Therefore, choosing authentic problems is essential for the reason that it might motivate the students because they can see the main purpose in solving the problems (Savin-Baden & Major, 2004). Lambros (2004) suggests a real–world reference factor is pertinent before a problem for PBL is chosen. According to Lambros, the PBL problems would be more effective if students are given a specific role in the scenario based problems. Lambros also explains that each student has a real-world reference that has to be taken into account before proceeding in implementing the scenario based problems in schools.

Cooperative learning plays an important role in implementing the PBL. By working in groups, the zone of proximal development (ZPD) as suggested by Vygotsky (1978), could be attained through social interaction amongst students and their environment. Lawson (1995) has
classified 2 types of learner’s thinking, which are Hypothetical Deductive (HD) and Empirical Inductive (EI). According to Lawson, HD is a term that is used for the level of thinking which enables teenagers to explore more than descriptive and create hypothesis for each finding. While EI is a term that is used for the level of thinking that enables teenagers to describe and order things that they observe in their life. For this study, Lawson Scientific And Reasoning Test (LSRT) is used to identify these types of thinking.

Conceptual framework for this study is divided into 2 parts: The Development and Usability study of PBL MathS-Set courseware as shown in diagram 1. The effectiveness and usability test will be carried out using the instruments that have been developed. The thinking and reasoning skills using Venn diagram will also be included in the usability study based on 5 constructs: investigation, compare and contrast, analyzing relationship, classification and decision making (Marzano, 2000).

A. Study of Development of Interactive Multimedia PBL MathS-Set Courseware

Preliminary Analysis:
- Study of documents
- Interviews and questionnaires

Teaching Analysis
- Learning Outcomes Objectives
- Content
- Development of Methodology

Study of Instrument for Level of Reasoning
- Reasoning Test
- Testing instrument

Design
- Teaching Strategy
- Courseware Interface

Programming Development
- Flow Cart & Story board
- Determine tools and courseware for development

Formative Evaluation and Development
- Preparation for multimedia elements
- Programming
- Formative evaluation

B. Usability Evaluation for PBL MathS-Set

Effectiveness Test
- Case Study & Quasi Experiment Pre and Post Test

Usability Test
- Case Study & Quasi Experiment Observation & Questionnaire

Results for both tests

Diagram 1: Conceptual Framework Study of Development and Usability of interactive multimedia PBL (MathS-Set) Courseware

RESEARCH PURPOSE
The purpose of the research is divided into 2 components:
Develope a courseware using PBL approach for topic Set Form 4 Mathematics

a. Define methodology for development of interactive multimedia courseware using PBL approach for Set topic Form 4 Mathematics.
b. Create Instructional Design Model (ID Model) for interactive multimedia courseware using PBL approach for Set topic Form 4 Mathematics.
c. Develop prototyping the content of interactive multimedia courseware using PBL approach for Set topic Form 4 Mathematics.
Carry out a research on the effectiveness of the interactive multimedia courseware using PBL approach for Set topic among Form 4 students who are studying for Civil Engineering Studies in Technical School, Sepang, Selangor, in one case study.

a. Test the effectiveness of using interactive multimedia courseware using PBL approach for Set topic based on the students’ achievement in pre test and post test.

b. Test the students’ attitude towards the usage of interactive multimedia courseware using PBL approach for Set topic.

RESEARCH QUESTION
To achieve the purpose of research, some main questions and research hypothesis are designed as below:

i. What is the methodology used in developing interactive multimedia courseware using PBL approach for topic Set that is suitable in order to increase thinking and reasoning skills using Venn diagram among Form 4 students?

ii. What is the Instructional Model that is suitable for instructional design to increase thinking and reasoning skills using Venn diagram among Form 4 students using PBL MathS-Set courseware?

iii. Does the development of PBL MathS-Set courseware followed the instructional design?

iv. Is there any difference in terms of achieving between students from experiment group using PBL MathS-Set and control group using conventional learning?

   a. Hypothesis Nol 1 (Ho 1): No difference marks in pre test and post test for the experiment group in Set topic.

   b. Hypothesis Nol 2 (Ho 2): No difference marks in pre test and post test for the control group in Set topic.

   c. Hypothesis Nol 3 (Ho 3): No difference marks in pre test and post test for the sample of HD students from experiment group in Set topic.

   d. Hypothesis Nol 4 (Ho 4): No difference marks in pre test and post test for the sample of EI students from experiment group in Set topic.

v. Is there any difference in terms of achieving students using PBL MathS-Set courseware compare to students using conventional learning?

   e. Hypothesis Nol 5 (Ho 5): No difference marks in pre test and post test between the experiment group and the control group in Set topic.

   f. Hypothesis Nol 6 (Ho 6): No difference marks in pre test and post test between the sample of HD from experiment group and sample of HD from control group in Set topic.

   g. Hypothesis Nol 7 (Ho 7): No difference marks in pre test and post test between the sample of EI from experiment group and sample of EI from control group in Set topic.

vi. Can PBL MathS-Set courseware improve thinking and reasoning skills using Venn diagram?

PRELIMINARY ANALYSIS
Preliminary analysis has been carried out by researcher to identify any weaknesses in the concepts in the Form 4 mathematics, especially in the Set topic.

Document Research
In table 1.1 indicates a summary report on the achievement for Malaysian Education Certificate or Sijil Pelajaran Malaysia (SPM) Mathematics paper 1 and 2 year 2002 from Ministry Of Education (MOE). It could be derived that on a whole, candidates’ achievement is at a satisfactory level as only 40%-59% managed to answer correctly. Failing to master the concept or symbol of set, especially the complement of set, is one of the main weaknesses in candidates. Candidates, as well, are weak in handling the operation of sets which involves two operations of set, especially the complement of set. As a result, candidates did not shade the correct region in the given Venn diagram.
Table 1.1: Progress achievement report on Mathematics Paper 1 and 2 for SPM examination, year 2002.

<table>
<thead>
<tr>
<th>Question</th>
<th>Progress of Candidates</th>
<th>Common Mistakes/Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 (Paper 1)</td>
<td>(a) Satisfactory (b) Satisfactory (c) Weak</td>
<td>For this question, various types of shading were obtained by guesses made. Most of the candidates did not understand the concepts of Set or Set symbols, especially the symbol of the complement of Set.</td>
</tr>
<tr>
<td>3(a)(i),(ii) (Paper 2)</td>
<td>Good</td>
<td>Only weak students are unable to list the elements for set P and elements for set $P \cap R$.</td>
</tr>
<tr>
<td>(iii) (Paper 2)</td>
<td>Satisfactory</td>
<td>Students are unable to list the elements for set $R$ correctly because candidates fail to understand the sentence “number where the sum of its digits is more than 8”</td>
</tr>
</tbody>
</table>

Table 1.2: Report On Quality Of the Answer Analysis in SPM 2004

<table>
<thead>
<tr>
<th>Question</th>
<th>Candidate</th>
<th>Answer for the question</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Shade $A \cap B'$ and $A \cup (B \cap C)$)</td>
<td>A</td>
<td>(a) <img src="image1" alt="Diagram A" /> (b) <img src="image2" alt="Diagram B" /></td>
<td>Excellent candidates present their answers as shown in example A.</td>
</tr>
<tr>
<td>B</td>
<td>(a) <img src="image1" alt="Diagram A" /> (b) <img src="image2" alt="Diagram B" /></td>
<td>In example B, candidates who obtained marks for section (a) only. On the other hand, candidates who answer as shown in example C did not obtain any marks.</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>(a) <img src="image1" alt="Diagram A" /> (b) <img src="image2" alt="Diagram B" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1.2 reports on the quality of the answer analysis in the SPM examination in 2004. It is clearly seen that students failed to shade the correct area in the Venn Diagram for questions on operation on Sets. This indicates that students' are weak in understanding the basic concepts of Sets such as the intersection of Sets, union of Sets and complement of Sets (MOE 2004).

**Interviews and questionnaires**

Test on Set topic was conducted on 120 Form 4 students from 5 secondary schools in Petaling district. The schools are Sekolah Menengah Kebangsaan Subang, Shah Alam, Sekolah Menengah Kebangsaan Seksyen 10, Kota Damansara, Sekolah Menengah Kebangsaan Seksyen 4, Kota Damansara, Sekolah Menengah Kebangsaan Seksyen 18, Shah Alam and Sekolah Menengah Kebangsaan Seksyen 19, Shah Alam. Table 1.3 shows the total number of correct answers which the lowest percentage of students’ answers concern on the problem solving involving combinations of set.
Table 1.3: Percentage of students’ correct answer

<table>
<thead>
<tr>
<th>Subtopic</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set Concepts</td>
<td>71.7</td>
</tr>
<tr>
<td>Concepts of subset, Universal Set and Complement of A Set</td>
<td>63</td>
</tr>
<tr>
<td>Operation On Sets:</td>
<td></td>
</tr>
<tr>
<td>(a) Solving problems involving intersection of Sets</td>
<td>56</td>
</tr>
<tr>
<td>(b) Solving problems involving union of Sets</td>
<td>58</td>
</tr>
<tr>
<td>(c) Solving problems involving operation of Sets</td>
<td>38</td>
</tr>
</tbody>
</table>

Table 1.4 displays the mean of difficulty based on the perceptions of teachers who have teaching experiences of more than five years and teachers who are markers for the SPM Mathematics papers. It is found that one of the students’ weaknesses are connected to the subtopic operation on Sets. Therefore, it is relevant for the researcher to use this topic as the content for the development of the prototype for the courseware.

Table 1.4: Mean of Difficulty Based on Perceptions of Experience Teachers

<table>
<thead>
<tr>
<th>Topic</th>
<th>Most Difficult Learning Outcomes</th>
<th>Teachers who are markers for SPM</th>
<th>Teachers who have experience more than 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3 Operasi ke atas Set</td>
<td>Solving problems involving intersection of Sets</td>
<td>3.86</td>
<td>3.73</td>
</tr>
<tr>
<td></td>
<td>Solving problems involving union of Sets</td>
<td>3.43</td>
<td>3.69</td>
</tr>
<tr>
<td></td>
<td>Determine operation on Sets</td>
<td>3.86</td>
<td>3.99</td>
</tr>
<tr>
<td></td>
<td>Solving problems involving operation on Sets</td>
<td>4.14</td>
<td>4.17</td>
</tr>
</tbody>
</table>

From an interview on 10 form 4 and form 5 Mathematics teachers with experience in teaching the subject for more than 10 years, problems on the teaching and learning process on the topic of set have been identified. These problems are lack of skill in writing operations on sets or union of sets when visualising a Venn diagram, not skillful in drawing or sketching a Venn diagram when operations are given and unable to solve long mathematical Set questions. Referring to the problems identified, the researcher plans to create and develop a courseware stressing on the concepts of Set and the skill to use Venn diagrams to visualise the concepts as well as assisting students to solve long mathematical questions.

Teaching Analysis
Set topic consists of 3 subtopics 1. Set 2. Subset, Universal Set and Complement of a Set 3. Operation On Sets (MOE 2004). In this courseware, the students are given a project work and at the end of the lesson, they have to produce a project report based on the project rubric. Project work had been implemented in Additional Mathematics for Form 4 and Form 5 students (MOE 2001). The project rubric in this courseware has the same format with the rubric for Additional Mathematics’ project.

Lawson Scientific And Reasoning Test (LSRT)
The purpose of LSRT is to identify students’ reasoning level which is EI and HD thinking. In this research, LSRT is used to categorize students into EI and HD thinking in order to form groups of students who are cooperative, consisting of both thinking types. LSRT uses the instrument of Classroom Test For Scientific Reasoning which is a written test with 24 multiple choices questions (Lawson, 2000). This test has been adapted from the Classroom test For Formal Reasoning which is a test consisting of 12 subjective questions (Lawson, 2000). LSRT has also been adapted from the instrument of Classroom Test For Scientific Reasoning based on SPM examination preparation format used by the Malaysian Examination Syndicate, MOE.

Table 1.5 presents the items distribution that is in LRST. Students’ classification of EI and HD thinking types are based on score from 0-13 classified as EI thinking type and the score from
14-24 classified as HD thinking type. Using the Kuder Richardson 20 formula (KR20), Lawson obtained reliability index of 0.81 for his test.

**Table 1.5: Item distribution of Lawson Scientific And Reasoning Test (LSRT)**

<table>
<thead>
<tr>
<th>Reasoning Skill</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Conservation of Weight</td>
<td>1-2</td>
</tr>
<tr>
<td>2. Conservation of Volume</td>
<td>3-4</td>
</tr>
<tr>
<td>3. Proportional Thinking</td>
<td>5-8</td>
</tr>
<tr>
<td>4. Identification and Control of Variables</td>
<td>9-14</td>
</tr>
<tr>
<td>5. Probabilitic Thinking</td>
<td>15-18</td>
</tr>
<tr>
<td>6. Correlational Thinking</td>
<td>19-20</td>
</tr>
<tr>
<td>7. Hypothetico-deductive Reasoning</td>
<td>21-24</td>
</tr>
</tbody>
</table>

**Pilot Test For Lawson Scientific And Reasoning Test (LSRT)**

Pilot test was carried out on form 4 students from Sekolah Menengah Agama Persekutuan, Kajang in Selangor. A total of 30 students were involved in the test. For the purpose of testing the reliability of the LRST instrument, the test was conducted twice which was tested and retested on the same students. According to Creswell (2005), the test and retest reliability procedure has the purpose to ensure the scores from a sample are stable from one test to another. To ensure the reliability, the researcher conducted the test in two different occasions on the same sample of students. The first test was administered on the 17th October 2006 and the second test was administered two weeks after the first test was conducted which is on the 31st October 2006. The reliability value that was obtained from the two tests was 0.92. For this study, LRST in electronic form was developed using Microsoft Visual Basic 6.0 and Microsoft Access 2003 as database. An electronic report will be generated by this test is useful for teachers to divide students in groups which have both students of HD and EI.

**Design Analysis**

The development of the multimedia PBL MathS-Set courseware also involves in the designing aspect which stressed on the strategy and approach, software face design, features for Instructional Design (ID), research on PBL and the production of the ID model courseware. The design will take into account the combination of the Interactive Multimedia (IMM) and the PBL such as the IMMPBL model on the development of scenario as well as the structure of the PBL problem scenario (Albion & Gibson, 1998). The courseware prototype will be developed using the Flash version 8 software with the addition of various software in designing and editing the graphics, animation, audio and video. In addition, MYSQL is used for database to store all the information that the students obtain from the scenario. During the development stage, testing and formative evaluation will be administered continuously from the reaction of the users on this courseware. The usage evaluation of the courseware will be tested through case studies.

Problem Scenario in PBL Module in the PBL MathS-Set courseware describes an authentic problem where student is given a role as a new consultant Civil Engineer in a consulting firm. The problem that the student has to solve is about building foundation for 4 proposed buildings as below:

(a) Types of piles to be used to build 4 proposed buildings according to plan.

(b) Determine the most economical cost in building foundation for all proposed buildings.

This problem scenario is divided into smaller scenes which consists of audio clip, video clip, graphics, text and animation which provide scaffolding to student to solve the problem. Construction Module is a module that briefly explained all the stages involve in building construction including using of piles for substructure work. This module will act as an activation task that is suggested by Albion & Gibson (1998). This module will activate students’ knowledge before they are exposed to the problem scenario that they have to solve. Module Development Concept Based On Scenario is a module where the students will
construct new concepts of Sets based on all the information that they have obtained from the module of Problem Scenario in PBL. Study conducted by Rajendran (2003) showed that Venn diagram is the most popular method used by students to solve any problem in Set topic. Hence, developing thinking and reasoning skills using Venn diagram is necessary for students which is emphasized in the module.

CONCLUSION
The researcher plans to develop PBL MathS-Set multimedia courseware that will assist and enable hands-on and minds-on teaching and learning activities. Students are given an authentic problem scenario where they can be motivated to solve the problem that would change students’ perception on Mathematics which is previously considered as a subject that is isolated and not integrated with other subjects. This might cause students to overlook the relationship between the mathematical concepts and everyday life. PBL is an effective vehicle for the students to have deep learning about any concepts in Mathematics which help them to improve their skills in problem solving. Thus, this interactive multimedia courseware using PBL approach is expected to benefit form 4 and 5 students and teachers as well as consumers that are interested in the field of Mathematics. Hopefully, this courseware could be seen as a motivation to integrate information and communication technology in the teaching and learning process and in everyday life.

REFERENCE