Journal of Basic Physical Research ISSN: 2141-8403 Prints, 2141-8411 Online
Vol.8, No.2 pp. 101- 116, January, 2018. Available online at www.jbasicphyres-unizik.org

ON THE DEVELOPMENT OF A WEB-ENABLED PROBLEM BASED LEARNING (PBL) SYSTEM

M. O. Onyesolu and N. G. C. Udensi
Department of Computer Science, Nnamdi Azikiwe University, Awka,, Nigeria

Abstract
The work aims at providing a better pedagogy that helps in enhancing students' learning in the field of programing. A teacher designs some problems for the students. Each problem contains proper description and resources with standard PHP output. Students can practice and submit answers pertaining to the problem with the help of the relevant resources and standard output. A hybrid methodology was employed in the design and development of the system. The system was implemented using MySQL server database engine and Hypertext Pre-processor scripting language embedded on Dreamweaver GUI. The result is a web-based socio-constructivist PBL model which gives students the opportunity of writing and submitting PHP codes to an administrator who guides the students towards achieving the best solution to a given problem set. The system provides the facility for the students to practice and experiment on coding with real-time error reporting mechanism. Students have the ability of editing codes repeatedly, comparing their outputs with the standard output within the specific duration. For grading, a tutor evaluates the student's code and awards marks accordingly. The system helps the students to engage in self-learning of PHP based on the real problems.

Keywords*: PHP, online learning, problem-based learning, programming skills, problem sets*

Introduction

Computer science as a discipline has been and continues to be regularly challenged, primarily due to the rapid evolution of the field. The dynamics involved with the continuous improvement in technology puts additional pressure on educational institutions to adopt explicit strategies for responding to change. Teaching computer programming can be an upheaval task if it is faced with high failure rate and students' dissatisfaction [1, 2]. Practitioners in computer science face many of the same issues as their peers in other disciplines. These include how best to enable deep learning in the subject matter, as well as standard issues such as retention rate and so on.

Traditional methods of teaching programming courses have been largely teacher-centred. The teacher provides most of the information in front of the class while students listen and absorb passively in the learning using mostly books as a source of learning and memorizing. Oftentimes, students were not able to understand the applications of the lessons learnt as they were mainly memorizing the knowledge rather than searching and applying the knowledge. While this may have worked in the past, new realities have demanded a paradigm shift in the way learning should happen in a programming course, as programming requires students to not only understand the relevant theory, but also to be able to apply it to solve real world problems. Therefore, it has become an important and challenging issue to develop effective strategies or tools for teaching computer-programming languages [3, 4].

A student-centered approach to teaching using Problem Based Learning (PBL) method should be implemented to enable students cope with the reality of learning programming languages, as PBL provides authentic opportunities to learners to foster active learning, promote critical thinking, support knowledge construction and associates the learning to the real life problems [5]. PBL is one of the most efficient and effective methods in education system. The term problem-based education was introduced since the 1960s. Day by day, its implementation increased. It is a teaching pedagogy based on learning by solving problems; hence, the phrase, problem-based learning. PBL is significantly different from traditional pedagogical methods [6] that employ the use of lecture as the primary method of instructional delivery [7]. Contrary to this traditional method, PBL places an emphasis on active engagement that involves learners in the

metacognitive process of thinking about their learning [8]. It is by this process that the learner moves from the shallow surface learning of traditional approaches to deep understanding that reflects the level or depth of understanding that is characteristic of problem-based instruction. PBL lets the students to learn through some practical problems, which help the students to face the reality in problems. In PBL, some sequential problems make the students to gather their knowledge where the teacher guides them to find answers. Students are allowed to discuss within their groups to share and enrich their prior knowledge. In their groups, they find related and effective methods to find the solutions. They develop knowledge related to the problems with the help of group study and come to a solution for the assigned problem [9].

Related Works

In the past decade, various teaching strategies and learning activities have been applied to computer-programming courses for beginners [1]. The widespread use of computers and the Internet gave a positive impact on the implementation of the PBL approach. This was demonstrated in previous studies that supported the use of ICT in implementing PBL. The PBL approach actually started in the field of medicine [10]. However, now the PBL approach is not limited to the medical field alone, but has spread to various areas. The programming field is seen as a field that is abstract, challenging, requires scientific skills, critical and creative thinking skills and problem-solving skills [5].

One of the earliest attempts at using the PBL approach in an online format occurred in the medical sciences. Kamin et al. [11] designed a hybrid web/CD-ROM course known as learning through interactive video education (LIVE). This system addressed issues of paediatric curriculum. This innovative use of technology for teaching provided students with cases that were delivered through digital video and presented scenarios in a realistic fashion. PBL activities provided students the ability to study the real world behaviours of physicians, learning professional behaviours through examining the modelled actions. Students were also engaged in discussing cases through the use of asynchronous forums. Through interactive discussion boards, students were provided an opportunity for discussion, reflection, and collaboration while critically evaluating the learning issues [12]. They concluded that using online PBL cases assisted students in collaborating, solving clinical problems, and pursuing self-directed learning over the Internet.

Researchers have indicated that PBL could be a promising approach for programming language learning [2]. For example, Galvez, Guzman and Conejo [13] reported a problem-solving environment to diagnose students' knowledge levels and to generate feedback and hints to help students understand and overcome their misconceptions in learning programming languages.

Valaitis et al. [14] in an attempt to examine the online experience developed a qualitative study to explore the overall picture of health sciences students' perceptions of their experiences while participating in PBL in the virtual environment. The study focused on students' views about learning and also the group processes that were necessary for participating in PBL online. They explain that the participants of this study were very experienced in the PBL process, but were novices where online learning was concerned. The study's PBL format followed the six step process, designed by Howard Barrow's at McMasters University. Students were comfortable with this process; therefore, issues with PBL itself were minimized. In order to deal with the issue of online learning, all participants, students and tutors, received introductory training on the learning management system (LMS); tutors received additional training in the area of online teaching and learning. Several groups participated in the online PBL study and researchers collected qualitative data through individual reflections by students, as well as focus group interviews. Analysis was conducted through the use of NVivo, a qualitative data analysis software program. Results of the data analysis suggest that PBL can be successfully implemented in an online format [14].

Analysis and synthesis of information was reported as being enhanced. Students also reported positively to the flexibility that the online sessions provided. Use of asynchronous and synchronous forums allowed student activities to be planned around the busy schedules of their medical program.

Wilhelmiina [15] carried out a first experiment of applying the problem-based method to a purely theoretical course of computer science in the University of Joensuu, Finland. Performing the course consisted of three parts: First, the new subjects were learnt according to the classical seven steps of PBL method, which contains both individual and group work, and problem reports were written. Second, the students participated in a traditional exercise session, in which the new techniques were practiced in details. And third, the students kept a learning diary, in which they processed the subjects further, tried to construct an overall schema of things learnt, and supervised their own learning. The results were successful: the students committed themselves well and the drop out percentage was very small; they achieved very deep understanding of the subjects measured by their grades and quality of learning diaries; the experience was enjoyable for both the students and the teachers; and finally, the method supported different kinds of learners very well.

Yan [16] examined the possibility of applying PBL to the teaching of computer network courses. The aim of the study was to provide guidance to higher professional educationists through application of the problem-based learning mode to the Computer Networks courses. He concluded that implementing PBL teaching pedagogy, will improve students' learning ability, as well as their attitude to learning and their study habits as PBL improves a student's ability to solve problems. In addition, group co-operative learning that is a feature of PBL helps students to improve their communication skills, their ability to co-operate, and their ability to collect and process information.

In Vocational school in Taiwan, Lee and Chung [17] investigated the use of PBL in teaching application software packages. A course website was devised and deployed to supplement learning activities in the traditional classroom. A series of experiments was conducted with innovative instructional designs, that is, online PBL, self-regulated learning (SRL), and their combinations. The impacts of these pedagogies on students, instructors, and course design were evaluated. The effects of the pedagogies were mostly positive. Jenkins [18] attempts to get students to participate actively in learning, to write and comprehend computer programs. His participative approach aims to make the learning of some abstract programming concepts such as procedures, parameters, pointers, and linked lists more accessible to students.

The PBL approach has already been used in many polytechnics and executed abroad [19]. The study by O'Grady et al. [20] using the PBL approach in the Singapore Polytechnic where the concept of "one-day, one-problem" was introduced to students to develop innovative human capital, possess problem-solving skills and create a lifelong learning attitude. Albion [21] developed interactive multimedia software for teaching of Information Technology subjects using a PBL approach. Lowther and Morrison [22] developed the Integrating Technology for Inquiry (Nteq) software for computer science subjects using PBL. Savin-Baden and Gibbon [23] developed the Students Online in Nursing Integrated Curriculum (SONIC) for nursing students using the PBL interactively to promote independent learning and investigation. Faaizah [24] examined the use of multimedia packages using PBL approach in the science subject - nutrition (form two) to enhance students' achievement.

Materials and Methods

We developed and implemented a web-enabled PBL system using Sublime Text Editor; MySQL Database Engine Version 5.6; Hypertext Preprocessor (PHP) Scripts Version 5.4; Hypertext

Markup Language (HTML) Version 5.0, Cascading Style Sheet (CSS) Version 3.0 and Dreamweaver GUI.

We adopted a hybrid methodology. The methodology was derived from the combination of the Structured System Analysis and Design Methodology (SSADM) and Object-Oriented Analysis and Design Methodology (OOADM). The investigative phase of the SSADM was deployed as the paradigm for systematic study in order to obtain information on the current trends in the research area of PBL. The information obtained necessitated the definition of a high-level model (HLM) for the system as shown in Figure 1. Using this HLM, an object diagram of the PBL system (Figure 2) and the class diagram of the system (Figure 3) were designed. Use case diagram, sequence diagram, activity diagram, communication diagram and state chart diagram were also used to represent processes within the system as shown in Figure 4 to Figure 8. The web-enabled PBL system was used in a class selected that offers web development course in the Department of Computer Science (course students) and a group of web programming enthusiast (booth camp students), Nnamdi Azikiwe University, Awka to assess the impact of the system on the students. The selected class was divided into two groups. The subject of the assessment was PHP fundamentals. Each group consists of 50 students. The students' knowledge improvements were tested and the students' attitudes about the web-enabled PBL system. The test consists of 20 numbers of multiple choice items on the PHP programming. The students were tested about general knowledge on PHP before the web-enabled PBL system was used on them. The test was administered four times.

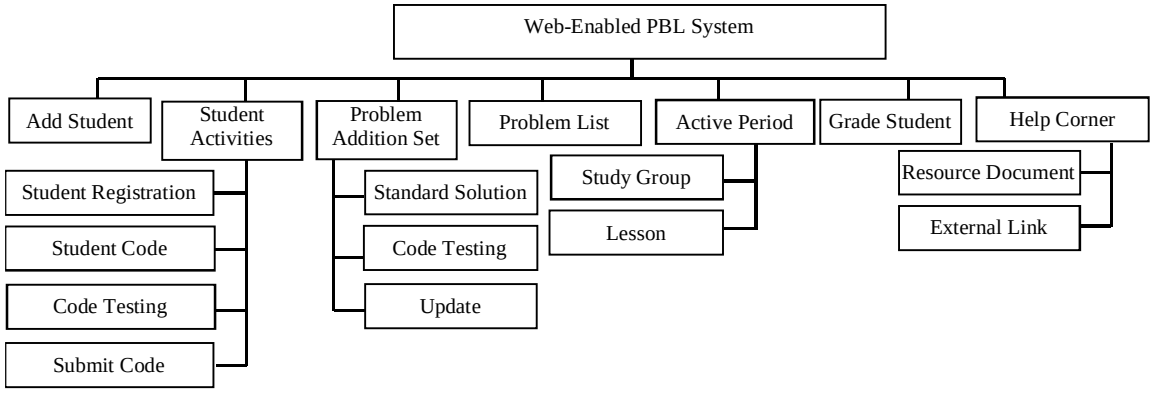


Figure 1: High level model (HLM) of web-enabled PBL system

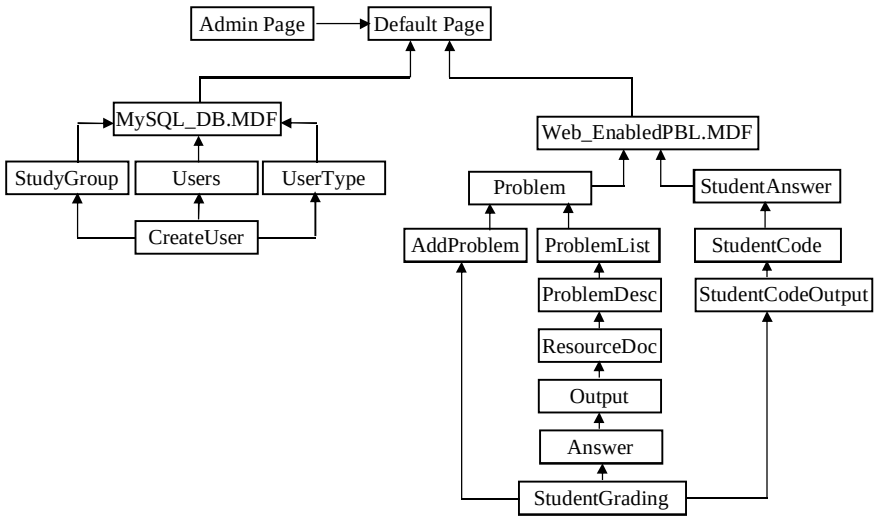


Figure 2: Object Diagram of Web-enabled Problem Based Learning System

System Design

The HLM of the web-enabled PBL system is represented by Figure 1. This figure shows the several modules in the system. These modules are: Add Student, Student Registration, Problem Addition, Problem List, Active Period, Grading, and Help Corner. Some of these modules have sub modules.

Add Student - In Add Student module, students are added to an appropriate group through the use of the student's registration number and email address. A registration code is issued after successful addition of a student. The student uses this registration code to complete registration.

Student Activities - In this module, a student will be required to supply the registration code issued during the time the student was added to a particular group. It is with this registration code and registration number that the student will use to gain access to complete registration. After registration, student will be able to access problem list, related articles, write and test code before submitting answers.

Problem Addition -In this module, problems are defined. All the data about the problems are committed to the database. Here teacher can set the output of the problem, and the related topic's title for the problem where students can gather knowledge to solve the problem.

Problem List - This module shows the list of lessons (Added problem set), that has been created by the admin at a glance.

Active Period -The tutor through this module is able to switch to different study groups in the system as well as different lesson types needed to be active at a point in time.

Help Corner -This section holds different resource topics with external links to help the student gather knowledge about the problem he is to solve. Problem solution or hint for the solution can be found in these references.

Student Submission Grading -In this module, teacher can evaluate and grade the students. Here all the answers of the students are arranged according to the user IDs of the students and the groups they fall under.

Figure 2 shows the object diagram that models the instances of things described by each class. The diagram shows a collection of named shapes – indicating types of object. The shapes have lines connecting them called links; each link is called an association. The object diagram is made up of two master data files (MDF), MySQL_DB.MDF and Web-EnabledPBL.MDF. MySQL_DB.MDF is specifically meant for creation of administrators and students (users) accounts. There is user type, users and study group. The admin creates account using the add admin login page and from there, add users (students) to a particular study group. Under Web-EnabledPBL.MDF, the administrator (tutor) has the authority of adding problem set (which includes problem description, resource document and standard system output), grading students' work and sending feedback via comment box for the student performance to be known. Students have the authority (once they have been added to a particular group and completes registration form) to access problem set, read resource documents (gathering knowledge), provide solution to the given question, generating output, and submitting code for evaluation.

The class diagram of the system (Figure 3) shows the building blocks of the web-enabled PBL system. This class diagram depicts the static view of the model, describing the attributes and behavior. Each class contains various attributes and methods which call other class attributes to share data. The administrator adds users to a particular PBL group and uploads problem set with

resource documents. The administrator has the ability of grading the student's work once the student submits assignment.

Student on the other hand, has the ability of accessing registration form and completing registration, access problem set (assignments) and gather knowledge using the resource document uploaded by the tutor and then work on assignments and submit before the deadline for submission.

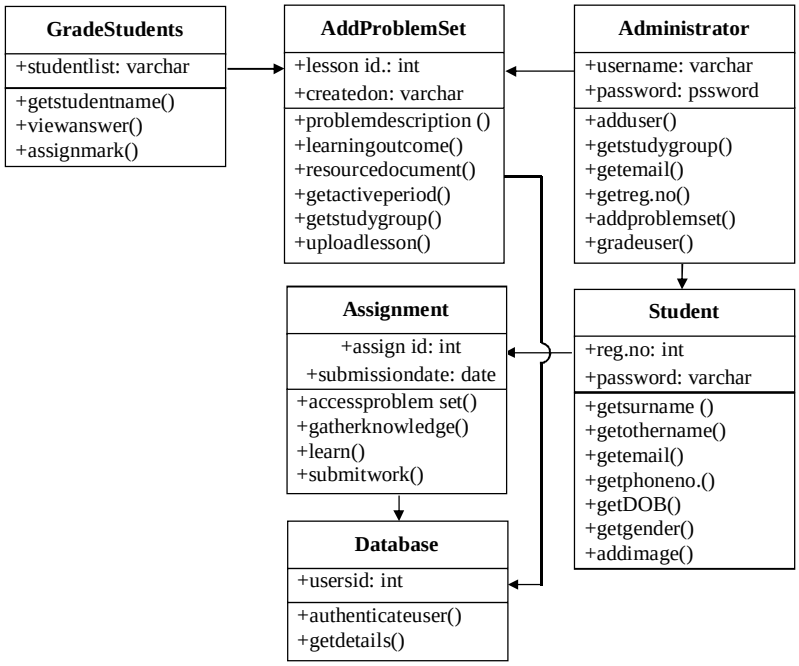


Figure 3: Class diagram of the web-enabled PBL System

Figure 4 shows the use case diagram of the web-enabled PBL system. Here, the students will be able to login with their details, access assigned problems, gather knowledge from the resource document uploaded by tutor. Student can practice and try to find the same appropriate output as the system's standard output by writing codes. Students can submit the code for final evaluation when they think the code is perfect for the given problem. Teachers has the ability to login with their details, define the problem, provide resource document and solution of the problem by writing code for the problem, after verifying the output to make sure it matches with the problem description, it is finally saved as a standard solution of the problem. To see the answer of a student, the teacher has to select the student first from the list of students that have submitted answers to a given problem. The teacher compares the student's answer with the standard system output. After analyzing the output of student submitted work, teacher then assigns marks for that student.

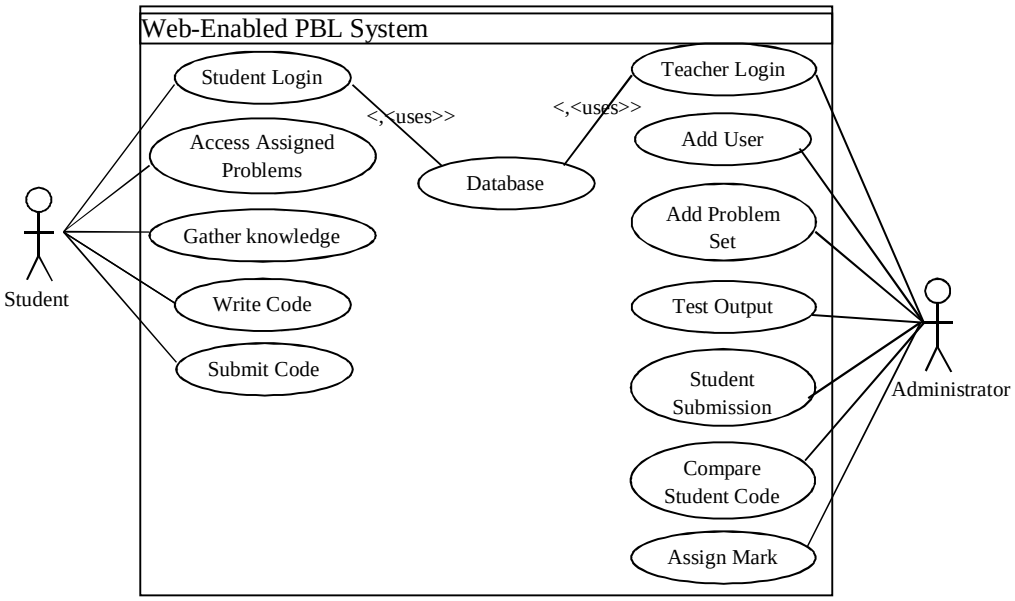


Figure 4: Use Case Diagram for Web-enabled PBL System

Figure 5 depicts the sequence diagram of the web-enabled PBL system. It shows objects as lifelines running down the page and with their interactions over time represented as messages drawn as arrows from the source lifeline to the target lifeline. Here, the administrator (tutor) starts by logging in into the system. The administrator has the option of adding student to a suitable group deemed necessary for the student. The administrator also has the ability of uploading problem set together with the system standard solution and resource document. Once a student submits assignment, the administrator has the ability to assess the student submitted work and grade accordingly. A student that has been added by the administrator uses registration number and registration code (issued to the student during student addition) to login into the system in order to complete student registration. Once done, the student will have the ability of accessing the problem set, read the resource document and instruction on how to carry out the assignment (gathering knowledge), solve the given problem and submit answers for evaluation. The whole information is stored in the database for future reference.

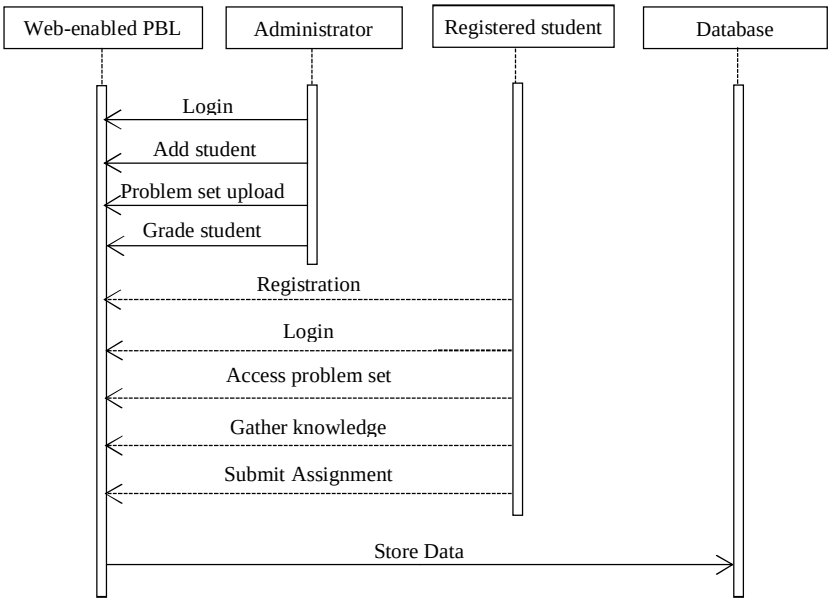


Figure 5: Sequence diagram of web-enabled problem based learning system

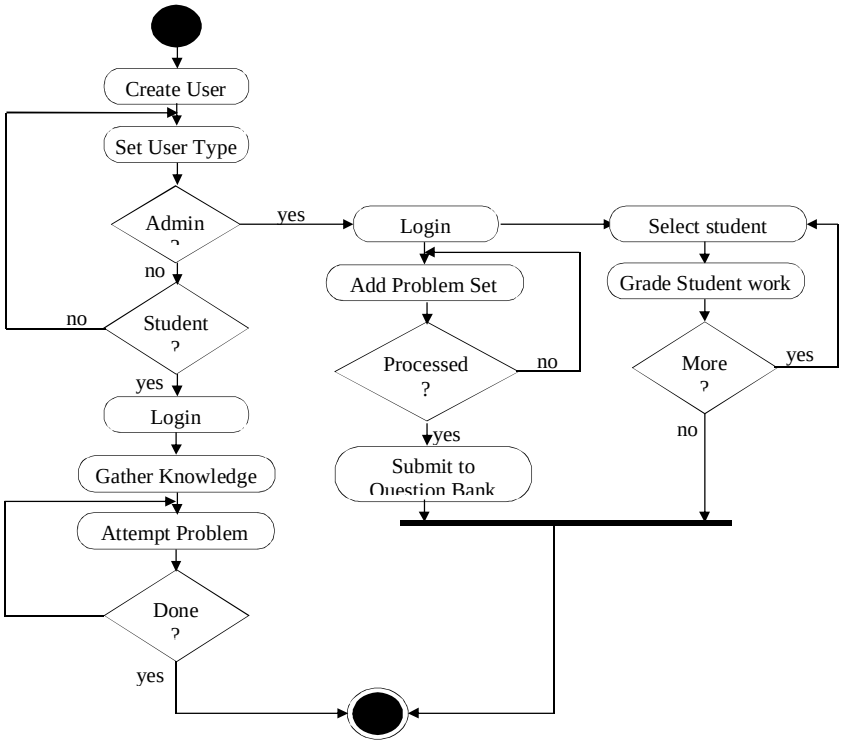


Figure 6: Activity diagram of web-enabled problem based learning system

In modelling the web-enabled PBL system, communication diagram was used. Figure 7 depicts the communication diagram of the system. Communication diagrams show how messages flow between objects in an object oriented application and also imply the basic associations (relationships) between classes. Messages are added to the associations and are shown as short arrows pointing in the direction of the message flow. The sequence of messages is shown through a numbering scheme. The communication begins with the administrator (tutor) adding user (student) to a study group, add problem set (i.e., create lesson note with resource document which the user can learn further on the topic). Student accesses problem sets, work on assignment given and submits work. Admin then grades student's submitted work.

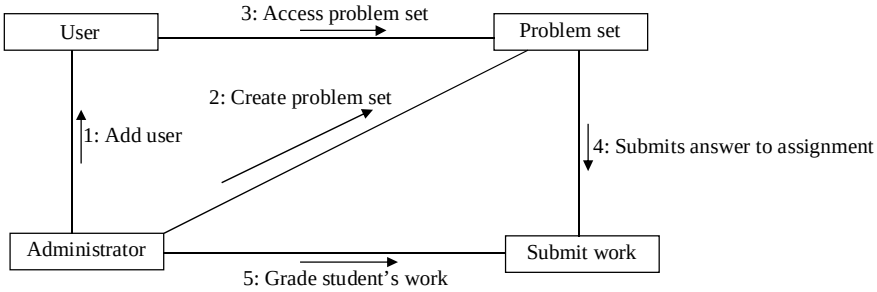


Figure 7: Communication diagram of web-enabled problem based learning system

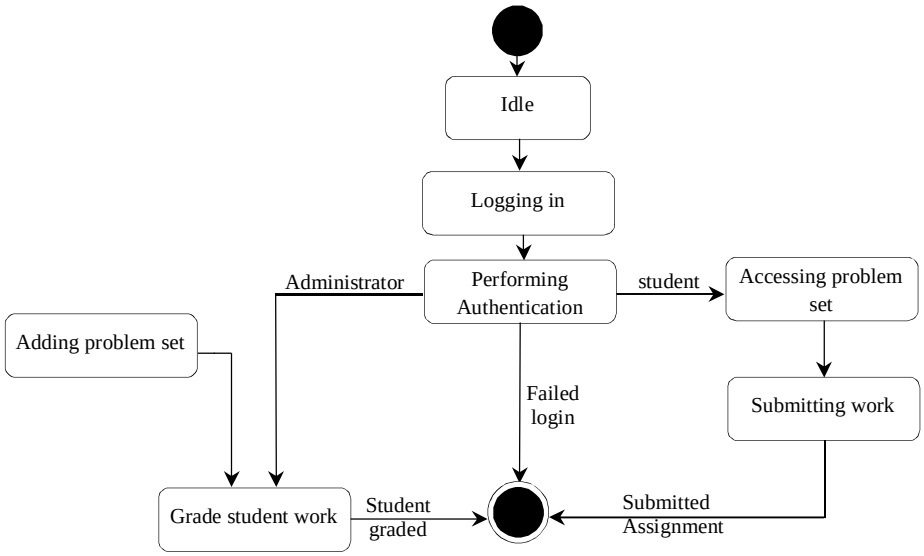


Figure 8: State chart diagram of web-enabled problem based learning system

Figure 8 shows the state chart diagram of the web-enabled PBL system. When the system is idle, the login page is displayed for the user to login as a student or an admin. The system performs password authentication, if the password is correct, the user gets access to his/her respective menus. The administrator will have the choice of creating lesson topic (adding problem set), grading student's work and assigning mark. The student accesses the problem set, learn the problem accessed and submit solution of the problem accessed.

Results and Discussion

The results of the web-enabled PBL system are shown in Figure 9 to Figure 14 while the impact of the system on students is shown in Figure 15 to Figure 18 and Table 2 to Table 5.

A. Web-Enabled PBL System

Problem-based learning is one of the promising learning pedagogy. Web-enabled PBL system was developed using Hypertext Preprocessor Programing (PHP) technology. The database of the system was created with MySQL Server 2008 Application. The system was developed to teach students PHP online by solving some practical problems. The tutor designs some problems. These problems are created for a particular group or groups of students. Students have to join one of these groups to solve these problems. The tutor includes full descriptions of the problems with the topics list. The tutor also includes a standard output code to make a problem specific. The students have to solve and submit the solutions of the problems within a specific allotted time. Within the specific allotted time, the students can modify and practice for an unlimited number of times to generate output as the given standard output. The students' codes are usually saved in the system so that the tutor can analyze their programming abilities. The tutor can check each student's codes manually. The tutor can compare students' codes and output with the system's standard code respectively. This system is supported with rich amount of contents. The tutor can add or edit resources for any one of the related PHP problems in the system. The system also provides an option for students to see the body of the resource document to have an idea of the contents coverage. The tutor can also refer students to content links.

i. Login Interface

Figure 9 is the login user interfaces. Users (administrator and students) access the system using the login interface. The administrator provides input parameters for authentication. A student gains access to the system by supplying registration number and password.

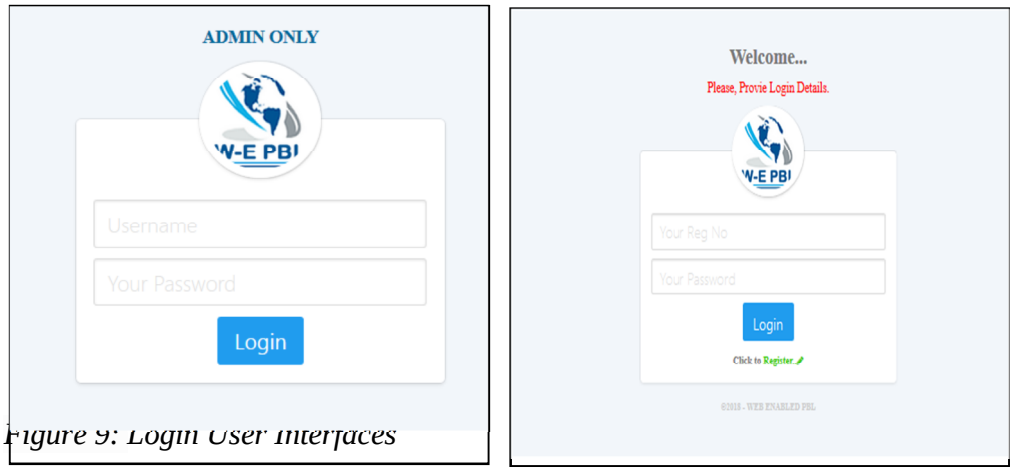
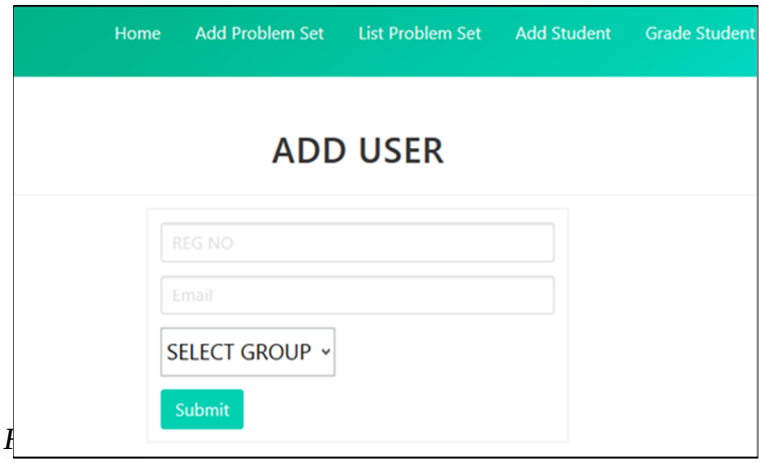


Figure 9: Login User Interfaces

ii. Add User Form

Figure 10 is the Add User Interface. This interface is used by the administrator to add students to a particular group before the student can complete the remaining part of the registration using the registration code that will be generated in the course of the addition.



F

i. Grade Student Interface

Figure 11 is the grade student interface. The administrator through this window views the entire student in a particular PBL group. It also shows the status of those that have submitted their work for grading, the students graded and the students yet to be graded. To grade a student who has submitted a work, the administrator clicks on grade student beside the student's name.

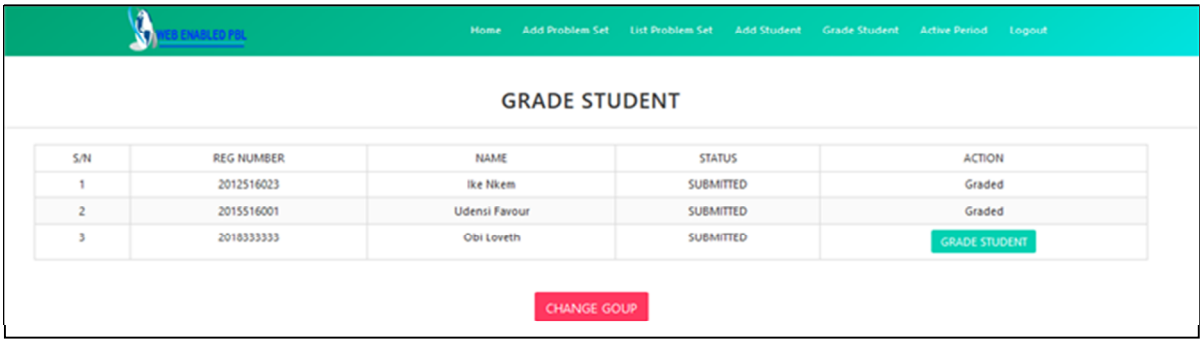


Figure 11: Grade Students Interface

ii. Problem Addition Page

Figure 12 is the problem addition interface. This form is used by the administrator to add the problem the administrator wants the students to solve together with the hint/articles that will guide the student towards finding the solution to the problem.

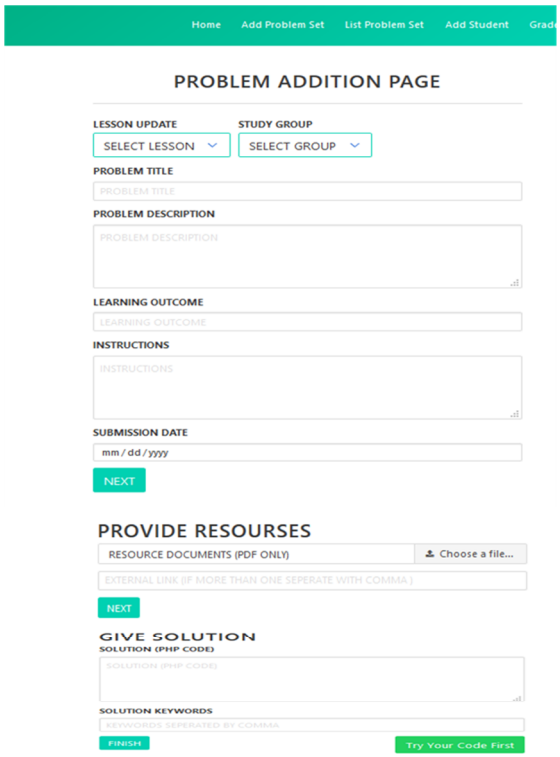


Figure 12: Problem Addition Interface

iii. PHP Editor Interface

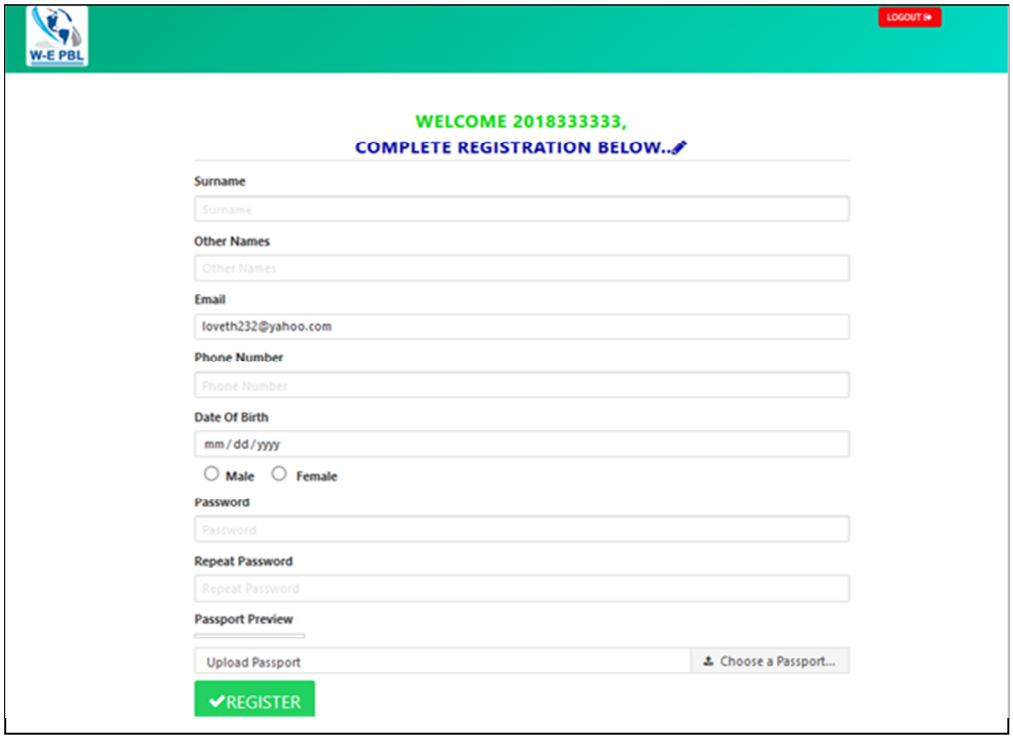
Figure 13 is the PHP editor interface. The administrator tests the sample codes through the PHP editor window to make sure the codes is generating output before submitting it as part of guide for students. This editor is also used by students to test codes before submitting. To access PHP editor, the student clicks “Try your code first”. After submitting the codes for grading, students sees result once the Administrator has finished grading and assigning marks to the student



Figure 13: PHP Editor Interface

iii. Completion of Registration Interface

Figure 14 is the complete registration interface. This form enables students to complete registration after supplying the registration number and the code provided to them when they were added by the administrator.



B. Impact of the Web-Enabled PBL System on Students

The impact of the web-enabled PBL system on students is shown in Tables 1 to Table 5 and Figure 15 to Figure 18. A table of the two groups used is presented in Table 1.

Table 1: Different Groups and Group Size

Group	Total Number
1a - Course Students without PBL System (CSPBL)	50
2a - Booth Camp Students without PBL System (BCPBL)	50
1b - Course Students with PBL System (CSWPBL)	50
2b - Booth Camp Students with PBL System (BCWPBL)	50

Table 2, Table 3, Figure 15 and Figure 16 show the academic performance of each group before they were exposed to the web-enabled PBL system and taught the PHP programming. The CSPBL group's performance is slightly lower than the BCPBL group. While lowest score recorded in the CSPBL was 2, the lowest recorded score in BCPBL was 3. The highest recorded score in CSPBL was 13, the highest recorded score in BCPBL was 15. The BCPBL (the web programming enthusiasts, booth camp students) performed better than the CSPBL (students offering the course) in that the course was new to CSPBL as most of them have not grasped the rudiments of the course better.

Table 2: Group 1a Test Performance

Test	1	2	3	4
Highest Score	12	13	12	13
Lowest Score	02	03	02	02
Range of Scores				
00-05	14	13	13	11
06-10	16	18	18	19
11-15	20	19	19	20
16-20	00	00	00	00

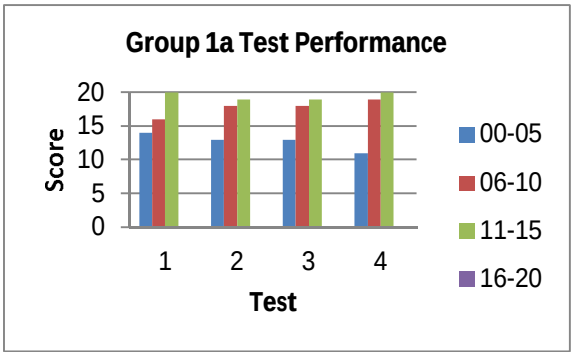


Figure 15: Graph of group 1a test performance

Table 3: Group 2a Test Performance

Test	1	2	3	4
Highest Score	14	14	15	15
Lowest Score	03	04	03	04
Range of Scores				
00-05	11	12	10	13
06-10	16	19	21	19
11-15	23	19	19	18
16-20	00	00	00	00

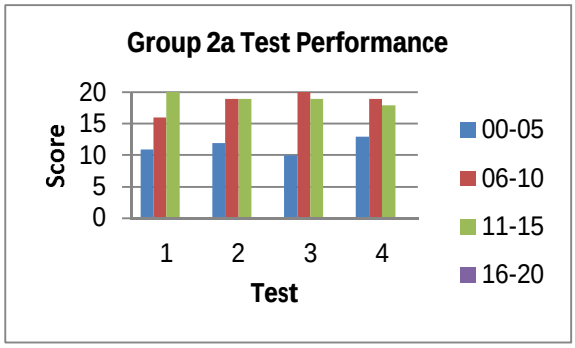


Figure 16: Graph of group 2a test performance

Table 4, Table 5, Figure 17 and Figure 18 show the academic performance of each group after they were exposed to the web-enabled PBL system. The CSWPBL group's performance though improved but is lower than the BCWPBL group. While lowest score recorded in the CSWPBL was 4, the lowest recorded score in BCWPBL was 5. The highest recorded score in CSWPBL was 16, the highest recorded score in BCWPBL was 18. This showed an improvement as a result of the web-enabled PBL system which the students used.

Table 4: Group 1b Test Performance

Test	1	2	3	4
Highest Score	15	16	16	16
Lowest Score	04	05	04	05
Range of Scores				
00-05	11	10	12	10
06-10	16	18	14	16
11-15	19	17	19	19
16-20	04	05	05	05

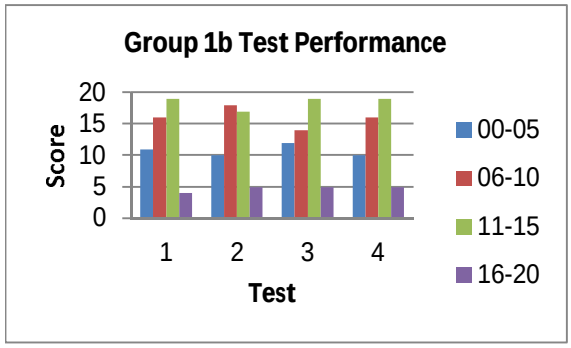


Figure 17: Graph of group 1b test performance

Table 5: Group 2b Test Performance

Test	1	2	3	4
Highest Score	16	17	17	18
Lowest Score	05	05	06	06
Range of Scores				
00-05	04	05	00	00
06-10	12	10	14	12
11-15	26	25	25	26
16-20	08	10	11	12

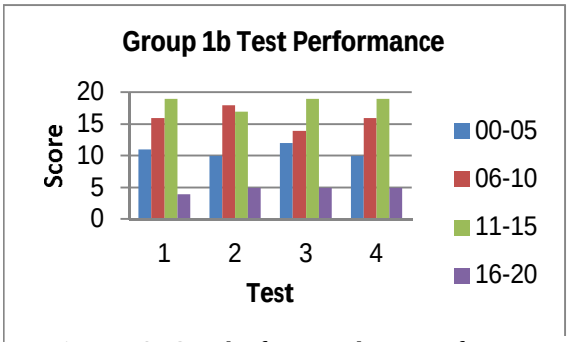


Figure 18: Graph of group 2b test performance

Conclusion

This work is a socio-constructivist, problem-based approach to learning. It helped in minimizing student's phobia for learning PHP programming course and improved students attitude to learning and study habits. Problem-based learning improved students' ability to solve problems as they can take control of their learning while being guided by their teachers/tutors within a specified scope. The work presented is an online learning of PHP programing using problem based learning as its pedagogical approach. A web-enabled learning system integrated with PBL approach was developed to help students share their codes with teachers which oftentimes is a problem faced by students. Not only is the system developed to assist students but also the teachers. The system was developed to help the teachers monitor students learning progress.

References

Govender, I. & Grayson, D. J. (2008). Pre-service and in-service teachers' experiences of learning to program in an object oriented language. Computers & Education, 51, 874–885

Kordaki, M. (2010). A drawing and multi-representational computer environment for beginner learning of programming using C: Design and pilot formative evaluation. Computers & Education, 54, 69–87.

Emurian, H. H., Holden, H. K., & Abarbanel, R. A. (2008). Managing programmed instruction and collaborative peer tutoring in the classroom: Applications in teaching JavaTM. Computers in Human Behavior, 24, 576–614.

Hwang, W.Y., Shadiev, S., Wang, C.Y., & Huang, Z.H. (2012). A pilot study of cooperative programming learning behavior and its relationship with students' learning performance. Computers & Education, 58, 1267–1281.

Savin-Baden, M., & Major, C.H. (2004). Foundations of problem-based learning. New York, NY: Open University Press.

Martin, K. (1996). What is problem-based learning? Issues of teaching and learning, 2(4). Retrieved April 9, 2017, from http://www.csd.uwa.edu.au//newsletter/issue0496/pbl.html

Jones, D. (1996). What is PBL? Retrieved April 9, 2017, from http://edweb.sdsu.edu/clrit/learningtree/PBL/WhatisPBL.html

Harper-Marinick, M. (2001). Engaging students in Problem-Based Learning. Maricopa Center for Learning and Instruction. http://www.mcli.dist.maricopa.edu/forum/spr01/t11.html

Garcia-Robles, R., Diaz-del Rio, F., Vicente-Diaz, S., & Linares-Barranco, A. (2009). An e-learning standard approach for supporting PBL in computer engineering. Education, IEEE Transactions on, 52(3), 328–339.

Barrows, H. (1999). Problem-based learning. Retrieved February 7, 2017, from http://www.pbli.org/pbl/pbl.htm

Kamin, C., Deterding, R., Wilson, B., Armacost, M. & Breedon, M.A. (1999). The development of a collaborative distance learning program to facilitate paediatric problem-based learning. Medical Education Online, 4(2). 1-12.

Oliver, R. & Omari, A. (1999). Using online technologies to support problem-based learning: Learners' responses and perceptions. Australian Journal of Educational Technology, 15(1), 58-79.

Galvez, J. Guzman, E. & Conejo, R. (2009). A blended E-learning experience in course of object oriented programming fundamentals, Knowlege-Based Systems, 22, 279-286

Valaitis, R.K., Sword, W.A., Jones, B. & Hodges, A. (2005). Problem-based learning online: Perceptions of health science students. Advances in Health Sciences Education, 10, 231-252.

Wilhelmiina, H. (2004). Problem-based learning of theoretical computer science. Department of Computer Science, University of Joensuu, Finland. 34th ASEE/IEEE Frontiers in Education Conference. October 20–23, 2004.

Yan, J. (2014). Applying PBL to the teaching of a computer network technology course: World Transactions on Engineering and Technology Education. 12(4), Henan Normal University Henan, People's Republic of China.

Lee, M.C. & Chung, Y.K. (2010). Using object-orientation to conceptualize an adaptive learning content management system modeling. In Advanced Computer Control (ICACC), 2010 2nd International Conference on IEEE, 3, 56–60.

Jenkins, T. (1998). A Participative Approach to Teaching Programming. In proceedings of ITiCSE, 1998.

Tseng, K., Chang, C.C., & Lou, S.J. (2011). The Process, Dialogues, and Attitudes of Vocational Engineering High School Students in a Web Problem-Based Learning (WPBL) System.

O'Grady, G., Yew, E.H.J., Goh, K.P.L., & Schmidt, H.G. (2012). One-Day, One-Problem: An Approach to Problem-Based Learning. Springer. http://dx.doi.org/10.1007/978-981-4021-75-3

Albion, P. (2000). Interactive Multimedia Problem-Based Learning for Enhancing Pre-Service Teachers' Self-Efficacy Beliefs About Teaching with Computers: Design, Development and Evaluation. Thesis University of Southern Queensland.

Lowther, D.L. & Morrison, G.R. (2003). Integrating Computers into the problem-solving process. *New directions for teaching and learning*, (95), 33-38. http://dx.doi.org/10.1002/tl.110.

Savin-Baden, M. & Gibbon, C. (2006). Online learning and problem-based learning: complementary or colliding approaches? In M. Saven-Baden and K. Wilkie (2006) (Eds.). Problem-Based Learning Online. Maidenhead: McGraw Hill.

Faaizah, S. (2008). *Pakej Multimedia Sains (Nutrisi) Menggunakan Pendekatan Pembelajaran Berasaskan Masalah Secara Hibrid (C2hadam)*. Tesis Doktor Falsafah, Universiti Kebangsaan Malaysia.