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Article *in* Journal of Computers in Education · December 2015

DOI: 10.1007/s40692-015-0050-1

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J. Comput. Educ. (2016) 3(1):105–129
DOI 10.1007/s40692-015-0050-1

E-learning of PHP based on the solutions of real-life problems

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Received: 17 June 2015 / Revised: 16 November 2015 / Accepted: 18 November 2015 /
Published online: 1 December 2015

Abstract PHP is one of the most popular web programming languages. Many people want to learn PHP because of its simplicity. One of the important features of PHP is that it is a server-side scripting language. Learning PHP is more effective if a student can learn through a real environment. Many PHP online-learning systems and hardcopy books are available at present. Problem-based learning (PBL) is an effective pedagogy used to increase the problem-solving skill of the students. Existing PHP learning systems support limited problems in real-life environment. In this work, we have integrated the conventional e-learning of PHP with the PBL pedagogy to improve the problem-solving capability of the students. In this system, a teacher designs some problems for the students. Each problem contains proper description and reference with standard PHP output. On the web server, students can practice and submit answers pertaining to the problem with the help of the relevant references, urls, examples, and standard output. System provides the facility for the students to practice and experiment on coding with real-time error. Students can edit codes repeatedly comparing their outputs with the standard output within the specific duration. For evaluation, a teacher can compare the students' submitted codes with the standard code of the system, predefined keywords, and outputs. This system helps the students to engage in self-learning of PHP based on the real problems.

Keywords E-learning · Problem-based learning · PHP · Problems

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Introduction

Problem-based learning (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 has been increasing. 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 teachers guide 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 (Garcia-Robles et al. 2009).

E-learning can be defined as all kinds of learning based on the electronic media. E-learning includes web-based learning and computer-based learning. Electronic media is more appealing and so dynamic that it can be used in versatile approach in learning structure. Electronic media can extend the duration of study for the student in noticeable way (Istrate 2009). Its organization and management is highly flexible and reliable. E-learning can be run independently to teach the students or it can be provided as a helpful tool for classrooms. It also encourages resource sharing across different organizations and among people with the same interests who are developing the e-learning community (Prakashe 2009; Lee and Chung 2010). E-learning system provides student evaluation system even with the students' progress and follow through on his study progress. E-learning system can be adopted as a tool to understand the student behavior (Pattnaik et al. 2010; Xianmei et al. 2010; Jantschi et al. 2008).

Problem-based e-learning (PBeL) is the electronic version of PBL. PBL is a learning method based on problems. PBeL is facilitated with different facilities of electronic media. From the beginning to the end of the problem, it can be well managed and well supervised with the help of electronic media. It helps to increase the accuracy level of the students as well as evaluation system.

PHP is one of the most popular web-programming languages for the dynamic web page manipulation. According to pyDatalog, PHP is the second most popular web-programming language from Sep 2013 to Sep 2014 (Index 2014). According to spectrum, a magazine of IEEE, PHP is the seventh most popular programming language (Cass 2014). Because of its popularity, most of the students have interest on learning PHP.

To learn a programming language, the most important step is to practice coding sequentially. This code practice can be accomplished with relative sequential problem solving. It is more valuable and effective to use web server to learn PHP according to the requirement of server for PHP.

There are several e-learning systems for PHP in the Internet. The existing systems support e-learning architecture. These systems focus mainly on content management. These are well supported with all kind of facilities of content management like video, text, audio, etc. Most of them support learning management system. Some of them provide the course management. They also support learner-activity management. The system that has been presented in this paper is to perform e-learning of PHP based on the

solutions of real-life problems. This system helps the students to engage for learning PHP based on real problems as well as the teachers to create problems sets with an easy-to-use interface. The teachers can assign the problems to the selected students' groups. They can evaluate the students' answers in a semi-automatic manner also.

Literature review

PBL has widely been used in the domain of study of medicines (Akili 2011; Kaldoudi et al. 2008; Shamad 2005). The effectiveness of PBL in engineering education has been shown in (Qiu and Chen 2010; Richardson and Delaney 2009). PBL approach has been applied in 'Advance Software Engineering' course in engineering education by Qiu and Chen (2010). Nontraditional teaching method was introduced for inexperienced students to understand in software engineering classroom by Richardson and Delaney (2009) using PBL. Qiu and Riesbeck (2005) have designed Web-based interactive learning environments for PBL. A software tool called INDIE was built to create web-based interactive learning environments where students can run simulated experiments, analyze test results, form rationales, and construct arguments to support or refute possible hypotheses. The PBL-based course of analog electronics was conducted in an environment that otherwise would have involved only a L/T/P approach. The pedagogy involved designing problems that covered the scopes of the subjects: carefully listing technical nodes and objectives; and handling the course, class, students, and their psychological issues, besides the technical ones. The Knowledge and Skill test showed remarkably better performance by the PBL group, compared to traditional group (Mantri et al. 2008). The effect of quality-assurance system on the implementation of PBL teaching strategy to courses has been studied by Lai et al. (1999).

Fontes (2011) introduced multi agents system to support PBL. According to this approach, four types of agents are proposed: a problem detector agent (PDAg), a student agent (SAg), an Animated Interface Agent, and work group creation agents (WCAg). Web-based environment to implement Problem-Based Learning has been developed by Yueh and Lin (2005). It describes the features and the rationale behind PBL approach, and introduces the development of web-based environment as well as its implementation of a university classroom in facilitating students' team work. Hiekata et al. (2007) proposed a new design engineering educational framework using an e-learning system called ShareFast, a Semantic Web-based software for document management system with workflow. The software offers a function to keep tracks of learners' behaviors so that the instructor can analyze it to improve learning materials and class efficiency. Kaldoudi et al. (2008) proposed the use of wikis and blogs not just for creation and promotion of information, but as active tools to support PBL in medicine. In this approach, students and instructors use the Web as a virtual place to collaborate and create new knowledge and new educational experiences. A two-tier test-based approach to improve students' computer programming skills in a web-based learning environment has been proposed by Yang et al. (2015). Hwang et al. (2008) developed a web-based programming learning environment to support students' cognitive development.

E-learning of PHP is found in the literature (Government of Ontario 2006; Refsnes Data and Consulting Company 1998; Java2s Developers 2013; Blackboard Inc. 1997; Suman 2011; Ullah 2012; Khan 2006; Alam 2010) but the use of problems as the learning environment is not found according to our survey.

E-learning system of PHP based on the solutions of real-life problems

Problem-based e-learning is an e-learning system based on the solutions of problems. There are some constraints and properties in PBeL system. We have managed these constraints and properties. As a result, the system becomes more effective. The system works through a sequential process. First of all, a teacher creates a group. Then s/he creates problems for the particular group. Only the members of that group can see the assigned problems. As a result, students have to join in a group to see the assigned problems. The students have to find the solution of that particular problem. Teacher sets some topics related with the problem. These topics help the students to find the solution of that problem. This topics differ from the internet random search. Teacher also defines some compulsory keywords which s/he expects that learners will have to use in their codes. These keywords-checking helps to evaluate the student's performance. Teacher also sets the closing date or time duration within which a student has to submit the answer for a problem .

An answer page has been developed where a teacher can see the submitted answer of the students. Teacher can compare the system's standard code and the students' codes manually. The system also matches the student's codes automatically and displays percentage of the matching. The keyword matching with the submitted codes of the students also has been done automatically. There are two other matchings. These are outputs and the dissimilarities between the students' codes and the system standard code. On the whole, a teacher can evaluate a student considering the four dimensions. These are code similarity, code dissimilarity, output similarity, and keyword similarity.

Figure 1 represents the problem-based e-learning component diagram. In this diagram, there are several individual components, as shown below:

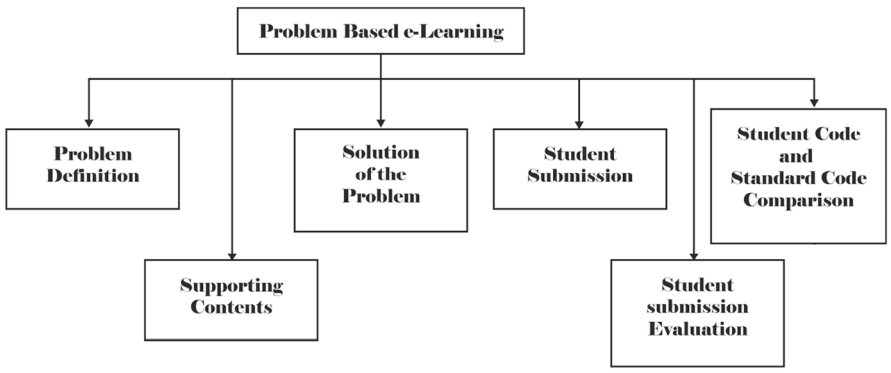

Fig. 1 PBeL of PHP modules

Definition: In this module, problems are defined as a text. All the data about the problems are saved. 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.

Supporting contents: This section holds different reference topics. Problem solution or hint for the solution can be found in these references.

Solution of the problem: This is the standard code to solve the problem that creates an output as per the description of the problem.

Student submission: The code that was written by the student is saved here. It can also save partial answer of the students. If a student wants to update or change the previously saved answer within the given time, he can load the saved answer.

Student submission evaluation: In this module, teacher can evaluate the students. Here all the answers of the students are arranged according to the user IDs of the students.

Comparison: This module compares the students' answers with the system's standard output, keyword, and code.

The problem answer page for teacher is different from that of the student. In the student page, there are several components. Reference links are for supporting knowledge to solve the specific problem. There is a code area to write and execute student's codes. Standard output component shows the expected output of the respective problem. The output of the students' codes can be seen on the student's answer output component. Title, description, learning outcome, and the duration needed to solve the problem are also given to the student answer page. In the teacher page, there are only two components—for writing the standard code for the problem and seeing the output of that code.

Figure 2 is the activity diagram of the student answering procedure. After logging-in into the system, students can select the problem list page, which is on the PBeL link. From the problem list, they can select specific problem. Problem link takes them to problem–answer page. In this page, student can practice and try to find the same appropriate output as the system's standard output. The student can submit for final evaluation when the student thinks the code is perfect for the given problem.

Problem list link for teachers lets the teacher to add new problems, add sample of the problem, examine students' answers, and edit old problems. In add problem, teacher can add details about a problem. The details are name, description, reference, groups, expiry date, etc. After completing the details of a problem, teacher moves on to 'add sample code' page. Teacher can find two boxes to add sample problem page, and here teacher can write the sample code. One of the boxes lets the teacher to write code, and another box displays the output of the code written by the teacher. To see the output of the code, teacher has to press the execute button. When teacher presses the save button, the system saves the code on the disk as a PHP file. After saving teacher's answer, teacher can load the output of the saved code by pressing load button.

Figure 3 shows activity diagram that visualizes the teacher's important activities in PBeL. This activity diagram describes the tasks that are performed

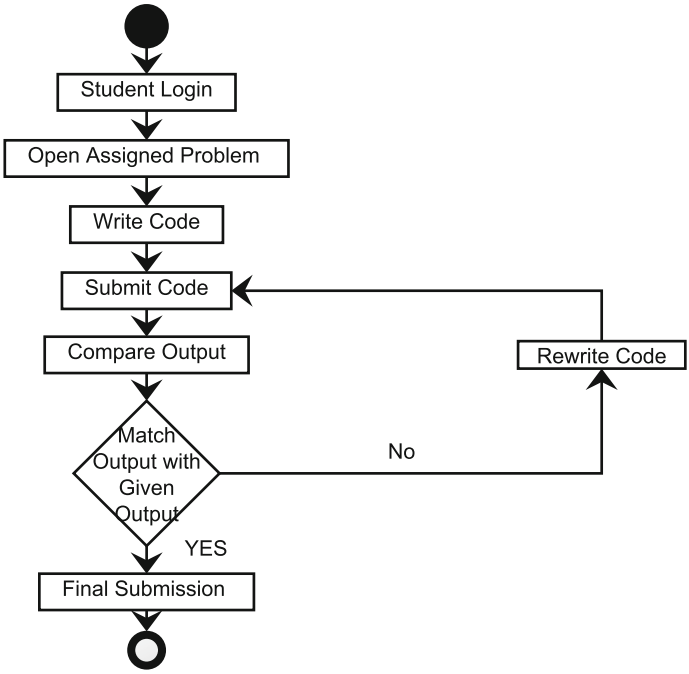

Fig. 2 Activity diagram for student

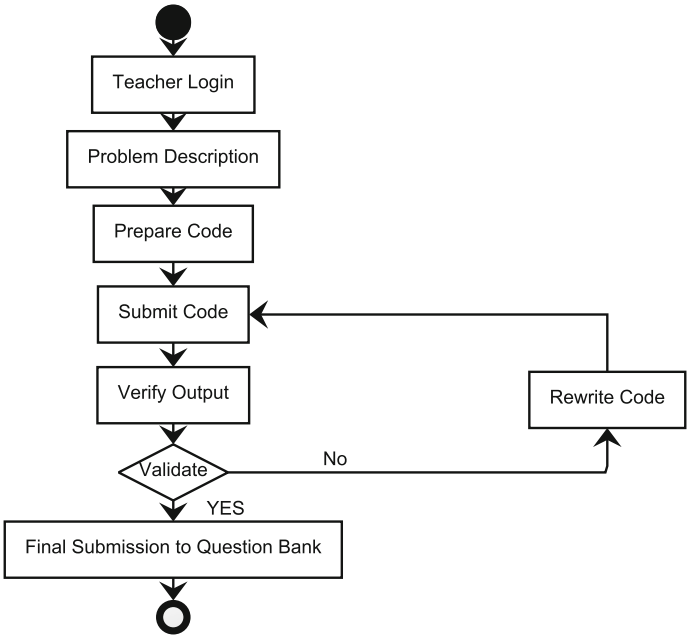

Fig. 3 Teacher-activity diagram: problem setup

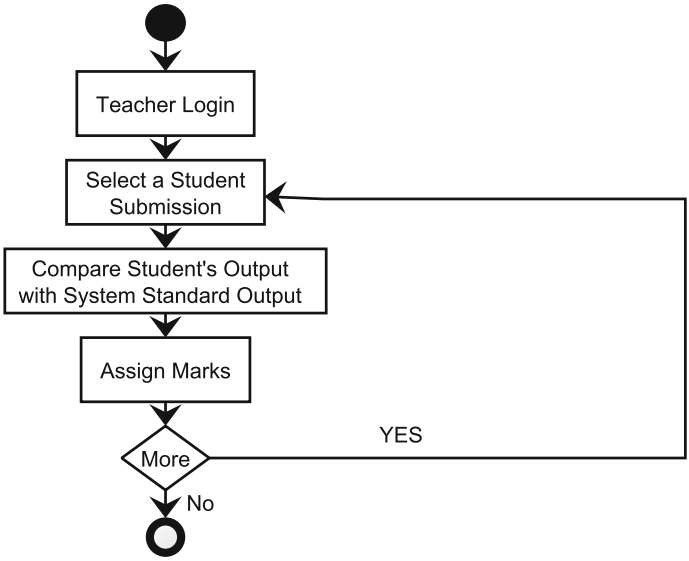

Fig. 4 Student answer evaluation diagram

by a teacher to set up a problem for a student group. Setting up problems by teachers requires a detailed knowledge of the existing problems in the system, the complexity, and estimated effort needed to solve the problem etc. The problems can have incremental complexity or incremental estimated effort. While problem is defined, the solution of the problem (write code for the problem) will be found, and after iteratively running the solution and verifying the output that matches the problem description, it is finally saved as a standard solution of the problem.

We can see the teacher evaluation process for the student answer in Fig. 4. To see the answer of a student, the teacher has to select him first from the list . He compares the student's answer with the standard system output. After analyzing the output of student, teacher assigns the marks for that student.

In user-answer page, the teacher can see the answers of the problems solved by a student. Teacher can select individual student to see their answers. There is an automatic evaluation system which checks students' answers in four aspects: The code similarity check, the keyword similarity check, output similarity check, and code dissimilarity check. Code checking matches the submitted code with the system's standard code which teacher saved as a sample for that problem. Keyword similarity checks that the keyword defined by the teacher exists in the student's answer. Output matching checks the user output with the system standard output. The dissimilarity checking finds out how much extra code is in students' codes.

The procedure of comparison code is explained in the Algorithm 1 and matching of keyword is explained in Algorithm 2.

Algorithm 1: Code Matching Algorithm

```
input  : Student's submited Code, System Standard Code
output: Percentage of Code Matching
X ← Standard Code;
Y ← Student Code;
SX[ ] ← split(X) ;
SY[ ] ← split(Y) ;
for ∀ A ← E ∈ SX[ ] do
    if A ∈ SY[ ] then
        counter ← 1+counter;
result ← 100 ∗ ( counter / NumberOfElement(SX[ ]) );
return result;
```

Algorithm 2: Keyword Matching Algorithm

```
input  : Student's Submitted Code, Problem Keywords
output: Percentage Of Problem Keyword Matching
X ← Student Code;
K[ ] ← keywords;
SX[ ] ← split(X) ;
for ∀ A ← E ∈ K[ ] do
    if A ∈ SX[ ] then
        counter ← 1+counter;
result ← 100 ∗ ( counter / NumberOfElement(SX[ ]) );
return result;
```

Whether code matching helps the teacher to identify that the student may miss some important part of the code to implement. On the contrary, the system checks the dissimilarity. By using dissimilarity check, the system can identify how much extra code student has written. Keyword matching helps to identify whether any important component is missed to answer the problem.

A teacher has option to edit both the details of a problem as well as the sample code of that problem.

Implementation

The system environment description

Environment

The system has been built on web environment. The system supports with all the properties of webpage. Whole system was hosted on the web server and can be found in http://www.i-evoke.com/buet/user/logform.php.

Requirement

The system was developed for the web, so Internet accessibility is important for the system. From any browser, user can access the system. The system supports with the

JavaScript and HTML5 properties. Browser which supports JavaScript and HTML5 can run the system.

Components

There are several components of the system. These parts are special for their functionality. There are four components of the system. These components are the core of the system, storage of the content, the interface design, and the system efficiency. The system was built through developing those components. The core of the system has been developed based on the HTML and PHP properties. All the functionality of the system was based on the PHP. The system storage has been developed using the data-storage systems: XML and MySQL. XML is document-oriented database. Contents of the system have been stored in the individual XML document. The relations among the content, user, and the system have been managed by the MySQL database. Interface has been designed by the style sheet language CSS. Interface design of the system has been maintained by observing the properties of human interest on web surfing.

JavaScript has been used to make the system efficient. JavaScript managed the user activity in the system. JavaScript save time for the user by managing the content and component of the system.

Specifications

The system has been developed on the web address "www.buet.i-evoke.com", built on the languages HTML, PHP, CSS, JavaScript, XML, JavaScript Library, JQuery, and MySQL database.

The e-learning system based on problems has been developed for a professional course running in Information Access Center under the Department of Computer Science and Engineering of Bangladesh University of Engineering and Technology (Korea and Work 2009). The title of the course is Quick Web Development. There are three different main modules in which we divided the system. These are

- Learning module
- User management module
- Content management module

All of them are interrelated but their properties are different from each other. These are essential parts of the system.

Learning module

Homepage is the anchor page of the system. From this page, we can get some idea about the whole system.

Figure 5 represents the screenshot of the home page of the system. In the screenshot, the visual interface of the system is presented. In the screenshot, eight (8) points are indicated. Indicator numbers 1, 2, and 3 are related with the learning

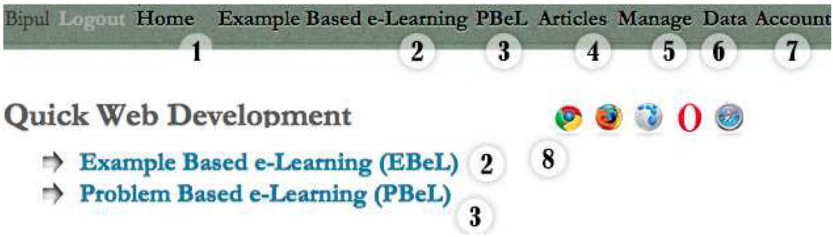

Fig. 5 Home page

module. Number 8 indicates the supported browsers' list. Numbers 4, 5, 6, and 7 are the links for the user management page.

The base color of the system is green. We have selected green because green has effect of calm, positive mood, relaxation, meditation, equilibrium and safety. It facilitates relief from tension. It has the characteristic of the passive, defensive, autonomous, and reluctant. It expresses concentration, safety, introspection, and self-evaluation. Text color is black, and link color is blue. The black is an impression of depth and fullness. Blue is characterized as sensitive and perceptive type (Istrate 2009).

Common menu of the system is placed on the top of the page. The entire page links exist on this top menu bar. It helps the user to navigate throughout the system as they want. Top menu bar consists with the necessary links. Menu bar displays user name when a user logs in the system. The system has another important property that it is faster than general web page. The system is built with JQuery library. JQuery provides the Ajax property which helps to load web content after the web page is loaded. In the system, when a page is loaded, then it updates the necessary content without reloading the whole page. If a user needs to change particular page content, then he does an event, and based on that event, the system detects the part that the user wants to change. Then the system loads the changed content. It saves lots of time on loading pages and page contents.

Problem-based e-learning structure

In the introductory page of PBeL, the users find some problems with the assigned group name. Page contents change according to the user type. User can only see an alert message to change their type when they try to access this page if user is neither a teacher nor a student. If user is a teacher then user can find some extra options to add problems, edit problems, and to see student's answers. If user is a student, then he can see only the problem list of his own group.

When a student selects a problem, the system loads some related information and place for code writing and checking output of the problem. These are the title of the problem, description about the problem, learning outcome, duration time to submit, reference Link, place for student's code writing, standard output of the problem, and place for student's answer output (Fig. 6).

For teachers, there are four types of links: add problem, manage problem, problem list, and students' answers.

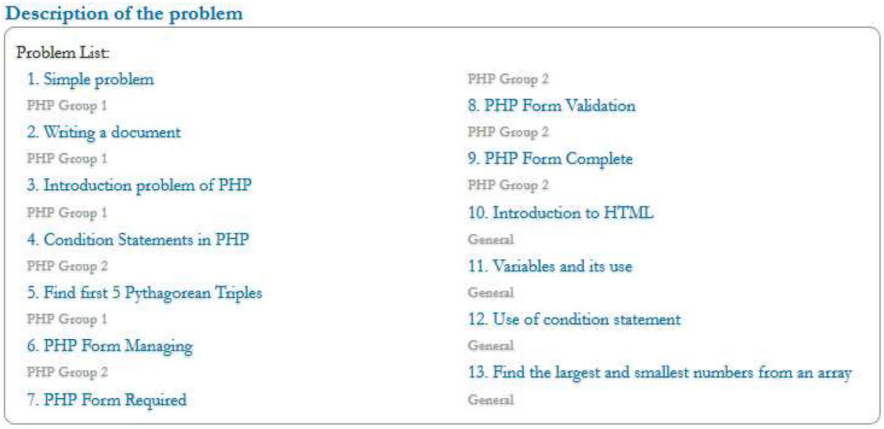

Fig. 6 Problem-based e-learning home page

Add problem property

Teacher can define some properties of a problem using the add problem link, and this link is on the right top of the problem list. To define a problem, the teacher fills up a form. Figure 7 displays the Add Problem pages.

On the beginning of the add problem form the teacher gives a title of the problem. The title is related with the problem type and is unique from other problem title. User can write about 100 character-long title, and it is enough length to write a problem title.

Teacher explains the question properly. Teacher writes a short and proper description of the problem. He can write about 1000 characters in the description field. In the learning-outcome field, teacher can brief what a student will learn after solving the problem.

There is a keyword field. In the keyword field, teacher writes some required keywords for the problem. Teacher must be careful about these keywords because keywords must be required to write code for that problem. The system compares the students' submitted keywords with the standard keyword set of the problem.

There are chapter and reference fields. If teacher follows some books, then teacher can give the chapter name to study or just to remind them. Reference is another important input field. This reference helps the student to find out the solution of the problem. This list of the reference belongs to the system. The system has large collection of topics related with web development. Teacher can select necessary topics from the reference list. External link field is to write the list of other sources which are not in the system, but the student can follow to find the solution of the problem. These selected references and external links reduce the attrition of time due to redundant online searching.

Group refers to the list of groups for whom the problem will be applicable. Only the group members can see the problems. Teacher selects the group of students to whom he wants to assign a problem. If any student who is not a member of that

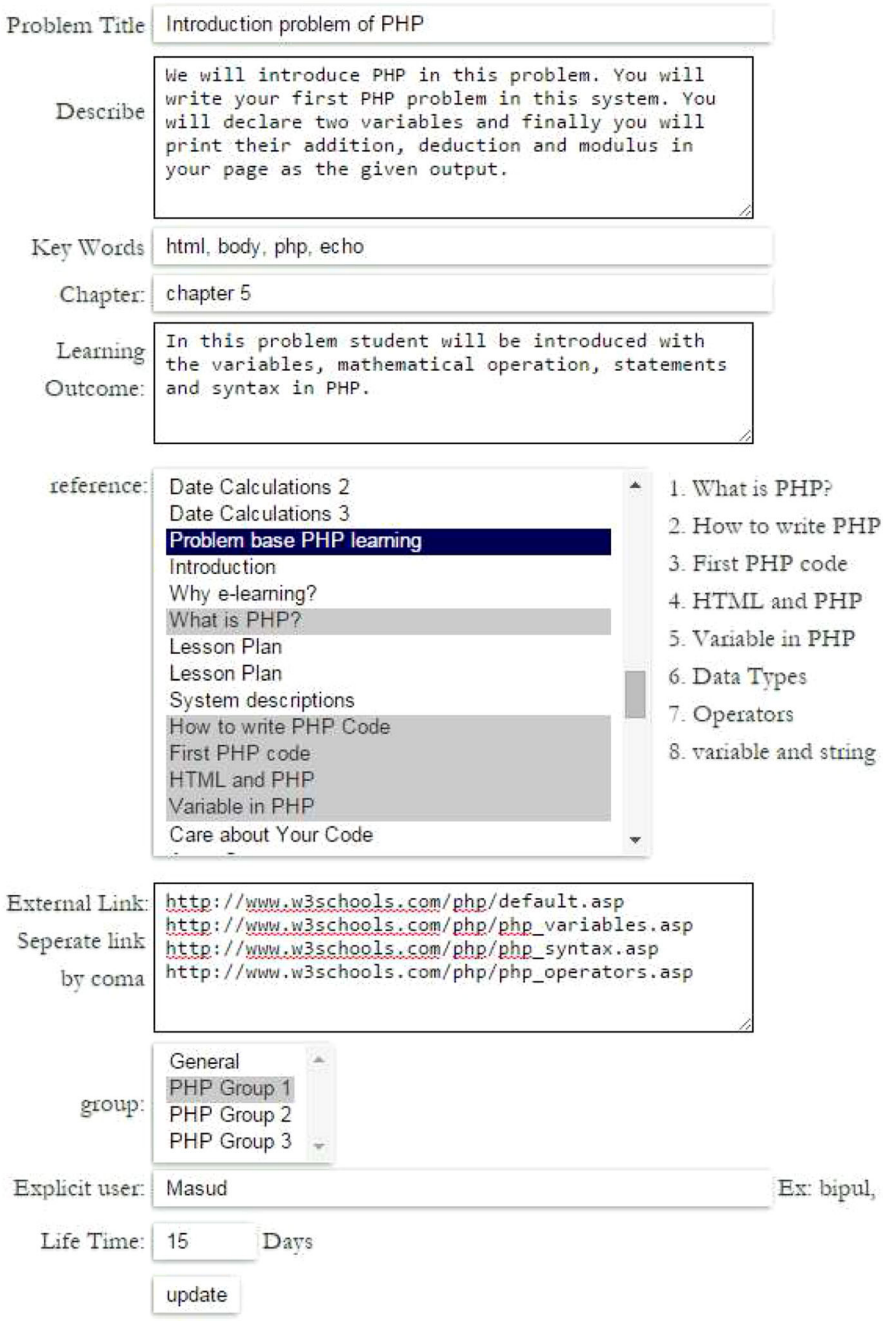

Fig. 7 Problem adding form

group and teacher wants to apply the problem to him, teacher can do it by adding the name in the explicit user field. Teacher can set the duration to solve the problem by assigning number of days.

Preparation of standard answer for problem

Teacher can see the title of the problem at answer code page in problem list (Fig. 8). If a problem is defined and teacher wants to write code for it, then teacher selects the

Fig. 8 Problem sample coding page for Teacher

problem title from the answer code page. The system will be loaded in the sample code page.

For every problem, teacher will write a standard answer. Student can only see the question output. This standard code will also be used as a comparison for student's answer. In this page, teacher will find two boxes: one to write the code and another to see the output. In the backend, it saves a copy of the code in a file and another copy in the database when teacher presses on the 'Save' button. There is a folder according to user name and a file with the name of problem in that folder. When teacher makes any change on that problem, it replaces the previous one. A file is made to save the answer for two main reasons. One of these reasons is to give proper output when the code is saved as a file. The saved file format is as same as individual PHP file. The result we see in our output box is same result like we call that file through link address from the server. Another reason is that it saves lots of space. If we prefer to save the code in the database, then it becomes difficult to decide the field size for the code. User may enter some code with characters which can be of size on order of several thousands. Each time a piece of code is saved in the database, it will occupy same space for either small or large-scale code. On the other hand, as we save as a file, it occupies only the space, which is written on the document. If the document is small then it holds only a small size, and if the file is large, it will hold that amount of space according to that file. It also saves lots of search time because it loads code by address.

Example 1 from section 3.2.4: Sample Code:

```
1  for($a=2; $a<100; $a++) {
2  for($b=2; $b<100; $b++) {
3  $c = pow($a, 2)+pow($b, 2);
4  $d = (int)+sqrt($c);
5  if(pow($d,2)==$c)
6  echo "(",$a.",".$b.") = ".$d."<br>";
7  }
8  }
```

Problem solution by students

For student type, student will see the same page in different format. In the answer page, the student window will be split into four parts (Fig. 9):

- Reference list,
- Problem description with standard output,
- Coding area, and
- Output area.

The reference list shows the reference list from inside and outside of the system. If student selects one link from the list, it opens the content of that article. Student can read and gather knowledge from these articles. If user clicks outside of the box it

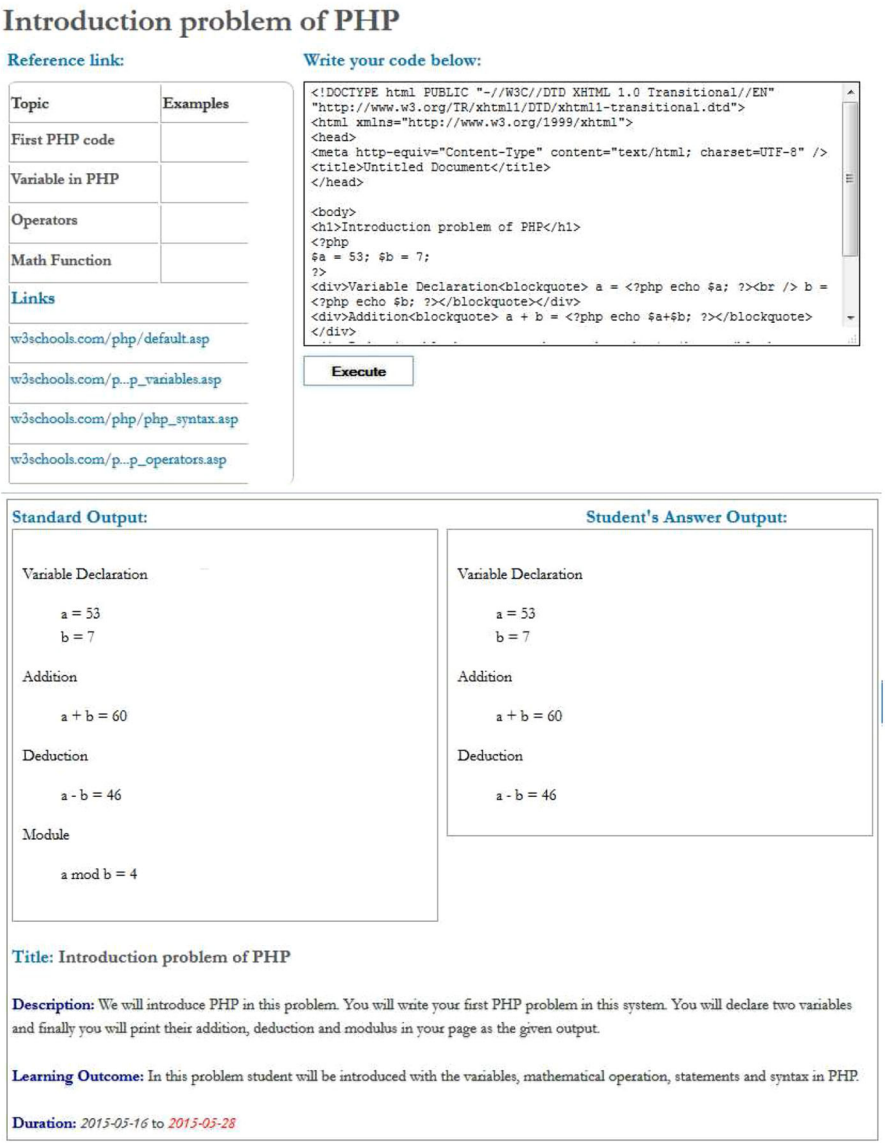

Fig. 9 Student answer page

closes the article content box. The content box is coded to show the content as like as book page.

Student can write code in the code writing part as like as text editor. Student writes plain PHP code. Student can run their code by pressing the Execute button. Output of the code can be seen in Student answer output box. When student presses on the "Execute" button, the system saves user code on the server as a PHP file and another copy on database. The system saves some part of the code on the database

and whole code in a PHP file. Database part is to check if there is any problem with saving data on file. It is known that there can be some students who may write some code that may harm the system, because of which we keep a list of harmful code. The system checks each time when user tries to execute his code. If they type any harmful code, then the system would not save that code. The checking method has been improved by analyzing the harmful codes in PHP or web development programs.

The question description part is arranged with output of the sample and short description of the problem. It also includes expiry date of the problem.

Evaluation of student's answer by Teacher

In the answer code section, the teacher can see student's answers. Each problem has a link of answer. Answer link takes teacher to student's submitted answer page. Student-evaluation page has six parts. They are

- Standard output,
- Student output,
- Standard code,
- Student code,
- Student's list, and
- Comparison result.

Student's list is the list of the students who submitted their code. Comparison result is the short evaluated output done by the system internally. Teacher can select a student from student list, and it changes the contents of student's output, student's codes, and the evaluated output (Fig. 10).

The software evaluation system is one of the unique parts in student's answer page. The evaluation method follows the similarity finding policy. This evaluation is not the final evaluation. From this evaluation, teacher can have an idea about the student's submission.

User management module

The structure of the user management is based on the user account. User account is related with one table which contains basic information about a user; they are id, email address, and password.

Account creation is an easy process but more effective. To create an account, the user has to give a user id, email address, password, and a simple test. User id is unique, and it can be used to log-in into the system. It also consists of a simple test for nonhuman. It is demo for check up; it can be improved by including number of options. It generates some simple mathematic statements; user has to find solution for that statement. The statement can be varied with various forms like simple human readable English line or can be a mathematical series or can be sum or any equation. It prevents nonhuman to create account in the system.

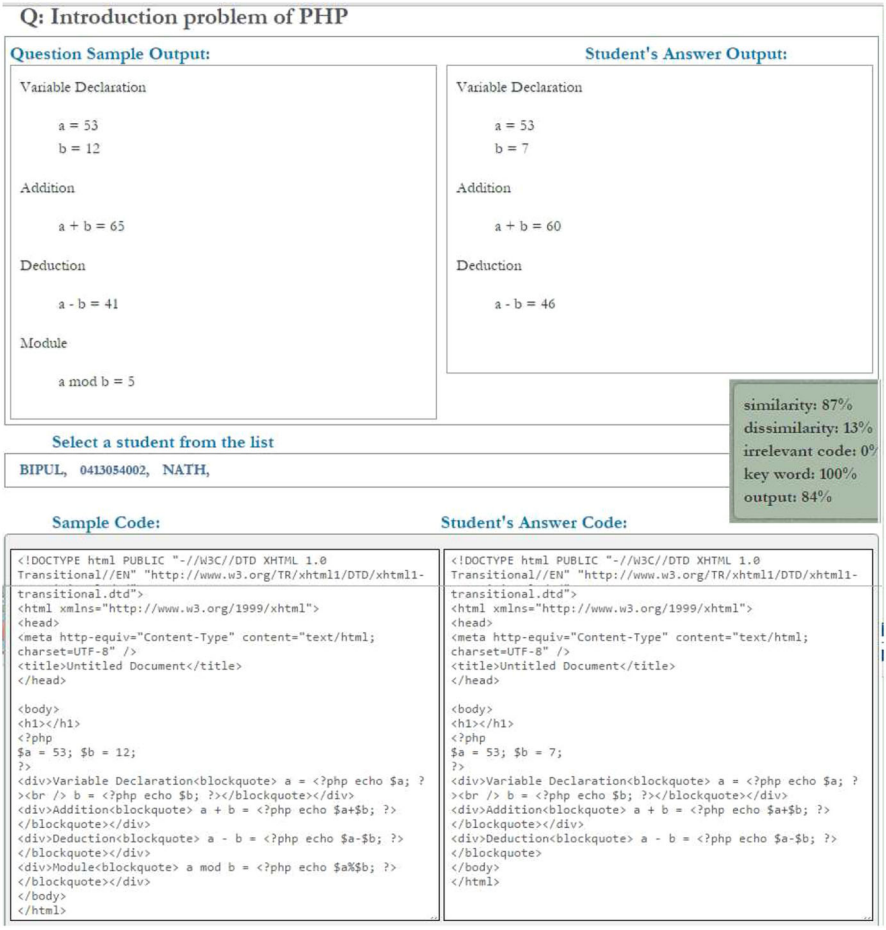

Fig. 10 Student answer evaluation

User session

At a time there can be several users on a same web page. The web server through http protocol supports each user with content. It is not possible to keep track of the http protocol, and it needs huge amount of work. On the other hand PHP helps us to track each user through session. Each time a user comes to server, PHP will create a session for that user. This session can keep alive as long as the user surfs that site. Session creates with a unique 32-character session id. Session has a time of expiry. Session expiry time can be set manually. User can be tracked by this session id. Even session can be combined with some variables. In this system, there are some tables to maintain the information of the session. Session variable and user behavior can be analyzed through this. User log-in into system is also related with the session. If any user fails to logout for any reason, then based on expiry time of session

variable, the user state goes to logout state. As a result, that particular user is protected from others abusing the system.

User information

The system keeps some basic information about the users. It contains user's name, gender, address, district, country, phone, a short description, profile photo, and date of birth. These data help other users to identify them.

User-type change

User-information page contains user-account-type field. User can change his/her type. The change of user type does not become effective immediately. Admin or Teacher has to approve the user type to make it effective. This is required as a precaution to prevent any abuse of the user's privilege.

User group 'creates' and 'joins'

Teacher can create group if they needed. Group is necessary for problem creation (Fig. 11). Only the group member can access a particular problem. Teacher needs to give a name of the group. Teacher can give some short description about the group and fix a number of members who can join in the group. Student can join any group through management page. They just need to select their favorite group and press 'join' button.

Content management module

Content management system is one of the most important parts of any e-learning system. E-learning system must equip with sufficient resources. The contents must follow some common structures so that it can be managed in large scale. XML can

Fig. 11 User approval and group joining

```
<? xml version="1.0" encoding="utf-8"?>
<! DOCTYPE PLAY SYSTEM "filename.dtd">
<lesson>
<subject>title of the subject</subject>
<identifier>
<title></title>
<author></author>
<date></date>
<language></language>
</identifier>
<chapter></chapter>
<section title="Name of the section">
<subsection title="title of the topic" id="001ASQL">
<description>
<paragraph id="midium">
<text></text>
<code></code>
</paragraph>
<figure>
<image src="" />
</figure>
</description>
<example id="simple"></example>
<reference>{\tiny }
<list desi=""></list>
</reference>
<furtherstudy></furtherstudy>
<keywords></keywords>
</subsection>
</section>
</lesson>
```

Fig. 12 Basic structure of the XML file

be one medium in which we can manage our content in any structure. For XML document design, it is needed to find out the requirement of the system. In this system, we are using mainly text, code, and some images. It is also possible to include audio and video in the system. The basic structure of the XML file is given in Fig. 12.

The first part of XML structure represents the ownership of the document, and the date on which and the language in which the content has been created. There is an option to give chapter name. Next part arranges the contents of the section.

Content part has several component tags. They are origin, description, example, reference, and so on. Origin is the source of the content. Description is the content of the section, i.e., the text, code, list everything that belongs. Description is the main part of the XML document. Example and reference contain the related example and reference of the article, respectively.

In PHP, XML parsing method reads XML files. In the system, SimpleXML is used to read XML file.

Content database

Database is another important part of the system. The system database can be divided into different parts. These parts are user management, content management, problem management, and user-activity management.

The user management part consists of the basic database tables of the system. This part contains the user-registration information and user-authentication information. The user-authentication tables are user and usertype. User-registration information tables are userdetail, usergroup, and userimage. All the data are linked through the unique id (email address).

User-activity management tables are provided to maintain information about user activities. Through these tables, the system can identify how long the user is spending time for a particular page. It also tracks user-page browsing history for a particular session which reveals the student's learning mannerism. Table pagelog, session_variable, and user_session maintain the information about the user activities on this site. These tables are also linked through an identifier-named email address.

Content management tables perform an important role for the system. These contents are related with the problem part and the user-activity part of the system. Content management tables maintain the linkable information of the basic content saved in XML files. Through these tables, the PHP will link a particular group of contents with the problem in PBeL and also the subject in EBeL. The tables for the content management are content, datafile, and exercise.

Problem management tables work with the PBeL part of the system. The tables in this part are exercise, phpproblem, and phpanswer. EBeL system exercises are stored in the table exercise. The phpproblem table contains the information about any problem. The table phpanswer contains a copy of the answer submitted by the student.

Site contents are managed by the table content, datafile, learningcode, and exercise. Table datafile contains the physical filename of the content. Table content contains the individual component of the lesson. Table learningcode contains the different arrangements of the content. Code tests are arranged from the table learningcode. Table exercise loads the drill for the students. The logical E–R diagram of the system database are given in Fig. 13.

E-learning system evaluation

We have organized a workshop to justify the applicability of our system for the students of higher secondary level of Bangladesh and can be found in http://cse.buet.ac.bd/PBeL/workshops/workshop1. In Bangladesh, ICT is compulsory course for all higher secondary level students. The ICT course includes html and php contents. Primarily, we have invited the teachers who teach this course to students of different colleges. Fourteen teachers from nine colleges participated in the workshop. We analyzed 9 (nine) e-learning systems related to the ICT course and evaluated them on the basis of type, language, in-video presence of the instructor, voice, software environment, interactivity, communication facility between teacher

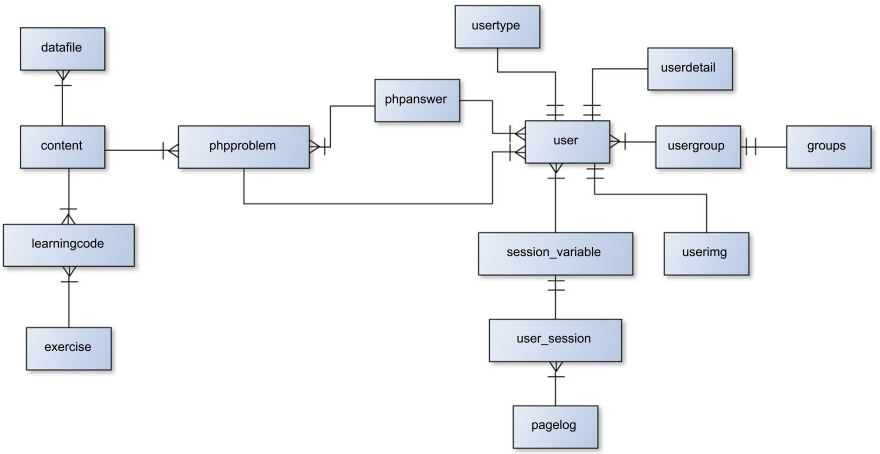

Fig. 13 Logical E–R diagram of the system database

and students, necessity of Internet, and self-evaluation or evaluation by teacher. On the evaluation, we have found the following tutorials and e-learning systems suitable for the course.

- HTML Bangla Tutorial using Notepad: This tutorial is the representative of those video tutorials which use the respective real environments of software. For example, for php or html learning systems, Dreamweaver, MS Visual Studio 2005, Notepad, etc. are used.
- HTML learning with problem-based e-learning strategy: This is the developed system by the current authors.
- Khan Academy: This is the renowned e-learning system created in 2006 by educator Salman Khan.
- DOC type tutorial: This tutorial is the representative of those document-type tutorials where texts and some snapshots of the software environment are used to deliver the message of learning.

We demonstrated these systems in detail to the participants of the workshop. At the end, we provided some queries to them on the above tutorials and e-learning systems. The queries were the following:

Among the tutorial and e- Learning systems:

- Which one is more easy or fruitful for learning of the higher secondary level students.
- Which one is more easy or fruitful for teaching of the higher secondary level students.
- Which one is more advantageous for both students and teachers.
- E-content design of which one is more suitable for higher secondary level students.

Table 1 Evaluation table

	HTML Bangla tutorial using notepad (%)	Our system (%)	Khan Academy (%)	DOC type tutorial (%)
Among the tutorial and e-learning systems which one is more easy or fruitful for learning of the higher secondary level students	28.6	57.1	7.1	7.1
Among the tutorial and e-learning systems which one is more easy or fruitful for teaching of the higher secondary level students	21.4	64.3	7.1	7.1
Among the tutorial and e-learning systems which one is more advantageous for both students and teachers	28.6	42.9	14.3	14.3
E-content design of which tutorial/e-learning systems is more suitable for higher secondary level students	14.3	64.3	7.1	7.1

The results of different questions for different tutorial and e-Learning systems are illustrated in Table 1. As per the results, our system was found to be 2–4 times more effective and easy from both learning and teaching perspectives, because of learning by solving problems, interactivity, design of the system, appropriate reference links, and semi-automated evaluation system. Khan Academy is serving good e-learning materials, but the teachers were not comfortable with the difficult English pronunciations for the students of higher secondary level. HTML Bangla Tutorial using Notepad was found more effective than Khan Academy because of the same reasons according to our thinking. Another reason for Khan Academy being less effective than others might be the lacking of contents matching with the higher level ICT course syllabus.

Discussion and Conclusions

PBL is one of the established promising learning methods. PHP is one of the most popular programming languages for the web development. We have developed a PHP learning system based on problems. The whole system is online so that the user can access or practice PHP programming from anywhere. PHP is server-side programming language. As a result, the system is more effective for learning PHP programming.

The system is developed to teach students PHP by solving some practical problems. The teachers design 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 teachers include full descriptions of the problems with the topics list. The teachers also include 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 teachers can

analyze their programming abilities. The teachers can check each student's codes manually. They can compare students' codes and output with the system's standard code and output, respectively. An automated checking module is included in the system. This automated module checks the similarities and dissimilarities of answers between the perspectives of code, output, and keywords.

This system is supported with large collection of contents. We have collected enough number of contents and examples for the system. The teachers can add or edit references for any one of the related PHP problems in the system. The system also provides an option to see the body of the contents to have an idea of contents' coverage. The teachers also can refer content links from the outside of the system.

This system has been built to help the teachers to lookup students' learning progress. It has been developed to help the students to share their codes with the teachers. Most of the time, students face the problems to share their answers with the teachers. It will also help the teachers to have the students' answers in an arranged manner.

Several e-learning systems exist in the Internet. These systems consist of learning management systems. Most of them support e-learning systems with content management modules. Some of them provide the course management and learning-activity management. A few of them support e-learning of PHP based on the solutions of real-life problems.

The system has been developed only for the PHP. The format of the system can be applied to implement other languages like JavaScript, C, etc. We can improve the system by collecting the user behaviors. It can be helpful if we collect information of user activities with the reference topics. It can also be helpful if we collect information of students' problem-solving time and the number of attempts required to solve a particular problem. The above values can be used to make the system more intelligent so that it can operate more smartly on the learning process.

Further research is required from students' perspectives of different levels. In near future, we will apply the system to the students of higher secondary level and students who completed certificate course on web application, who come from different educational backgrounds. We will collect feedback from them to improve our system which will be more suitable and applicable to them. We will take different groups of students from both rural and urban areas to investigate in depth how the students look at the system, and how they think the system would help them to learn the contents of their syllabus.

Acknowledgments This research was performed in the Department of Computer Science and Engineering (CSE), Bangladesh University of Engineering and Technology (BUET) supported by the Information and Communication Technology Division, Ministry of Posts, Telecommunications and Information Technology, Government of the People's Republic of Bangladesh.

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