Computer as Mathematics Facilitator in Problem Based Learning

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Abstract: The purpose of this paper is to investigate and study Electronic Problem-Based Learning (e-PBL) systems as well as proposing a method of learning which involves deeper understanding and comprehension in terms of Bloom's Taxonomy. The PBL system allows students to become self-directed and self-disciplined and simplifies elimination of lecturers' physical presence in mathematics and related fields. It also overcomes some problems of other electronic-based systems in such fields of science.

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Introduction

In recent years, concurrent with development of various sciences, the production of Expert Systems has had considerable growth and all people have seen their efficiency clearly. These systems are designed and presented by expert individuals and specialists of digital world in various subjects so that they will be finally able to help people as an expert person (such as surgery, teacher, psychologist …). Thus, fundamental problems are often seen in all branches of this science that it takes many years to resolve them. Furthermore, it should be emphasized that most of these systems have interactional posture with their users and they do not act partially. For example, in a medical expert system, the patient can not suffice only to the voice or films broadcasted from computer. As the place of a medical book in traditional world is different the physician himself, the condition in instruction is the same. In fact, e-books or instructional films and voices are not called a instructional expert system. In a instructional expert system, the computer should be able to receive and perceive all questions, states, answers and related interactions presented by by user, and present user's answer after inspection as an expert teacher. as much as expert these systems are, learning can be more profound (according to Bloom's Taxonomy) and it will be more stable in learner's mind.

As it was stated before, some problems occur in designing expert systems that they should be resolved. In this article, a new approach has been presented to design instructional expert system that want to perceive mathematical concepts and have more realistic interactions.

Many studies have been made about E-Learning (Clark, 1994 and Dillon, 1998) and they have been compared with traditional systems (Draxler, 2003). The aim of this article is not to propose these topics and it is assumed that the necessity to instructional expert systems and their efficiency is a plausible fact. Thus, instruction has been assessed and categorized from different points of view that we state just on kind of taxonomy, referred in the following. E-Learning is divided in three kinds of "obtaining information", "training to strengthen response", and "training to build knowledge". The topic of this article includes the two last types and basically, for the first training type there is no need to apply achievements of this article in expert systems and it is truly used in low levels of learning. In response reinforcement method, the teacher poses a question and then considers a reward for the correct answer and a punishment for the wrong answer. The teacher's duty is to provide short sections of content and then a few questions with appropriate feedback. In this kind of instruction known as directive training directory, selecting appropriate questions and proportional interactions of the teacher and learner is an important issue and it should be carefully considered in similar expert systems. In the third training method, referred above, the learner tries to solve his/her problem in a new way and by teacher's guide. This method of training is also called Guided Discovery.

Learning and training have always been of high importance and have been presented in various ways across different centuries. They gradually turned into a science and many brilliant scientists have studied about the important factors in learning process and how they influence deep understanding of students.

With the expansion and development of science, different scientific institutions were established in education sector which their researchers analyzed this science in-depth and more carefully. After many considerations and proposals, the older version of education which concerned different levels of learning process was later presented in terms of Bloom's Taxonomy (Bloom, 1956). These will be discussed further in Section II.

Studying educational methods soon turned into an important scientific discipline which paved the grounds for fundamental changes in more traditional methods of teaching and learning. Each of these techniques is of special and major significance and is used in different subjects. One of the new methods of learning is Problem-Based Learning (PBL). In this method the lecturer's role is to guide the students; he/she only explains the problem without giving the answers and guides them through solving and learning it. This method has numerous advantages which will be discussed in detail in Section III.

Electronic learning is another branch of learning which was developed about 40 years ago. Computers and digital technology are used in this form of learning which has made an impressive progress and development ever since. However, teachers in e-learning environment have not still been able to entirely replace the traditional classroom teachers. In Section IV, we are aimed to take an important step towards ways of improving the efficiency of electronic educational systems in mathematics and similar topics. The results of this research will be presented in the last section and finally the new challenges that researchers are facing today will be introduced.

Bloom's Taxonomy

In this section, we review Bloom's taxonomy and its revised version (Pohl, 2000). Then we will use it in the next section and will show how our approach can be used in E-PBL for deep learning in terms of Bloom's taxonomy.

An academic team led by B. Bloom categorized learning activities into three domains, namely cognitive (describing activities concerned with intellectual and mental abilities), affective (describing activities concerned with motivation, attitudes and valuation) and psychomotor (concerned with physical abilities and skills) domains. Since the paper is about cognitive domain, we don't describe about affective and psychomotor domains. The Bloom's team also produced an elaborate compilation for the cognitive domain. In this taxonomy, cognitive domain is arranged according to a hierarchal order, ranging from simple intellectual activities to highly complex intellectual performances.

This taxonomy is only one of the systems in the educational world, but it is the most applied one in use these days.

As we mentioned earlier, the cognitive domain is related to intellectual skills. We need these skills in e-learning as well as learning. Different types of skills in this taxonomy (in the first version) are the recall or recognition of facts, procedural patterns and concept that serve in the development of intellectual skills. There are six categories in Bloom's taxonomy starting from the simplest to the most complex behavior. For shortness we review the revised version of Bloom's taxonomy and use here.

One of the Bloom's students revised the cognitive domain in the learning and made some changes. This new taxonomy (six steps) is describing as follow in brief:

- Remembering: recalling data and Information
- Understanding: understanding the meaning translation and interpretation of problems and presenting a problem in one's own words
- Applying: using a concept in a new situation and applying what was learned into novel situations in the work place.
- Analyzing: separating concepts and materials into components such that organizational structure can be understood
- Evaluating: making judgment about the value and correctness of ideas
- Creating: building a new structure from diverse elements and putting parts together to form a whole with a new meaning

As we mentioned in the first section our main idea help the e-PBL systems to move upper steps of the Bloom's taxonomy when we learn mathematics or related concepts. In other words, our proposed approach develops student conceptual and helps learners gain a deeper insight into mathematical concepts.

Problem Based Learning and Mathematics

Problem-Based Learning (PBL) presents a new learning environment where learning begins with a problem to be solved, and the problem is posed is such a way that students need to gain new knowledge before they can solve the problem. Rather than seeking a final correct answer, students interpret and describe the problem, gather information, discuss on possible solutions, evaluate options, and present conclusions. Their experiences in managing their own knowledge and working team also help them to solve mathematical problems well (Schoenfeld 1985, Boaler 1998). Problem-based learning is a classroom strategy that affords students more opportunities to think critically, present their own creative ideas, and communicate with peers mathematically (Krulik 1999, Hiebert 1997). I e-learning world, Jafarabadi et al. (Jafarabadi 2011) have recently presented to run an e-PBL method in Mathematics learning.

Since PBL starts with a problem, so students working in a PBL environment must have skills in problem solving, creative and critical thinking. The effectiveness of PBL depends on student characteristics, facilitator's ability and classroom culture as well as the problem tasks. When students develop methods for constructing their own procedures, they gather their conceptual knowledge with their procedural skill. Limitations of traditional ways of teaching mathematics are associated with teacher-oriented instruction and the "ready-made" mathematical knowledge presented to students who are not receptive to the ideas (Schoenfeld, 1988). In these approaches, students imitate the procedures without deep conceptual understanding.

Within PBL environments, the instructional abilities of teachers are more important than in the traditional teacher-centered classrooms. Teachers in PBL environments must engage students in using their knowledge in applied settings. It is very important that the teachers in PBL settings should have a deeper understanding of mathematics that enables them to guide students in applying knowledge in a variety of situations. Teachers with mathematical knowledge may not work efficiently in PBL environments. Without an in-depth understanding of mathematics, teachers would neither choose appropriate tasks for nurturing student problem-solving strategies, nor plan appropriate problem-based classroom activities (Prawat 1997, Smith 1997).

Furthermore, it is important that teachers in PBL environments develop a wide range of pedagogical skills. Teachers must not only supply mathematical knowledge, but also know how to engage students in the processes of problem solving and applying knowledge to novel situations. Changing the teacher role to one of managing the problem-based environment is a challenge to those unfamiliar with PBL. We have the same difficulty in electronic learning and we discuss in this paper on how we can solve that.

E-PBL and Math related learning

As we discussed earlier, in electronic problem-based learning (e-PBL) the learner must use computer (as a facilitator) and other facilities of the system for learning. The initial or lower levels of Bloom's Taxonomy are the simplest in terms of learning process; they just involve the learner to gain information and knowledge from the system. This information can be stored in a database and retrieved from it whenever required. For instance, if during a learning process the student is required to recall and use a well-known trigonometry equation, all he/she must do is to retrieve it from the database via a search technique. This case is equal to asking the system about the capital city of a particular country. During this procedure, the system does not perform any special type of mathematical processing. Therefore, these levels of the taxonomy are not the main focus of this paper.

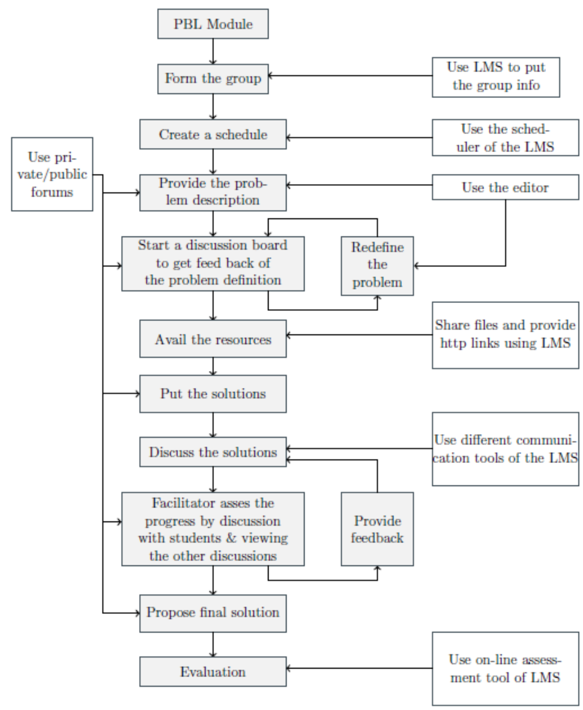

Figure 1. A diagram for PBL and LMS

As we move to the higher levels of Bloom's Taxonomy, the questions of students may require a considerable amount of calculation which their answer can no longer be found in the database. A simple example of this situation is the answer to this multiplication operation 256*42. Facilitator systems in e-PBL can manage and perform such type of tasks once a connection is made between a calculator and the e-PBL system. However, the existing e-PBL systems, as shown in Figure 1 (Souman 2010, Woods 1994), still have major deficiencies in mathematic related topics and cannot carry out all the possible operations that learners need from the system. As mentioned previously, the purpose of this paper is to present a method which enables learners to become self-directed and gain deeper understanding using the e-PBL systems.

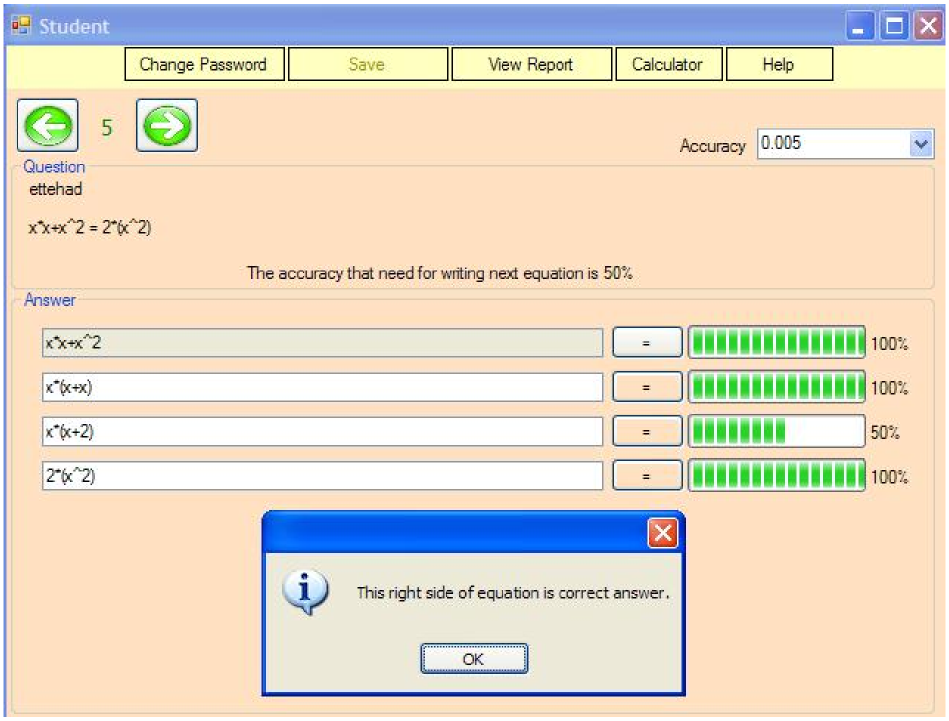

Figure 2. Student page: solving an equivalency problem

In the new proposed method, once the student reads the problem he/she must be able to find the answer on his own and without any help. He/She might be able to solve the problem independently or share it with other students and put it into discussion. Also, while using the e-PBL system, the student can share his findings and thoughts with others under supervision of the facilitator. Another important technique which helps students to solve problems in e-PBL is to change the existing problem into one equivalent to it. In fact, the main concern in this method is the ability of e-PBL system in recognizing and operating the equivalent mathematic formulae. In other words, the system cannot use the database or a calculator in such cases. Therefore, the main objective is to apply an interface in such systems so they can carry-out operations of any subject similar to MATLAB or Maple software.

For instance, once the student enters any mathematic expression equivalent to $(x + y)^2$, the system must be able to recognize them. This expression is equivalent to infinite number of other expressions which are not supposed to be stored in the database. $(x + 2y – y)^2$, $(x^2 + 2xy + y^2)$, $(3x – 2x + y)^2$, and $(x^2 + y*y + 2xy)$,… are all equivalent to $(x + y)^2$. It might be presumed that by standardizing the format of inputs, we can overcome this problem and there will be no need for a new method. However, the problem arises when the expressions become more complicated. For example, for a simple expression such as ($\text{Sin}2x + \ln x^3$), the student can find numerous equivalent expressions which their correctness must be carefully examined. This way the new proposed system will completely overcome the existing problems and improve speed and accuracy of e-PBL systems as well as making them more capable.

In the designed system which is being introduced in this paper, there are three levels of accessibility. Figure 2, shows one of the special pages of the learner where he/she is being active in solving a problem which is equivalency. Even the learner has provided a wrong solution in a specific step of problem solving and it is being reported that the level of accuracy of the answer is 50% of the both sides of equation. This system enables the student to solve the problem and also enables the student to independently interact better with the computer which acts as a facilitator. Figure 3 shows a page which is related to the tutor where he/she would be engaged in designing the quiz and specifying the attributes of the quiz. The system would require more than routine and normal information about the system from the tutor (which is custom in the normal traditional method). It is with the help of this information that the intelligence of the system is being guaranteed.

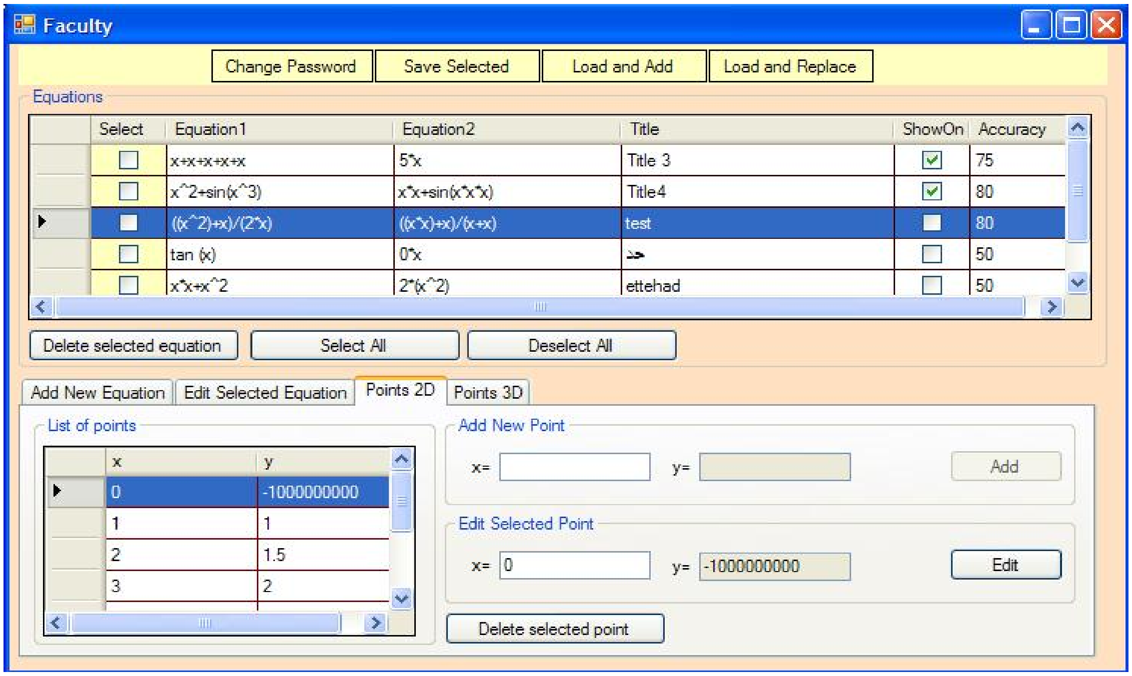

Figure 3. Faculty page: Designing a quiz

The major aim in this research is to propose a strategy to improve the quality of PBL based electronic systems that specially used in learning of mathematics fields. After proposing the strategy and develop the test system, we implemented this method and applied in 2 high schools and colleges. With executing this software that was trained to mathematic teachers, we provided a questionnaire and gave it to the students. The questionnaire included 18 questions in separate classes, that each has 4 options called: "Fully adverse", "adverse", "consistent" and "fully consistent" and we matched numbers 1 to 4 to these options. Also, we explain that a empty field in questionnaire means that "I have no idea!" and matched to zero. After using the software, the questionnaires were completed and evaluated in statistics. The mean of each question's mark is shown in table 1. The mean index of each question that is a number greater than 10/5 = 2 shows the legality of method for that question that in major of cases is true.

Table 1:

	SEX	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Mean	1.59	2.82	2.52	2.63	2.66	2.55	3.04	2.84	2.42
Std. Error of Mean	.071	.129	.126	.110	.111	.142	.132	.141	.129
Std. Deviation	.497	.905	.875	.761	.760	.974	.908	.986	.895
Variance	.247	.820	.766	.580	.577	.948	.824	.973	.801
N	49	49	48	48	47	47	47	49	48
Minimum	1	1	1	1	1	1	1	1	1
Maximum	2	4	4	4	4	4	4	4	4
Sum	78	138	121	126	125	120	143	139	116

The next question in this sampling is that: Can these attained results generalize to the whole of society. Following this question we use the test. By considering the assurance percentage 0.95 (and also semantically level equal 0.05) and by using 49 questionnaires we gain to Table 2 that the final result for will be equal to 29.939. By considering the assurance percentage that we used, because this is greater than 7.8, the result can generalize to whole of the society.

Table 2.

	Observed N	Expected N	Residual
kamelan mokhalefam	4	11.8	-7.8
mokhalefam	12	11.8	.3
movafegham	27	11.8	15.3
kamelan movafegham	4	11.8	-7.8

Test Statistics

	Q4
Chi-Square	30.021
df	3

ConcluSion

In this paper we have provided a system in e-learning with the help of which the depths of learning (as per Bloom's Taxonomy) in Math Related problems in the field of E-learning systems are being increased. Also with the usage of those, stronger e-PBL systems can be developed which would enable the life span of the learnt topics can be increased.

The provided system is being coded for three levels of administrator, tutor and learner and being tested regarding certain problems of mathematical experiments in a college and a high school.

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