

INFORMATION SCIENCE PUBLISHING

701 E. Chocolate Avenue, Suite 200, Hershey PA 17033, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com **ITB12415**

This chapter appears in the book, *Tools for Teaching Computer Networking and Hardware Concepts* edited by Nurul Sarkar © 2006, Idea Group Inc.

Chapter XIII

Assistant Tool for Instructors Teaching Computer Hardware with the PBL Theory

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Abstract

Students often get a good score in written exams but fail to apply their knowledge when trying to solve real-world problems. This is applies particularly to computer hardware courses in which students are required to learn and memorize many key terms and definitions. Also, teachers often find it difficult to gauge students' progress when teaching computer hardware fundamentals. These problems are related to the learning process, so it is necessary to find an appropriate instructional model to overcome these problems. This chapter describes a Web-based tool called the assistant tool, which is based on problem-based learning (PBL) theory and not only assists instructors in teaching computer hardware fundamentals but also overcomes the above-mentioned problems.

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Learning Objectives

After completing this chapter, you will be able to:

- Discuss the usefulness of PBL theory in teaching and learning contexts.
- Discuss the effectiveness of the assistant tool in enhancing teaching and learning computer hardware concepts.
- Define the following key terms: problem-based learning, brainstorm map, concept map, and cooperative learning.
- Suggest further enhancements to the assistant tool proposed in the chapter.

Introduction

There are numerous key terms, definitions, and abstract concepts in computer hardware fundamentals courses that students are required to learn and memorize to pass the exam. Therefore, it is often difficult to motivate students to learn computer hardware because many students appear to find the subject rather abstract, technical, and boring. Teachers also find it a bit difficult to gauge students' progress in their classes.

There are two primary issues a teacher must investigate to gauge student progress: (1) memorization, that is, how many terms or abbreviations students have learned; and (2) relations between concepts (e.g., whether students know that both Pentium and Athlon are processors or whether students know the difference between a printer and a scanner). Memorization can easily be measured by a simple quiz or test. However, determining whether a student understands the relationships between concepts is not an easy task. Furthermore, a teacher needs to be assured that students have acquired the knowledge required and understand the numerous abstract concepts.

Sometimes students make mistakes and incorrectly group together concepts on different levels. For example, a student may have memorized ViewSonic VE700, an output device, and incorrectly associated this with the CPU and motherboard instead of Intel Pentium IV and IWill P4SE2. The questions arise, how can a teacher teach students about the conceptual relations among computer components and what concepts should a teacher provide as supplemental instruction.

To overcome the above issues and problems, we have proposed an assistant tool based on problem-based learning (PBL) theory that can be used in assisting instructors teaching computer hardware courses.

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Background and Motivation

The author's past teaching experience at a vocational school showed that vocational students often obtain high scores on tests but fail when applying what they have learned when trying to solve related problems in the real world. A problem can then be said to exist in the learning process. It is necessary and urgent to find an appropriate instructional model to resolve this problem in education. In the 1960s, researchers at McMaster University in Canada obtained a similar finding. They argued that students cannot apply education-based knowledge and skills to their work (Albanese & Mitchell, 1993). To solve this problem, the School of Medicine at McMaster University developed and applied a PBL method for medical education ("What is PBL?", 2004).

Problem-based learning is a student-centered teaching method in which students are placed into small groups and the teacher acts as a facilitator or guide (Barrows & Tamblyn, 1980). A poorly structured problem (real-life problem) is used as a starting point for the instructional process in PBL (Simon, 1973), and students acquire problem-solving and self-directed learning skills (Barrows, 1996).

According to Barrows (1996), there are several key characteristics of PBL: It is student-centered, it employs small student groups, teachers function as facilitators or guides, and instruction begins with unstructured problems. A goal of PBL is to transform the teacher's role from that of a lecturer to a facilitator and the student's role from that of a passive observer to an active participant in the learning process (Ahern-Rindell, 1999).

To motivate students, PBL employs realistic situations (unstructured problems) to promote group discussions. These realistic situations can be used to create relationships between their education and their professional lives. Unstructured problems are utilized to force students to define problems for themselves, which leads to learning by critical thinking. A brainstorm map, which is drawn by student(s) according to their pre-learned knowledge, and group discussion can enhance a student's ability to think creatively, reason critically, make decisions, and communicate and cooperate with other students while exposing them to different viewpoints. During a PBL activity, acquiring knowledge coincides with solving the problem, enabling students to identify what they know and what they need to know. Thereby, learning becomes meaningful.

Problem-based learning is based on several cognitive theories: constructivism, situated learning, experimentalism, and cooperative learning.

A. **Constructivism**: Constructivism assumes that knowledge is not absolute but rather constructed via the learning process and based on a learner's

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previous knowledge and their overall view of the world. According to Savery and Duffy (1995), the three primary constructivist principles are (1) understanding is a product of our interactions with the environment; (2) cognitive conflict stimulates learning; and (3) knowledge evolves through social negotiation and evaluation of individual beliefs. Constructivism then is the basis for changing the student role from passive to active by placing students into groups for discussion and social negotiation.

B. **Situated learning**: Situated learning argues that learning should take place in realistic settings to make learning meaningful (Anderson, Reder, & Simon, 1996; Brown, Collins, & Duguid, 1989; Young, 1993). There are four primary claims of situated learning with respect to education principles in situated learning: (1) Action is grounded in the concrete situation in which it occurs; (2) knowledge does not transfer between tasks; (3) training by abstraction is of little use; and (4) instruction needs to take place in complex social environments (Anderson et al.). According to these principles, instruction in the sciences should be rooted in real-world experience. The situational nature of cognition renders education more effectively for promoting student development of practical knowledge. This rationale, perhaps, explains why students pass tests with high scores but have difficulties solving real-world problems.

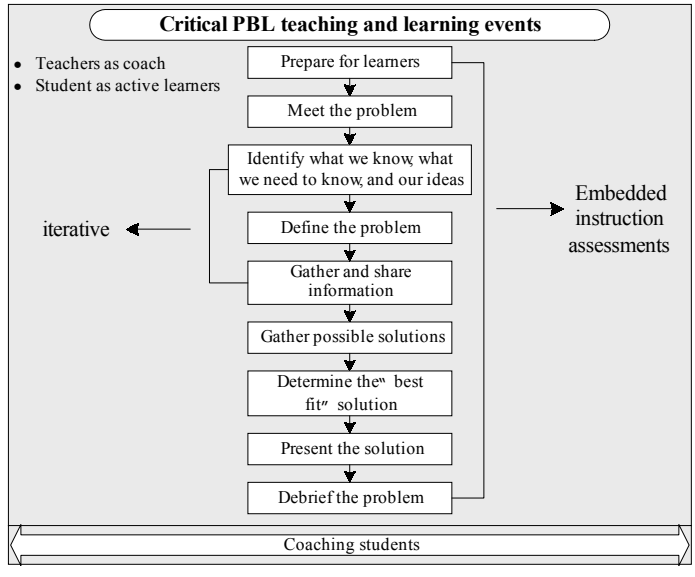
C. **Experimentalism**: Dewey (1938) argued that knowledge acquisition is a product of perception and is active rather than static; that is, acquiring knowledge is a process of discovery. Based on this notion of learning, students can only learn from experience, that is, learning by doing.

D. **Cooperative learning**: Cooperative learning focuses on student interaction (Ahern-Rindell, 1999). Cooperative learning must comprise the following elements: positive interdependence, individual accountability, face-to-face interaction, and, interpersonal skills (Johnson, Johnson, & Smith, 1991). Cooperative learning proposes that the different perspectives in a group can enrich each member's understanding. Furthermore, cooperative learning can enhance critical and reasoning skills and enhance tolerance of different perspectives.

The PBL method has been implemented for the last decade. Different from a traditional education model, there are a number of instructional decisions that need to be made based on factors such as class size, instructor preference, and course objectives. Duch (2001) classified those models into four types to allow instructors to teach large numbers of students: medical school model, floating facilitator model, peer tutor model, and large class model. In the floating facilitator model, the teacher is a facilitator working with groups no larger than four to five students. When the teacher identifies confusion in a group, the

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Figure 1. The instructional template of PBL units (Sage, 2000)



teacher may provide guidance to assist the group in resolving their confusion. When all groups become stuck on the same issue, the teacher suspends group discussions and discusses the issue with the whole class.

Figure 1 shows the eight steps in the PBL instructional template. Sage (2000) noted that the teacher should be a coach and guide students and that students must actively complete the problem-solving activity.

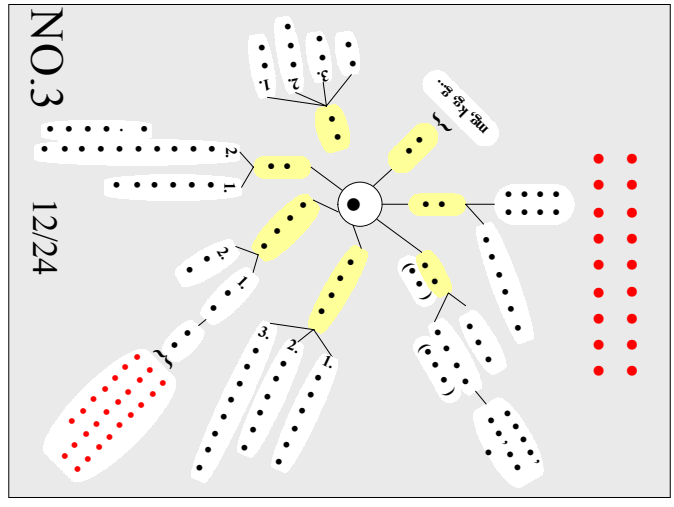
Teachers always need to gauge the progress of their students. Problem-based learning allows teachers to measure student learning via a brainstorm map constructed by students. The brainstorm map is created (Figure 2) when students try to solve a problem proposed by a teacher. Since this map represents concretely the concepts a student understands, teachers can use this map to measure student knowledge and to guide the direction future classes should take.

The experimental lecture used in this chapter is a portion of a lecture on computer hardware. The teacher is first asked to teach the fundamental concepts of the computer components. Then, based on the PBL instructional theory, the teacher poses a real-world problem for the students to solve. In this case, the problem is for small groups of students to design their dream computer.

For Chinese students a dream computer is either a high-performance computer or a computer that a student most wanted. Students are asked to discuss and

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Figure 2. Brainstorm map for force in physics (Hsu, Chen, Chang, & Yang, 2003)



create a brainstorm map for their dream computer. Students are required to discuss and identify all details from the abstract level to the product level on their brainstorm maps.

Students should, for example, discuss whether their dream computer needs a display card. Then, if they decide that it needs a card, they have to discuss which brand they want, WinFast or S3, then, in greater detail, they have to decide which product they want, such as WinFast 3D S680 or S3 Tri64 D2/V2.

If the students pick the HP brand as their display card, then they may have an incorrect conceptual relation between computer modules and computer accessories. Actually HP does not have any display card accessories. Similarly, if students decide they do not need a display card or forget to discuss whether they need a display card, then they may have missed one or more concepts. These two problems can be identified quickly by the teacher via the brainstorm maps.

However, as the brainstorm map is drawn by a small group (five to seven students), it is difficult to understand at first (Figure 2). Moreover, when the PBL process is applied to Internet teaching, the question arises, how can a teacher rapidly provide students with feedback based on the student discussions. This chapter presents a novel feedback tool based on PBL theory for Web-based teaching. This feedback tool first retrieves discussion records from a database and then restores the brainstorm map in hierarchical form to the concept-map relational database management system (RDBMS). With the concept-map

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RDBMS, the tool can replay the concept map to identify the differences of the brainstorm maps of the students and the teacher.

There are several issues that will be involved when this feedback system is developed. One major issue is who the system is designed for. This system is designed to provide teaching suggestions to teachers rather than learning methods to students. Another issue requires comparing methodologies for identifying the differences of the brainstorm maps of the students and the teacher. As we know, if teachers want to judge whether the brainstorm maps of students are right or wrong, they must have their brainstorm map first. The difference between traditional education and Internet-based education is that when teachers teach in the traditional classroom, the map could be stored either in the teacher's mind or in the computer, but the teachers must store the map in the computer when they teach in the Internet-based environment. The final issue is how to determine the sequence for teachers to provide the missed concepts to students.

The most challenging task is how to communicate to the teacher which concepts were missed by the students and how these concepts should be prioritized for future instruction. It is considerably easier to teach with the PBL method on the Internet if there is a tool that can provide feedback regarding the concepts students have missed. Such a tool would allow the teacher to feel more comfortable using PBL theory on the Internet. In the next section, the proposed Web-based PBL environment and the novel assistant tool (feedback system) are described.

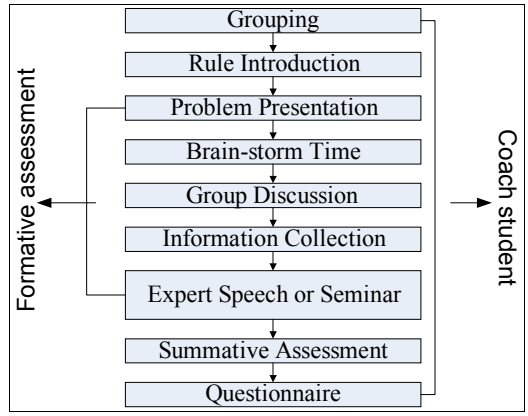
Description of the System

There is considerable research into how to best implement PBL theory in a Web-based learning environment (Hsu, Chen, Chang, & Yang, 2003). Chen, Kuo, Chang, and Yang (2003) developed an instructional model for PBL-based Internet learning called the Problem-Based Internet Assisted Learning System (PBIALS). Figure 3 displays the pedagogical model of the PBIALS.

Although the brainstorm map represents the knowledge students have learned, the concept map is easier for teachers to interpret (Figure 2). The concept map (Novak, 1981; Novak & Gowin, 1984) was designed to represent what knowledge students had learned and to aid teachers in determining the concepts that students are lacking. The concept map is significantly more hierarchical than the brainstorm map; the concept map is a semantic description of concepts and can do whatever the brainstorm map can do (Jones, Palincsar, Ogle, & Carr, 1987). Hence, the concept map was adopted in the development of the assistant tool.

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Figure 3. Pedagogical model of the PBIALS



Therefore, this chapter redevelops two parts of PBIALS, brainstorm time and group discussion, to provide teachers with suggestions about the concepts students lack. Although the brainstorm map is drawn by students during a brainstorm discussion, this map does not allow teachers to quickly identify the supplemental concepts students may require. To resolve this problem, the assistant tool generates a concept map-like tree map, which is based on the original brainstorm map and is stored in the discussion database in the PBIALS.

Before we present the assistant tool, the instructional process and the experimental PBIALS should be first described. According to the instructional model of the PBIALS, the instructional process is designed to include three major stages in school and one for outside school: School I, School II, School III, and Outside School. Figure 4 shows the whole instructional process. The rectangular with single line in Figure 4 is the instruction function in the PBIALS, and the double line represents the activity in class.

Based on the instructional process of the PBIALS designed in previous research, the architecture of the PBIALS is systematically constructed by integrating several tools for personal use, teamwork use, and recording (Figure 5). An Internet virtual classroom (IVC) is a Web-based learning system with community architecture, which supports knowledge management, community behaviors (chat room/bulletin board, etc.), and personal tools (Chang, Chang, & Heh, 2000; Lin, Chang, Cheng, & Heh, 1999). The instructional model/process of the PBIALS is evaluated with the IVC system.

The assistant tool is designed as a feedback system for teachers while using PBL theory to teach a class on computer hardware (Delisle, 1997; Gallagher, Sher,

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Figure 4. Instructional process of the PBIALS

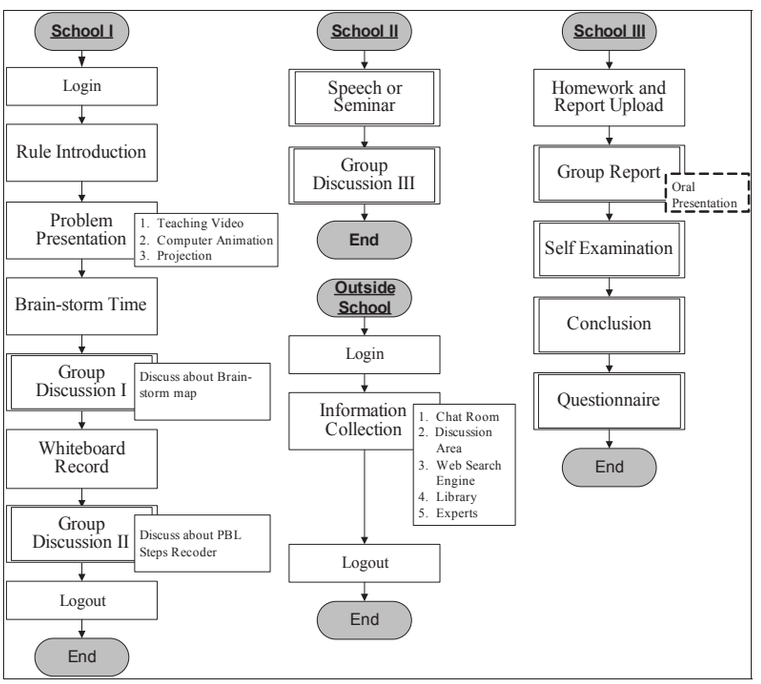
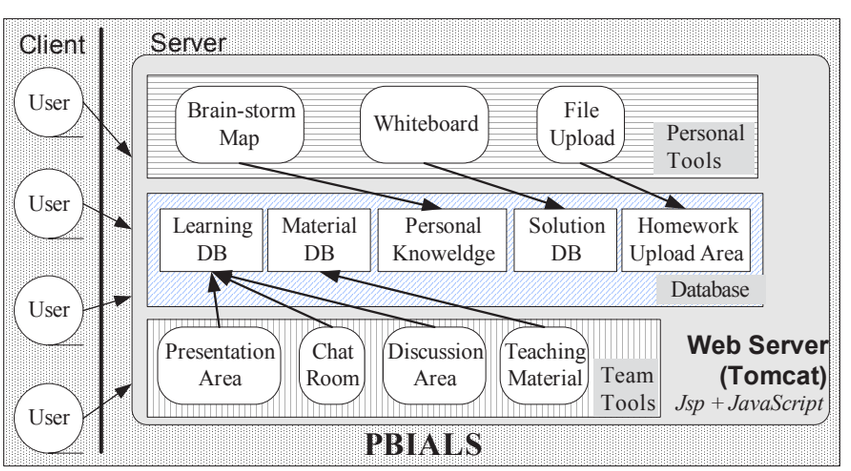
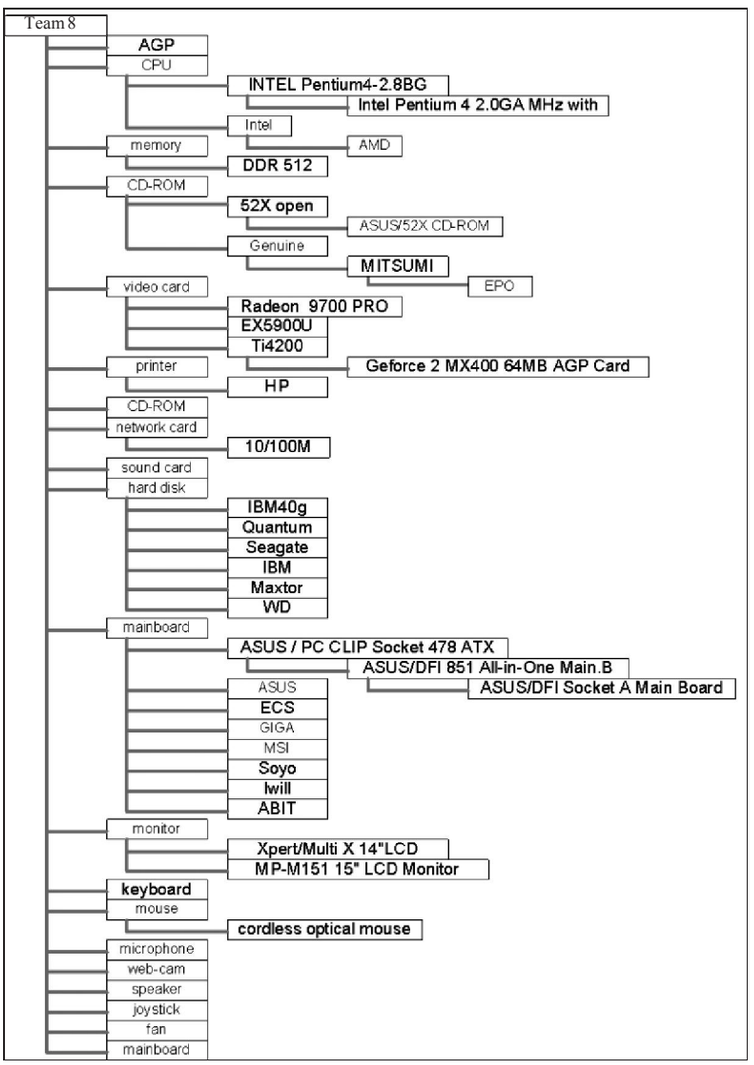


Figure 5. System architecture of the PBIALS



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Figure 6. Retrieved concept map for Team 8

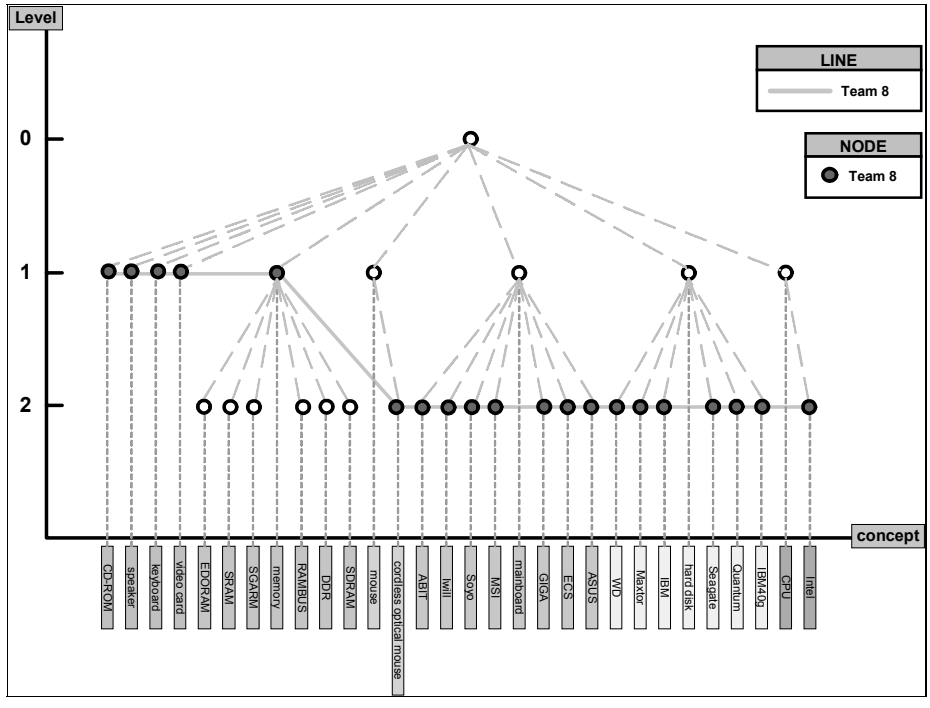


Stepien, & Workman, 1995). The feedback system first retrieves the concept map for each group from the discussion database which is integrated into the PBIALS (the Learning DB and the Personal Knowledge in Figure 5). The system then constructs the concept map for each team (Figure 6).

After constructing the concept map for each team, the system transforms the concept map into a two-dimensional plane. The x-axis of the two-dimensional plane is the concept-axis, and the y-axis is the abstraction level of the concept

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Figure 7. Consequent concept map of Team 8 on a two-dimensional plane

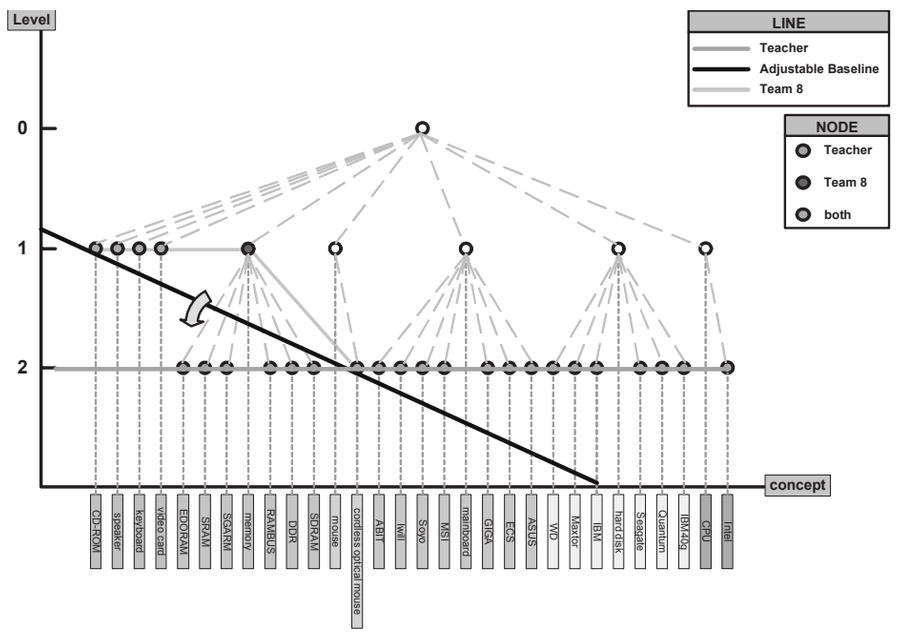


(level-axis). This concept map is similar to a tree map in that its branches can bend either left or right. The system will attempt to bend together those branches in which the leaf concept nodes belong to the same abstraction level. Figure 7 illustrates the concept map for Team 8 on a two-dimensional plane after the system bent (transforming) the original concept map (Figure 6).

Once the system merges both the teacher's concept map and the students' map on a two-dimensional plane (Figure 8), an adjustable baseline can be calculated. By rotating the adjustable baseline until it approaches the teacher's baseline, feedback identifying the concepts that require reteaching by teacher is generated. To generate the feedback, the system will rotate the adjustable baseline incrementally. If the adjustable baseline touches a teacher concept that students lack, then the system will report this to the teacher. This simple methodology is employed because once students receive the supplemental materials from the teacher, students will perhaps remember other things and correct their brainstorm map accordingly. For example, assume a group of students lacks both a display card and a sound card for designing their dream computer. When teacher tells the students that they lack a display card in their brainstorm map, they might

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Figure 8. Feedback according to the adjustable baseline



recall that they are missing a sound card too. If so, the adjustable baseline will be recalculated by the system.

The latest version of the assistant tool can be downloaded at http://maiga.dnsalias.org/PBL/tools/feedback.htm.

Usefulness and Evaluation of the System

Most assistant tools focus on how to best provide interactive services for students. This chapter presents an assistant tool designed to provide teaching recommendations for teachers based on PBL theory. In the PBIALS, students use keyboards and a discussion database instead of pencils and paper during discussions. The goal of this chapter is to provide a method that provides suitable teaching suggestions to instructors teaching in PBL-based e-learning systems.

This novel assistant tool is integrated into the PBIALS. There is a discussion database in the PBIALS that stores the discussion records for each team and can

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be retrieved by the assistant tool as previously described. Two questionnaires were developed to do an assessment of the PBIALS and the novel assistant tool. One questionnaire, the Curriculum Opinion Investigation, targets students learning about computer hardware through the PBIALS. The other questionnaire, Satisfaction and Usefulness Investigation for the PBL Assistant, is for teachers needing to make supplemental material with the assistant tool.

The Curriculum Opinion Investigation comprises two parts. The first part has 26 questions with answers measured on a 5-point Likert scale: strongly agree (SA), agree (A), neutral (N), disagree (DA), and strongly disagree (SDA). The second part has open questions allowing participants to make suggestions and ask questions regarding any aspect of the PBL and PBIALS. The Satisfaction and Usefulness Investigation also contains two parts, comprising five questions measured on a 5-point Likert scale and two open questions.

Two teachers in two semesters were enrolled in the study. The participants, roughly 50 students each semester (mostly male), were 1st-year students in the Information Program at Chih-Ping Vocational School. After the teaching unit finished, the questionnaire was handed out to the participants and teachers. There were 59.4% of students who considered brainstorming time very useful, allowing students to discuss and construct a specific map according to a given objective.

Both teachers reported that the assistant tool identified what they should know about the concepts the student groups lacked. The teachers also reported that using the assistant tool, it was easy to identify the concepts and the appropriate sequence in which they needed to be taught to students. Based on their responses, this assistant tool will be significantly improved if it can provide instant or, say, real-time feedback. Currently, the assistant tool is provided to teachers after the discussion stage (in PBL theory) is completed. However, this discussion stage covers more than one class, and students could also be allowed to continue their discussions after class. Hence, the assistant tool should be able to be used by teachers anytime during the discussion stage. To let teachers use the assistant tool mid-discussion is not a difficulty as it requires only a minor adjustment to the operational process of PBIALS; that is, the assistant tool is always ready.

Conclusion

Applying assistant tools and feedback systems to the e-learning field is not new. However, most of these applications focus on providing interactive services for students. This chapter presents a new assistant tool that produces teaching

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recommendations for teachers based on the PBL theory. The PBL theory is a student-centered teaching strategy which allows students to discover knowledge through small-group discussions. The teacher in this scenario acts merely as a facilitator. The goal of this chapter is to develop a possible solution that provides suitable teaching suggestions about students for instructors using a PBL-based e-learning system.

According to the questionnaire results, the teachers reported that the feedback tool was of considerable assistance in identifying and reporting what the students (small groups) were learning and thinking. Moreover, it was easy for the teachers to determine which concepts the students lacked and, thereby, teach these concepts to students. This assistant tool also increased teacher comfort levels when employing PBL theory.

The assistant tool was provided to teachers when the discussion stage (in PBL theory) was complete. However, the discussion stage could cover more than one class, and students could also be allowed to continue their discussions after class. Teachers reported that the assistant tool would be much better if it could provide instant or, say, real-time feedback; this feedback tool will be improved in the near future to allow teachers to use it at any point during a discussion stage of the PBIALS.

Summary

There are numerous key terms, definitions, and abstract concepts in computer hardware courses that students are required to learn and memorize in order to pass the exam. Therefore, it is often difficult to motivate students to learn computer hardware fundamentals because students appear to find the subject rather abstract, technical, and boring. Teachers also find it a bit difficult to gauge students' progress when teaching computer hardware concepts. These problems are related to the learning process, and therefore it is necessary to find an appropriate instructional model to overcome these problems. This chapter described a Web-based tool called the assistant tool, which is based on problem-based learning (PBL) theory and not only assists instructors in teaching computer hardware fundamentals but also overcomes the above-mentioned problems.

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Key Terms and Definitions

Brainstorm map: A brainstorm map and discussion can improve students' creative thinking and critical reasoning, communication, cooperation, and decision-making skills and provide students with various viewpoints. Students record their thoughts regarding what they already know and what they need to know on a brainstorm map (Figure 2).

Concept map: A concept map is a knowledge representation commonly used in education. It is a graphical node-arc representation illustrating the relationship among concepts (Novak, 1981; Novak & Gowin, 1984). The concept map, based on the cognitive map, can be in three forms: spider map, chain map, and hierarchy map (Jones et al., 1987). Different concept maps can be applied to handle different types of knowledge. The hierarchy map was selected in this chapter for being easily understood.

Constructivism: Constructivism assumes that knowledge is not absolute but rather constructed via the learning process and based on a learner's previous knowledge and worldview.

Cooperative learning: Cooperative learning focuses on student interaction. Cooperative learning exposes students to different perspectives that can enrich their understanding. Cooperative learning can enhance critical and reasoning skills and improve tolerance of and willingness to adopt new concepts.

PBL: Problem-based learning is student-centered, uses small student groups, and positions the teacher as a facilitator or guide. Life problems (real-world problems) are used as the starting point for the instructional process in PBL. Clinical problem-solving and self-directed learning skills can then be learned via the learning process.

PBIALS: The instructional model of the PBIALS is similar to the instructional template proposed by Sage (2000). There are eight principal stages (excluding the questionnaire stage) in this instructional model (Figure 3).

Situated learning: Situated learning argues that learning should take place in realistic settings to make learning meaningful. From this, we can infer that scientific curriculum should be incorporated into students' experiences. Without situated learning, traditional education loses its ability to teach practical knowledge.

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Review Questions

1. Discuss the difference between the PBL system and the traditional learning approach.
2. Discuss the effectiveness of PBL theory in teaching and learning introductory computer hardware courses.
3. Discuss the difference between a brainstorm map and a concept map.
4. Discuss the architecture of the Problem-Based Internet Assisted Learning System (PBIALS).
5. List and describe three main features of the assistant tool.
6. List and describe possible enhancements to the assistant tool.

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