

Design and Implementation of a Problem-based Digital Textbook

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Abstract

This paper proposes a problem-based digital textbook (DT) by defining an instructional model of problem-based learning (PBL) for DTs. The objective was to develop a DT that stimulates self-directed learning through the support of a wide range of student-centered learning activities to enhance the overall learning experience and effectiveness. As an application, a problem-based DT that performs PBL according to the proposed instructional model was developed for the subject of general computing used by high schools in South Korea. For the experiment, the DT was applied to practical classes for one semester at a commercial high school and there were generally very positive responses and enhanced problem-solving achievement.

Keywords: *Digital textbook, Problem-based digital textbook, Problem-based learning*

1. Introduction

Information technology (IT) has transformed the content and methods of education, providing a ubiquitous educational environment where anyone can access educational information beyond traditional time and space limitations. With these changes in diversified educational environments, printed textbooks (PTs), which play a significant role in schools, are undergoing a transformation into digital textbooks (DTs), which can implement various additional functions and roles that analog media cannot offer [1]. To address these changes, the South Korean government, under the Ministry of Education, Science, and Technology (MEST), announced the Smart Educational Strategy Action Plan in October 2011 to transfer current PTs in all subjects in elementary and secondary schools to DTs by 2015 [2]. Not only textbooks, but also reference books, exercise books, dictionaries, and glossaries are going to be integrated into DTs with various types of multimedia features, including audio, graphics, video, and animations. Ultimately, the aim is to create a cloud-based educational service environment for future education in South Korea. MEST had already begun this project with the establishment of the Mid- and Long-term Digital Textbook Commercialization Strategy in 2007 [3]. In 2009, MEST developed prototypes for the major subjects taught in elementary schools (e.g., Korean Language, Mathematics, English, Science, Music) and these DTs are currently being tested in 132 schools as a pilot study for the development and distribution of all DTs to all nationwide schools by 2015 [2, 4].

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The main focus of the current development of DTs is to completely transfer the contents of all PTs to computer-based books by integrating several learning materials with the benefits of multimedia features. This effort is worthwhile to give birth to new forms of future education materials; however, the development of DTs should also focus on the implementation of various instructional methods to provide more diverse learning activities and improve student learning achievement with greater efficiency and effectiveness. In this paper, we propose a DT that enables the performance of problem-based learning (PBL) to enhance the overall learning experience and its effectiveness, and to provide a much wider range of learning activities in a self-directed learning environment. The problem-based DT aims to help students develop more flexible knowledge, problem-solving skills, and collaboration skills through means of self-directed learning [5]. As a prototype for this proposal, we defined an instructional model of PBL for DTs and developed a problem-based DT for the subject of general computing used in commercial high schools in Korea [6].

The remainder of this paper is organized as follows. Section 2 reviews the theoretical background of the study, including that pertaining to PBL and DTs. Section 3 presents the instructional model of the PBL we defined for the proposed DT, and Section 4 presents the prototype of the DT implemented to perform PBL in accordance with the proposed PBL instructional model. Section 5 concludes the paper with some results from an experimental application to real classrooms.

2. Theoretical Background

2.1. Problem-based Learning

Student-centered pedagogies have long attracted much attention in the education sector; one of them is PBL [7]. PBL switches the educational paradigm from teaching to learning, emphasizing what students are learning rather than what instructors are teaching [8]. In this methodology, a problem is given to students first in the process of learning, unlike traditional instruction approaches. Students then achieve their learning from the process of working towards understanding and solving the problem and reflecting on their practical experiences in solving the problem [9]. PBL helps students become active learners by situating learning in real-world problems in the direction of experiential learning. The goals of PBL are to help students to “1) construct an extensive and flexible knowledge base, 2) develop effective problem-solving skills, 3) develop self-directed, lifelong learning skills, 4) become effective collaborators, and 5) become intrinsically motivated to learn” [5]

Figure 1 shows the learning cycle of PBL. First, the teacher has to develop a problem scenario and present it to the students. Problems should be developed carefully so that they are complex, multifaceted, and realistic [10] Students analyze the problem scenario carefully by identifying key issues and relevant facts. Following this, they formulate hypotheses on possible solutions to the problem. Then they derive their learning needs by identifying what they already know that is relevant to the problem and what they need to know to be able to solve the problem. After that, students conduct research and gather the knowledge and information required to solve the problem, referring to various forms of learning resources and acquiring new knowledge and information through self-directed learning, then applying them to resolve the problem. Then, they evaluate their ideas and hypotheses based on the new facts they acquired and finally they generate solutions. The role of the teacher is that of a facilitator to guide student activities and learning through the process of PBL [5].

3. Design of Problem-based Digital Textbook

3.1. Instructional Model of Problem-based Learning for Digital Textbooks

In this study, an instructional model of PBL for DTs was defined on the basis of the learning cycle of PBL, described by Barrow [16] and Hmelo-Silver [5]. Barrow, a founder of PBL, suggested the process of PBL in three phases: problem analysis, self-directed learning, and synthesis and application of newly acquired information. Hmelo-Silver divided the process into six phases, as presented in Figure 1. We redefined these procedures to suit DTs, as shown in Figure 2.

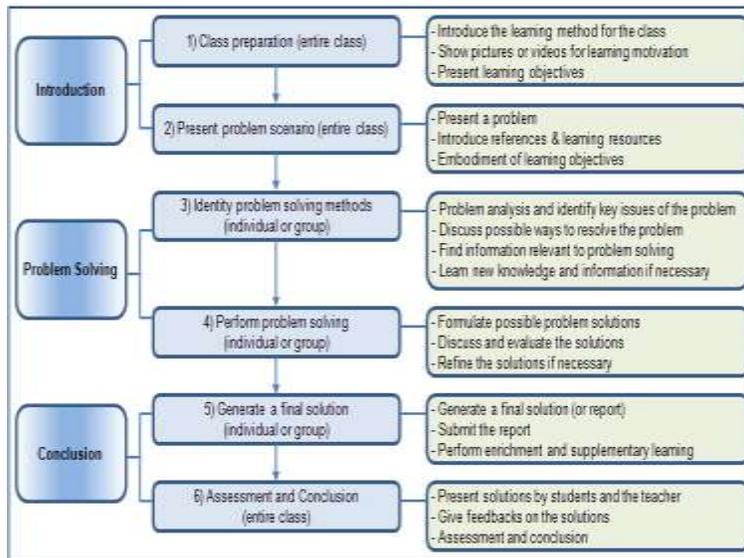


Figure 2. A Proposed Instructional Model of PBL for DTs

3.2. Instructional Model of Problem-based Learning for Digital Textbooks

Table 1 shows the features of the DT we propose in this study. It focuses on the features that can support the process of PBL, along with the basic and multimedia features of DTs. Various outside learning resources and materials, such as references, blogs, glossaries and dictionaries, images, and pictures, are also provided and hyperlinked to the DT to stimulate self-directed learning. Search features are also supported to allow students to find new knowledge and information associated with problem solving within the DT or in outside learning resources linked to the DT. Assessment functions are also provided for evaluating the problem-solving results and for determining each student's level of understanding for supplementary and enrichment learning. Furthermore, various interactive features, such as e-mails, bulletin boards, chatting, and specific websites to allow students to communicate with each other for problem solving, are supported. Moreover, a number of authoring tools are provided to enable teachers to create problem content, as well as allowing student to generate problem-solving results (reports).

4. Implementation of a Problem-based Digital Textbook

As an application of the above protocols, we developed a problem-based DT for a unit of the general computing subject used in commercial high schools in Korea. The unit content was related to the understanding of a graphics editing program (Adobe Photoshop) and learning how to use it. The DT was implemented to perform PBL in lesson units following the instructional model of the six phases presented in Figure 2.

Table 1. Features of the Proposed Problem-based Digital Textbook

Feature	Details	Explanation
Basic Learning Function	Features as a textbook	Perform the functions and roles of traditional PTs Achieve the same educational goals as traditional PTs (e.g., writing, memos and notes, underlining and highlighting, page turning, page moving, bookmarks, table of contents, index)
	Multimedia Function	Provide various types of multimedia objects (e.g., images, sounds, graphics, 3D motion graphics, animations, videos, virtual and augmented reality)
Learning Support Function	References	Provide various learning materials for self-directed learning
	Glossaries	Provide glossaries and dictionaries required for learning
	Search Function	Find information or knowledge within the DT or in other learning resources hyperlinked to the DT
	Hyperlinks	Hyperlinks to a variety of learning materials and resources to stimulate self-directed learning
	Interactions	Interactions between the teacher and students on the Web (e.g., e-mail, bulletin board, websites, chatting)
Learning Management Function	Evaluation Tools	Support assessment tools Provide supplementary or enrichment learning content by student understanding level
	Learning Management	Manage students' e-portfolios Determine each student's understanding level
	Authoring Tools	Create/Edit/Print problem-solving results using authoring tools (e.g., edit text, picture, 3D graphic, music, audio)

The screen composition of the DT basically adheres to the paradigm of general PTs, considering students' experience with PTs. The content of the DT is composed of text, sound, graphics, animations, virtual reality, and augmented reality. The teaching and learning materials of the DT were designed to be applicable to actual school classes. Furthermore, lecture notes in PowerPoint format (.ppt) were also provided for teacher-centered classes. The DT was developed on a desktop computer, but could be operated on a tablet computer. Figure 3 shows the screen configuration of the proposed problem-based DT. Following the proposed PBL instructional model for DTs, the teacher first give a brief explanation of the learning method for the lesson and selects the learning unit for the lesson in the DT.



Figure 3. Screen Configuration of the Proposed Problem-based DT

The teacher starts the class by showing animations or an audio to motivate the students and presents learning objectives and guides students to download the problem for PBL. The problem can be solved by individual learning or group learning, depending on the content of the learning unit. The students are informed about the learning materials and resources needed to solve the problem. Students analyze and identify the key issues of the problem, and then review possible ways to resolve the problem with group members, along with finding information and knowledge related to problem solving. After that, the students generate their final report on the learning activity sheet provided on the DT using the authoring tools. Then they submit their final report to the teacher through the DT, and the reports are released on a bulletin board in the DT for cross-referencing. The teacher can provide feedback on the final results. Figure 4 and Figure 5 show the description of a problem and an example of finding information associated with the problem. Figure 6 and Figure 7 show examples of a group-registration process for group learning and a final result submission for the problem.



Figure 4. An Example of a Problem Description



Figure 5. An Example of Finding Information Related to the Problem



Figure 6. An Example of a Group-registration Process for Collaborative Groups

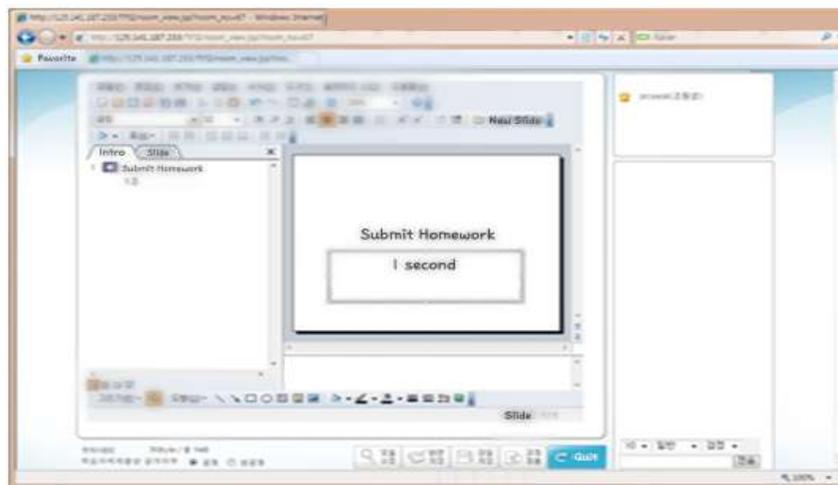


Figure 7. An Example of a Final Result Submission

5. Conclusion

We designed an instructional model for PBL with DTs and developed a problem-based DT that performed PBL following the proposed PBL process. The objective was to develop a DT that supported a self-directed learning environment through a much wider range of student-centered learning activities, as well as a customized learning environment to accommodate students' needs, preferences, and understanding levels to help students develop more flexible knowledge and problem-solving skills, and improve their learning achievements.

As an application of the proposed approach, a DT was implemented and applied to actual classrooms for one semester at a commercial high school in Korea. To verify the educational

effectiveness of the problem-based DT, two learning achievement tests (LAT) and three surveys on the DT were conducted after using the DT for two semesters. The experimental results showed that students' problem-solving performance and abilities were improved after using the DT, compared to using PTs. In particular, the learning performance of lower-level students (i.e., the 0~24.9% percentile) was improved after DT usage. In addition, the results of a survey on user satisfaction, usability, and perceptions about the DT were generally very positive. In future research, more diversified teaching and learning methods should be implemented in DTs to enhance their pedagogical advancement. This study will provide some guidance and direction for the development of other instructional methodologies in DTs.

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2018. Design, Selection, and Implementation of Instructional Materials for the Next Generation Science Standards: Proceedings of a Workshop. Washington, DC: The National Academies Press. doi: 10.17226/25001. —. Suggested Citation: "4 Models for Developing and Distributing Instructional Materials ." National Academies of Sciences, Engineering, and Medicine. 2018. Design, Selection, and Implementation of Instructional Materials for the Next Generation Science Standards: Proceedings of a Workshop. Washington, DC: The National Academies Press. doi: 10.17226/25001. —. The book is broken into three sections : digital system design concepts, use of tools, and systematic design of digital systems. This book will be of interest to hardware design practitioners who are already familiar with basics of logic design and want to move into the arena of automated design and design implementation using field programmable devices. For this audience, this book provides a recap of digital design topics and computer architectures and shows the Verilog language for synthesis. In addition, for an industrial setting, the book shows how existing design components are used in u