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DESIGNING A DIGITAL TEXTBOOK FOR THE INSTRUCTOR-LED CLASSROOM BASED ON THE PRINCIPLES OF LEARNING

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Abstract. *Digital textbooks have evolved into a variety of forms. This study explores the dimensions and future development of digital textbooks. We suggest several design strategies for developing digital textbooks for instructor-led classrooms. First, digital textbooks should support questions, answers, and assessments, which are fundamental to the activities of a classroom. Second, they should have the ability to collect and utilize data generated from learning processes, which is a critical way to observe students' learning behaviors. Third and fourth, they should facilitate the engagement of students in learning activities and support some of the functionalities of course-management systems. These strategies are based on the principles of learning. Finally, we present several prototypes of the learning resources available on digital textbooks.*
Keywords: Digital textbook, Functionalities of digital textbook, Instructor-led classroom, Learning activities, Learning effectiveness

1. **Introduction.** In higher education, the textbook is the most basic teaching tool in the classroom. The information contained in textbooks provides a basis for the interaction between teachers and students. Textbooks help standardize the material that teachers present for different subjects, ensure that classroom content is aligned with mandated curricula, provide a focal point for instructional activities, support pedagogical approaches, and give structure to homework [1,2].

Digital textbooks provide a new form of teaching material that differs from traditional printed textbooks. They were originally known as electronic books (e-books), but since 2007 they have been called digital textbooks to highlight their instructional role in the classroom [3]. It is important that instructors understand students' perceptions of textbooks because instructors are continuously challenged to find innovative, novel, and attractive learning opportunities to match the different ability levels of students. Digital textbooks may be an effective means by which instructors can engage students on multiple levels [4].

There are currently three types of digital textbook available. The first type is essentially a scanned version of the printed textbook. These are often available as PDF files and usually have no dynamic or active items. The second type has some additional functions, such as links to related web sites, questions and answers, and term searching. The last type is a textbook that does not look at all like the existing printed version [2,5].

The focus of current digital textbook research is to transit the contents of all printed textbooks entirely to computer-based books. This is important in that it suggests a new vision of teaching and learning materials [6]. However, questions about the educational effect of each type of digital textbook remain. More specifically, how should digital textbooks evolve as they get used in educational institutions? This study was designed to

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answer this question. Survey studies of student satisfaction have revealed that some students agreed that reading a text in electronic format was beneficial [7], but the majority of student experiences were negative [8,9]. Digital textbooks are most effective and engaging when they support learning by including interactive materials with learners [10,11]. In this context, we believe that digital textbooks should support a wider range of learning activities and facilitate a high level of learning achievement. In this article, we design a digital textbook for the classroom based on the principles of learning. We first suggest some design strategies for the development of digital textbooks. Then, we present the prototypical learning objects of the digital textbook examined in this study.

2. **Design Principles.** Many studies have outlined the potential strengths and weaknesses of digital textbooks. Digital textbooks include the fundamental features of printed textbooks and provide additional functions related to information technology and the digital environment [12-14]. However, students have reported that digital textbooks are hard to read, underline, and mark to highlight important parts [15].

The model of digital textbooks ultimately selected should be based on the requirements of the learners and the instructors. In this section, we suggest some design strategies for the development of next-generation digital textbooks.

- ***Questions and responses***: Postman [16] has argued that all knowledge results from questions, which is another way of saying that questioning is our most important intellectual tool. Kerry [17] suggested that questions are important in teaching for the following reasons: to stimulate interest and awaken curiosity, to monitor students' learning, to help students learn from one another, to respect and evaluate the contributions of others, and so on. Even without such arguments, questions and responses (QaR) are the most fundamental and important activities in education; they are reflections of the levels at which each student understands specific materials. Digital textbooks, therefore, should be able to support QaR, particularly instructors' questions and students' reactions, and to collect and manage data on the QaR in further steps.
- ***Monitoring students based on learning data***: Instructors should monitor student learning data, including learning time, participation in learning activities, learning scores for specific topics, and so on, to track students' progress and provide feedback [18,19]. Collecting and analyzing a large amount of learning data would be difficult or impossible in the traditional classroom environment, but it is entirely possible to do online. Data generated from learning processes are a valuable resource for investigating students' learning behaviors. Matsui and Okamoto [20] defined learning data in terms of students' performances on examinations and information in the operation log of the learning tools used in a given time span. Several studies have indicated that the use of learning data can contribute to increased student performance [21-23].
- ***Assessment***: Another function of digital textbooks is the ability to support assessments. As education has evolved, many types of assessment have been developed. Traditionally, assessments have been conducted through various forms of evaluation, such as matching questions, fill-in-the-blank questions, essays, and multiple-choice questions [24,25]. These forms are usually employed offline to assess students' understanding. In an online environment, we can quickly and accurately use additional approaches, including self-assessment and peer-assessment, in addition to traditional ones. The next-generation digital textbooks should support alternative as well as traditional types of assessment.
- ***Experimental learning and learning-by-doing***: Engaging students in learning activities in the classroom is a highly effective method for encouraging active learning [26]. For example, Cummiskey et al. [27] emphasized that engaging students in the

process of data collection leads them to be more interested in the results derived therefrom. The idea of student engagement is based on the conviction that learning is improved when students are involved and concentrating in class. Student engagement and concentration are primary objectives pursued by instructors. Future digital textbooks, therefore, should support a flexible framework for learning-by-doing or experimental learning. This is the "something" that traditional printed books can never offer.

- ***Including some functionalities of learning management system and course management system***: A learning management system offers various functions that involve the storage and maintenance of information about students, including data on student interactions with the learning content and communication between students and the administration. The fundamental goal of course management system is to administer everything required for live, instructor-led classrooms. Instructors can mark and evaluate learners' work while online and can integrate appropriate support materials, including exercises, reference materials, and tests, by course or curriculum [28]. Next-generation digital textbooks will not be restricted to the duplication of printed pages on a digital device [5] and will be able to provide more types of learning content and digital tools. To these ends, they should include many of the functionalities of the systems.

3. **Learning Objects for Digital Textbooks.** Educational psychologists and pedagogues have established some principles of learning, also referred to as laws of learning. These principles provide additional insight into what makes people learn most effectively. A century ago, Thorndike [29] described three basic laws of learning: readiness, exercise, and effect. This section presents some learning objects designed for classroom teaching based on the learning laws.

The first primary law of learning, 'readiness', is the motivational aspects of learning, and it implies a degree of concentration and eagerness. There are many ways in which students concentrate in class. One involves active learning, including class discussions, debates, and questions and responses. Clickers, for example, are an interactive technology that enables instructors to pose questions to students and immediately collect and view the responses of the entire class [30]. We believe that student-response systems, such as Clicker, can be included in digital textbooks. Indeed, it would be more efficient if such systems were integrated with other learning objects. Figure 1 presents an example of questions and responses included in the digital textbook developed in this study. Instructors can generate questions when they want. The responses of students are immediately collected, provided to the instructor as well as the students, and used for further data analysis. In addition, digital textbooks should be able to provide many types of homework and assessment tools.

Figure 2 shows an example of the way in which the learning status of students is monitored based on the learning data collected by a digital textbook. Such data enable teachers to grasp each student's level of understanding of specific learning content and provide appropriate feedback in real time.

The second law of learning, 'exercise', states that those things that are repeated most often are remembered best. We generally use homework to elicit repeated practice. Homework reinforces learning because it encourages repetition or extends understanding.

Figure 3 presents an example of an activity-based object for learning-by-doing or experimental learning. In statistics, for example, many students have difficulty understanding the concepts of probability and conditional probability. The best approach to clarifying these concepts is for students to perform random experiments. This experimental learning can help enhance the third law of learning, 'effect', which is based on the emotional reaction of the student. The principle of 'effect' states that learning is strengthened when

accompanied by a pleasant or satisfying feeling. Activity-based objects can lead to an improved concentration and satisfaction. The experience of being rewarded for the results of practice leaves students feeling satisfied, and their chances of success are increased when learning is pleasant.

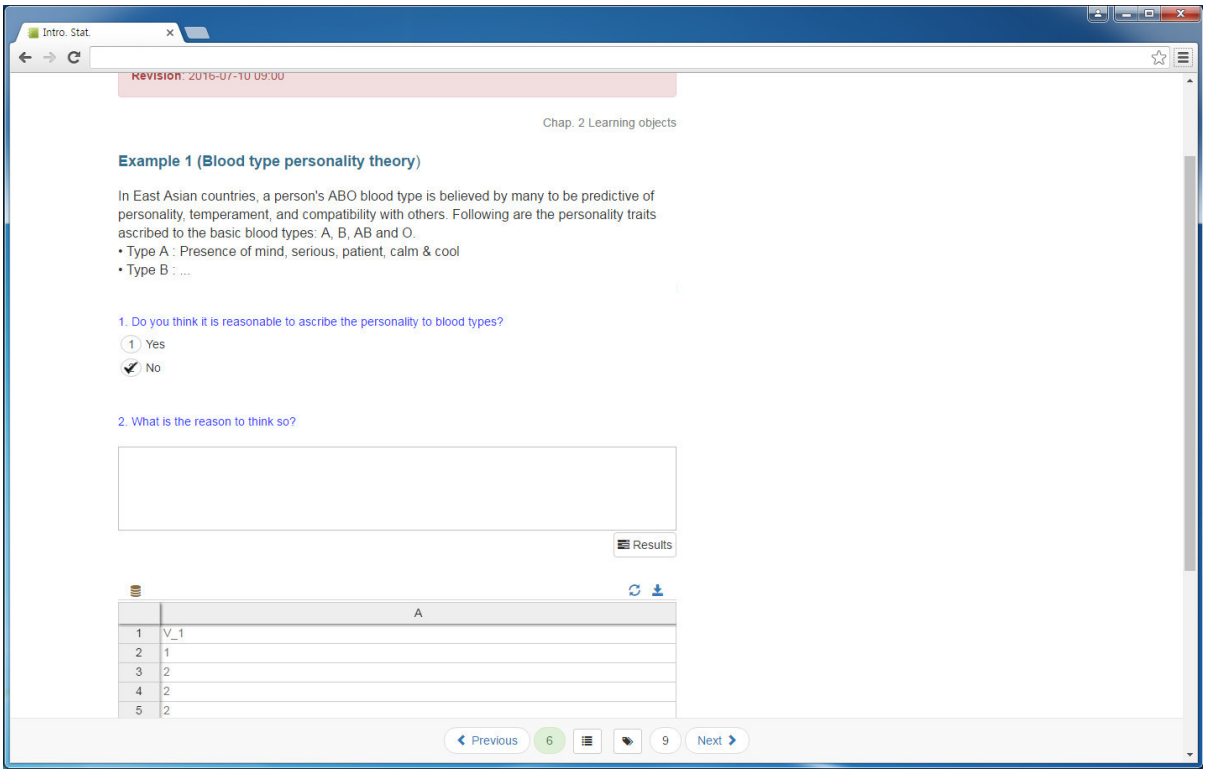

FIGURE 1. Question and response

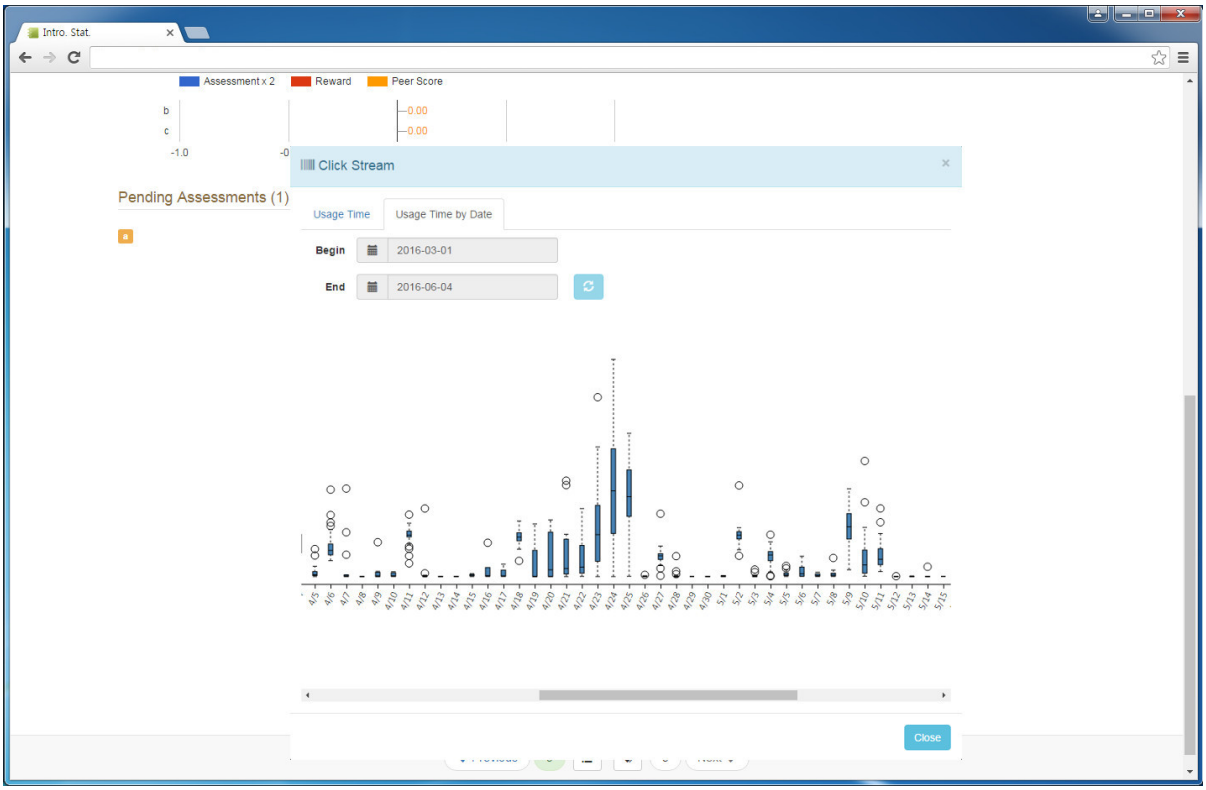

FIGURE 2. Learning data

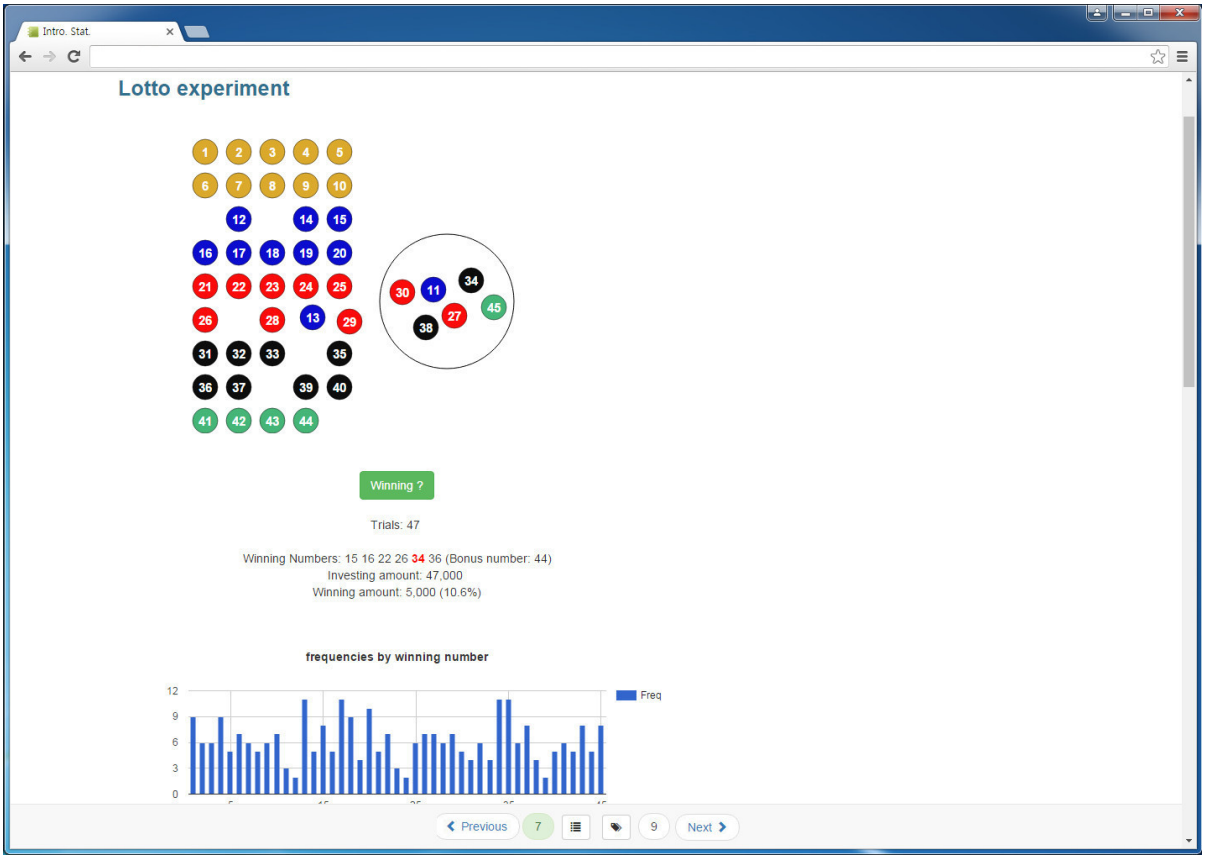

FIGURE 3. Activity-based object for learning-by-doing

4. **Discussion.** A key element of the revolution in education is the emphasis on interactive, exploratory, and collaborative learning activities [31]. Many of these activities will be implemented using tablet devices that are connected, through the cloud, to the systems and devices used by other students, teachers, parents, content publishers, and educational institutions [32]. Digital textbooks can support richer learning activities with a combination of various learning materials, including textbooks, reference books, workbooks, dictionaries, and hyperlinks, as well as with multimedia content, such as audio, 3D graphics, animations, video, and virtual and augmented reality [6].

There has been an ongoing discussion on the future of digital textbooks. Young [33] argued that publishers may soon control not only the textbook material but also the course content as well. In their push to increase the interactivity and usefulness of digital textbooks, publishers have included interactive content, such as dynamic quizzes, that feed results back into learning and course management system (LCMS) grade books. Junco and Clem [34] wrote that the merger of textbook companies with LCMSs, adaptive learning, and learning-analytics products hints at the future of digital textbooks. Valjataga et al. [35] emphasized the roles of teachers and students as creators and authors of content. In the context of these concepts, we think digital textbooks should be designed to support the learning principles.

Consequentially, we think digital textbooks should include the basic features of printed textbooks and the supplementary features of information technology and digital media. To support more effective learning, digital textbooks need to support student-centered learning by including interactive materials with learners and the use of learning data.

5. **Conclusions.** In this paper, we explored the design principles for digital textbooks for the classroom based on the laws of learning and presented several prototypical learning objects available in digital textbooks. There are many forces re-shaping higher education,

and whatever future faculty teach it is likely that much of that teaching will be done differently [5]. We expect digital textbooks will evolve into something completely different from what is available today to help teachers teach and students learn.

There are many issues that need to be explored in the future. First, electronic materials have a lot of advantages that they can provide interactive learning objects and cater to individual learning styles. However, most instructors do not have the requisite technical skills of creating these materials. To solve the problem, numerous component modules should be provided, and further expansion of the modules should be available in the planning stage. It is also necessary to develop visualization and analysis modules to extract meaningful information from data generated in the learning process.

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