Double Loop: A Model of Scenario-Based Instructional Design and Implementation

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ABSTRACT
Design of usable and useful interactive systems requires a model that explains the activities and context of use. Similarly, design of instruction requires a valid model that illustrates the activities of student and teacher in class and classroom context. This paper describes a process model for designing and implementing instruction using various multimedia instructional materials. Our model takes a scenario-based approach as its central concept. It conceptualizes the whole process of evolving multimedia instructional material as a double-loop of activities in which teachers and students work together to enrich it. The external loop comprises planning, implementing, checking and evaluating instruction, whereas the internal loop is made up of its implementation, verification, and modification. We provide a formal definition of the scenario used in the double-loop model and illustrate an example of how scenarios are used in the model. We also explain our instruction system, which facilitates activities in the double-loop model.

Author Keywords
Claims analysis, instructional design, model, multimedia instruction, scenario.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Recent development of information and communication technologies provides opportunities to design and use new forms of education such as e-Learning and distance learning. On the one hand, this form of education affords us the flexibility of time and place; thus, it truly presents the possibility of enhancing the students' educational opportunity and outcomes.

On the other hand, it may increase instructors' workloads. Instructors must learn how to create, edit and present documents with various multimedia tools such as authoring, database and presentation tools. Instructors may be compelled to allocate more time to creating multimedia documentation than just developing conventional ones for class activities. In addition, use of multimedia documents in teaching may restrict the flexibility of instructors' class activities because of technological limitations of current tools. For example, instructors work on multimedia documents in advance of their classes and follow a sequence of multimedia documents in class; however, it is difficult to update the multimedia documents while teaching. Such a situation is much worse in computer-supported distance learning situations because the technology used in teaching plays a central role.

This paper is intended to propose a process model of evolving multimedia instructional materials. The paper examines the model using an example and illustrates our instruction system, which supports the process model execution. Our motivation on this project is derived from theory and practice in human-computer interaction [2]. To be precise, design of usable and useful interactive systems requires a model, which explains the activities and context of use. Similarly, design of instruction requires a valid model that illustrates activities of students and teachers in class and in the classroom context.

SCENARIO-BASED INSTRUCTIONAL DESIGN AND IMPLEMENTATION

Scenario-based instructional design and implementation is a process model in which instructors define instructional contents by writing instruction scenarios, implementing them, evaluating the implemented scenarios, and revising the original instruction scenarios. Different communities use different views of scenarios [4]. Therefore, we employ the following definitions relating to scenarios.

Definition 1 (Instructional material): Instructional materials are multimedia documents used in class to teach. Examples of teaching materials include video clips, pictures, diagrams, and web pages. Instructional material is also called teaching material.

Definition 2 (Instructional content): Instructional content c is defined as a sequence of teaching material m. Put more formally, $c = m_1, m_2, \ldots m_n$. Instructional content is also called instruction. In a class situation with information and communication technologies, instructional content

represents the presentation order of multimedia instructional materials.

Definition 3 (Instruction scenario): An instruction scenario is a story that contains instructional contents and various related information. The instruction scenario (*IS*) is defined as a four-tuple (*A, B, G, e*) for which *A* is a set of actors, *B* is a set of background information, *G* is a set of goals, and *e* is a sequence of actions and events. Elements in A, B and C have correspondence: actor a_1 has specific background information b_1 and a specific goal g_1. An instruction scenario is represented as (*a, b, g, e*) if each set contains a corresponding element. In a class situation, the actor is usually a student, a teacher, or both.

A sequence of actions and events *e* contains the instructional content *c*; that is, *e* interleaves the instructional materials of *c*.

Definition 4 (Scenario-based instructional design and implementation): Scenario-based instructional design and implementation are working processes of creating and examining an instruction scenario or its iteration.

PROCESS MODEL OF SCENARIO-BASED INSTRUCTIONAL DESIGN AND IMPLEMENTATION

Double Loop Model

Scenario-based instructional design and implementation forms a double-loop structure. Design and implementation require a whole process of evolving multimedia instructional material as a double-loop of activities in which teachers and students work together to enrich it. Figure 1 depicts an overview of the double loop model. The external loop consists of four phases: planning, implementing, checking and evaluating instruction. The internal loop comprises three phases: implementing, checking and modifying instruction.

Example of a Double Loop Model: A Computer Science Class for First-year Students

Assume an instructor has a course of introductory computer science (course number: CS1024) for first-year students in college. In this course, she teaches liberal arts students basic knowledge and skills with regard to computers. The first class of CS1024 (shown as CS1024-1) aims at a brief introduction to the history of computers.

Planning phase

She works on and prepares instructional materials of the class summarized in Table 1. She uses a web page of the course website to show the day's agenda. She shows a video clip to briefly explain a history of computers. She presents an MS PowerPoint slide to discuss the relationship between computer hardware and software. She conducts a demonstration of actual software such as MS Word and Excel to show examples of computer applications. She shows a web page of the course website to explain the day's homework.

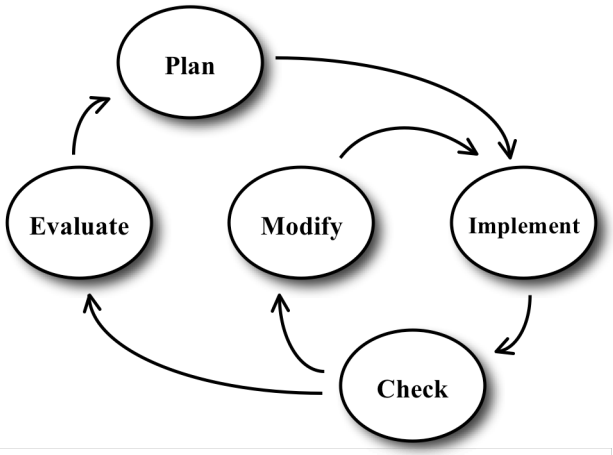

Figure 1. Double loop model of scenario-based instructional design and implementation

Her initial lesson plan is to present the prepared instructional materials in the following order of presentation that represents the instruction content of the class. It starts at showing the day's agenda and ends at explaining homework.

Instructional content: $c(CS1024\text{-}1) = m_1, m_2, m_3, m_4, m_5$

The instructor envisions a class scenario while she is preparing the instructional materials. As specified in Definition 5, the scenario consists of actors, background information, goals, and a sequence of actions and events. The following scenario is in textural narrative form.

Material id	Content	Format
m_1	Agenda for today's topics	Web page
m_2	Brief history of computer	Video clip
m_3	Diagram of the relationship between computer hardware and software	MS PowerPoint slide
m_4	Example of computer application	Software
m_5	List of homework	Web page

Table 1. Instruction materials of CS1024-1

Basic Scenario (Nick experiences the first class of CS1024): *Nick is a first-year student of history department. He takes CS1024, the introductory computer science class at the first semester in college. He will learn computer and information literacy for college students in this class.*

CS1024 is held at a computer lab on campus. The computer lab furnishes a desktop PC at the instructor's desk. The PC display image can be presented on the front screen of the computer lab using the ceiling projector. In addition, each student's desk has a desktop PC.

In class, Nick looks at the day's agenda, which is projected on the front screen. As directed by the instructor, he operates the PC and opens a web browser to display the day's agenda page on the screen. The instructor's talk progresses to the history of computers. The instructor shows a video clip for the history of computers on the front screen. The video clip shows basic computer components and how they function together. Nick becomes interested in how a CPU processes data in its main memory.

After the video clip presentation, the instructor displays a diagram that illustrates basic computer components, which include the relationship between CPU and main memory. The instructor draws an additional freehand diagram and comments on it. Nick finds the importance of the capacity of main memory when a computer processes a large amount of data.

The basic scenario is a success story; at the same time, it functions as a problem scenario [8]. The instructor analyzes it and assumes exceptional scenarios as follows. The exceptional scenarios are obtained using a claims analysis technique [1] or scenario-based inquiry.

Exceptional Scenario 1 (Nick hesitates to interrupt): *Nick looks at a video clip that is projected on the front screen. He becomes interested in the topic of how a CPU processes data in its main memory. He does not grasp a clear idea of how the CPU interfaces with its main memory, but he feels that he does not want to disturb the class while the video clip is showing. Instead, he uses the PC on his desk and seeks the answer himself. He focuses on searching for the answer himself. For that reason, he misses the discussion following the video clip. Eventually, he becomes unable to understand the remainder of the class.*

Exceptional Scenario 2 (Nick has an advanced question): *Nick asks the instructor a question regarding the way in which a CPU processes data in amounts that are greater than its main memory size. The instructor has no pertinent diagram that explains this process. She tentatively combines two diagrams on main memory and a hard disk of computer, then explains the concept of virtual memory.*

The instructor examines the exceptional scenarios to clarify the following claims.

- The characteristic and usage tip of the instructional material M_2: Video clip provides rich information to students, but may inhibit discussion among teachers and students when it plays.
- Students might have advanced and unexpected questions.

The scenarios provide mental preparation for the instructor. In this sense, the scenario used in the planning phase works as that for strategic planning [9]. Examining the claims and scenarios, for example, the instructor works further on an additional instructional material (m_a), which could be used for explaining the virtual memory concept. Now the instructional content would be the following sequence of instructional materials, where parentheses represent an alternative.

Instructional content after examining the advanced question claim: $c'(CS1024\text{-}1) = m_1, m_2, (m_a), m_3, m_4, m_5$

The reflective activity in the planning phase, with its scenarios and claims, provides the instructor mental preparation for and flexible attitudes to the class.

However, it is impossible to envision all possible exceptions and prepare for them before the class session. Therefore, instructors must modify instructional contents during class activities when unexpected events occur in class. This situation indicates the internal loop of the double loop model, an iterative cycle of implementation, checking, and modification of instructional content.

Implementation phase

The instructor conducts the class in a classroom. The implementation phase consists of in-class teaching activities with instructional contents. In this example, the instructor manages the initial instructional content examined during the planning phase: *c(CS1024-1)*. She explains the day's agenda, shows the video clip, and so forth. She may use a computer tool that supports execution of the instructional content. Notwithstanding, the classroom is a dynamic environment. It always contains exceptional events. She needs to cope with unexpected events that occur in class.

Checking phase

Unexpected events can be recognized if the instructor has a clear instructional content. In this example, she has *c(1024-1)* as the instructional content of the first class.

Exceptional Scenario 3 (Printout does not come out): *Nick wants to print out the homework page of the course website displayed on his PC screen. He sends a printout command and goes to pick up the printout to the printer, located at the rear corner of the computer lab. He is unable to locate his printout, so he returns to his desk and sends a printout command again. Once again, he visits the printer, but he is not able to locate his printout. Nick starts thinking that either he should send a printout command again or ask for help from the instructor.*

This is an unexpected error scenario that occurs in the class. The instructor must cope with the error context. She helps to solve Nick's printer problem and reports it to other students in the classroom because they might have a similar, or even identical, problem.

Modification phase

The instructor resolves unexpected situations in class to adjust the instructional content or create instructional materials if necessary. For instance, the instructor seeks appropriate documents in a database and combines them to show it to students. The following scenario illustrates this situation.

Exceptional Scenario 4 (Printer runs out of paper): *The instructor notices that Nick might have a printer problem. After observing some of Nick's trials, the instructor confirms that the printer has no hardware problems. She finds that the printer has run out of paper. As she refills the printer with paper, it prints out several copies of Nick's printouts. She decides to explain tips of printer usage to all the students in class. She searches for a web page of printer information from the computer lab's website, shows the page on the front screen, and explains how students should use the printer appropriately.*

This unexpected scenario occurs in class. Therefore, if we assign m_b to the web page of printer tips, the actual implemented instructional content is as follows.

Implemented instructional content: $c_{result}(CS1024\text{-}1) = m_1, m_2, m_a, m_3, m_4, m_b, m_5$

Evaluation phase

The instructor conducts a summative evaluation of the planned instructional content and the resultant instructional content, which is obtained through execution of the internal loop of the double loop model. In addition, the instructor conducts a formative evaluation of the instructional content through reflection of all activities performed in the process.

In this example, the instructor compares $c_{result}(CS1024\text{-}1)$ with $c(CS1024\text{-}1)$ and examines how she would teach the instructional content of CS1024-1 in future class sessions.

INSTRUCTION SYSTEM

We are currently developing and evaluating an instruction system that supports the entire process of the double loop model. It allows teachers to create, record, present, and modify instruction while collaborating with students online.

The instruction system consists of instructor's terminals, student's terminals, lecture servers, and web servers. These components are connected online. Figure 2 shows the look-and-feel of the instructor's terminal. An instructor simply drags and drops multimedia objects from the database window to the main window to create, display and share them.

CONCLUSION

This paper proposed the double loop model of scenario-based instructional design and implementation. It illustrated the model using an example and explained our instruction system, which supports the model. We are currently using the system for evaluation. So far, we have received favorable comments on the system—it allows instructors and students to leverage timely information throughout all phases of the double loop model.

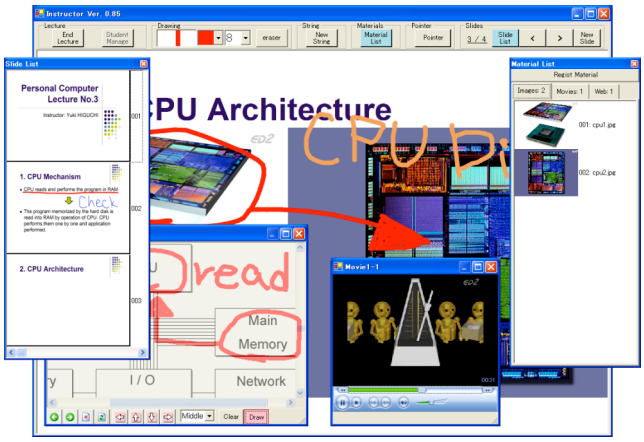

Figure 2. Look-and-feel of the instructor's terminal of the instruction system

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