An Extenics-based Intelligent Distance Learning System

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Summary
Recently, the web-based learning is becoming one of the major applications of the internet. By applying the extenics engineering method, a moodle-based intelligent curriculum website has been proposed in this paper. For implementing the proposed website, we take the course "Multimedia Implementation Using JAVA" as a case study. A moodle-based course management system has been constructed by providing friendly interface to fit most students in e-learning. In order to recognize the learning status of students to the provided course effectively, the content of the course is divided in detail, so as to record the web page and the period that students browsed more accurately. Through the experiments in our research, more accurate information of students' learning conditions can be obtained and analyzed. By applying the proposed extenics-based mechanism, instructors can provide students more adequate learning materials in accordance with individual student's aptitude.

Key words:
Course management system, Extenics engineering method, Moodle, website

1. Introduction

Web-based learning is currently one of the major applications of the Internet and it is to be a new and sophistically tool of the distance education [1]. While implementing any kind of distance instruction, it is necessary to setup a curriculum website for teachers and students to interact after class and for students to download related information from the curriculum homepage if necessary. It is very important for teachers to make sure if students really use the curriculum homepage to discuss or read related data. Most of the current educational web systems have functions to record students' learning history, provide on-line tests, and support group discussion, however, there lacks the function to provide a suitable assistance for individual students.

By applying the web-based instruction, the time-space limitation can be released, multiple teaching materials and individual teaching can also be provided. Well designed web-based instruction can achieve the effective study, reduce the learning period, promote the learning efficiency, and improve the learning attitude of students[2].

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The educational potential for instructional technology, specifically the use of the Web and Internet, continues to increase [3]. Shick [4] pointed that for meeting the current information society, teachers should have ability to apply the information technology effectively in teaching for improving students' learning efficiency and training students to apply the information technology effectively.
Many universities have their own web-based educational systems, such as ceiba [5] of National Taiwan University, The Cyber University [6] of National Sun Yat-sen University, Moodle-based educational system [7] of Ming Chuan University, and OnDemand, staring from 2001, of Waseda University. Starting from 2003, in Waseda University, based on OnDemand system, an eSchool was constructed to provide on demand mechanism for all courses. Functions of web-based educational systems in different universities are not the same and most of them are closed systems which cannot be used by teachers or students of other universities. However, moodle-based educational system is an open platform which supports more than 40 different languages and can be modified according to the purposes of users.

Our research is trying to design a moodle-based intelligent curriculum website which will be suitable for students and will make teachers to understand the learning situation of each student. The study expects to record the students' web browsing behavior accurately, so as to allow the teacher to understand what are students' needs, interests as well as their learning progress. Thus, the teacher can provide appropriate assistant for individual student's needs or interests. So the curriculum website can be created as a personal curriculum homepage to fit each student's needs and interests. For instance, more information and auxiliary materials according to the students' interest can be provided for students to learn by themselves.

2. Related Work

2.1 Website Interface Design

For designing a website interface, user-centered design, clear navigation aids, and feedback and dialog supports must be considered. User-centered design is a key

principle for interface design, which can reduce design costs and increase user satisfaction and effectiveness [8]. An effective instructional software user interface may reduce not only the cognitive load of learners who are performing tasks, but also the possibility of disengagement. However, in order to develop an effective user interface, designers must investigate and understand the target learners' characteristics, including computer skills, prior knowledge of the subject, and visual habits [9]. According to the research of Lin [10], we know that different interface design will influence learners' browsing behavior.

2.2 Learning Style and Cognitive Style

The concept of learning style traces the influence of a cognition and learning-centered approach to the psychology of individual development [11]. Many scholars indicate that the actual learning outcome of learner is different form the original expectancy, since there are individual differences among learners. The most popular model used is "Onion model" which is built by Curry [12, 13] to establish a complete structure of learning style categories. In addition, Riding [14] suggested that all cognitive styles could be categorized according to two orthogonal dimensions: the wholist-analytic and the verbaliser-imager dimension. The findings of Ford, Wood and Walsh [15] and Wood, Ford, and Walsh [16] suggested that individuals possessing different cognitive styles employ different search strategies.

As described by Harris et al. [17], the relationship between individual learning styles and Web-based instruction has received very little attention in the research literature. However, individual differences have significant effects on learners' behaviors, and one of these differences includes cognitive styles has been described in literatures Durfresne & Turcotte [18] and Riding & Rayer [19]. Thus, Baird & Fisher [20] suggested that future distance education research should consider the distance learners' unique characteristics and needs.

2.3 Instructional System Design and CMS - Moodle

Instructional System Design (ISD) is integrated consideration of the educational process. It considers every element which will affect the instruction interactivity. Moreover, teach and learning should be considered as an integrated system and must be analyzed and designed to achieve the perfect educational result. ISD is a methodology, while ISD Models are process flow of stages by applying ISD method. According to the educational application situations, different steps and sequence of operations are emphasized [21]. Linear ISD model is adopted generally. An ADDIE general model consists of analysis, design, develop, implement, and evaluation operation steps.

As mentioned previously, many universities have their own web-based educational systems. Most systems are closed and offered for their own faculty members and students only. Since moodle system released, more and more schools develop their own web-based educational system based on moodle. Moodle is a course management system (CMS), a free, Open Source software package designed using sound pedagogical principles, to help educators create effective online learning communities [22].

According to the research of Uzunboylu, Ozdamli, and Ozcinar [23], we know that moodle has Communication Tools, Productivity Tools and supports Group work. For students, they can discuss with others, share files, access context sensitive help, and have a home page that includes their personal information and their photos. For instructors, through the moodle-based system, they can schedule a chat using the course calendar; assign students to groups, or the system can randomly create groups and build student community. Figure 1 shows a sample user interface of a moodle-based system. Left hand side of the figure is for users to view all classmates' list and maintain their basic data; the right hand side shows calendar and course events. The course content is shown in the center of the interface.

Fig. 1 User interface of a moodle-based system

2.4 Extenics Engineering Method

The extenics engineering method was proposed by Cai [24] to solve the incompatible problem through the systematic transformation. Such as using a staff, that maximum of load-bearing is 200 kilograms, to survey the number of

tons of elephant in the traditional Chinese fable story. Incompatible problems cannot be solved directly. The key point in the Chinese fable story, "Tsao Chung weights an elephant," is to exchange an elephant for rocks. In order to solve the incompatible problems, the relationship of events, characteristics, and amounts must be considered. The extenics associative function is defined to find the relationship of events, characteristics, and amounts. It is defined to quantify the relationship between an element and a set. The range of associative function is (-∞, +∞) which means that an element belongs to a specific set with a certain degree.

2.4.1 Distance

In extenics theory, the relation between a point and a region is considered. The distance between two points has been defined in the classical mathematics, i.e., ρ(x, y) = | x - y | , is the distance between points x and y. In order to establish an associative function, the distance between a point and a finite region should be defined.

Let x be any point in the domain of real, (-∞, +∞), and X = [a, b] is a region in the domain, then the distance between point x and the region X can be defined as the equation 1 and illustrated as Figures 2 and 3.

$$\rho(x,X)=\left|x-\frac{a+b}{2}\right|-\frac{1}{2}(b-a) \tag{1}$$

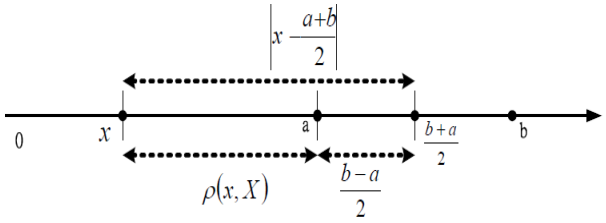

Fig. 2 Distance between a point and a finite region (x is outside the region)

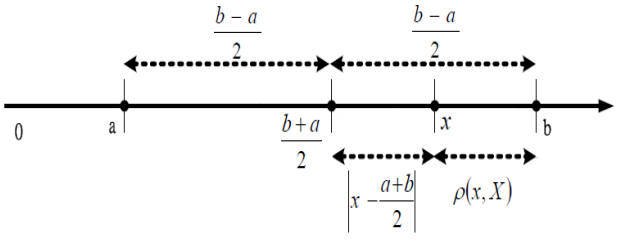

Fig. 3 Distance between a point and a finite region (x is inside the region)

2.4.2 Value of the position

In addition to considering the relation between a point and a region, the relation between two regions and the relation between a point and two regions should also be considered. The relation between a point and two regions can be expressed by a value of the position D, defined as follows: Let X_0 = [a, b], X = [c, d], and $X_0 \subset X$, then the value of the position D is the relation between the point x and regions X_0 and X.

$$D(x,X_0,X)=\begin{cases}\rho(x,X)-\rho(x,X_0), & x\notin X_0\\ -1, & x\in X_0\end{cases}$$

2.4.3 Basic associative function

Let two regions be X_0 = [a, b] and X = [c, d], and there is no common end point of two regions, then the basic associative function can be expressed as:

$$K(x)=\frac{\rho(x,X_0)}{D(x,X_0,X)} \tag{2}$$

The extenics associative function K(x) is used to calculate the degree of the associability of relationship between a point and a region X_0. If K(x) < 0, the degree of the associability of x is interpreted as not related to X_0. If K(x) ≧ 0, the degree of the associability of x is related to X_0. When -1 < K(x) < 0, then the current situation of x is not related to X_0, but it can be transferred to be related to X_0.

In the proposed mechanism, the extenics associative function is applied to determine which helping material is most appropriate to be provided to the student.

3. Extenics-based Intelligent Curriculum Learning System

For implementing the proposed intelligent curriculum website, we take the course "Multimedia Implementation Using JAVA" as a case study. A moodle-based course management system has been constructed by providing friendly interface to fit most students in e-learning. The functions of the website will consist of course contents, on-line exercises, on-line tests, resources sharing, and discussion board, etc.

In addition to providing students a web-based learning environment, Information of individual student's behavior can be recorded. By analyzing the collected information and applying the extenics engineering method, instructors

can provide students more adequate learning materials in accordance with individual student's aptitude.

3.1 Moodle-based Curriculum Website

In order to recognize the learning status of students to the provided course effectively, the content of the course is divided in detail, so as to record the web page and the period that students browsed more accurately. Furthermore, students can submit their opinions for each excise, such as the difficulty and meaning about the exercise, etc. For example, to implement an applet in JAVA, four steps are presented in one page originally, as shown in Figure 4. This kind of page design is not only too crowded but also cannot recognize the problem of the step which student encountered exactly. Moreover, the browsing period of each step which students studied cannot be recorded. In the proposed system, four steps are presented in four web pages for recording the browsing period of each step which students studied. The separated page design can recognize students' behaviors more accurately and can feedback to the students according to the specific step which the student is interesting or encountering a problem. The original 4-step page design is shown in Figure 4, while the modified page design, it leaves only outline of four steps on the home page is shown in Figure 6.

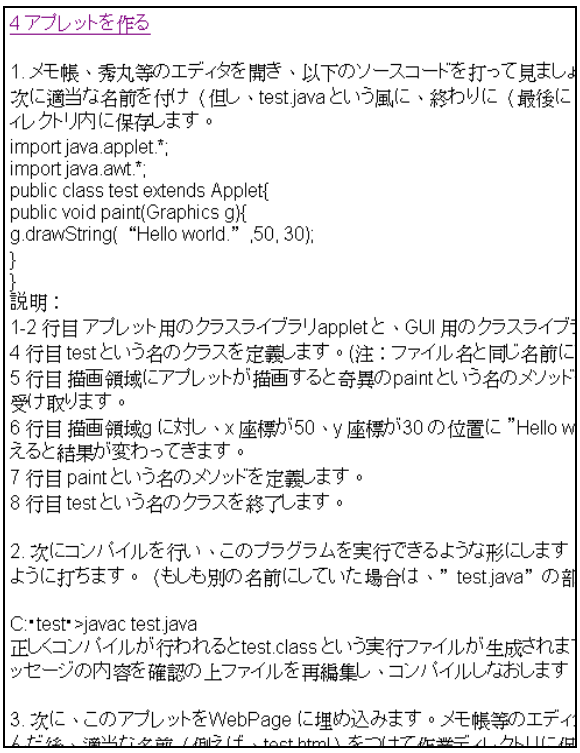

Fig. 4 Original 4-step page design for implementing Java Applet

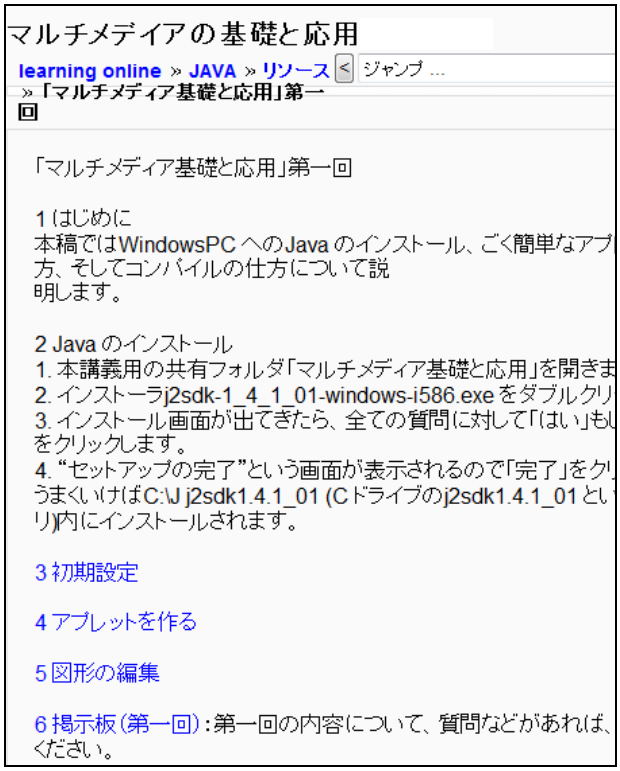

Fig. 5 Modified 4-step page design for implementing Java Applet

Figure 5 presents the content of chapter 1, implementation of Java applet is the fourth unit of this chapter. Figure 6 illustrates four steps for implementing Java applets. The first step to implement the Java applet is presented in Figure 7.

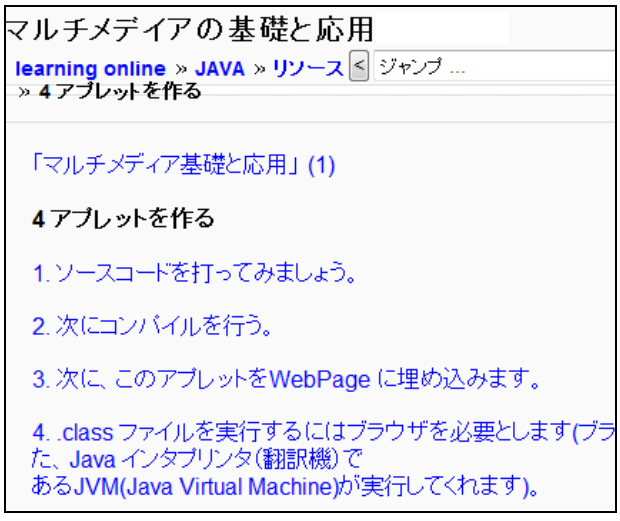

Fig. 6 Home page of the index of four steps for implementing Java Applet

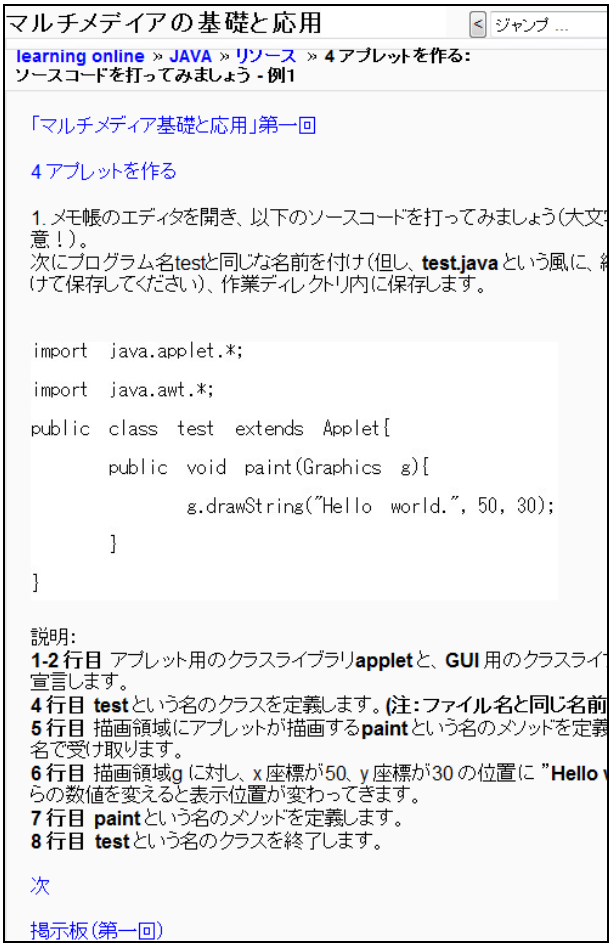

Fig. 7 Step 1 for implementing Java Applet

3.2 Extenics-based Evaluation Mechanism

Through the curriculum website described above, the information of learning behaviors of each student, including on-line period, click times, browsing path, and how to interact with other learners can be recorded. According to these records, accompany with the student's provided information, Computer ability and learning interest, teachers can decide which materials are needed to supply to which student. Once a rule has been established, according to the learning condition of a specific student, the distance instruction system will support each student with appropriate learning materials automatically. The behavior recoded and analyzed is the actual time spent to complete an exercise according to the degree of difficulty of course content, length of the course content, learning sequence, number of web pages referenced.

There are 59 subjects in the selected course and the total number of samples is 295. By deducting the uncompleted subjects, 259 subjects were actually completed by students. Relationships among variables, including the degree of interest to the course, degree of familiarity to the computer, learning sequence, length of the course content, degree of difficulty of the course content, amount of references, and number of browsing web pages are studied. Since samples obtained are not large enough, Fisher's exact probability test has been applied for analysis. Analyzed experimental results are shown in Table 1.

Table 1: Analyzed experimental results

Factor	Degree	Average	Interpretability
Computer ability	low	503.86	0.044
	medium	567.49	
	high	340.48	
Learning interest	low	472.39	0.002
	medium	341.20	
	high	539.85	
Learning sequence*	1	344.81	0.004
	2	541.05	
	3	341.71	
Difficulty of the course content	easiest	311.48	0.095
	easier	358.70	
	medium	478.44	
	more difficult	818.87	
	most difficult	1469.75	
Length of the course content	short	342.72	0.028
	medium	592.75	
	long	804.38	
Number of web pages browsed	low	245.60	0.128
	medium	326.61	
	high	774.38	

*1 represents taking an overview of entire contents and then reading in detail, 2 is reading in detail directly, 3 is performing the exercise directly and went back to read the resource while encountering problems.

By applying the recorded and analyzed data, an extenics-based evaluation mechanism can be established to evaluate the learning performance. The evaluation flowchart of the extenics evaluation process is illustrated as follows:

1. Build 6 corresponding associative functions according to parameters obtained from students' behaviors.
2. Set weighting for each condition according to corresponding interpretability.
3. Calculate individual learning performance from the value of corresponding associative function.

4. Normalize the calculated individual learning performance.
5. Calculate the integrated learning performance by integrating individual learning performance and corresponding weighting to obtain the final learning performance.

Currently, the extra learning materials are divided into 5 levels, according to the learning performance of individual student, instructor can provide the student with an appropriate learning material.

4. Conclusion

In this paper, an Extenics-based Intelligent Curriculum Website has been proposed. From recording the behaviors of students performed on the web site, the learning performance of the students can be evaluated by the proposed extenics evaluation mechanism for providing student with appropriate learning material. Since moodle platform for this course is just used as experiment, there are still some functions we need but not supported by moodle. Thus, if those functions can be implemented, a more effective course management system for promoting student learning performance will be achieved. In the future, the conformation of the moodle functions, the collection of items to be analyzed, and the integration of the moodle system with the evaluation mechanism should be made. Moreover, effectiveness of the teaching and learning by using this system will be evaluated.

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