A New Personalized Syllabus Model based on Achievement Standards Analysis and Evaluation

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Abstract—**This paper provides an approach learning activity evaluation and learning path generation for students based on achievement statements analysis and evaluation. At first, we design an integrated learning ontology that combines and connects different learning domain concepts like curriculum, syllabus, achievement standards, bloom taxonomy, and learning topics. Our syllabus model defines hierarchical structured achievement statements and maintains connections between the statements and learning activities as well as the statements and learning units. Next, we design an algorithm to compute achievement scores by evaluating learning activities and generate a learning path composed of low scored learning units for each student.**

Index Terms—**achievement standards, learning activity, learning ontology, learning path, syllabus management**

I. Introduction

A syllabus is a blueprint and guide to lead students manage their learning successfully. The instructor designs a syllabus as an outline of learning topics to be covered in a course. The most important purpose of a syllabus is to interact and establish a contract with students by informing goals, policies, expectations, requirements, and procedures of the course[1]. The current syllabus model, however, represents just a brief description of the course. It is a summary of the course to help students assess their readiness for the course by identifying prerequisite courses and by identifying what will be taught and learned. Students need a syllabus before the decision of the course's taking. They may not use the syllabus for all class sessions. They usually refer the syllabus at the beginning of the class[2].

The current syllabus model has not all learning concepts to be covered in every class session and connections between learning outcomes and learning activity and between learning outcomes and learning units. The learning outcome in the syllabus is described as course objectives, which are skills and knowledge the instructor wants students to gain. But, there are no the detailed learning outcomes of every learning unit, which is taught in every class session. If the achievement level generated from the evaluation of learning activity, such as assignments, practices, exams, and projects, is represented in the syllabus, students can figure out their learning progress during the semester.

In this paper, we describe learning outcomes as achievement standards and statements. We design a new learning ontology, which includes concepts of curriculum, achievement standards, syllabus, and learning topics. Our integrated learning ontology forms concept hierarchy from curriculum to learning topics. We create a new syllabus model for providing personalized learning progress information to students according to their learning activities and evaluation. In addition, we design an algorithm to compute achievement scores by evaluating learning activities and generate a learning path composed of low scored learning units for each student.

Here is the structure of our paper. In section 2, we describe syllabus management and applications for understanding the previous approaches to use the syllabus model in an e - learning environment. Section 3 represents the design process of the integrated learning ontology and personalized syllabus model. And then, section 4 describes an algorithm for computing the achievement level of students and for generating a personalized learning path for low scored students. In section 5, we represent conclusion and future work for intelligent services based on achievement analysis.

II. Related Work

The researches applying ontology technology to education field are classified into curriculum or syllabus ontology creation[3],[4], ontology-based learning object organization, and ontology-based learning content retrieval. The studies for the creation of education-related ontology include curriculum ontology creation[5] and personal subject ontology creation[6]. Mizoguchi[7],[8] proposed an ontology-based solution to solve several problems caused by intelligent instructional systems. Other works defined metadata of learning objects and learning path including curriculum based on ontology engineering technology[9],[10].

These works concentrated on the management of learning objects and materials and performance enhancement of instructional systems. Ontology technology, however, can be used to make the knowledge structure, which improves the interaction among teachers and students and enables spontaneous learning of students, of teaching contents and learning materials for students based on semantic information[11]. Yu *et al*[12] propose a method to construct a syllabus repository storing the structured syllabus. They collect freely available unstructured syllabus from Internet, extract topics and convert to the structured format. In order to

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do, they define an entity mapping table and hierarchy structure of the syllabus.

III. Integrated Learning Ontology

The purpose of our syllabus design is to deliver information about achievements of learning to students. Thus, they can understand their learning progress and determine the success or failure of their learning. We represent a student's learning progress by applying Bloom's cognitive model, i.e. knowledge, skill, and attitude. To enable this, we create connections between achievement statements and Bloom's taxonomy in our syllabus model. Figure 1 shows a model of knowledge, skill, and attitude for displaying the achievement status of a student.

We consider a curriculum as the top-level information of educational data entities of a university. Generally, a curriculum is composed of a list of courses, which are scheduled for education period. Commonly, a curriculum can be represented as a set of description of courses and syllabuses. A syllabus, which is identical and skeleton of a course, can be represented as a collection of several kinds of resources related to a certain course. We design the curriculum ontology in order to organize various semantic relationships, which include hasSubtype, prerequisiteOf, basicOf, advancedOf, combinedOf, and so on, existing between individual. The curriculum ontology conceptualizes the knowledge of curriculum concepts, i.e. ProgramOfStudy, Course, KeyConcept, AttainmentGoal, AttainmentLevel, and includes the direct semantic connections between courses and their syllabus ontologies.

The syllabus ontology conceptualizes the internal and external structures of syllabuses. A syllabus class, which is the core concept of syllabus ontology, has 9 data type properties, i.e. titleOfCourse, description, gradingPolicy, goalOfCourse, and 12 object type properties, i.e. oldVersionOf, hasInstructor, hasMaterial, hasSchedule, hasLectureRoom, to describe the content and relationships extracted from traditional textual syllabus templates.

Fig. 2 shows an example of classes and individuals of our learning ontology. The example of figure 2 represents the relationships between achievement statements and other entities like learning activities and learning units. Learning activity is composed of works, like assignment, exam, quiz, practice, and project, to be performed by students for learning topics taught in class sessions. By using these relationships, we can generate achievement scores from the result of evaluation of learning activities. More detail is expressed in chapter 4.

IV. Learning Path Generation

A. Data Structure and Flow Design

In this section, we describe data structure and data flow design for supporting achievement evaluation and learning path generation for each student. Figure 3 shows the data flow structure that includes two processes and ten data files. The first step is achievement evaluation, which computes an achievement score of each student by evaluating one or more learning activities, i.e. assignments, exams, presentation, and projects, in terms of achievement statements. The second step is learning path generation, which identifies the unfulfilled learning units that a student has low achievement scores and creates a learning sequence of the learning units to study again. An algorithm of learning path generation is represented in section 4.2.

In figure 3, the achievement evaluation process accepts learning objectives, achievement statements, bloom taxonomy, and learning activities as input data. These data are interconnected by means of achievement statements as shown in figure 4. The achievement evaluation generates achievement scores of each student. The achievement score is indicated to determine whether the achievement level is satisfied or not. The achievement scores of all students are passed into the learning path generation process to identify the unfulfilled learning units of each student. These extracted learning units can be arranged according to learning sequence designed in the course syllabus to encourage studying them again.

The more detailed structure of learning data above described is represented as a table schema in a relational database in figure 4. These tables are physical schema to implement classes defined in the integrated learning ontology introduced in chapter 3. From the diagram depicted in figure 4 the AchievementStatement table is placed in the center of the diagram because the other tables have foreign keys to make reference the statementId column of the table. The AchievementStatement table has three columns, knowledge, skill, and attitude, to connect to the BloomTaxonomy table. The foreign key relationships between AchievementStatement and Bloom Taxonomy tables, denotes cognitive characteristics of an achievement statement.

Learning activity performing with students during class sessions can be described as records of Homework, Exam, Practice, and Project tables in the diagram. The tables for modeling learning activity can be extended and variated according to types of studying with students. Learning activity tables contain a column to refer to the AchievementStatement table. By evaluating learning activities of students we can figure out the achievement levels of students for every achievement statement. The computed achievement scores are stored in the AchievementMatrix table in which two columns, studentId and statementId, are used to represent that a certain student has achievement scores of some statements.

B. Learning Path Generation Process Design

An example shown in table 1 informs the relationships among LearningUnit, AchievementStatement, and LearningActivity, which is a just group name of

Homework, Exam, Practice, and Project tables. A learning unit has a connection to one or more achievement statements as well as one or more learning activities. A learning activity has a connection to one or more achievement statements. Also, an achievement statement has a connection to one or more different types of learning activities.

For each student, we perform the following steps to produce achievement scores and generate a learning path, which is composed of the low scored learning units.

Step 1. Achievement scores computation.

Given a set of achievement statements, A in equation (1), which are connected with the learning units studied by a student, an achievement score of each statement of the set can be computed by evaluating learning activities and making summation of the normalized scores of learning activities. In equation (2), B denotes a set of all learning activities, which are connected with the statements of the set of achievement statements. Equation (3) computes the achievement score of a statement by adding the evaluated scores of learning activities.

$$A = \{a_i | 1 \leq i \leq n\} \quad (1)$$

$$E(a_i) = \{e_j | 1 \leq j \leq k\} \quad (2)$$

$$f_a(a_i) = \sum_{p=1}^{q} N_{score}(e_p) \quad (3)$$

For example, a statement, a_1, has connections with e_1, e_2, and e_3, which are an assignment, an exam question, and a practice problem about Java array declaration respectively. The achievement score of a_1 can be computed by performing an expression, $N_{score}(e_1) + N_{score}(e_2) + N_{score}(e_3)$. A normalized score is a decimal value ranged between 0 and 1.

Step 2. Learning unit extraction.

The result of the above step is an achievement-scoring matrix implemented as the *AchievementMatrix* table. From the matrix, we extract a list of achievement statements that have scores below a specific threshold for each student. In addition, we determine each learning unit's achievement score by performing equation (4) and (5). A learning unit's achievement score can be calculated by accumulating achievement scores of the statements, which connect with the learning unit.

$$U = \{u_l | 1 \leq l \leq x\} \quad (4)$$

$$f_u(u_l) = \sum_{i=1}^{y} f_a(a_i) \quad (5)$$

Step 3. Learning path generation.

In this step, we create a sequence of the extracted learning units from the above step. Our designed syllabus model contains a learning pathway of learning units that are taught by an instructor during class sessions of the course. A learning path can be created by extracting nodes and edges of the extracted learning units from the learning pathway of a syllabus.

V. Conclusions

Achievement standards are a set of statements about the ability and characteristics of knowledge, skills, and attitude that students must achieve through learning, to be presented as a practical basis of teaching/learning and assessment. Our syllabus model designed in this paper contains achievement statements with the hierarchical structure to represent what has to be studied and achieved by students. These achievement statements can be used to measure learning progress of students and determine learning units with low achievement scores. Students can figure out their learning status and select learning units to study again by using our proposed learning path generation approach.

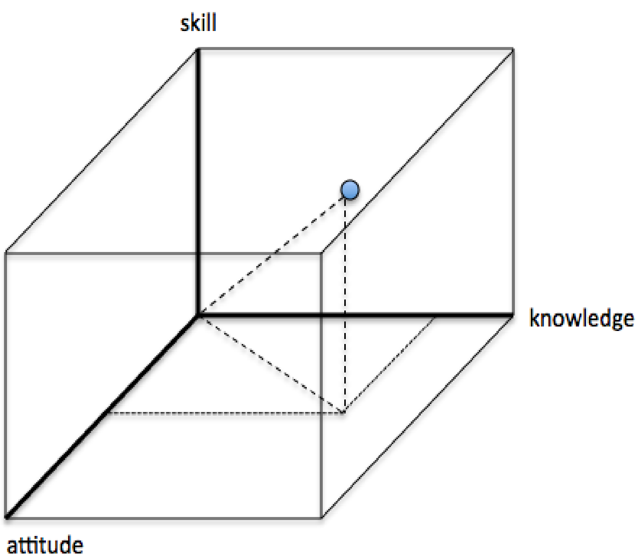

Fig. 1. Achievement status of a student in terms of knowledge, skill, and attitude. One of goals of our proposed evaluation model is to provide a clear view about learning result to each student.

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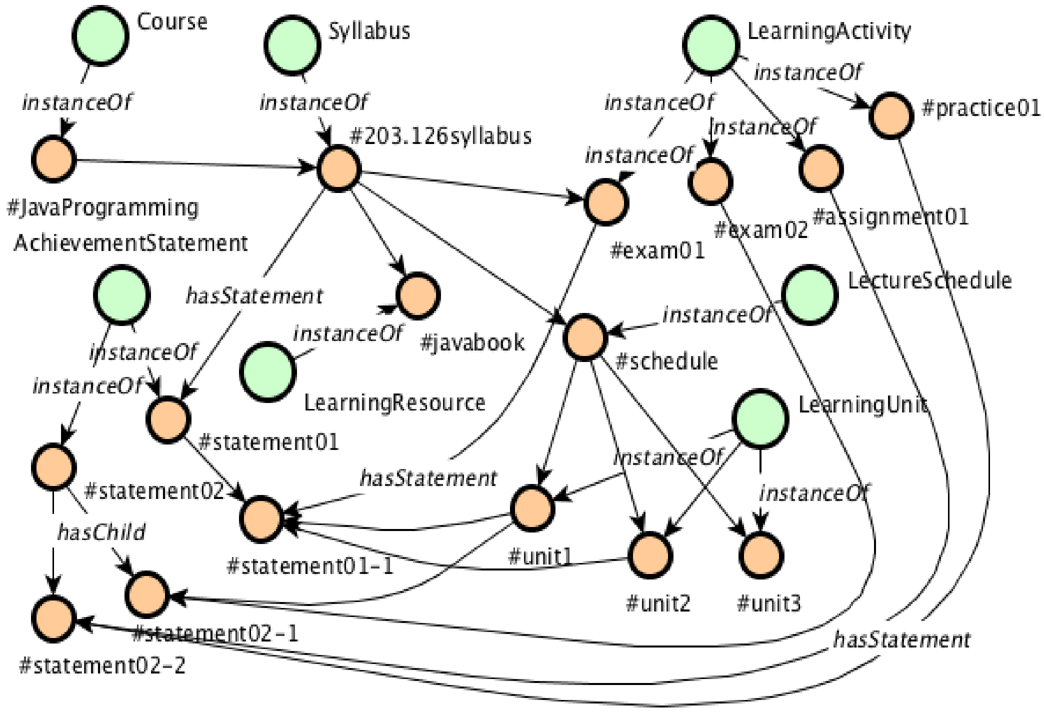

Fig. 2. Class and instance relationships of the integrated learning ontology.

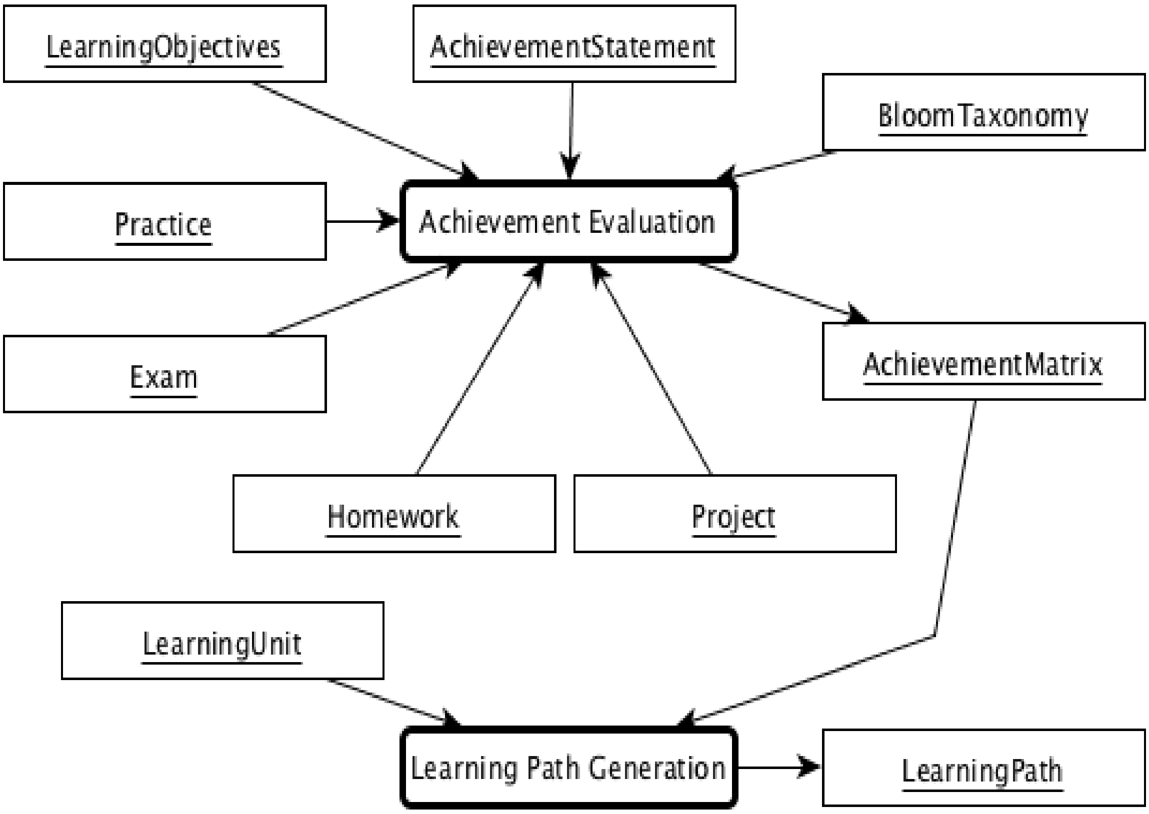

Fig. 3. Data flow structure for Achievement Evaluation and Learning Path Generation processes. A rounded rectangle denotes a process and a rectangle denotes a data file. The process, Achievement Evaluation, generates values of the AchievementMatrix data file as output. Next, the Learning Path Generation process create learning paths using the generated values of AchievementMatrix data file.

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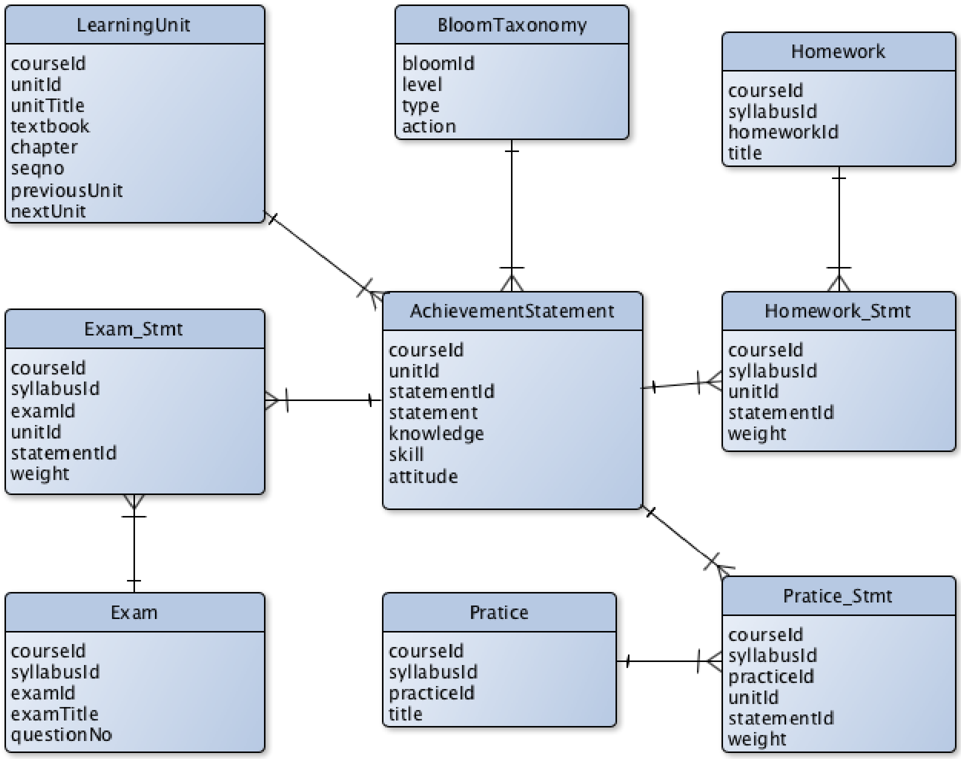

Fig. 4. E-R diagram of tables and relationships.

TABLE I
AN EXAMPLE OF LEARNING UNITS, ACHIEVEMENT STATEMENTS, AND LEARNING ACTIVITIES

Learning unit	Achievement statement	Learning activity
Array declaration in Java	Understanding of array structure Capable of array declaration	Practice #4-1. Integer set creation Exam #1-5. Declare an array sized 9
Loop expression	Understanding of loop structure Differentiation of while, for, do while, for each loop Programming loop codes	Assignment #3-1. Factorial operation using a loop expression Exam #1-3. Translate while loop into for loop
Inheritance and Polymorphism	Understanding class inheritance Design super class and sub class Understanding method overriding	Practice #8-1. Design Shape class and Rectangle class Exam #2-2. Explain the concept of polymorphism

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