Evaluation System in e-Learning Through the Knowledge State Analysis Method

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Evaluation of student's knowledge state should include the significant knowledges in the order of difficulties in student's mentality. Most contemporary evaluations have been performed in the purpose of measuring student's academic achievement. Since such evaluation results doesn't contain enough information about individual knowledge state. The contemporary evaluation methods might not be useful for diagnostic and formative purpose. In this study we introduced and developed a new evaluation system for science education to draw the individual or grouped informations which were not able to acquire them from the contemporary evaluation method. Our evaluation system is especially useful for e-learning system where students cannot be seen closely by their instructors. We analyzed the result of student evaluation using our system based on the theory of knowledge space, and also we proposed a model of a prospective learning for the individual student. Theory of knowledge space is of great benefit to analyze the knowledge state of strongly hierarchial subjects such as mathematics and science. An evaluated result also helps course-ware designers to correct their e-learning program based on the evaluated knowledge structure of class students.

Keywords: evaluation; e-learning; knowledge state; hierarchy of concepts

1. Introduction

E-learning is a education via the Internet, network, or standalone computer, network-enabled transfer of skills and knowledge. E-learning often refers to using electronic applications and processes to learn. And it applications and processes include Web-based learning, computer-based learning, virtual classrooms, and digital collaboration where contents can be delivered via the Internet, intranet/extranet, audio or video tape, satellite TV, and CD-ROM [1].

Evaluation in e-learning systems used to gather information about the impact or effectiveness of this Web-based learning event [2]. Measurements might be used to improve the offering, determine if the e-learning objectives were achieved, or determine if the offering has been of value to the organization [3].

The Online Teaching/Learning Systems (OT/LS) have been successfully used to provide the learners with an environment of one-to-many education, learning without limited time and place, different kinds of knowledge sources, open learning systems, information delivery with multimedia format, cooperative learning, and storing and quickly accessing huge amount of learning materials [4].

In this study we introduced and developed a new evaluation system for science education to draw the individual or grouped information which were not able to acquire them from the contemporary evaluation method. Our evaluation system is especially useful for e-learning system where students cannot be seen closely by their instructors. We analyzed the result of student evaluation using our system based on the theory of knowledge space, and also we proposed a model of a prospective learning for the individual student.

2. Hierarchy of concept using knowledge state analysis method (KSAM)
For question a and b, an event which can be occurred to arbitrary student is one of the next four cases.

1. all answered correctly
2. answered a correctly but b incorrectly
3. answered a incorrectly but b correctly
4. all answered incorrectly

We can suppose that the next result (Table 1) had been given in the case of evaluating to some group for question a and b. In the table, ○ is in the case of correct answer, but × is not.

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>No. of student</th>
</tr>
</thead>
<tbody>
<tr>
<td>○</td>
<td>○</td>
<td>n₁</td>
</tr>
<tr>
<td>○</td>
<td>×</td>
<td>n₂</td>
</tr>
<tr>
<td>×</td>
<td>○</td>
<td>n₃</td>
</tr>
<tr>
<td>×</td>
<td>×</td>
<td>n₄</td>
</tr>
</tbody>
</table>

If n₃ = 0, the student had better study the concept about question a than question b. So in this case, let's represent a ≤ b for meaning of learning hierarchy. The meaning of a ≤ b is "the student must study the concept about question b after study about question a". In the case of n₂ = 0 and n₃ = 0, we can represent a = b.

The relation '≡' means equivalent. If question a and b are equivalent, the relation '≡' is reflexive because of n₃ = 0. In the case of a = b, it means that all students give correct answer for question a and b, or none. Therefore, the relation '≡' is symmetric. In the other hand, we suppose a=b and also b=c. If some student P give correct answer for question a, he must be correct for question b. So, we can think he is correct for question c. The other way, if he is incorrect for question a, he must be incorrect for question b. So, we can think he is incorrect question for c also. Namely, there is no student who is correct only for one question among question a and c. Therefore, the relation '≡' is transitive.

The relation '≤' is sequence relation. It is clearly a ≤ a. If we suppose relation a ≤ b or b ≤ a, it's the case in relation a = b because there is no student who is correct only for question a or b. Namely, the relation '≤' is anti-symmetric. If we suppose in the case of a ≤ b and b ≤ c. This means that there is no student who is incorrect for question a, b and no one answered correctly for question b. And also, there is no student who is incorrect for question b, c, and no one answered correctly for question c. If there is student who is incorrect for question a, and correct for question c, he must be incorrect for question b or correct for question b. If he is correct for question b, it is conflict in supposition because it is in the case that he is incorrect for question a and correct for question b. If he is incorrect for question b, it is the case that he is incorrect for question b and correct for question c. This is also conflict in supposition. Therefore, the relation is a ≤ c.

3. Development of knowledge state analysis system (KSAS)

The operational process of knowledge construction is illustrated in Fig. 1. The teacher defines a subject, decomposes the defined subject into a number of knowledge elements (scientific concepts) and defines their relationships, and organizes the knowledge state that is formed with nodes (scientific concepts). The KSAS is developed with the capability of obtaining scientific concepts, confirming relationships of scientific concepts, and organizing and illustrating knowledge states.
The operation process of knowledge construction in e-learning system.

The structure of the developed KSAS is illustrated in Fig. 2. It contains four steps: Inputting & Defining (step 1), Deriving & Construction (step 2), Eliminating & Updating (step 3), and Construction & Storing (step 4). The step 1 is designed for allowing an teacher to provide scientific concepts and to define relations among the provided concepts. Deriving the relation of the provided concepts and construction of the knowledge states are performed in the step 2. The step 3 allows a user to modify the provided concepts and to redefine their relations. The step 4 is created to store subject and its scientific concepts and to represent their relations. It allows a user to efficiently update knowledge contents to maintain the knowledge state current.

The users that can operate the system could be the teachers or scientific concept providers. A friendly user interface designed for the developed KSAS can facilitate the interaction between the user and the system. The domain knowledge that is included in OT/LS can be decomposed into a number of scientific concepts through the designed interface. This task will be over when there are no more concepts that can be decomposed. Each concept is regarded as a node of the generated knowledge state. All nodes that are regarded as hyper links are used to construct the whole system. After the domain subject is fully decomposed and relations among all concepts are identified, the confirmation of the relations on the process of scientific concepts (definition and formation) of the knowledge state is performed to ensure that the knowledge state can be built without any logical conflicts. A logical conflict occurs whenever a concept that is defined to be an immediate super concept of a concept at an early stage is later defined to be a sub element of that concept.
4. Application case

When the knowledge state from KSAM illustrated in Fig. 3 is used in OT/LS, it is found that Q1 has dependent relations to Q2 and Q3 while Q2 and Q3 are independent. As a result, Q1 and Q2 as well as Q1 and Q3 can form this structure. This can be implicitly explained as: Q1 has to be covered before giving Q2 and Q3; once Q1 has been finished, either Q2 or Q3 can be given. Therefore, the research attempt is that the scientific concepts provided by the teachers need to be appropriately organized into a knowledge state in order to help a beginner obtain knowledge. Fig. 4 illustrate for arbitrary student P. In the figure, gray squares are in case of incorrect.

To achieve the aim, three processes that need to be solved are definition of scientific concepts, confirmation of relations among defined scientific concepts, and construction of knowledge state. The definition of scientific concepts deals with the inputs and the relations of the provided inputs. However, conflicts may occur while defining relations of the inputs. In the complex definition process, for instance, SC1 is defined prior to SC2, SC3 and SC4 at the early stage. Later, the SC4 may be defined to be prior to SC1: This situation may result in an endless cycle and cause the knowledge construction mechanism.
having a difficulty to terminate the construction process. Therefore, it is necessary for the relations of scientific concepts to be logically acceptable. Formation of the knowledge state can be then processed when confirmation is finished.

5. Conclusions

As the Internet becomes increasingly important to the information delivery, OT/LS may be very useful for distance education. The Internet technology brings learners plentiful materials from all over the world. However, a learner who does not have a relevant degree of understanding may not be able to know where to effectively and efficiently obtain the whole domain knowledge that could be integrated with the knowledge he/she already has. The KSAS developed in this research is described in detail to help managing domain scientific concepts in a structured format while developing OT/LS.

The goal of OT/LS is to help learners obtain the whole domain knowledge rather than pieces of knowledge. In order to improve the capability of an OT/LS, researchers pay increased attention to instructor modeling that deals with defining scientific concepts, ordering scientific concepts, grouping scientific concepts, and appropriately directing learning paths. Therefore, a structure for knowledge elements becomes essential due to the requirements of organizing the massive amount of learning materials. Doignon (1999) suggested that creating a knowledge structure needs to identify specific pieces of knowledge and consider their relationships.

It is almost impossible to solve all problems via a single study. In spite of our study that has presented a solution of knowledge construction model based on the consideration of educational design, many problems still need to be solved, such as online content editing for scientific concepts, performance evaluation of an OT/LS, etc. From an teacher's point of view, what is mainly concerned with may be a methodology that can not only produce learning materials that are reusable, accessible, durable, interoperable, adaptable, and affordable, but also carry out teaching/learning effectively, efficiently, and coherently in the networked educational environment. Moreover, a tool that can help the whole task of designing and developing an OT/LS from constructing knowledge and editing contents to evaluating performance may be also valuable to the web based education community.

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References