Guiding Students to do Remedial Learning in School Campus with Learning Objects' Spatial Relations

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Abstract: There are more and more students learning in the real environment. Remedial learning is an educational process of providing supplemental learning materials and directions to students according to their learning assessment results. Due to the ubiquitous learning environment may have numerous and various learning objects, for example, a garden in the school campus, how to plan an effective path for students doing remedial learning activities and searching the supplemental learning objects is very important. This paper proposes a method to plan a shortest path for students when they are doing remedial learning activities outside of the classrooms, for example, in the school campus. The shortest remedial learning path planner applies Formal Concept Analysis (FCA) to build learning scenes for students; uses spatial relation map to switch learning scenes for students; uses one-third theory to decide learning priority of the concepts students have to learn; and, finally generates shortest paths for students doing remedial learning activities. At the end of this paper, an example with many rounds shows how to plan a shortest path and switch the learning scenes for students when they are doing remedial learning activities of elementary school's botanical learning unit.

Keywords: remedial learning, self learning, ubiquitous learning, learning path, navigation, spatial relation, situated learning

1. Introduction

There are more and more ubiquitous learning applications which make students learning in the real environment, because of researchers think the learning performance in the real world would be much better than in the classrooms [3][4]. The mobile devices now can provide many useful functions and higher computing ability for students doing learning activities anytime and anywhere, for examples, wireless connection, web browsing, and positioning technology [8]. When the student obtains the knowledge by observing specific learning objects, the system can know where the student is at (location-awareness) and realize what concepts the student has observed and understood (context-awareness and learning assessment). The mobile device can get the learning performance of the student according his/her test results. After the mobile device got the misconceptions of the student, the mobile device can plan remedial learning path for the student's next round of learning.

The research goal is helping students planning a remedial learning path for clarifying their misconceptions and observing relevant learning objects in the real world. When students do remedial learning activities in a real place, gardens in the school campus for example, they may need to observe many trees and plants via walking through the whole school campus. In addition to the remedial learning path, there is another issue needed to consider during planning the path: how to find the most efficient leaning path for the student? The efficient learning path means the student will spend less time in searching and observing specific learning objects at the real environment. In order to solve this issue, this paper designs the real environment model and the spatial relation map to build the relations among learning objects.

Section 2 talks about the literatures of ubiquitous learning and remedial learning researches. Section 3 builds the real environment model to store the distance and area information of the real environment for learning; uses Formal Concept Analysis (FCA) to cluster learning objects into different learning scenes based on the concept similarity; and, designs a spatial relation map to switch learning scenes for students. Section 4 explains the process of planning an efficient remedial learning path and Section 5 uses a complete example to verify the research idea and method. At the end, Section 6 makes a summary and describes possible future works of this research.

2. Remedial Learning in Ubiquitous Learning Environment

Students usually learn from traditional materials, books for example, in the classroom. Most of e-learning applications provide students multimedia materials [9], and students can learn in their home with networked computers. The e-learning applications are also limited by the computers and the networks. Researchers propose mobile learning to solve the fixed learning place problem. Mobile learning emphasizes that students can learn anytime and anywhere by mobile devices [10], moreover, complies the theories which believe that students can learn knowledge and skills by interacting with the real world [1][2]. Different to mobile learning which always focuses on a specific domain knowledge, ubiquitous learning is a new direction which allows students learning anything at anywhere when they want, that means, ubiquitous learning proposes a transparent multidiscipline learning experience and service to students [11].

Both of e-learning and mobile learning applications usually use concept maps to store domain knowledge. The concept map has proposed by Joseph D. Novak (1984), is a graphical tool for organizing and visualizing knowledge [7]. Kuo *et al.* (2002) develop a knowledge map to store not only the hierarchical relations among the concepts by using hierarchical concept map, but also stores additional knowledge, explanations, examples, and information for each concept within the concept schema [6]. This paper uses a context-awareness knowledge structure proposed by Wu *et al.* based on the knowledge map to store the relations between concepts and learning objects in the real environment [5].

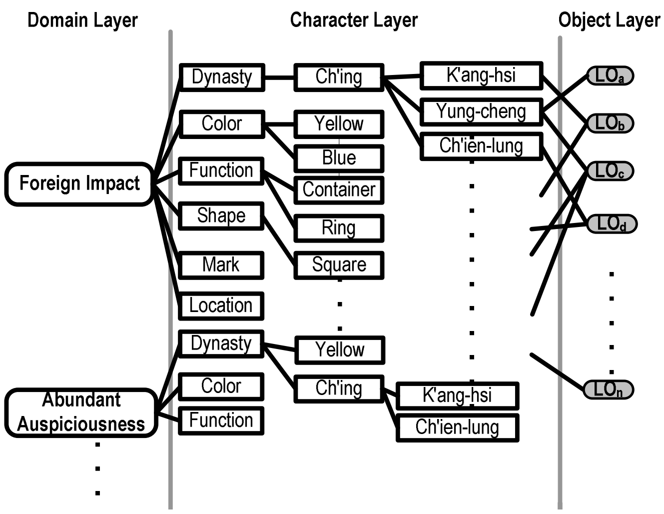

Figure 1 A context-awareness knowledge structure of museum

Figure 1 shows an example of context-awareness knowledge structure used for museum learning. There are three layers in the context-awareness knowledge structure: domain layer, characteristic layer and object layer. Domain layer stores the learning subjects and topics, characteristic layer stores the correspondent characteristics of the domain, and object layer stores the learning objects in the real environment.

How to offer students the learning sequence automatically according to the students' misconceptions is an important issue for applying remedial learning into ubiquitous learning applications. In our research, a post-test will be given to students via mobile devices at every learning round. A learning diagnosis will be generated after students answered the post-test items. The mobile devices can find out students' misconceptions and use the context-awareness knowledge structure to retrieve the learning objects that students must learn again. Furthermore, the mobile device can plan an efficient remedial learning path for students according to the geographical information of the learning environment.

This paper has two problems needed to solve in order to plan shortest remedial learning paths for students based on their misconceptions and the geographical information and relations among required/supplemental learning objects:

Problem 1: How to store the spatial relations between learning objects and areas?

Solution: This paper proposes a spatial relation map to solve this issue, please refer to Section 3. □

Problem 2: How to divide learning objects into different learning scenes?

Solution: This paper uses FCA to classify learning objects which have similar concepts, please refer to Section 4. □

3. Learning Objects in the Real World

The real learning environment has a lot of learning areas and learning objects. This paper designs a real environment model to store the information and relationships between learning areas and objects.

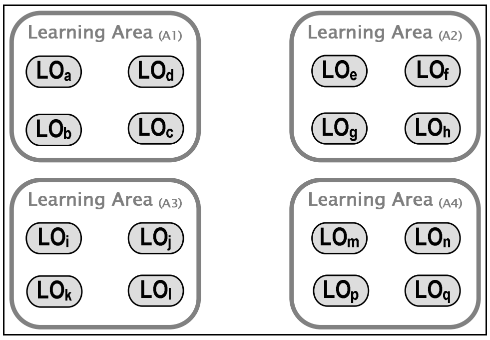

Figure 2 Ubiquitous learning environment

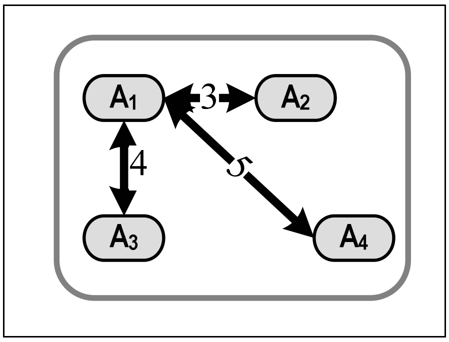

Figure 3 Real environment model

Figure 2 represents the learning areas and objects in the real learning environment. There are two relationships among different learning areas needed to store: the directions and the distances. Figure 3 shows the real environment model of Figure 2's learning environment. The oval-shaped boxes represent areas; arrows represent directed paths among areas; and, the numbers on the arrows are the distances between the two areas.

Learning areas may not be the best unit to students when they are learning in the real environment, because the learning objects which are required for students learning may exist in the different learning areas. This research defines "learning scenes" to record learning required objects which have similar learning concepts in the real learning environment. The learning scene also records the information about where the learning objects are at. A learning scene might cover more than one learning area; each learning area is a physical place and learning scene is a virtual place. Figure 4 shows six learning scenes, some of them cover more than one area, e.g. S_2 and S_4; and, some learning scenes have only one learning object, e.g. S_5 and S_6.

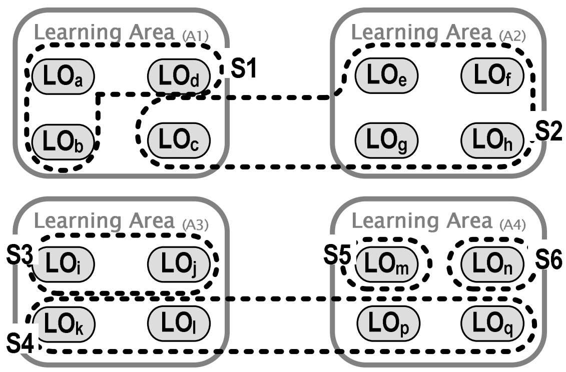

Figure 4 Learning scenes in the real environment

This paper designs a spatial relation map to store the learning scenes. The spatial relation map includes the relationships of learning scenes, learning areas and learning objects. Figure 5 shows the spatial relation map of Figure 4. The rectangle boxes represent learning scenes; the circles represent learning areas; and, the oval-shaped boxes represent learning objects. Take the structure of Figure 5 for example, learning scene S_2 covers two learning areas, A_1 and A_2; and the learning objects belong to S_1 in A_1 is LO_a, LO_b, LO_d.

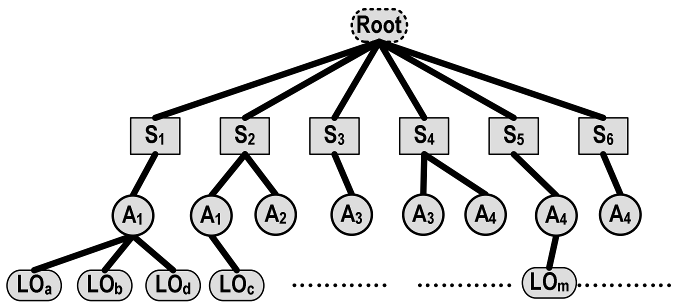

Figure 5 Spatial relation map

The spatial relation map can guide students learning from one learning scene to another based on the relationships of geographical location and distance. For example, there is a student who needs to move from S_1 to S_2 after the student finished his/her learning at S_1, there are five learning object candidates in S_2: LO_c, LO_e, LO_f, LO_g and LO_h, what is the best learning object that the student should go for it first? This research will first navigate the student to LO_c of S_2 via considering geographical location, because LO_c and S_1 are all at the same learning area A_1. The method can help students save their time to do remedial learning when they need to switch among learning scenes.

This paper uses six-step flow to design ubiquitous remedial learning activity for a student:

Step 1: Building a ubiquitous context-awareness knowledge structure for learning environment.

Take botanical garden in the school campus for example. Every plant in the school campus is a learning object and each learning object has many concepts.

Step 2: Finding the student's misconceptions via a test

The misconception related learning objects can be found via digging out the relations between concepts and learning objects within the context-awareness knowledge structure.

Step 3: Dividing the student's misconceptions into several learning rounds and considering all of rounds as a ubiquitous remedial learning activity.

Step 4: Using the spatial relation map, system can navigate the student going to the must-learn learning objects which are involved in a learning round of the remedial learning activity.

Students could save much more time to search where those learning objects are. This is one of the research goals of this paper.

Step 5: Giving the student another post-test after the student finished each round of the remedial learning activity

There are two situations after the student took the post-test may happen:

Situation 1: The student does not pass the test, which means, the student still does not learn the knowledge yet. The student's misconceptions will be added into his/her next learning round.

Situation 2: The student passes the test, which means, he/she has learned the knowledge. The student then can do his/her next round of the remedial learning activity.

Step 6: Going to Step 4 if the student does not finish yet, or stop the remedial learning activity if there is no more learning round left.

4. Planning Efficient Remedial Learning Path

As the step 3 of the six-step flow of designing ubiquitous remedial learning activity mentioned, the remedial learning activity has several learning rounds. There are two reasons of having many rounds in a single remedial learning activity: (1) don't ask students learn too much at one time (cognitive load issue); (2) let students learn general concepts first. This paper uses 'one-third theory' to divide student's misconceptions into different learning rounds, which means, in every round, students learn only one-third knowledge related to their misconceptions. After counting how many learning objects a learning concept is related to, the learning object number can be used to categorize general and specific concepts.

This paper uses FCA to analyze learning concept correlation, for example, there are sixteen learning objects in Figure 4 and this paper assumes there are eleven concept sets: C_1, C_2, C_3, …, C_{11}. Every concept set has at least one concept. Learning objects that have similar concepts will be grouped into one learning scene. This paper first uses one-third theory to decide which concept sets the student must learn in specific round; then uses the learning object number to decide the remedial learning sequence.

For example, if all of the eleven concept sets belong to the student's misconceptions, three of them will be selected as the first round concept sets based on the one-third theory. The learning objects which cover the concepts in the three misconception sets will be selected for the student doing his/her first round of ubiquitous remedial learning activity. At the end, the learning object number of each misconception set will be used to decide the learning sequence.

A post-test will be provided to students after every round of the remedial learning activity. The concepts the student still misunderstands will be found out via learning diagnosis, and the misconceptions will be added into the next round.

How to build remedial learning path in ubiquitous learning environment? If the student needs to learn LO_a, LO_b, LO_c and LO_m, then the system will navigate student to LO_a and LO_b first. According to the spatial relation map, Figure 5 shows that LO_c is also in the same area A_1. The system decides the next learning object the student needs to learn is LO_c

because of the LO_c is closer to the learning objects in scene S_1 than LO_m. Furthermore, the real environment model in Figure 3 also shows the distance between area A_1 and A_4 is 5 meters. At the end, the system plans a shortest remedial learning path for the student: $LO_a \rightarrow LO_b \rightarrow LO_c \rightarrow LO_m$.

5. Complete Example with Elementary School's Botanical Learning Unit

This section shows a remedial learning example of botanical unit in the elementary school. First, the teacher analyzes the leaf concepts of learning objects. There are three concepts: phyllotaxy, leaf-blade unit number, and margin Table 1 lists ten different kinds of learning objects which contain the misconceptions the student has: banyan, Chinese juniper, yellow stripe, azalea, murraya paniculata, madagascar almond, common crepe myrtle, cajeput tree Punk tree, comphor tree and mauritius hemp. Figure 6 shows part of context-awareness knowledge structure which covers all of the ten learning objects.

Table 1 attributes of each plant

Plants	Phyllotaxy	leaf-blade unit #	Margin	Alias
Banyan	Alternate	1 (simple leaf)	Entire	LO_1
Chinese juniper	Opposite	1 (simple leaf)	Entire	LO_2
Yellow stripe	Alternate	1 (simple leaf)	Entire	LO_3
Azalea	Alternate	1 (simple leaf)	Entire	LO_4
Murraya paniculata	Alternate	2 or more (compound leaf)	Entire	LO_5
Madagascar almond	Whorled	1 (simple leaf)	Serrulate	LO_6
Common crepe myrtle	Opposite	1 (simple leaf)	Entire	LO_7
Cajeput tree	Alternate	1 (simple leaf)	Entire	LO_8
Comphor tree	Alternate	1 (simple leaf)	Serrulate	LO_9
Mauritius hemp	Resulate	1 (simple leaf)	Undulate	LO_{10}

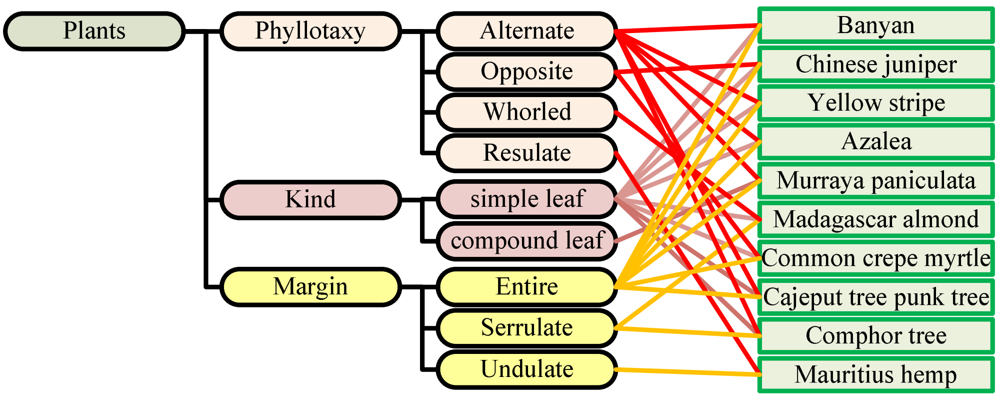

Figure 6 Part of context-awareness knowledge structure

Secondly, the system uses FCA to analyze the student's misconceptions. There are thirteen nodes, which are concept sets, in Figure 7. Figure 8 shows the learning scenes, the real environment model and the spatial relation map for designing the student's ubiquitous remedial learning activity in the school campus.

Thirdly, with the one-third theory and the learning object numbers, four concepts will be learned by the student first. The learning sequence of learning concepts will be simple leaf → entire → alternate → {simple leaf, entire}. At the first round, four learning objects banyan (LO_1), yellow stripe (LO_3), azalea (LO_4) and cajeput tree (LO_8) all have the remedial learning concepts which are selected in the first round.

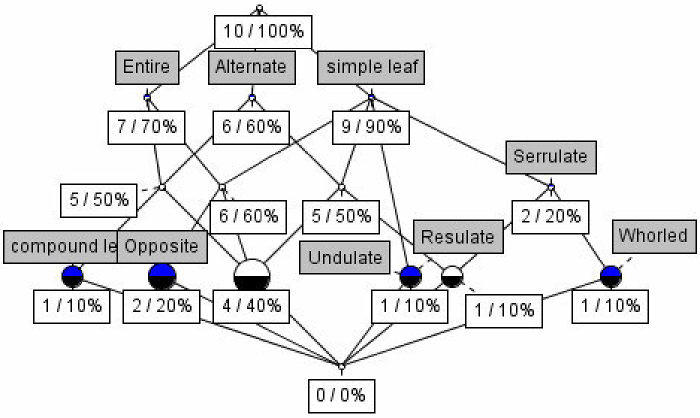

Figure 7 Analyzing concepts via FCA

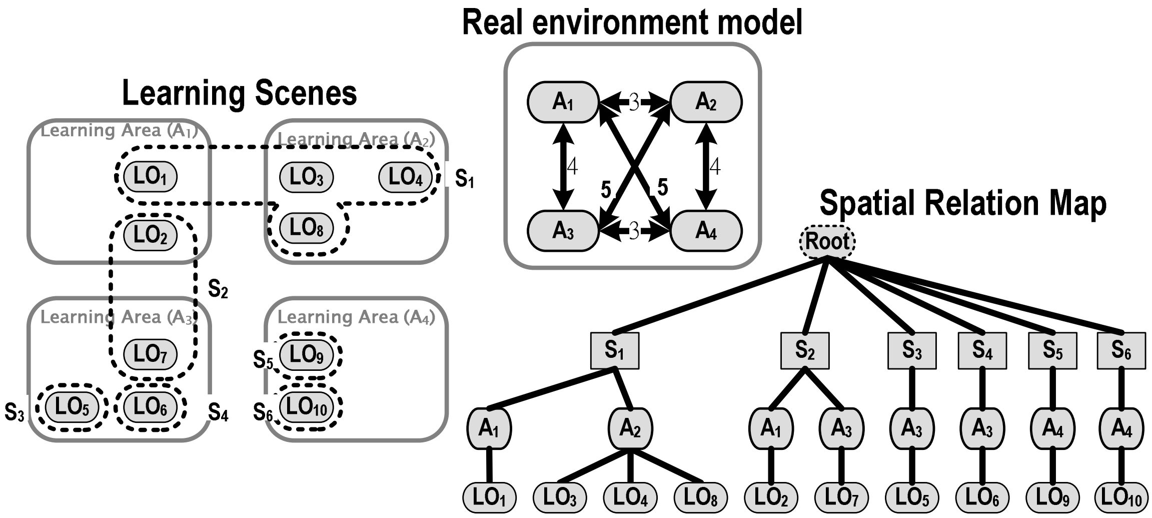

Figure 8 Learning Scenes, Real Environment Model, and Spatial Relation Map

Spatial relation map in Figure 8 shows that the learning objects of the first round all belong to the learning scene S_1. The system pops out a message box with “Go to area one, and observe simple leaf, entire and alternate concepts of banyan” to guide the student moving to LO_1. After the student observed LO_1, the system needs to guide the student moving to others learning objects. Because the rest of the learning objects are at area A_2, the system will tell the student going to area A_2 directly according to the real environment model in Figure 8.

After the student finished the first round of remedial learning activity, the student needs to do a post-test in order to check if he/she has fully understood the misconceptions he/she had before. Assuming there is no misconception anymore after the first round, the second round will continue with one-third remain concepts: {entire, alternate}, {simple leaf, alternate}, {entire, simple leaf, alternate}. At the second round, there are also four learning objects: banyan (LO_1), yellow stripe (LO_3), azalea (LO_4) and cajeput tree (LO_8), have the remedial learning concepts which are selected.

Learning path of the second round is same as the first round’s path, because learning objects are also the same. Assuming there is still a misconception existed after the second round, the misconception set is {entire, alternate}. The misconception set will be added to the next round.

The third round then has three misconception sets: opposite, serrulate and {entire, alternate}. There are also four learning objects: Chinese juniper (LO_2), common crepe myrtle (LO_7), comphor tree (LO_9) and banyan (LO_1). Because LO_1 and LO_2 are at the same area according to the spatial relation map, the learning path of the third round will be $LO_1 \rightarrow LO_2 \rightarrow LO_7 \rightarrow LO_9$. When student finished observing LO_2, the system will pop out a message box with "Please go to area three, and observe phyllotaxy of common crepe myrtle". The reason why the system tells the student go to area A_3 first is because the distance between A_1 and A_3 is only 4 meters but the distance between A_1 and A_4 is 5 meters based on the real environment model in Figure 8..

6. Conclusion

This paper focuses on planning shortest ubiquitous remedial learning path for the student according to his/her misconceptions and the context-awareness knowledge structure. The research also develops a spatial relation map to guide the students doing remedial learning activity with the most efficiently ways.

There are still two future research issues. The first one is the cognitive level diagnosis issue: suitable learning guidance could be given by the system based on different cognitive levels of the knowledge. The second one is the location-awareness moving guidance issue: the system should be able to guide the students from one learning spot to another via location-awareness technologies, e.g. GPS and Angle-of-Arrival (AOA) Positioning.

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