Delphi Method for Multi-Expert Knowledge Integration - Applied to Ubiquitous Learning Environment for Teaching Content Design

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Abstract: In the era of rapid development of e-learning, how to design digital teaching content is very important. Therefore, to build ubiquitous learning materials, this study proposed a multi-expert knowledge integration approach based on Delphi method, which lets experts use the anonymous and questionnaires way to repeatedly communicate and coordinate until experts' opinions reach consensus. Thus, it will be able to ensure that the knowledge is correct and complete. The knowledge can be stored into a learning material database and provide to students for ubiquitous learning.

Keywords: Ubiquitous learning, learning material, Delphi method, knowledge integration

Introduction

Due to the rapid development of information technologies, mobile devices have become an indispensable part of people's lives. The learning mode has gradually developed into ubiquitous learning, so that learners can learn free from the restrictions of time and space. In the ubiquitous learning environment, to provide the right learning resources in the right location is very important (Huang, Huang & Hsieh, 2008) [6]. When design the ubiquitous learning system, it's necessary to provide learning materials by multiple experts to increase the speed of building. Therefore, how to effectively integrate the teaching content is very important (Chen, Kao, & Sheu, 2003) [1]. To build ubiquitous learning materials, Hwang, Chen and Huang (2012) developed an EMCUD-based knowledge integration system. But part of knowledge in the integration process may produce the cases that knowledge can't be integrated or no data in the entries of the knowledge tables [8]. Therefore, to solve this problem, this study proposed a multi-expert knowledge integration approach based on Delphi method. In the process of integration, the system lets experts use the anonymous and questionnaires way to repeatedly communicate and coordinate until experts' opinions reach consensus. The integrated knowledge will be deposited into learning material database which the u-learning formative assessment system developed by Hwang et al. (2010) can utilize it to conduct u-learning for campus' plant identification [9].

1. Literature Review

1.1 Ubiquitous Learning (U-Learning)

In the era of science and technology, learners can conduct u-learning by mobile devices at any place and any time. In the learning environment which combines wireless networks, mobile devices and sensing technologies, the learning system can detect the situation of learners in the real environment. This context-awareness helps learners to learn in the real environment (Hwang, Yang, Tsai, & Yang, 2009) and is called context-aware u-learning (Hwang, Tsai, & Yang, 2008) [12, 11]. Hwang et al. (2010) proposed a u-learning formative assessment system which used the degree of importance of attributes in the Attribute-Ordering Table (AOT) as the basis of formative evaluation feedback [9].

1.2 Knowledge Acquisition and Integration

Chu, Hwang and Tsai (2010) mentioned that in the process of the development of expert systems, the knowledge acquisition strategies which are used to assist experts to summarize and finish knowledge, will contribute to the diagnosis or decision-making related to learning activities [3]. In the construction of expert systems, knowledge acquisition has been the most important and challenging issue. The process to get a lot of problems solving strategies and the rule of thumb from the experts is called the knowledge acquisition (Davis, 1979) [14]. Among the methodology of knowledge acquisition, the repertory grid proposed by Kelly (1955) is the most frequently used one [5]. Because the repertory grid can only express simple attribute characteristics, Hwang and Tseng (1990) further proposed EMCUD (Embedded Meaning Capturing and Uncertainty Deciding), which uses multi-data types of a knowledge table to express the attribute characteristics of objects and uses the AOT (Attribute-Ordering Table) to express the relative importance of the attributes [10].

However, different experts in the same field may have different experiences and knowledge. Therefore, to integrate knowledge from different experts can ensure the correctness of the source of knowledge and also get a more complete knowledge base. In the past, many researchers have proposed several methods of knowledge acquisition and integration, such as Chu and Hwang (2008) used repertory grid as the method of knowledge acquisition and used the Delphi method to integrate multi-expert knowledge [2]. Hwang and Lin (2011) designed knowledge acquisition system based on EMCUD [7], which can provide teaching material to the u-learning system developed by Hwang et al. (2010) [9]. Hwang, Chen and Huang (2012) extended this system so that it can integrate multi-expert knowledge. However, some problems that part of knowledge can’t be completely integrated existed in the integration algorithm [8].

1.3 Delphi Method

Delphi method was developed in 1950 by Helmer and Dalkey of the U.S. Rand Corporation. It adopted the way of the mail to let experts express their opinions regardless of location. The Delphi method is a kind of group decision. It is different from the traditional questionnaire survey. The traditional questionnaire survey only conducts questionnaire survey once. The Delphi method needs a series of intensive questionnaires to complete the survey (Yu, 1996) [15]. Delphi method has the characteristics of anonymity, written expression, provision of feedback, repeatedly conducting and judging by experts (Couper, 1984) [4]. At the end of each Delphi questionnaire, three agreement indicators must be calculated: mean (M), stability mean and quartile deviation (Q). The purpose is to ensure that the opinion of the experts reach the high degree of consistency (Murry & Hammons, 1995) [13]. In the field of education, the Delphi method is often used

in the course of decision-making, development or design, evaluation and reform. Delphi has been regarded as a tool that can be applied on educational research and curriculum development (Yu, 1996) [15].

2. Delphi-Oriented Multi-Expert Knowledge Integration System(D-MEKIS)

2.1 System Architecture

The system is designed to provide u-learning materials, for example, plant identification for elementary school students. The system includes 4 modules. The knowledge of experts or teachers can be obtained by the knowledge acquisition module. The manager can use the integration module to integrate the knowledge of multiple experts. The LOAS Module and the AVI Module are responsible for judging whether the questionnaires loop of Delphi method should stop. After the end of the Delphi method, then this knowledge will be stored into learning material database of the server so that the students can conduct u-learning. The u-learning system architecture is shown in Figure 1.

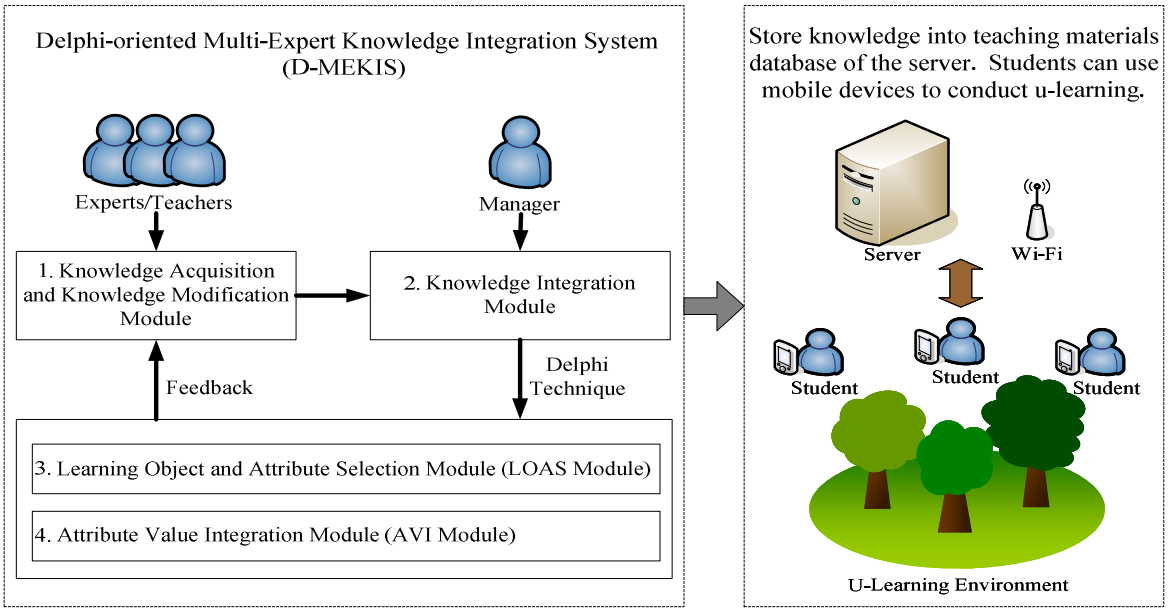

Figure 1. U-learning system architecture.

2.2 The Modules of D-MEKIS

2.2.1 Knowledge Acquisition and Knowledge Modification Module

This module adopted the knowledge acquisition module developed by Hwang and Lin (2011) [7]. We modified the module so that the teachers can modify their knowledge in Delphi loop.

2.2.2 Knowledge Integration Module

This module adopted the knowledge integration module developed by Hwang, Chen and Huang (2012) [8]. We modified the module so that the Delphi loop can be conducted automatically.

2.2.3 Learning Object and Attribute Selection Module (LOAS Module)

When the manager for the first time integrate the knowledge of several teachers, the numbers of the generated objects and attributes may be very great. However, the teaching time is limited, so this module is designed to allow teachers can pick out suitable teaching objects and attributes from the integrated knowledge database. Then through the Delphi questionnaire (5-point Likert scales), experts can select objects and attributes. If experts' opinions are inconsistent, the Delphi questionnaire should conduct to ask the experts to select objects and attributes again until the three agreement indicators converge ($M \geq 3.5$, Stability mean $\geq 75\%$, $Q \leq 0.5$). The flow chart of this module is shown in Figure 2.

2.2.4 Attribute Value Integration Module (AVI Module)

When the Delphi loop of LOAS module was completed, the integration module will refresh the results of knowledge tables. Then, the Delphi questionnaire will ask experts whether the entry values of knowledge tables is correct, if the experts disagree, the acquisition and modification module can let experts modify their attribute values. After that, the system integrates the knowledge again until the three agreement indicators converge ($M \geq 3.5$, Stability mean $\geq 75\%$, $Q \leq 0.5$). The finally integrated knowledge tables will be deposited into learning material database. The flow chart of this module is shown in Figure 3. This module can eliminate the cases that knowledge can't be integrated or no data in the entries of the knowledge tables.

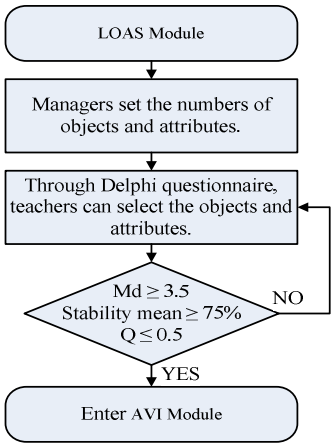

Figure 2. Flow chart of LOAS module.

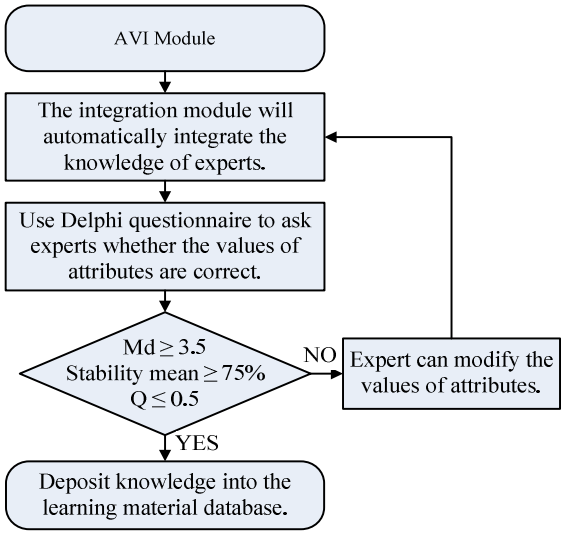

Figure 3. Flow chart of AVI module.

3. Conclusions and Future works

This study proposed a multi-expert knowledge integration approach based on Delphi method. Through Delphi questionnaire, the system can let several teachers conduct repetitive communication and coordination to produce a suitable learning material. This approach can solve the problems of the system proposed by Hwang, Chen and Huang (2012) [8]. In the future, we will invite teachers to use D-MEKIS and the obtained knowledge will be provided for developing u-learning content of an elementary school natural science course. This makes the u-learning formative assessment system developed by Hwang et al. (2010) become practical in real cases [9].

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