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Development of an Adaptive Learning System Based on Individual Difference Theories

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ABSTRACT

Most computer based education systems are being produced with the development of computer technology. However, the most of these computer based education systems only consider the functions of the computer without fully supporting educational theories. The computer based education system requires a proper combination of the functions of the computer and the educational theory to enhance the learning effect. The purpose of this study is to appropriately match educational theories and computer functions. Recently the education field has emphasized individualized learning considering individual characteristics of learners. This study introduced an adaptive learning system considering various individual differences theories, such as Achievement Treatment Interaction, Aptitude Treatment Interaction, and Content Treatment Interaction. And it described how to support adaptability such as learner' achievement, learner' learning style, and learning content based on individual difference, which are the most important factor affecting learning effects in the adaptive learning system. This study describes an adaptive learning system applying Brunner's EIS theory for Achievement-Treatment Interaction Theory. We describe an example of applying adaptability to each learner according to Gardner's multiple intelligence for Aptitude Treatment Interaction, This study describe an adaptive learning system that differentiates the learning method according to the instructional model for Content Treatment Interaction. Also, this study suggests the development of a direction of a learning system by mapping educational theories and adaptive learning systems together.

KEYWORDS: Indifference difference theory, Adaptive learning system, Adaptive functions, Achievement-treatment interaction, Aptitude-treatment interaction, Instructional model.

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1. Introduction

Adaptive learning system developed to accommodate a variety of individual differences. Recently, in order to improve learner' interaction and learning outcome, ways of developing adaptive learning for use in various courses have been developed. While developing the adaptive learning system, it is important to identify the factors that influence learner' learning outcome to further understand learner' individual differences [1]][2].

Although the ideas behind the adaptive learning systems are dreams of all educators, the implementation of these ideas is really difficult. While the idea "adaptation based on individual differences" sounds good, it may cause problems if these differences and appropriate methods to pertain these differences are not identified correctly [3][4].

The system has to identify the differences such as background, prior knowledge about the content, learning style and offers a learning environment to suit these differences. If the systems are not carefully designed, it will not bring advantages only cause problems. The maintenance of adaptive systems is additional weaknesses them. Possible technical or technology related problems can prevent the effectiveness of adaptive learning systems [5].

Most adaptive learning systems are being developed without sufficient educational theoretical background. It is important to be supporting strong educational theory for developing an effective adaptive learning system.

The purpose of this study is to develop an adaptive learning system based on educational theory. Therefore, this study presents the theories of individual difference as an educational theory. Based on these educational theories, we describe how adaptive learning systems can be developed with examples.

In Section 2, we describe theoretical background. In Chapter 3, we describe how individual differences theories apply to the adaptive learning system. Finally, Section 4 describes the direction of adaptive learning system and conclusion.

2. Theoretical Background

The individual difference theories can be said to be the theoretical basis for an adaptive learning system. In other words, an adaptive learning system is possibly the realization of the individual difference theories. Therefore, this study will deal with the individual difference theories as the basis for an adaptive learning system. In addition, this study will illustrate adaptive functions that were utilized to develop this adaptive learning system.

The most important function determining performance in adaptive learning systems depends on the adaptability factor. This chapter describes adaptive elements corresponding to individual difference theory and authoring functions to support adaptability.

2.1 Individual Difference Theories

The basis for an adaptive learning system is based on individual learning theories, of which Cronbach's Aptitude-Treatment Interaction Theory [6] is a background theory. Cronbach suggested Aptitude-Treatment Interaction that adapts classroom procedures and strategy to students' personalized characteristics. Many related theories were derived from the Aptitude-Treatment Interaction Theory [6]. Tobias proposed the Achievement-treatment Interaction Theory [7] as a special form of the Aptitude-Treatment Interaction Theory rather than interaction between aptitude and treatment. According to studies by Tobias and many other researchers, the learner's current level of knowledge in curriculum content to be learnt acts as a strong variable in determining the learner's demand for class [7]. Jonassen [8] proposed the Content-treatment Interaction Theory. According to Jonassen, Content-Treatment interaction can provide a more stable and generalized relationship because inquiring into the quality of content is easier than categorizing the learners' characteristics [9].

Individual difference theory has become the basic theory of adaptive learning system. It has developed into an adaptive learning system based on this theory of individual differences

2.2 Adaptive and Authoring Function

Adaptive learning systems can provide adaptability in a variety of ways. It provide adaptability includes prior learning, learning style, cognitive style, learner level, learning objectives and learning content. Among various adaptive functions, learning styles have been considered as an important factor for developing adaptive learning systems [9]. There have been several learning style theories proposed by researchers, such as those proposed by Keefe , Kolb and Felder and Silverman [10] [11]. The Felder–Silverman Learning Style Model (FSLSM) developed by Felder and Soloman have been recognized by many researchers as being a highly suitable model for developing adaptive learning systems [12]. Carver, Howard and Lane indicated that FSLSM could be the most appropriate measurement for developing hypermedia courseware by taking into personal factors into account. Kuljis and Lui [24] further compared several learning style models, and suggested that FSLSM is the most appropriate model with respect to the application in e-learning systems [13].

The previous studies described the function of the adaptive learning system. They did not mention them in connection with the educational theories on which they are based.

This study deals with learning style, learner' knowledge level, and learning content among the adaptive functions proposed in the previous research. It refer to these adaptive functions by matching them with individual difference theories.

3. Adaptive Learning Systems Based on Individual Difference Theories

This chapter refers to individual differences theories and describes how they apply to the adaptive learning system. Achievement Treatment

Interaction, Aptitude Treatment Interaction, and Content Treatment Interaction theory are presented as individual difference theory. And an example of an adaptive learning system based on each educational theory is presented. An adaptive learning system considering learner' knowledge level, learner' learning style and learning contents are described with examples.

3.1 Achievement-Treatment Interaction Theory

Achievement-Treatment interaction theory supports individual difference according to learners' knowledge level. The Achievement-Treatment interaction theory proposed by Tobias [11] interacts with the level of knowledge of learners.

This Achievement-Treatment interaction theory produced adaptive learning system that is provided a leveled learning according to the learner' knowledge level. This study describes an adaptive learning system applying Brunner's EIS theory with example [14].

Table 1. Adaptability of Learner's Knowledge Level

Learner's level	Instructional method
Higher level	Explanatory sentences and numerical formular
Middle level	Vertical line Explanatory sentences and numerical formular
Lower level	Concrete material Vertical line Explanatory sentences and numerical formular

<Table 1> is an example of the adaptability of an adaptive learning system that provides leveled learning according to Brunner's EIS theory. The system divides learners into three knowledge levels: higher, middle, and lower level. And depending on learner' knowledge level, the learning content is provided differently. The higher level learners are presented the learning contents by the formula. The middle level learners are provided the content by the vertical line and by the formula. The lower level learners are provided contents continuously by concrete material, vertical line, and formula. Finally, the content and method of learning contents are different according to the learner' knowledge level.

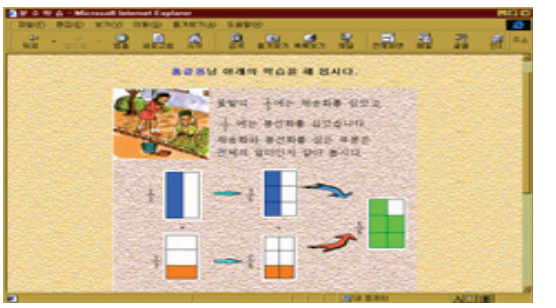

Figure 1. Addition learning through the concrete materials

<Figure 1> shows an example of <Table 2>, which shows how low level learners are learning using concrete material as the first stage of learning. After learning by the concrete material in <Figure 1>, the lower level learners complete the learning using vertical line and formula as mentioned in <Table 1>. The middle level learner and the upper level learner do not learn using concrete materials. Only the lower level learner

learns by using the concrete material in <Figure 1>. Finally, this adaptive learning system provides differentiated learning according to the learner' knowledge level.

3.2 Aptitude-Treatment Interaction Theory

Aptitude-Treatment interaction theory by Cronbach [11] supports individual differences according to learners' learning styles. Therefore, Aptitude-Treatment interaction theory supports the individual difference according to their learning styles. This is the most typical example of an adaptability support method in an adaptive learning system. The adaptive learning system provides learning contents in a different and effective way to learners, even with the same contents. In this paper, we describe an example of applying adaptability to each learner according to Gardner's multiple intelligence. The Gardner's multiple intelligence is the theory that each learner has excellent intelligence [15]. The adaptive learning system identifies firstly the superior intelligence of each learner and supports the learning contents considering each learner's superior intelligence.

This study shows an example of an adaptive learning system in which learning contents are applied to learners with excellent spatial intelligence. Spatial intelligence can recognize the temporal spatial world, and abilities to change forms through these perceptions. In this domain, mind mapping as shown <Table 2> takes place with the general knowledge about "Goryeo" that is old and historic Korea' country name and is a place that conducts learning based on spatial intelligence. For the learning method, prior knowledge learned about "Goryeo" in the basic learning is used to create a mind map about "Goryeo". First, circle and the branches are transferred to appropriate locations, and titles of major branches are inserted as shown in <Figure 2>. After save the major branches, sub branches are created and title is inserted in the circle. After generating the mind map, learners can print out what they created. The intense supplementary learning screen of spatial intelligence domain is the same.

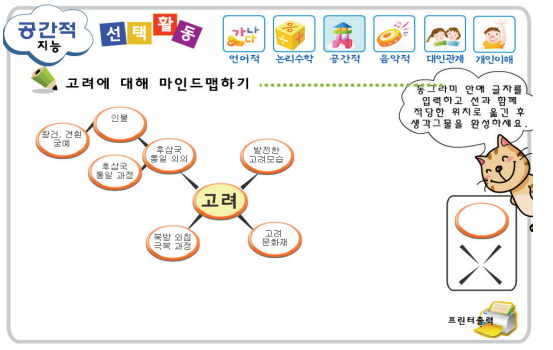

Figure 2. Learning for spatial intelligence learner

The example of <Figure 2> shows an example of the content provided with adaptive learning system for learners with high spatial intelligence.

3.3 Content-Treatment Interaction Theory

The Content-Treatment interaction theory proposed by Jonasen [13] provides differentiated learning according to the learning contents. The adaptive learning system based on Content-Treatment interaction theory differentiates

the learning method according to the learning contents, not the learning style of the learner.

Currently, the adaptive learning system based on Content-Treatment interaction theory has high learning effect, but there are not many examples developed. This study describe an adaptive learning system that differentiates the learning method according to the contents of the task.

Table 2. Adaptability of Learning Content

Knowledge domain	Instructional Model
Conceptual Knowledge	Advanced organized learning model
Principal Knowledge	Discovery learning model
Procedural Knowledge	Direct instructional model

<Table 2> shows an example in which learning contents are presented by differentiating the instructional model according to the learning content. As shown in <Table 2>, when the learning content is concept knowledge, the content is presented in order of the advanced organized learning model, in the order of discovery learning model in case of principle knowledge, and in the order of direct instructional model in case of procedural knowledge. Therefore, the adaptability according to the learning contents provides the instructional model differently considering the learning knowledge. Finally, the learning content is provided adaptively by instructional model considering learning content.

4. Conclusion

In this study, individual difference theories are presented as an educational theory which is the base of adaptive learning system actively. In addition, It is introduced an adaptive learning system considering various individual differences, such as Achievement- Treatment interaction, Aptitude-Treatment interaction, and Content-Treatment interaction. It described an adaptive learning system based on these individual difference theories. And it described how to support adaptability such as learner' achievement, learner' learning style, and learning content, which are the most important factor affecting learning effects in the adaptive learning system.

Specifically, this study demonstrated an adaptive learning system that considers learners' achievements by applying Bruner's EIS theory to mathematics learning. It also demonstrated an adaptive learning system that applies Gardner' multiple intelligence theory to social study; In addition, It demonstrated an adaptive learning system that considers learning content. This system provided the proper learning content by different instructional model considering learning content.

This study also suggested the direction of learning system through mapping of educational theory and adaptive learning system.

The instructional design is the most important considering individual differences of learners for the learning effect of adaptive learning system. Instructional designers should strive to maximize the functionality of the computer as well as the learning environment of the learners.

Adaptive learning systems require new support

for adaptability to improve performance. It is necessary to develop adaptive learning system with high learning effect that supports new adaptability by integration with artificial intelligence and data mining technologies. Also, it is necessary to develop authoring tools to minimize the difficulties of adaptive learning system development.

The most of adaptive learning systems are still available only in certain domains. The most difficult part of an adaptive learning system is the development of the general purpose adaptive learning system. It will be needed research and investment for this general purpose adaptive learning system.

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개인차 이론에 근거한 적응형 학습 시스템 개발

이재무

부산교육대학교 컴퓨터교육과 교수

요 약

컴퓨터 기술의 발전과 함께 많은 컴퓨터 기반 학습 시스템들이 개발되고 있다. 그러나 대부분의 컴퓨터 기반 학습 시스템들은 충분한 교육 이론의 뒷받침 없이 컴퓨터의 기능만을 고려하여 개발되고 있다. 컴퓨터 기반 학습 시스템의 학습 효과를 높이기 위해서는 컴퓨터 기능과 교육 이론의 적절한 결합이 필요하다. 이 연구의 목적은 교육 이론들과 컴퓨터의 기능들을 적절하게 연결하는 것이다. 최근에 교육 분야에서 학습자들의 개인차를 중시한 개별화 학습을 강조하고 있다. 본 연구는 성취-처치 상호작용, 적성-처치 상호작용, 내용-처치 상호작용 이론 등 다양한 개인차 이론을 고려한 맞춤형 학습 시스템들을 제시한다. 그리고 맞춤형 학습시스템에서 학습 효과에 가장 중요한 영향을 주는 개인차 이론에 기반한 학습자 성취도, 학습자의 학습 스타일, 학습과제 내용에 따라 적응성을 지원하는 방법을 기술한다. 또한 교육이론과 맞춤형 학습 시스템을 어떻게 연결할 것인지에 대한 개발 방향을 제시한다.

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