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# A Development of Adaptive Learning System Considering Learners' Knowledge Level

**Jaemu Lee**[*1], **Minhee Kim**[2]

[1]*Department of Computer Education, Busan National University of Education*
[2]*Ulsan Maesan Elementary School*

## ABSTRACT

The biggest advantage of computer based education is providing differential learning considering each learner's situation. Recently, adaptive learning system to support individualized learning has been actively studied. This study is about the adaptive learning system considering learners' individual achievement. This paper examines an adaptive learning system applying van Hiele's learning theory in order to support differential leveled learning in geometrical figures for elementary students. We classified learners' level of knowledge into three levels; lower level, middle level and upper level through the online test. We provide the leveled appropriate courses for the geometrical figures learning. A PHP script language is used to implement for learning algorithm and to manipulate the database. Finally, a Flash is used to present for adaptive learning object. The learning achievement of our proposed adaptive learning system will be increased because the learning system is constructed using the figure learning teaching strategies proposed by proven van Hiele' theory. Futhermore, the adaptive learning system considering learners' knowledge level will increase not only learning effects but also learning motivation by providing proper leveled learning and content. This study contributed to realize an adaptive learning system that takes into account the learner's knowledge level. And we showed how mathematical theory can connect with an adaptive learning system.



**KEYWORDS:** Computer based education, e-Learning, Adaptive learning, Personalized learning, Achievement treatment interaction, Geometrical figures, Personalized learning.

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[*]Corresponding author is with the Busan National University of Education, 24 Gyodaero Younjegu, Busan, 47508, KOREA.
*E-mail address:jmlee@bnue.ac.kr*

## 1. Introduction

The advantage of the computer in education field lies in personalized learning. Therefore, the individualization function of computer must be enhanced further to increase the quality of the learning [1][2]. Most of the computer based education systems do not adequately consider the learners'preferential instruction methods or individual characteristics. The students learning through the same content, in the same manner, and the same amount of time [3][4]. Computer based education systems need to provide adaptive learning that considers the individual's learning situation, learning objectives, learning history and preferred learning style in order to maximize learning outcomes [5][6].

Additionally, the field of geometrical figures is essential to many parts of mathematics textbooks and is closely related to students' lifes. Although it acts as a foundation for abstract visualization, which students find difficult, proper level of learning is difficult [7][8].

In order to solve these problems, appropriate courses at various levels were supplied according to the knowledge level of students. Even now, superior class are determined by group formation, there are excessive amount of work for teachers, and deficiencies are reoccurring. These problems make the educational process operations difficult for various levels [9][10].

Therefore, we need to provide adaptive learning with enhanced personalized education [11]. This study provide various leveled learning considering individual differences. Additionally, adaptive learning system applying van Hiele's theory was developed in order to support different levels of studies in geometrical figures learning for elementary students.

In Section 2, we describe related works. In Chapter 3, we describe the design and implementation of an adaptive learning system focussed on leveled learning. Finally, Section 4 describes the effects of our system and conclusion.

## 2. Related Work

Currently, most adaptive learning systems incorporate learning styles with learning strategies to improve effective learning.

Hwang, Sung, Hung and Huang [12] developed an adaptive learning system based on a similar learning style approach for natural science course. From a practical application, they reported that the learner result better learning achievements and attitudes.

Tiantong and Siksen [13] presented the online project-based learning system. But, it was not customizable to the aptitude of the students and focused only on learning the project.

Nye, Pavlik, Windsor, Olney and Hajeer [14] developed adaptive learning system by

combining the AutoTutor conversational tutoring system with the Assessment and Learning for mathematics. This system uses a service-oriented architecture to combine these two web-based systems. And, self-explanation tutoring dialogs were used to talk students through step-by-step worked examples to algebra problems.

Schneider [15] describes a concept that helps authors with the structure creation process, focussed on sequencing of content. The study was approached from the authors' perspective. They extract information for sequencing by investigating the linear structure of learning content.

Although there are lots researches for adaptive learning to improve learning effects, most of adaptive learning systems proposed instructional methods suitable for general students but failed to provide content for those who slowly fall behind because they did not consider the learner's knowledge level.

Therefore, we have provided adaptability for the various learners' knowledge level through psychometric questionnaires of the online test about the geometrical figures. These proposed adaptive learning system tried to be realized effective learning not only by individual aptitude but also by individual achievement through the students' knowledge level.

## 3. Development of an Adaptive Learning System

### 3.1 Developmental Direction

The developmental direction of the proposed adaptive learning system in this study is as follows:

First, to realize the adaptive learning, we are diagnosed the learners' knowledge level through the online level test. Depending on the diagnostic results, appropriate learning content for each learner's knowledge level is provided.

Second, we introduce van Hiele' theory for the implementation of an online test to diagnose the learners' knowledge level.

### 3.2 The Structure of the Adaptive Learning System

We used PHP script language to implement the learning algorithm and manipulate the database. Additionally, we used Adobe FLASH as authoring tool to present each learning object.

The most crucial function of the adaptive learning system is distributing appropriate courses considering learner's individual difference.

This adaptive learning system provides appropriate courses and contents based on each learner's knowledge level about the geometrical figures.

<Figure 1> displays the process of selecting the level by adaptive learning system. After the learner logs in, the learning system evaluates the level of the learner through a test. This process diagnoses the each learner's knowledge level by the test to provide properly leveled learning. This system divided the learning process into

three leveled sections for the adaptive learning as lower level, middle level and upper level in order to determine the learner's knowledge level. The van Hiele level test sheet is used with 20 multiple choice questions. This knowledge level test by van Hiele's learning theory were implemented online. Depending on the score of the test, the learner is assigned a level. Each item has a weight. The sum of the weighted values is classified as lower level below 1 point, middle level below 3 points, and upper level above 7 points. This system assigns the proper leveled learning by results of the online level test. The learner is able to move to a higher leveled learning after completing the assigned level learning and passing the test. The van Hiele's level test sheet used in this research included elementary level with 20 multiple choice questions.

In addition, the system assigns leveled learning content for adaptive learning which considers each learner's achievement. Therefore, this adaptive learning system is compatible with each learner's level by supplying content for a lower level, middle level and upper level. The learning difficulty in mathematics learning, greatly affects the learning effects.

Finally, this adaptive system provides learning contents suited to the learners knowledge.

### 3.3 Leveled Learning

This section provides a detailed explanation for each level of learning. Each level of the learner was initially determined by the test.

#### 3.3.1 Lower Level Learning

This stage provides the easiest level of learning. The geometric knowledge of learners entering this lower level through the level

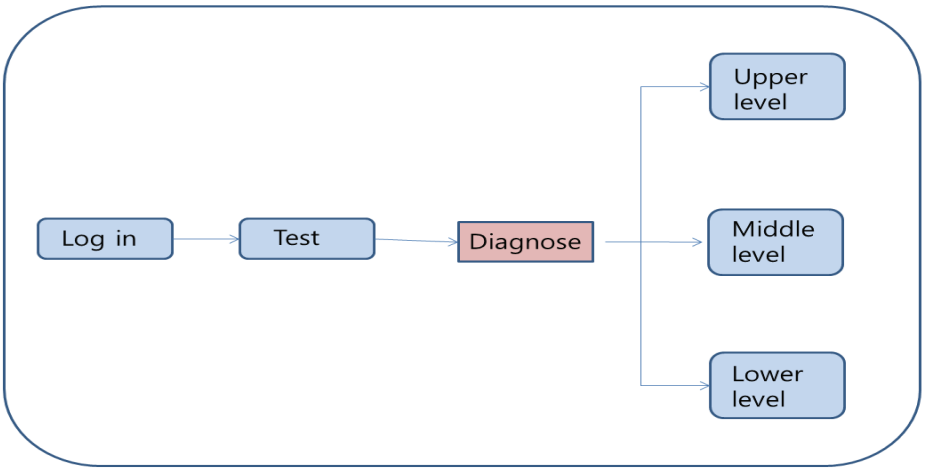


Figure 1. Knowledge level selection for adaptive learning

tests are learners whose knowledge is below the visual recognition level. Geometric terms include triangles, a shape that is more circular than polygonal, a triangular shape, and rectangular shapes. Learning is provided so to help the learners to recognize the figures. In addition, learning that focuses on the overall shape of the figure instead of the partial characteristics of each shape such as squares, rectangles, and parallelograms is provided. Finally, this step is to learn the basic concept of a figure. Evaluation of whether efficient learning takes place to evaluate whether the learner can move on to a higher level of learning.

### 3.3.2 Middle Level Learning

This step is to learn the features and differences of shapes. This level is execute by learners who have attained the geometrical thinking standard of visual level after test. In the middle level, learners can understand about the relationships amongst the components of geometrical figures through different operational activities. Through these activities, learners are able to distinguish between different figures. Learners recognize that there are different parts in figures, and when these parts are combined, they form different shapes.

<Figure 2> is the learning example for a middle level learner. As shown in <Figure 2>, 'Capture the Figure' is a learning activity where shapes are searched for on the screen with limited time where cards are divided into upper and lower parts that are moving. In 'Capture the Shape', different kinds of shapes is searched for as they are visually recognized. On the other hand, cards with different figures such as rectangles are provided so that the learner can learn about the definition and properties of the figures.

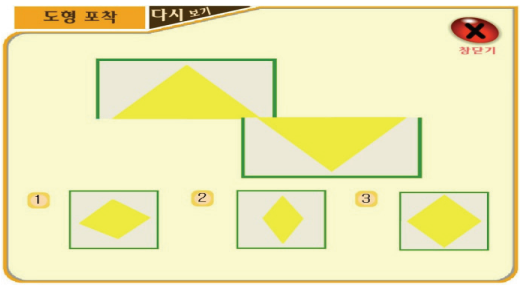


Figure 2. Middle Level Learning for the Figure

### 3.3.3 Upper Level Learning

Learners who enter this upper level after passing the level test are children who have attained the geometrical thinking standard of the analytical level. They learn about the relationships between qualities of figures and different kinds of figures. Learners are able to logically order and distinguish figures due to the characteristics of the figures by learning. Learners are able to recognize a square as a special form of rhombus, and can come to comprehend the relationship of quadrilateral figures.

The upper level learning consists of three types of learning. In this upper level learning, shapes are made of various patterns or

through a rotating game. Here the learner can come to understand the relationships between different kinds of shapes. One example of upper level learning is as Figure 3. As shown in <Figure 3>, 'Pentomino' is a game where 'Pentomino' is used to create rectangles and squares. Through this learning, learners can understand the relationships between rectangles and squares. In the end, learners complete the most complex and difficult learning in this stage.

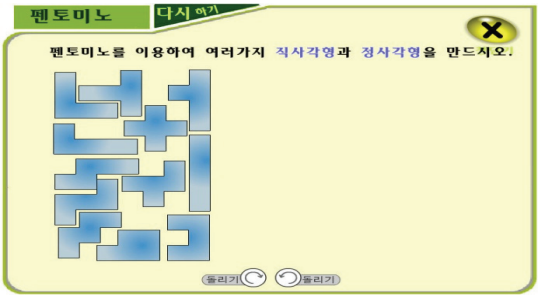


Figure 3. Upper Level Learning for the Figure

## 4. Conclusion

We have developed an adaptive learning system for geometrical figures that considers individual differences. This adaptive learning system provides appropriate courses depending on learners' knowledge level. It is real implementation of personalized learning by maximizing the merits of the computer. The main contribution of this study is proposing an implementation approach on how to maximize the advantage of the computer in education and by generating an adaptive learning system that considers each learners' knowledge level and achievement.

The characteristics and the expected effects of this study are compared with the existing learning system.

First, most computer based learning systems focus on technical implementation rather than on educational theory. In this study, we use the van Hiele's learning theory as the foundational theory for constructing the leveled learning system. The learning effect will be increased because the learning system is constructed using the figure learning teaching strategies proposed by proven van Hiele' theory.

Second, most learning systems target learning effects. Generally, students lose motivation to learn when confronted with difficult math concepts. This study reveals that it is possible to increase learning motivation and acquisition of knowledge by understanding the learning modalities and gearing them to the level of the students.

Third, most adaptive learning systems provide adaptive learning that takes into consideration the learners' learning styles. In this study, we propose an adaptive learning system that takes into consideration the level of the learner. This greatly influences mathematics learning, and it is meaningful in adopting a model of adaptive learning in mathematics learning.

Additionally by providing various operational activities that take into consideration a learners' cognitive development level, learners can understand

and learn about geometrical figures more efficiently.

However, our proposed adaptive learning system has some limitations. It cannot produce significantly better learning achievements. Our study stresses learners' knowledge level but it needs to further consider other factors in order to provide a better learning environment.

In the future, we need to develop adaptive functions to provide more effective learning including adaptive motivation, adaptive advice, and adaptive feedback. Furthermore, we need more research on adaptive learning systems based on learning theories and individual difference theories.

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## 학습자의 성취 수준을 고려한 적응형 학습 시스템 개발

**이재무[1], 김민희[2]**

[1]*부산교육대학교 컴퓨터교육과 교수*

[2]*울산 매산초등학교 교사*

**요 약**

교육에서 컴퓨터가 활용될 때 가장 큰 장점은 학습자들의 각 학습 상황에 따른 개인차를 지원한다는 것이다. 최근 개별 학습을 지원하기 위한 연구가 활발히 진행되고 있다. 이 연구는 학습자들의 개별 성취도에 따른 적응형 학습 시스템에 관한 것이다. 이 연구는 초등학교 도형 학습에서 반힐레의 이론을 적용하여 준별 학습을 지원하는 적응형 학습 시스템을 예로 제시한다. 본 연구는 테스트를 통하여 학습자 수준을 하위수준, 중간 수준, 상위 수준의 세 집단으로 나누었다. 그리고 학습자의 수준에 적합한 도형 학습 내용을 제공한다. PHP 스크립트 언어를 사용하여 학습 알고리즘과 데이터베이스를 관리한다. 그리고 Flash를 이용하여 각 학습 내용을 표현하였다. 우리가 제안한 적응형 학습 시스템은 학습자 수준에 적절한 학습 내용을 제공함으로서 학습 효과는 물론 학습 동기도 높일 수 있을 것이다. 본 연구는 학습자 수준을 고려한 적응형 학습 시스템의 실현에 기여하였다. 그리고 수학 이론이 적응형 시스템에 어떻게 표현할 수 있는가를 보여주었다.

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**Jaemu Lee** received Ph.D. degrees from the Osaka University in Japan. He has been a professor in the Computer Education Department at the Busan National University of Education in Korea since 1987. His research interests include Educational ontology and Adaptive learning systems.

*E-mail address*: jmlee@bnue.ac.kr

**Minhee Kim** completed master course at Department of Computer Education, Busan National University of Education in 2006. She is interested in Computer Based Education System and Computer Teaching Methods.

*E-mail address*: minira5@naver.com