

## A case study on learner modeling based on conceptual change theory for adaptive learning system

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**Abstract:** Adaptive learning system had been widely used for enhancing the user experience in ICT environment. And, there is a lot of research of how adaptive system could use in education and be focusing on approaches to construction system and the technology for software implementation. But, it maybe makes some negative consequences. If designer don't know nature of learning (such as learning target, the influence factor of learning achievement) well and construct an accurate learner model, the learning system should become a tool only used for representation and communication. The purpose of this study is to explore how to construct a learner model based on conceptual change theory for adaptive learning system in order to improve its accurate and efficiency.

The first question should be answered is what is being modeled. The learning target and specific learning process should be clear, and the influence factor of learning achievement should be figure out. This study chooses conceptual change theory as the based theory to illustrate how learning process is acting. Second, the structure and the representation of information above should be considered to create a logical learner model. Finally, choosing the appropriate approaches to construction and maintenance. And a case study in junior high school following these steps is shown in this paper.

### 1. Introduction

Adaptive Learning System(ALS or AES) is developed through three periods. It first appears as Intelligent Tutoring Systems(ITS) using in instruction field in 1970s. For example, TICCIT (an acronym for Time-shared, Interactive, Computer-Controlled Information Television) was first developed by the MITRE Corporation in 1968 as an interactive cable television (CATV) system. Then in 1971, the National Science Foundation (NSF) Technological Innovations Group granted a contract to MITRE to further develop the TICCIT system as a computer-assisted instruction (CAI) system for community colleges. TICCIT system can diagnose the learning status of students and report the conclusion to their teachers.

In 1990s, the internet develops sharply and it extent the potential of ALS. The user could find so many learning resource, learning partners, and chose different learning styles. ALS should not only be a diagnose-report system, but also a navigate system. Adaptive Hypermedia System(AHS), the two main parent areas are hypertext and ITS (diagnose by user model), was grew rapidly (Brusilovsky, 2001). The conceptual structure for adaptive systems generally consists of interdependent components: a user model, a domain model and an interaction model (Brusilovsky, 1993). The mainly function of AHS is adaptive presentation resource and offer adaptive navigation support.

Since 2000, there is a lot of new ideas used in education like Learning Analytics (Siemens 2012), MOOC (Mcauley 2010), clipped classroom (Baker 2000), etc. It shows the technology of data mining and artificial intelligence, learning theory has improved, and the understanding of ALS should innovate. Brusilovsky (2007) conclude a develop process of ALS in three level: what to be modeled, the structure and representation, construction and maintain.

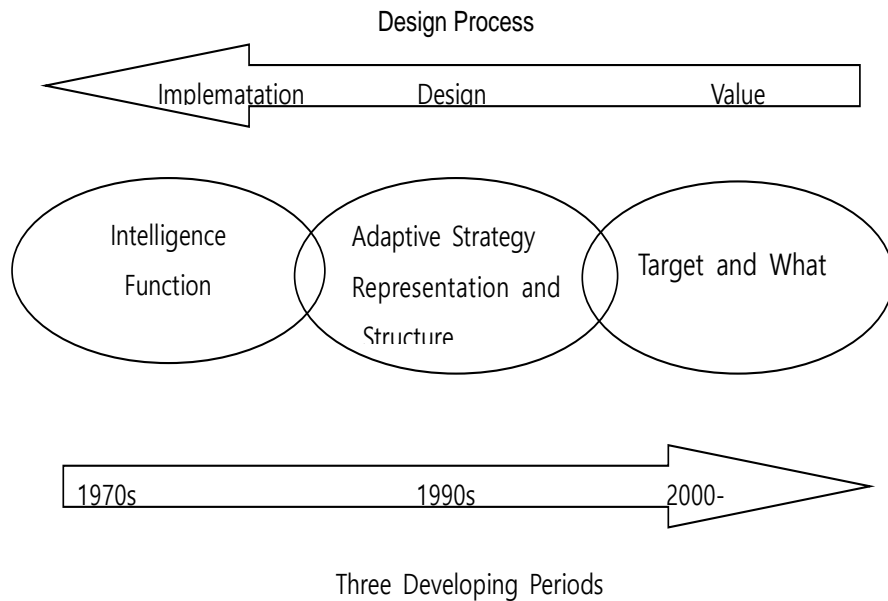


Fig 1 Three developing periods and the design process of ALS

### 1.1 What to be modeled

Judging the value and cost, the designer would determine what problem should the system solve. Then, based on learning theory and cognitive theory, what function should the system have will decide. After that, what information should be collected and be analysed will confirm.

### 1.2 The structure and representation

An appropriate type modeling method should be chosen for representing the information which is going to be modeled. The user model, domain model and interaction model of ALS, the relation between them and adaptive strategy should be designed.

### 1.3 Construction and maintain

This level is about the algorithm and the approach for software implementation. It depends on what have been designed in the two steps above.

This study follows the three steps above, and focus on construct the user model, also called learner model.

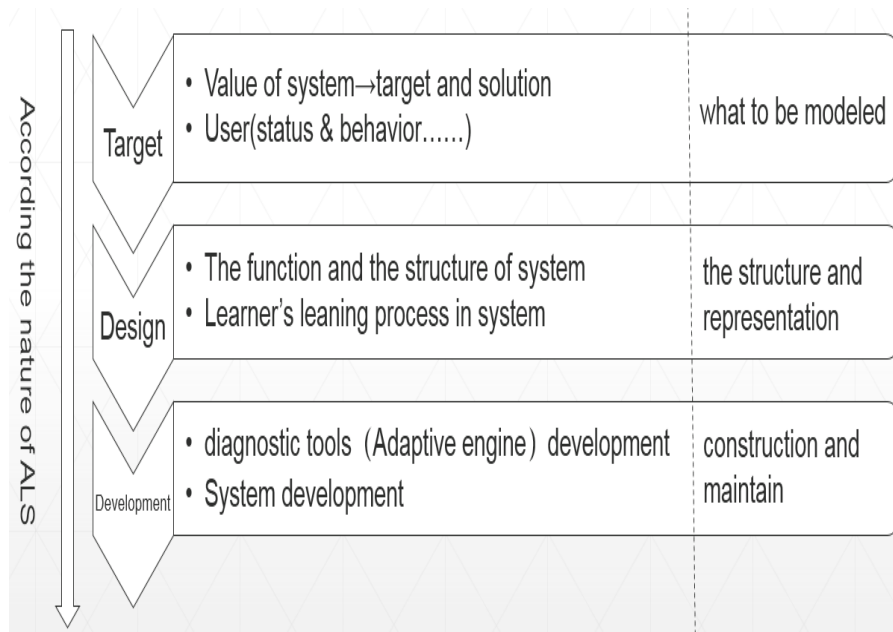


Fig 2 The process of designing ALS

## 2. Design

### 2.1 What to be modeled?

The value of ALS come from improving learning efficient. ALS should solve the real, serious and critical problem which hinder learning process. Preconceptions is a kind of simple conceptions from daily life. They appear before formal study, and always differ from science conceptions. So, they confuse learners and hinder the learning process. So, this study focus on how to solve the preconception problem.

According to the conceptual change theory (Strike & Posner 1992), the specific preconception and the relevant elements should be found. The conceptual strategy and resource is design based on it.

### 2.2 Research design

#### 1) Select research sample

Five hundred and sixty students of two junior high school participated in this research. By the reason of the specialty of physics, students of junior high school are greatly influenced and their preconceptions is easy to observe.

#### 2) Design research process

First, developing the diagnostic test to diagnose students' specific preconceptions (P in Fig.3). The specific preconceptions can conclude by the answer of questionnaire (AoR in Fig.3).

Second, exploring the elements related to preconceptions. Some variables are observed directly, some are not. The invisible elements should be deduced.

Then, we could forecast the preconceptions in future (PiF in Fig.3) and others may block learning.

At last, the adaptive strategy (AS in Fig.3) could design according the information wo get from the last three steps.

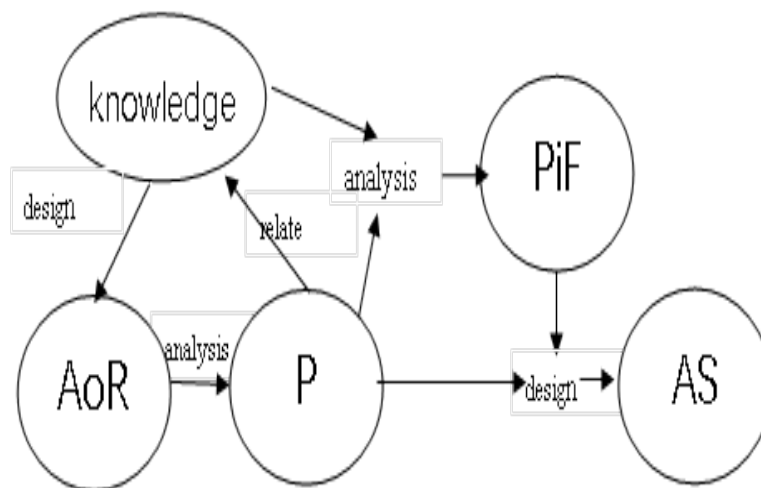


Fig 3 Design Research Process

## 3. Method

### 3.1 To diagnose students' preconceptions by developing a two stage diagnostic test (Treagust 1988).

1) Defining the content, and draw the concept map to confirm the test should cover all the knowledge point.

2) Obtaining information about students' preconceptions.

a) Reviewing the relevant research literature to gain the knowledge of preconceptions.

b) Non-structured interviews and subjective diagnostic questionnaire were conducted to confirm the preconceptions of students.

c) The feedback of the students will be the options of objective questionnaire.

3) Developing a two stage objective diagnostic test

a) The first stage, design three to four options for students to answer.

b) The second stage is ask students to fill a reason for the corresponding options in the first period, usually containing four options, including the options for correct answers, the wrong answer options has verification and not through the verification, and other wrong answer options which is necessary to add.

c) There should be pre-test one times or more, and the test would modify if anything is not appropriate in literal presentation or logic.

### 3.2 To explore the relevant elements invisible.

1) Reviewing the relevant research literature to select the relevant elements, like ability to abstract.

2) Analysis of Partial Correlation in preconceptions, conception to learn, students' capacities and its operation in SPSS

### 3.3 To forecast the preconceptions in future

With the information we have collected, we should forecast the probabilities of troubles in future by Bayesian Network method.

## 4. Results

As the research result, the leaner model concludes the learner's essential information, the learner's the specific preconceptions, the preconceptions the learner may have in the future and it's prability.

Table 1 The Essential Information of Student

Student_ID	8559601
Student_NAME	Oliver
Learning process	M(M1-M4),F(F1-F5),N(N1),G(G1,G2)

Table 2 The Preconceptions of Student

Student_ID	8559601
Preconception	detail
L1	The student is confused about the concepts of force and energy, he thought things only move with a sustained "move force".
L4	There is not force on the static objects, and there must a force on the moving objects whose direction is same as motion.
...	
L40	The student ignore objects still has inertia when it is moving.

Table 3 The Adaptive Strategy

Student_ID	8559601	
Conception point with preconceptions	Probability	Strategy
M1	0%	-
M2	10%	1(60%)>2(25%)>5(10%)...
...		
G1	100%	1(70%)>4(20%)>2(5%)...
G2	60%	3(50%)>1(30%)>4(15%)...
N1	50%	1(30%)>2(25%)>5(15%)...
Preconceptions in future(forecast)	Probability	Strategy
N3	25%	1(40%)>2(30%)>5(15%)...
...		
C3	0%	-
Capacity lack	Probability	Strategy
logic	85%(low)	a(60%)>b(30%)>c(5%)...
...		
comprehension	10%(high)	a(90%)>e(5%)>c(2.5%)...

40 preconceptions have been found, and its relation to the knowledge point has been calculated. The learner's relevant elements concluding: logical confusing, comprehension capacity, analysis capacity

The learning strategy designed according to the theories of Conceptual Change theory. The conclusion of the system diagnose is a describe in different point with probabilities. The priority of adaptive strategy is determined by the probabilities.

Three tables illustrate the diagnose feedback based on the learner model of a student named Oliver.

## 5. Conclusion

The research shows how to design learner model according to the theories of Conceptual Change theory. First, designing learner model should integrate learn science and instruction strategy. Second, Learner modeling should not just present learner's characters. The process of learning should also be considered. Finally, as the key model of ALS, the feedback function should be designed as soon as learner modeling.

The research also illustrate a new method to construction learner model in ALS considering data mining and learning theory. It is not only add preconceptions as a new diagnosis object, but also consequence a new view in learner modeling and feedback designing.

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