

Research on Personalized Learning Model under Informatization Environment

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Abstract—Due to the influence of psychology and cognitive science, personalized learning has gradually drawn the attention of many researchers. The purpose of this paper is to research an acceptable personalized learning method for learners. In this paper, we perform a study by literature review from four aspects. Firstly, we construct learner model based on learner's learning style and cognitive ability. Then, we introduce the process of personalized learning in online learning environment. Moreover, we propose the way of information presentation by knowledge visualization, and pose corresponding intervention strategies for different learning stages. Finally, we conduct experiments, and prove that the personalized learning method is more effective than the conventional learning method.

Keywords—personalized learning; learner model; knowledge visualization

I. INTRODUCTION

Recently education has witnessed rapid change in methods, curriculum design and pedagogical approaches [1]. The term personalized learning has proliferated over recent years especially with the advancement of several educational technologies, conceptual frameworks and mobile and wireless internet technologies [2]. Personalized learning focuses highly on individual students' needs, acknowledges that students have their own learning styles, interests and supports each student in learning in their own unique way [3]. In recent years, personalized learning has been widely studied. Yang proposed that a perfect personalized learning system was composed of user model, learner interest model, learner cognitive level model, learning resources and resource recommendation [4, 5]. Brusilovsky introduced an open social student modeling for personalized learning. He added social dimension compared with OSM, and explored the impact of the social dimension of OSSM. Finally, he proved that OSSM could improve students' learning effectiveness compared with OSM [6]. Amiera summarized the related literatures of personalized environment, and introduced a personalized e-learning system based on the Felder and Silverman Learning Style Model (FSLSM) [7]. Liming proposed the way of personalized learning resources organization based on knowledge point index and user's personalized demand information, and verified that the method was effective and useful [8]. Wongwatkit posed a personalized learning support system in physics that could monitor individual student's ongoing learning situations and provide effective personalized learning activities. Finally, he proved

that it was more effective than conventional system for student learning physics [9]. Lin used decision rules to select personalized learning pathways, and the personalized learning pathways could improve learners' cognitive ability and learning results [10]. In summary, research on personalized learning had been comprehensive, but most of studies were based on some aspects of personalized learning. Personalized learning methods for the overall study based on e-learning environment was relatively few. Therefore, the study of personalized learning method under e-learning environment is essential.

II. PERSONALIZED LEARNING FOUNDATION: LEARNER MODEL

A. Personalized Learning Elements

Personalized learning method under e-learning environment is shown in Fig. 1. Figure 1 shows that personalized learning elements include personalized learning style, personalized learning prediction and personalized learning intervention. In personalized learning progress, firstly, students choose learning style, and personalized learning is a major learning style which can effectively promote learners learning under e-learning environment. In the following, we predict learner's learning results based on learner's behavior data in learner's learning progress. If the difference between predicted results and expected results is large, some appropriate intervention strategies will be used for learners, moreover, learners will improve learning activities. Personalized learning under e-learning environment is a circle, and learner's learning activity is also a circular process, in which learners can constantly improve their own capability.

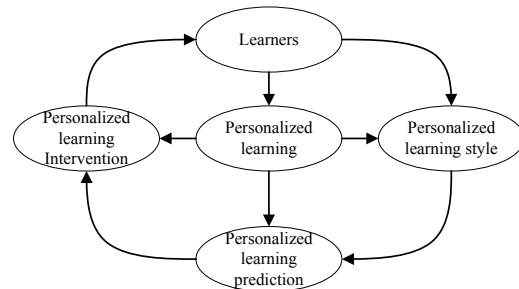


Fig. 1. Personalized learning method under e-learning environment.

B. Learner Model Construction

Achieving educational equity and respecting individual differences is the goal of personalized learning. Learner model is an important section for personalized learning. Based on study of existing learner characteristics model and current situation of personalized learning, combined with convenience of data collection and real-time of data analysis under e-learning environment, considered some factors that affect learners' individual differences, such as learner's basic information, cognitive ability, learning style and other factors, followed the CELTS-11 learner model specification, integrated coverage model and cognitive model construction method, we construct learner model from two major factors which are learner's cognitive level and learning style. The construction process of learner model based on online learning is shown in Fig. 2.

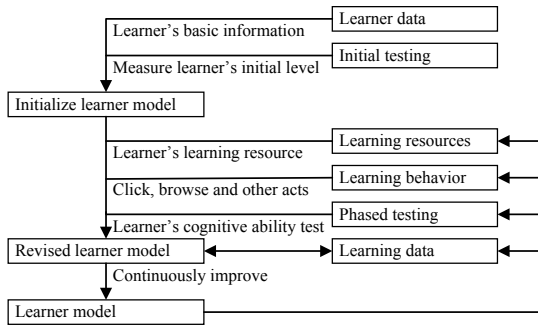


Fig. 2. Construction process of learner model based on online learning.

In Fig. 2, learner model is firstly initialized by learner's dataset and initial test information. We obtain learner's basic information by learner's registration information, such as name, sex, date of birth, educational level, and cultural background and so on. We test learner's learning style by Felder-Silverman Learning Style Scale, and test learner's initial cognitive level by ability test. After learner model initialized, we continuously revise learner model according to learner's learning progress. At this stage, we dynamically modify learning style by different types of media resources and interactive information which includes clicking, browsing, posting and other interactive behavior. After learning, we create a phase test to measure the level of cognitive competence. Learner model is constantly improved based on learning styles and cognitive level. Finally, learner model will be applied to personalized learning process, and it will be conducive to learners' personalized learning.

III. PERSONALIZED LEARNING PROCESS UNDER INFORMATIZATION ENVIRONMENT

Personalized learning process under e-learning environment majorly includes choosing learning methods, predicting and intervening learning results.

A. Learning Methods: Personalized Learning

A number of online learning platforms are emerging under information technology conditions, such as MOOC, edX. So it requires learners to choose learning method according to their needs, and personalized learning is more suitable for learners to

learn effectively in online learning environment. Figure 3 shows personalized learning in online learning environment. First of all, learners' learning motivation and purpose is determined. In the following, online learning system assesses learner's learning ability, and system recommends learning resources according to learner's ability and learning style. Moreover, system dynamically determines learning results by stage tests in learning process. Finally, learners do unit tests. If learners don't achieve their learning objectives, they will do unit tutorial; but if they get it, they can terminate this study or start a new learning unit. In summary, the key of personalized learning is learning ability assessment and personalized learning resource recommendation.

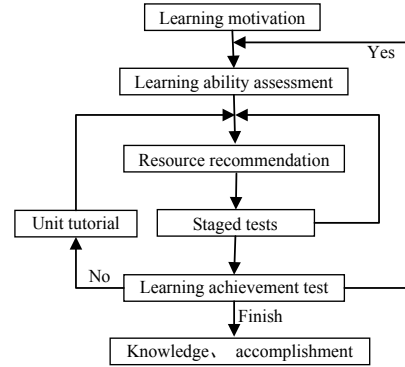


Fig. 3. Personalized learning in online learning environment.

1) *Learning ability assessment*: We assess learner's initial learning ability according to learner's learning motivation and learner's cognitive ability. In online learning environment, learners' learning motivation and learning purpose are determined by questionnaire and historical behavior data. Before learning, learners do relevant test. Then, we measure learners' cognitive abilities through test records, historical data, and so on. Test records include score, type, difficulty, frequency, time, and so on. Historical data include practice, examination, browse, communication, feedback, retrieve information, and so on. In summary, the learners' initial learning ability in online learning environment is determined according to learners' learning motivation and initial cognitive ability.

2) *Resource recommendation*: Based on the learner model in Fig. 2, we use content-based recommendation method to recommend personalized learning resources for different learners. Before learning, learners' learning style is determined according to the Felder-Silverman Learning Style Scale. Online learning system recommends some resources for learner by using content-based recommendation, and the resource is matched to learners' learning style. In learning progress, online learning system dynamically corrects learning style according to learner's behavior data, and dynamically recommends resources which matched with learner's learning style. After learning, according to learners' answer situation, especially the wrong questions, online learning system uses the content similarity retrieval method to recommend learning resources which are similar to wrong topic.

B. Information Presentation: Knowledge Visualization

With the rapid development of information technology, information presentation is becoming more and more diversified, more and more technologies are used to visualize knowledge, such as mind map and Baidu brain map. Knowledge visualization, as the way of information presentation in personalized learning, includes knowledge structure visualization, learning path visualization and learning progress visualization. Knowledge structure visualization is used to represent architecture and hierarchy of knowledge. Learning path visualization shows learner's personalized learning path. In this paper, nodes represent concepts, connections represent relationships of concepts, different shapes represent hierarchies of knowledge and arrows indicate mapping relationships. We use these rules to construct a knowledge visualization example about knowledge structure visualization and learning path visualization as shown in Fig. 4. In Fig. 4, the example is divided into two layers. The first layer represents the knowledge map which indicates learning point and hierarchy of learning content. The second layer maps a node which is contained the first layer, and it shows personalized learning path which denotes learner's learning sequence and learning process.

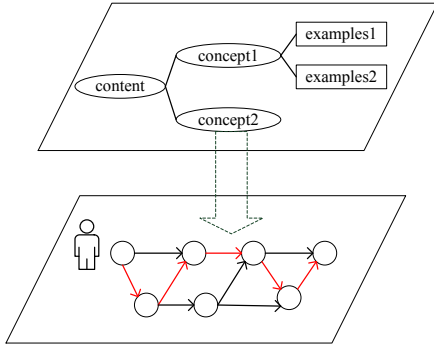


Fig. 4. Knowledge visualization example.

In learning process, there will be a large number of learning data and interactive behavior data. In this paper, we collect these data from system log. We analyze these data using learning analysis techniques and extract some elements of learning process, such as learning content, learning progress, learning time and other factors. Then, we have made a visualization example about learning process, as shown in Table I. In Table I, h is an abbreviation for hour. This example mainly uses text description. In future, we will improve the example. Such as we will use progress bar or pie chart show learning progress and use pictures or emoticons describe learning results.

TABLE I. LEARNING PROCESS VISUALIZATION EXAMPLE.

Learning content	Expected time	Actual time	Expected /Actual	Learning progress	Learning results
Content 1	3.0h	5.0h	1.7	70%	General
Content 2	0.5h	1.0h	2.0	100%	Skilled
Content 3	1.0h	0.7h	0.7	50%	Not mastered
Content 4	0.7h	1.0h	1.4	100%	Unskilled

C. Learning prediction and intervention

With the development of information technology, big data, learning analysis technology is widely used in teaching and learning. Nowadays, a number of learners learn online. So it is very convenient to collect learner's data, and it is also very real-time to analyze learner's learning behavior. Based on real-time analysis of learners' learning behavior, we can predict and intervene learning results in time, and this way will promote learners' effective learning.

The progress of learning prediction and intervention based on learning analysis technology is shown in Fig. 5. First of all, we obtain initial variables by collecting learner's learning data from system log and extracting variables relating to learning behavior. In the following, we eliminate irrelevant variables by plotting initial variable scatter plot, and finally we get the initial Set 1. Moreover, we perform a simple binary analysis of initial Set 1 to remove irrelevant variables and finally we get initial Set 2. Furthermore, we select variables that are significantly related to learning behavior by performing a multiple regression on initial Set 2, and obtain predictive expression according to regression equation. Finally, we use predictive expressions to predict learners' next behavior or learning results. If learning results are separated from their learning objectives, personalized intervention will be taken.

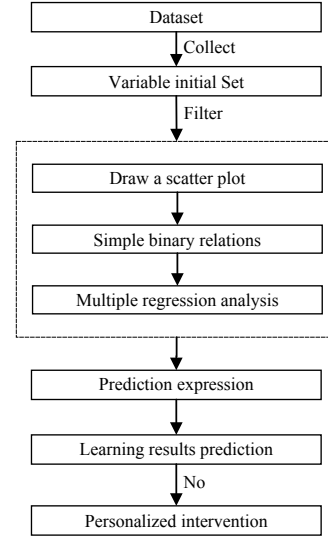


Fig. 5. Progress of learning prediction and intervention.

Under e-learning environment, the design of personalized learning intervention is shown in Table II. Personalized intervention is divided into three stages according to learning progress. Before learning, learners' learning materials are interfered according to learners' learning style and initial cognitive level. In learning process, learners' behavior is tracked and analyzed in time using large data technology. If learners' learning progress is lower than expected progress, bulletin message, learning progress visualization chart and e-mail will be used to remind learners to reflect on their learning. After learning, there are examinations and some charts displaying learning results. If learning results are far from expected learning targets, online learning system will suggest

learners to do some unit tutorial which is extracted from knowledge weak point.

TABLE II. DESIGN OF PERSONALIZED LEARNING INTERVENTION.

Stage	Strategy	Means
Before learning	Test learning styles and cognitive initial levels	Recommended resources
Learning process	Learner behavior analysis, learning progress visualization	Bullet boxes, e-mail and other reminders
After learning	Stage testing, visualization of learning outcomes	Unit tutorial

IV. EXPERIMENTS AND DISCUSSION

To verify effectiveness of personalized learning method under e-learning environment, we ran a study where we compared two different methods, one named personalized learning method, and another, named conventional online learning method. The study was performed in two online learning platforms at the School of Central China Normal University, one named cloud classroom, and another, named starC educational cloud. We selected the Variables chapter of C Language Programming as learning content. Two methods were introduced to learners before learning. Then students done a pretest to check their Variables knowledge. After pretest, each student accessed the learning system with a link. All user interactions with the system were logged. Four weeks later, learners took a posttest.

A. Participants

The total number of students in two groups of the course was 60. Of the remaining 60 students, 30 students learned with the personalized learning method, called Experimental Group (EG); while another 30 students learned with conventional online learning method, called Control Group (CG). They were freshmen at Central China Normal University whose profession was educational technology. All students were familiar with information technology in general.

B. Pretest

The pretest included ten questions that checked learners' knowledge. These questions included multiple choice questions and statements. They were somethings about basis of variables. And each question had a corresponding score. After test, we obtained learner's achievements. Learner's pretest results are shown in Table III. From Table III, we could see that the average score of two groups were at a level, and $p > 0.05$. Thus, there was not significant difference about two groups' scores.

TABLE III. STATISTICAL TABLE OF PRETEST.

Group	N	Mean	SD	Sig. (two-tailed)
EG	30	69.400	10.493	0.952
CG	30	68.370	11.177	

C. Experiments environment

In this paper, we had two groups that were EG and CG. Learners of two groups learned in corresponding system. CG learning environment is shown in Fig. 6, EG learning environment is shown in Fig. 7.

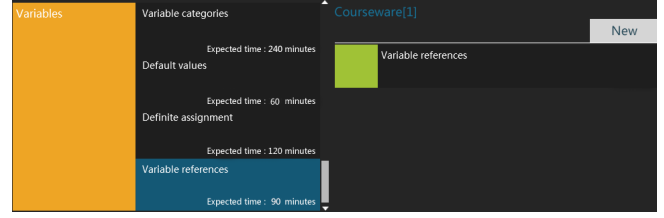


Fig. 6. CG learning environment.

Figure 6 is CG learning environment. There were two parts in Fig. 6. Chapters for learning content presented in left, the corresponding courseware for each chapter showed in right.

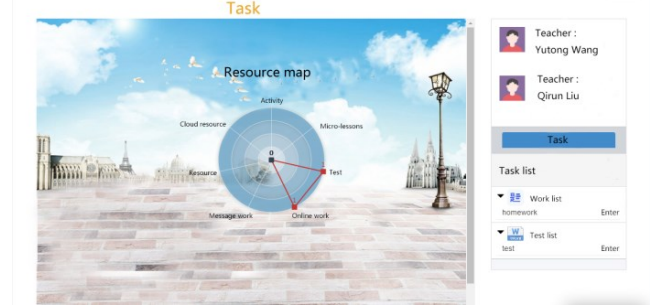


Fig. 7. EG learning environment.

Figure 7 is EG learning environment. There were two parts in Fig. 7. Left was resource map, right was learner's teacher information and task list. In resource map, there were seven parts, such as activity, test, online work, message work, resource, micro-lessons, and cloud resource. Learners could choose their own learning resource. Task list had work list, test list and so on. Different learners had different tasks.

From above, we could see that two groups learned in different environment. One system supported personalized learning method, another system supported conventional online learning method. And learning content was single type in conventional online learning environment. The content was courseware which was uploaded by their teacher. And all students used single type. While in personalized learning system, teacher would assign personalized task according to learner's cognitive ability. In addition, learners could choose different resource type, such as cloud resources and micro-lessons resource, to accomplish their task. Micro-lessons resource mainly includes excellent course video. Cloud resources mainly include courseware, course video and other interrelated knowledge. And personalized learning system also had some personalized tests which could examine learner's learning. The tests included message work, online work and so on.

D. Posttest

After learning, all learners took posttest. Posttest included twenty questions which were majorly Variable questions. These questions were designed by instructor. And we examined learner's learning results by using these questions. So we could obtain learner's score. And we plotted the data in descending order. The X axis stands for different students. The Y axis stands for student's score. Two groups score is respectively shown in Fig. 8 and Fig. 9.

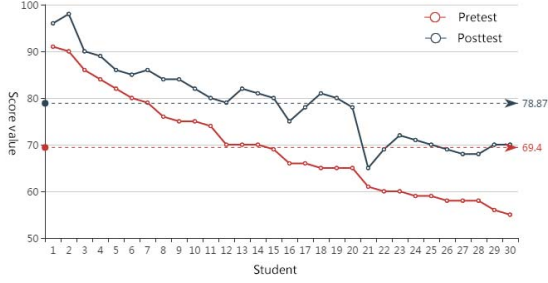


Fig. 8. EG score.

Figure 8 is EG score. It included pretest score and posttest score. From above, it displayed that the average score of posttest is higher than pretest. It proved that learner's scores of experimental group greatly improved after learning.

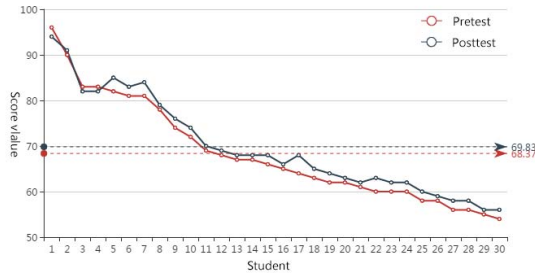


Fig. 9. CG score.

Figure 9 is CG score. It included pretest score and posttest score. From above, it shows that the average score of posttest is higher than pretest. It proved that learner's scores of control group improved after learning.

E. Research Results

The results of two groups are shown in Table IV. In Table III, it showed that two groups' score were basically similar, there were not significant difference. After 4 weeks of study, from Fig. 8 and Fig. 9, we could see that two groups' posttest average score was higher than pretest, and $p < 0.05$. It proved that learners had improved their academic performance after learning. And in Table IV, it displayed that experimental group's average score is 9.04 higher than control group, and $p < 0.01$, experimental group's learning effect is significantly better than the control group. In short, although both learning methods were effective, personalized learning method under e-learning environment was more effective than conventional online learning method.

TABLE IV. STATISTICAL TABLE OF POSTTEST.

Group	N	Mean	SD	Sig. (two-tailed)
EG	30	78.870	8.500	0.001
CG	30	69.830	10.687	

V. CONCLUSION

In this paper, we proposed a personalized learning method under the information condition. In this method, there are four learning elements, such as learner model, learning style, learning prediction and learning intervention. The article describes how to construct learner model based on learner's

learning style and cognitive ability. Furthermore, we illustrated that the personalized learning is the major learning method. The key of personalized learning is learning ability assessment and personalized learning resource recommendation. The article describes how to predict the learning results and how to intervene in different learning stages. However, we only have validated the proposed method in a small-scale. In future, we will examine those in large-scale.

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