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Research of Influencing Factors of College Students' Personalized Learning Based On Smart Learning Environment

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ABSTRACT: *Smart learning environment, as a high form of digital learning environment, accelerates the wide spread of personalized learning supported by Information Technology. Based on the literature analysis and Delphi method, this paper constructs a scale of influencing factors of college students' personalized learning based on smart learning environment. By factors analysis, descriptive statistical analysis, average difference test and regression analysis, this paper obtains four factors that affect college students' personalized learning based on smart learning environment, i.e. learner factor, teacher factor, learning environment factor and learning resource factor, and explores the relationship among these factors through structural equation model. The purpose of this paper is not only to provide a theoretical basis for further study, but also to provide advice and guidance for the effective launching of personalized learning based on smart learning environment, which helps to stimulate college students' potential and expertise, teach according to each student's individual differences, and promote the educational reform.*

Keywords:*smart learning environment, personalized learning, influencing factors, factors analysis*

I. Introduction

Striving for providing every student with personalized learning and life-long learning environment and services, promoting students' all-round development, and accelerating the formation of learning society are important missions of higher education in the forthcoming ten years. College students have active mind, enough time to self-allocate, and more freedom to learn. How to inspire them to make full use of their spare time and exert their potential according to their individual differences, special needs or interests has become a popular issue in recent years. One of the directions of future education is personalized learning based on network (or online personalized learning). Personalized learning emphasizes on starting from the learner's individual difference, centering by learner's needs and interests, taking learner's ability development as the ultimate goal, and enabling learner to adjust learning content, style or even step during the course of learning. This learning pattern helps to transform teaching and learning styles or models, stimulate learner's potential and expertise, make learner more active, and finally achieve an overall and individual development of each learner. Fortunately, the emergence of all kinds of smart devices and techniques (for example, Big Data) accelerates the popularity of personalized learning by solid hardware equipment and robust software support, especially the occurrence of smart learning environment (SLE). Professor Huang [1] regarded SLE as a place or activity space for learner to achieve effective learning by automatically perceiving learning context, identifying learner's features, offering suitable learning resources and convenient collaborative tools, and automatically recording learning process and assessing learning results. All these merits make SLE a perfect choice for college students to pursue personalized learning. Currently there are some researches on the field of personalized learning and smart learning environment theoretically and practically, and some cases in terms of personalized teaching based on SLE as well. Generally speaking, few research points to the learning effect or influencing factors of personalized learning, and there is hardly any research on the basis of college students or SLE. To this end, this paper hopes to enrich the theory of personalized learning and provides some guidance on personalized learning practice.

II. Related Work

In 2004 professor SannaJärvelä argued that the following seven aspects were critical problems towards utilizing personalized education [2]: (1) key skills development related to different areas; (2) directly improved student learning skills; (3) encourage learning by setting up motivation; (4) collaborative knowledge construction; (5) new assessing mode; (6) regard technology as personal cognitive and socializing tools; (7) teachers are critical. In 2006, Finnish minister of education Steve Maharey [3] pointed out at a symposium that there were eight components in personalized learning, including effective teaching strategies, resources, powerful leadership, etc. Powell [4] proposed five critical factors in personalized learning from pedagogy's point of view, i.e. (1) student's cultural and language feature, learning style and likeness; (2) teacher's cultural bias, teaching style, belief and expectation for students; (3) prospective and value of the course; (4) assess ability; (5) good

relationship with colleagues. Song [5] thought that there were many individual factors that affected a person's learning, including self efficacy, self motivation, cognitive strategy, social cooperation and co-learning ability, etc. Ling-Hsiu Chen [6] found through empirical study that apart from knowledge structure, learner's knowledge level and cognitive style also affected learner's personalized learning performance. YuxiaMa [7] got seventeen factors about learner's personalized learning from four dimensions: teacher, learner, school and environment.

Literature analysis reveals that there are several aspects related to the effect of personal learning, though existing researches vary a lot. From learner's perspective, influencing factors include learning style, learning motivation, learning strategy. From teacher's perspective, influencing factors include teaching concepts, teaching methods, teaching models. While from environment and resource perspective, they are personalized services, intelligent perception and identification, resource acquisition and recommendation, etc. There all give positive instruction and guidance to our research.

III. Research Idea And Methods

3.1 Research methods

This paper adopts literature analysis method to give related works a brief review, and gets initial influencing factors according to the connotation, elements and features of SLE. Based upon that three rounds of expert consultation are followed, in order to determine details of the associated factors. Accordingly a questionnaire is established and finally data are collected to make further analysis. Therefore there are mainly three research methods used in this paper: literature review, Delphi and questionnaire survey. In addition, factors analysis, descriptive statistical analysis, average difference test and regression analysis are used to analyze the survey results.

3.2 Questionnaire design

Through literature review and expert consultation, four influencing dimensions are obtained: learner, teacher, learning environment and learning resource. Furthermore every dimension is divided into several sub-dimensions as illustrated in Fig. 1. Initial questionnaire is designed accordingly, which consists of 56 questions. Among them 51 are in the form of Likert scales, and the remaining 5 are related to personal information.

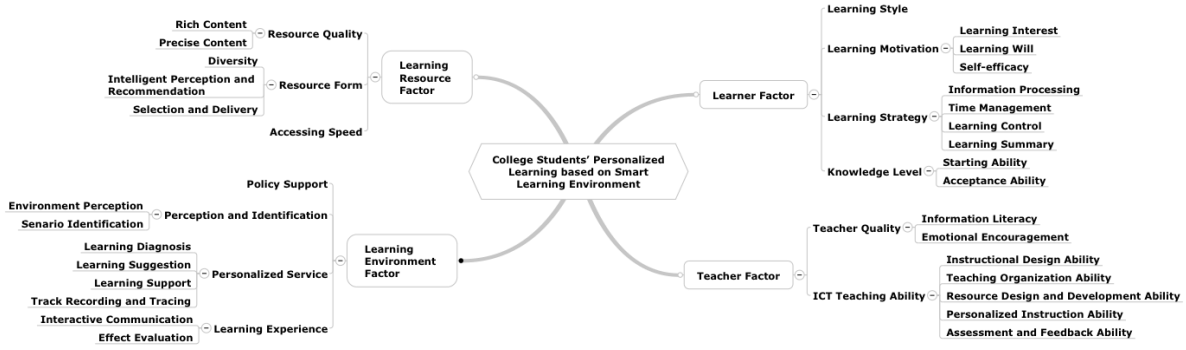

Figure1: Content framework of influencing factors of college students' personalized learning based on SLE

3.3 Research object and data processing

3.3.1 Testing of the initial questionnaire

Undergraduates and graduate students of Educational Technology Department in South China Normal University are involved in this initial testing. 80 questionnaires are delivered, and 76 are reclaimed, with effective reclaiming rate 100%. After that, SPSS 17.0 is used to help data analysis, and finally 5 questions are deleted to produce a formal questionnaire. Reliability analysis is then made and results show that the scales are of great internal consistence, with four Cronbach Alpha values 0.866, 0.853, 0.918, 0.832 respectively (each dimension is a subscale). In the end validity analysis is made and results show that the scales are of great structural validity, with four KMO values greater than 0.773, $p = 0.000$, and MSA values greater than 0.500.

As a result, there are 51 questions total in the formal version of questionnaire. Among them 46 are in the form of Likert scales, and the remaining 5 are related to personal information. And among the 46 questions, 18 are related to learner, 8 related to teacher, 12 related to learning environment, and 8 to learning resource.

3.3.2 Testing of the formal questionnaire

Considering the fact that SLE has not been widely applied in higher education, this paper restricts testees in the following way: he or she should have the experience of learning in a smart environment (e.g. smart classroom),

and he or she should have basic understanding of SLE or smart education. To this end, only students of Educational Technology Department are taken into account, with the requirement of some related projects undergoing in their university, such as future classroom, smart classroom or smart library projects. Based on this criterion, students in 6 famous universities are selected as representatives: South China Normal University, East China Normal University, Central China Normal University, Beijing Normal University, Tsinghua University and Nanjing University of Posts and Telecommunications. 390 questionnaires are delivered, and 330 are reclaimed, with effective reclaiming rate 87.9%. Table 1 shows the demographic characteristics of these testees.

Table 1: Demographic characteristics of formaltestees

Group	Group Characteristic	Number	Ratio
Gender	Male	88	30.3%
	Female	202	69.7%
Educational Background	Undergraduate	115	39.7%
	Graduate Students	175	60.3%
University	South China Normal University	50	17.2%
	East China Normal University	55	19.0%
	Central China Normal University	47	16.3%
	Beijing Normal University	45	15.5%
	Tsinghua University	50	17.2%
	Nanjing University of Posts and Telecommunications	43	14.8%
Total		290	100%

Exploratory factor analysis reveals that the questionnaire is of great structural validity, with four p values of the subscales significant at level of 0.05, MSA values are greater than 0.50, and commonality greater than 0.200. As for the leaner factor, after deleting factors with workload under 0.45, four sub-factors are abstracted and named as "learning motivation", "information literacy", "learning style" and "knowledge level", with KMO 0.864 and combined variance 59.563. As for the teacher factor, two sub-factors are abstracted and named as "ICT teaching ability" and "teacher quality", with KMO 0.783 and combined variance 56.348. As for the learning environment factor, three sub-factors are abstracted and named as "learning support and service", "learning experience" and "perception and identification", with KMO 0.858 and combined variance 63.234. As for the learning resource factor, two sub-factors are abstracted and named as "resource quality" and "resource form", with KMO 0.771 and combined variance 56.348.

Reliability analysis is again used on this abbreviated version, and the overall Cronbach's Alpha value is 0.931, which shows great internal consistence. By AMOS17.0 confirmatory factor analysis is also made, and the results are shown in Table 2.

Table 2: Results of confirmatory factor analysis

Fit index / Dimension	X^2	df	X^2/ df	CFI	NFI	IFI	RMSEA
Learner Factor	131.098	79	1.659	0.958	0.903	0.959	0.048
Teacher Factor	22.703	15	1.513	0.986	0.962	0.987	0.042
Learning Environment Factor	93.320	36	2.592	0.946	0.916	0.947	0.074
Learning Resource Factor	31.450	14	2.246	0.975	0.956	0.975	0.066

As can be seen from Table 2, X2/ df values of learner factor and teacher factor are smaller than 2, and those of learning environment and learning resource factor are between 2 and 5. With all CFI, NFI, IFI of these factors greater than 0.900, RMSEAs between 0.048 and 0.074 (smaller than 0.080), the model can be graded medium or good fitted. Comprehensively the four-factor model of learner factor, two-factor model of teacher factor, three-factor model of learning environment factor and two-factor model of learning resource factor are all truly verified.

Consequently there are 42 Likert scales total in the final version. Among them, 15 are related to learner, 8 related to teacher, 11 related to learning environment, and 8 to learning resource. By confirmatory factor analysis, the results of exploratory factor analysis are also verified.

IV. Influencing Factors Analysis And Results

4.1 Descriptive statistical analysis

4.1.1 Learner factor's descriptive statistical analysis

Table 3 shows the results of learner factor's descriptive statistical analysis. The second column and the third column illustrate the mean and standard deviation of its four sub-dimensions, while the last four columns are correlation coefficients between them.

Table 3: Results of learner factor's descriptive statistical analysis

Sub-dimension	Mean	SD	1	2	3	4
Learning Style	3.9931	.53407	1			
Learning Motivation	4.4052	.55030	.337**	1		
Information Literacy	4.1214	.47950	.332**	.547**	1	
Knowledge Level	4.0897	.49721	.347**	.343**	.429**	1

As can be seen from Table 3, there are considerable correlations between each pair of sub-dimensions, and the mean values prove that these sub-dimensions have great influence on personalized learning, with learning motivation as the greatest.

4.1.2 Teacher factor's descriptive statistical analysis

Table 4 shows the results of teacher factor's descriptive statistical analysis. The second column and the third column illustrate the mean and standard deviation of its two sub-dimensions, while the last two columns are correlation coefficients between them.

Table 4: Results of teacher factor's descriptive statistical analysis

Sub-dimension	Mean	SD	1	2
Teacher Quality	4.1563	.44636	1	
ICT teaching Ability	4.3414	.49553	.363**	1

As can be seen from Table 4, there are considerable correlations between these two sub-dimensions, and the mean values prove that these sub-dimensions have great influence on personalized learning, with ICT teaching ability as the greater.

4.1.3 Learning environment factor's descriptive statistical analysis

Table 5 shows the results of learning environment factor's descriptive statistical analysis. The second column and the third column illustrate the mean and standard deviation of its three sub-dimensions, while the last three columns are correlation coefficients between them.

Table 5: Results of learning environment factor's descriptive statistical analysis

Sub-dimension	Mean	SD	1	2	3
Perception and Identification	4.0379	.46203	1		
Learning Support and Service	4.0287	.48935	.490**	1	
Learning Experience	4.3414	.49804	.417**	.439**	1

As can be seen from Table 5, there are considerable correlations between each pair of sub-dimensions, and the mean values prove that these sub-dimensions have great influence on personalized learning, with learning experience as the greatest. In fact, learning experience focuses on learning evaluation, feedback and satisfaction, which matchespersonalized learning's emphasis on the importance of evaluation and feedback.

4.1.4 Learning resource factor's descriptive statistical analysis

Table 6 shows the results of learning resource factor's descriptive statistical analysis. The second column and the third column illustrate the mean and standard deviation of its two sub-dimensions, while the last two columns are correlation coefficients between them.

Table 6: Results of learning resource factor's descriptive statistical analysis

Sub-dimension	Mean	SD	1	2
Resource Quality	4.2391	.46102	1	
Resource Form	4.0248	.50841	.549**	1

As can be seen from Table 6, there are considerable correlations between these two sub-dimensions, and the mean values prove that these sub-dimensions have great influence on personalized learning, with ICT resource quality as the greater.

4.2 Individual differences analysis

Independent sample t test is adopted to compare some individual differences, with results shown in Table 7 and Table 8.

Table 7: Significance test of difference in mean for students' personalized learning with different gender

Dimension	Gender	Mean	SD	SE	T value	P
Learner Factor	Male	4.2909	.26187	.02792	4.476	.000
	Female	4.1102	.41438	.02916		
Teacher Factor	Male	4.3746	.23984	.02557	4.574	.000
	Female	4.1941	.42747	.03008		
Learning Environment Factor	Male	4.2604	.25480	.02716	4.461	.000
	Female	4.0818	.41764	.02939		
Learning Resource Factor	Male	4.2485	.31265	.03333	3.603	.000
	Female	4.0812	.45938	.03232		

From Table 7 it is easily seen that students with different gender vary greatly in the effect of personalized learning under SLE. And these four factors have greater impact on males than on females.

Table 8: Significance test of difference in mean for students' personalized learning with different educational background

Dimension	Educational Background	Mean	SD	SE	T value	P
Learner Factor	Undergraduate	4.2470	.37307	.03479	3.003	.003
	Graduate	4.1112	.38159	.02885		
Teacher Factor	Undergraduate	4.3142	.35743	.03333	2.337	.020
	Graduate	4.2059	.40367	.03051		
Learning Environment Factor	Undergraduate	4.2048	.38255	.03567	2.495	.013
	Graduate	4.0908	.37962	.02870		
Learning Resource Factor	Undergraduate	4.2148	.43018	.04011	2.691	.008
	Graduate	4.0775	.41684	.03151		

From Table 8 it is easily seen that students with different educational background vary greatly in the effect of personalized learning under SLE. And these four factors have greater impact on undergraduate students than on graduate students.

4.3 Regression analysis

According to theory of teaching system elements and learning condition theory, learner factor has the most direct influence on one's learning effect, serving as the heart of all factors. Furthermore, the other three factors rely on learner to explicitly reflect their influences. Hence in regression analysis learner factor is treated as dependent variable, whereas teacher factor, learning environment factor and learning resource factor are viewed as independent variables.

4.3.1 Regression analysis of teacher factor to learner factor

Multiple linear regression is adopted, taking the two sub-dimensions of teacher factor as independent variables. Results are shown in Table 9.

Table 9: Regression analysis of teacher factor to learner factor

Dependent Variable	Independent Variable	β	t	R	R2	△R2	F
Learner Factor	ICT Teaching Ability	0.735	47.352***	0.887	0.787	0.787	1062.236***
	Teacher Quality	0.420	27.089***	0.970	0.940	0.153	2249.506***

***P≤0.001 **P≤0.01 *P≤0.05

Table 9 tells that two predictive variables fall into regression equation, with predictive regression coefficients significant at level of 0.001. In addition, the most predictive power for learner is ICT teaching ability, with explained variance accounting for 78.7%. By contrast, the predictive power of teacher quality is 15.3%. Judging by the standardized regression coefficient, two β (Beta) values are positive (0.735 and 0.420), so that they have positive effect on learner factor.

4.3.2 Regression analysis of learning environment factor to learner factor

Multiple linear regression is again adopted, taking the three sub-dimensions of learning environment factor as independent variables. Results are shown in Table 10.

Table 10: Regression analysis of learning environment factor to learner factor

Dependent Variable	Independent Variable	β	t	R	R2	△R2	F
Learner Factor	Learning Experience	0.542	34.609***	0.831	0.691	0.691	642.882***
	Perception and Identification	0.338	20.969***	0.932	0.868	0.178	945.310***
	Learning Support and Service	0.338	20.687***	0.973	0.947	0.079	1710.367***

***P≤0.001 **P≤0.01 *P≤0.05

Table 10 tells that three predictive variables fall into regression equation, with predictive regression coefficients significant at level of 0.001. In addition, the most predictive power for learner is learning experience, with explained variance accounting for 69.1%. By contrast, the predictive power of perception and identification is 17.8%, and that of learning support and service is 7.9%. Judging by the standardized regression coefficient, three β values are all positive (0.542, 0.338 and 0.338), so that they have positive effect on learner factor.

4.3.3 Regression analysis of learning resource factor to learner factor

Multiple linear regression is again adopted, taking the two sub-dimensions of learning resource factor as independent variables. Results are shown in Table 11.

Table 11 Regression analysis of learning resource factor to learner factor

Dependent Variable	Independent Variable	β	t	R	R2	△R2	F
Learner Factor	Resource Quality	0.716	44.453***	0.922	0.850	0.850	1069.920***
	Resource Form	0.375	23.288***	0.974	0.948	0.098	2617.924***

***P≤0.001 **P≤0.01 *P≤0.05

Table 11 tells that two predictive variables fall into regression equation, with predictive regression coefficients significant at level of 0.001. In addition, the most predictive power for learner is resource quality, with explained variance accounting for 85.0%. By contrast, the predictive power of resource form is 9.8%. Judging by the standardized regression coefficient, two β values are positive (0.716 and 0.375), so that they have positive effect on learner factor.

4.4 Structural Equation Model Analysis

Since the inter influences among factors are diverse and complicated, this paper discusses relations among factors by structural equation model (SEM) supported in AMOS17.0 through several iterations. Results show that the only significant influence lies between teacher factor and learner factor. To be specific, teacher quality

and ICT teaching ability significantly affect each other, teacher quality and ICT teaching ability significantly affect learner's learning style, and learning style significantly affect learner's learning motivation, knowledge level and information literacy. The fitness testing results are illustrated in Table 12, and the standardized coefficients of SEM and their respective hypothesis testing results are depicted in Table 13.

Table 12: Fitness testing results

Fit Index	X2	df	X2/ df	CFI	NFI	IFI	RMSEA
Result	289.470	212	1.365	0.971	0.901	0.971	0.036

Table 12 tells that the fitness card square value of SEM is 289.470, and X2/ df is 1.365 (smaller than 2). In addition, CFI, NFI and IFI values are greater than 0.900, with RMSEA smaller than 0.050, which shows a decent model fitness.

Table 13 Path hypothesis testing results

Theoretical hypothesis path	Standardized path coefficient	P value	Validation of Hypothesis
Learning Style <--- ICTTeaching Ability	0.98	***	Yes
Learning Style <--- TeacherQuality	0.47	***	Yes
Learning Motivation <--- LearningStyle	0.76	***	Yes
Knowledge Level <--- LearningStyle	0.66	***	Yes
Information Literacy <--- LearningStyle	0.79	***	Yes
Teacher Quality <--> ICTTeaching Ability	0.52	***	Yes

***P≤0.001 **P≤0.01 *P≤0.05

From Table 13 it is clear that all P values of these six hypothesis paths are significant at level of 0.001, and the standardized path coefficients fall in the standard range. All these help to make theoretical hypothesis valid.

V. ConclusionAnd Implication

Based on the literature analysis, Delphi method and questionnaire survey, this paper constructs a scale of influencing factors of college students' personalized learning based on SLE. By several statistical analysis methods, this paper obtains four factors that affect college students' personalized learning, i.e. learner factor, teacher factor, learning environment factor and learning resource factor. Upon exploring the relationship among these factors through structural equation model, they vary greatly in the following ways. First, there are significant differences in the learner's characteristics, where males are more likely to be affected by these four factors than females, and impact on undergraduate students is greater than on graduate students. Second, learning style, information literacy, knowledge level, teacher quality, perception and identification, learning support and service, and resource form have significant influence on college students' personalized learning under SLE, while learning motivation, ICT teaching ability, learning experience and resource quality are extremely significant. Third, teacher quality and ICT teaching ability have significant impact on learner's learning style, while learner's learning style has significant impart on learning motivation, knowledge level and information literacy.

As a result, many factors contribute to affecting student's personalized learning as mentioned above, which entails the fact that we should pay attention to this kind of learning under SLE. To be specific, we should: (1) start from the learner's individual differences and try to stimulate his / her learning motivation. As motivation determines a learner's learning initiative, enthusiasm, tendency and choice making, teacher should make students feel that they're not ignored when implementing personalized teaching, and make use of different strategies, e.g. teach in groups, stratified activities, etc. Moreover, teacher should give instant feedback and encourage students to share their learning experience, so that everyone is respected with high self-efficacy. (2) try to enhance teacher quality in different ways to make them proficient in teaching under SLE. For example, as assessment is important to personalized teaching, teacher should be trained to be able to use different evaluation methods according to different situations. A good example is how to utilize self-evaluation, teacher evaluation, peer evaluation and adaptive evaluation and feedback under the circumstance of e-schoolbag (a portable device) environment [8]. (3) improve learning support and services of SLE to enhance learning experience. SLE is a high-end form of digital learning environment, paying special attention to track record, content delivery, personalized assessment, and diversified learning services. Teacher and students should dynamically build suitable learning environment according to different needs, to enhance its fitness and intelligence so as to provide learning context perception, learner feature identification, and portable communication tools, which in a gross achieves better learning experience. (4) enrich resource forms and pay attention to resource upgrading. In SLE resources are normally provided through portable device in forms of audio-video, animation, or image [9].

Of course teacher and students are eligible to use any kind of resource in any form, so long as it is helpful and necessary. Diverse resources help students visualize and memorize knowledge points, especially some excellent or high quality resources. With the aid of asynchronous collaboration, teacher and students can upgrade the resources at anytime by any device, forming a virtuous cycle to produce more and more useful teaching and learning materials.

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