College Students' Smart Learning Adaptability: Structural Framework and Development Status

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Abstract: With the advent of the digital intelligence era, the smart learning environment has become increasingly prevalent in higher education. Understanding the learning adaptability of college students within this context is crucial for enhancing their academic performance. The purpose of this study is to explore the structure of college students' adaptability to smart learning within the digital intelligence environment and to understand the current development status of their adaptability. The research, grounded in existing literature on learning adaptability and considering the unique characteristics of the digital intelligence environment, constructs a comprehensive framework for college students' smart learning adaptability, covering dimensions such as ability adaptability, psychological adaptability, behavioral adaptability, environmental adaptability and interpersonal adaptability. Based on this framework, a detailed survey questionnaire was developed and administered to 279 college students who had prior experience with smart learning. Data were collected and analyzed using statistical methods to identify patterns and differences in adaptability among various groups. The results indicate that college students generally exhibit a moderate level of adaptability to smart learning in the digital and intelligent environment. There is no significant difference in overall smart learning adaptability between male and female students, suggesting that gender does not play a major role in this context. However, significant variations were observed across different university types and academic disciplines. This highlights the need for tailored educational interventions to address the unique challenges faced by students from different backgrounds. Future research should further explore the underlying factors contributing to these differences and develop targeted strategies to improve the adaptability of all students in the digital intelligence era.

Keywords: Smart Learning; Adaptability; Digital and Intelligent Environment; College Students

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1 Introduction

The digital transformation of education is profoundly changing the learning environment and learning methods of students [1]. The new infrastructure of education supported by 5G network, big data, cloud computing, artificial intelligence and other emerging digital technologies is gradually becoming a digital base for empowering education reform [2]. As an important base for talent training, campus information construction is gradually transforming from IT (Information Technology) to DT (Digital Technology), forming a new learning environment of digital intelligence integration [3, 4]. In particular, the extensive and in-depth application of arti-

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ficial intelligence technology in the field of higher education is continuously changing the learning and life style of college students [5], and promoting colleges and universities to enter the digital intelligence era of virtual-real integration, human-computer collaboration, co-creation and sharing.

Compared with the large-scale and standardized teaching methods in the traditional learning environment [6], great changes have taken place in the learning environment, learning content, learning methods and learning evaluation in the digital intelligence era. These changes disrupt routines and give rise to new circumstances to which the individual has not habituated [7-9]. It has been found that in the process of gradually intellectualizing the learning environment in colleges and universities, some college students have a sense of learning inadaptability and negative learning emotions due to the integration of virtual and real learning environments and the transformation of learning methods, which affects the learning effect [10-12]. So, in order to adapt to the new learning environment and learning style, college students must make corresponding adjustments in learning so as to achieve good learning results. Recently, Martin and his partners have proposed 'adaptability' as a means of understanding individuals' capacity to constructively regulate psycho-behavioral functions in response to new, changing, and/or uncertain circumstances, conditions and situations [13-16]. So, in the digital intelligence era, what is the concept of learning adaptability in the age of intelligence? What are the key components that constitute college students' smart learning adaptability? What is the development status of college students' smart learning adaptability? In the current study, we sought to analyze the definition and components of smart learning adaptability of college students and develop a corresponding questionnaire to investigate the current adaptability of college students in the smart learning process. Findings of this study may help us to understand the components of college students' smart learning adaptability, master the current status of college students' smart learning adaptability and its differences, provide data evidence for providing targeted learning adaptability intervention strategies, and solve the learning adaptability problems of college students in the digital intelligent learning era.

2 Smart Learning Adaptability: Definition and Development

2.1 Adaptability

Adaptability was originally a concept in the field of biology, referring to biological traits that organisms adapt to environmental conditions through competition and natural selection. Later, it was borrowed by psychology and given new interpretations. In his theory of cognitive development, psychologist Piaget defined adaptability as the psychological process in which an individual's cognitive structure is actively changed due to environmental restrictions, and the process of adaptability includes assimilation and accommodation, whose ultimate goal is to reach a state of balance [17]. From the concept of adaptability, we can refer that the components of adaptability should include three basic elements: the individual, the environment and the change. The individual is the subject of adaptability. The environment is a natural and social requirement for individuals, and also a source for individuals to realize their self-needs. The change is the central of adaptability, which not only includes changes that individuals make themselves to adapt to the environment, but also includes changes individuals make the environment to meet their needs [18]. The purpose of adaptability is to achieve harmony between the individuals and the environment.

2.2 Components and Process of Smart Learning Adaptability

Smart Learning Environment refers to an educational environment that uses information technology, especially intelligent technology, to support and enhance the learning process [19]. This environment aims to improve learning efficiency and effectiveness through intelligent teaching tools, data analytics, personalized learning paths, and interactive learning experiences [20, 21]. Smart learning environment has the characteristics of intelligence, integration, customization, interactivity and adaptability, which can create a more dynamic, personalized and intelligent learning space to promote students 'active learning and deep learning [22]. So, Smart Learning refers to the learning activities that take place in the smart learning environment and its goal is to make learning more efficient, interesting and meaningful through technology

empowerment, while cultivating and developing learners' ability and literacy.

According to the characteristics of smart learning environment and the definition of learning adaptability above, smart learning adaptability refers to learners' basic adaptive ability formed in the process of interaction with smart learning environment, which enables learners to actively adjust their own psychology and behavior to adapt to the changes and development of smart learning environment so as to achieve good academic outcomes. Corresponding to learning adaptability, smart learning adaptability also includes three parts. The first part of smart learning adaptability is about the characteristics and foundation of college students themselves as adaptability subjects, such as knowledge and skill of intelligent literacy, which provide the background for learning adaptability under the smart learning environment. The second part is the change of learning resources, learning content, learning style and learning evaluation caused by smart learning environment, which is the external source for college students to adjust to achieve balance. The third part is the subject changes as the central element of adaptability, including the behavioral change and psychological change of college students in the process of smart learning, which respectively reflect the degree of behavioral adaptability and psychological adaptability of college students in the process of smart learning. Among them, learning behavior adaptability includes the adjustment of learning habits in smart learning environments, such as using intelligent learning tools to plan learning arrangements, and flexibly adjusting and changing existing learning behaviors with the personalized support of teachers and AI learning assistants. Psychological adaptability refers to college students' sense of identity and acceptance by adjusting their cognition and emotion towards smart learning, so as to form their motivation and attitude towards smart learning.

3 Method

3.1 Sample and Procedure

The sample comprises 279 college students with in 5 classes from 3 colleges in three cities in China. All the 279 students took part in smart learning for that their teachers used the intelligent technology-enabled online learning platform, smart classroom and generative AI to conduct teaching activities for a semester. Class 1 is from a key university, class 2 and 3 are from an ordinary college and class 4 and class 5 are from a higher vocational college. Throughout a semester, students engage in a diverse array of smart learning activities: they watch online teaching videos to acquire knowledge at their own pace, conduct scientific experiments in virtual laboratories where they can safely manipulate hazardous chemicals or perform complex physical experiments through simulation software, and study courseware that enhances their understanding of various subjects with interactive modules. Additionally, they experience historical scenes or complex scientific concepts through VR headsets, such as virtually visiting museums or exploring the internal structure of the human body, and use m-learning applications to complete assignments like reading, writing, and math exercises on mobile devices or tablets. Students also engage in dialogue and co-create content with generative artificial intelligence, fostering their creative and critical thinking skills, and receive personalized learning resources and learning path recommendations from AI learning assistants, which cater to their individual needs and learning styles. These integrated activities not only enrich the learning experience but also promote a more dynamic and personalized approach to education within smart learning environments.

After a semester of study, students' learning adaptability was measured by questionnaire at the end of the semester. The questionnaire was edited and released online. With few exceptions, all targeted students in attendance on the day of the testing participated in the survey. Teachers administered the instrument to students during class. Students were asked to complete the instrument on their own and to submit the completed instrument at the end of class. The data collected from the questionnaire survey were processed by SPSS statistical software.

3.2 Materials

Since there is no scale can be used directly to measure the college students' smart learning adaptability, we develop the 'questionnaire for measuring college students' smart learning adaptability' based on the interpretation and analysis of the theoretical connotation and structural framework of learning adaptability, as well as referring to other learning adaptability scales [23].

3.2.1 Questionnaire Design

Before designing the questionnaire, reasonable dimensions should be set up first. If too many dimensions are

selected, a single factor will appear higher load on multiple variables and lose practical significance. If too few dimensions are selected, the relationship between real variables cannot be reflected. According to the handbook of learning adaptability test compiled by Zhou B C et al., learning adaptability mainly includes learning attitude, learning environment, learning techniques and physical and mental health [24]. However, this scale is mainly used to measure the general state of learning adaptability of primary and secondary school students, which is not suitable for college students in terms of the measurement objects, and cannot reflect the characteristics of smart learning. Others research results showed that the college students' adaptability scale include five dimensions: learning motivation, teaching mode, learning ability, learning attitude and learning environment [25]. And according to Simon L & Roland R, learning adaptability includes nine factors such as learning beliefs, learning behaviors and learning emotions etc. [26].

By integrating the existing learning adaptability scale and the framework of learning adaptability, and fully considering the characteristics of the smart learning environment, this study initially set five dimensions of smart learning adaptability which includes ability adaptability, psychological adaptability, behavioral adaptability, environmental adaptability and interpersonal adaptability. Ability adaptability refers to the learning skills and strategies adopted by college students in smart learning, as well as their personal intelligence literacy, and also includes the ability to quickly identify the differences between the smart learning environment and the traditional learning environment, and the ability to quickly make adaptive changes. Psychological adaptability refers to the process by which individuals modify their attitudes, beliefs, and cognitions in response to the changes and challenges in the smart learning environment or online communication, which mainly includes the motivation, acceptance, satisfaction and cognition of the smart learning. Behavioral adaptability refers to the application ability of digital and intelligent technology during learning process after the university students switch from the traditional learning environment to the smart learning environment. Environmental adaptability refers to the adjustment ability of college students to carry out man-machine collaborative learning in the smart learning environment composed of 5G, big data, cloud computing, artificial intelligence technology and other technologies. This human-machine collaborative ability includes not only the autonomous adjustment ability of college students to carry out self-paced and self-customized learning in the smart learning environment, but also the ability to expand and customize the smart learning environment. Interpersonal adaptability means that college students can quickly shift from face-to-face interpersonal communication to online community communication and human-computer communication supported by digital intelligence technology. They can use digital intelligence tools to express their views objectively and truly, listen carefully and take into account the feelings of others, and adjust their learning ability through high-quality community interaction and human-computer communication.

According to the five dimensions of smart learning adaptability of college students and the existing questionnaire on learning adaptability, 22 questions are compiled. Among them, there were 5 questions in the dimension of psychological adaptability, 6 questions in the dimension of ability adaptability, 2 questions in the dimension of environment adaptability, 4 questions in the dimension of interpersonal adaptability and 5 questions in the dimension of behavior adaptability. After the first draft of the questionnaire was completed, relevant experts and teachers in the learning field were invited to give some guidance, and then some questions were revised and adjusted. The five-point Likert scale was used to score the questionnaire, and scores of 5, 4, 3, 2 and 1 were given respectively from "strongly agree", "agree", "neutral", "disagree" and "strongly disagree".

3.2.2 Item Analysis

After the preparation of the initial questionnaire, the initial test was conducted in two classes in China West normal university in grade 2023 through the online questionnaire website. A total of 168 questionnaires were issued and 168 questionnaires were collected, with a recovery rate of 100%, among which 156 were valid and the effective rate was 92.6%. SPSS20.0 software was used for statistical processing of the recovered data. First, the critical ratio method was used to analyze the items in the initial questionnaire, and the results showed that t values of all items were greater than 3 and $p<0.05$, indicating a significant difference. Then, homogeneity test was used, and the results showed that the person correlation coefficient of all items and the total score of the scale was greater than 0.5, and all of them were significantly correlated ($p<0.01$). The results of item analysis show that the 22 questions of " questionnaire for measuring college students' smart learning adaptability " are appropriate.

3.2.3 Exploratory Factor Analysis

An exploratory analysis has been conducted to derive the most robust factor solution that could encapsulate the constituent dimensions and items of college students' smart learning adaptability. Exploratory factor analysis (EFA) involved principal axis factoring with oblique rotation using SPSS for Windows. First, KMO and Bartlett sphericity tests were performed on the scale. The results were shown in Table 1, *KMO*=0.969, greater than 0.6, $\chi 2$=7641.814, and the significant probability was *P*<0.01.

Table 1 KMO and BARTLETT'S Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.969**
Bartlett's Test of Sphericity	Approx. Chi-Square	7641.814
	df	231
	Sig.	.000*

Note: p<0.05

To further determine the structure of the questionnaire, orthogonal rotation method was used to calculate the load values of each factor, and the results showed that the factor load of all questions was greater than 0.3, and there were no questions loaded on both factors. Therefore, all 22 questions were retained to form the formal questionnaire on college students' smart learning adaptability under the digital and intelligent environment.

In psychological measurement, content validity and structural validity are generally used as the validity indicators of the questionnaire. This study used these two kinds of validity to represent the validity of smart learning adaptability questionnaire for college students. Firstly, in terms of content validity, the questionnaire compiled in this study is based on the comprehensive analysis of existing studies on learning adaptability, and fully considered the impact of intelligent technology on students' learning, and gradually refined the various items of the questionnaire. During the preparation of the questionnaire, experts in this field were invited to evaluate and modify the questionnaire items, and the items and structure of the questionnaire were modified in strict accordance with the requirements of item analysis and the results of exploratory factor analysis, so as to ensure that the questionnaire has good content validity. In terms of structural validity, the correlation matrix between each factor and the total questionnaire shows a moderate degree of correlation, which is lower than the correlation between each corresponding factor and the questionnaire part, reaching the level of significance, indicating that there is some independence between the factors. Therefore, this questionnaire has a good structural validity.

3.3 Data Analysis

In this study, we distributed a total of 279 questionnaires, removed invalid questionnaires, and finally obtained 247 valid questionnaires. And then IBM SPSS20.0 software was used to conduct descriptive statistical analysis of the obtained data, independent sample t-test, one-way analysis of variance and other methods to analyze the college students' smart learning adaptability survey data.

3.3.1 Descriptive Analysis of Various Dimensions of College Students' Smart Learning Adaptability

In order to better understand the overall adaptability level of college students and the adaptability level of various dimensions during the smart learning, this study conducted descriptive statistical analysis on the overall level and five dimensions of smart learning adaptability of college students. For preliminary analyses, we calculated means, standard deviations and variance for the various variables to descript the level of university students' smart learning adaptability. The statistical results are shown in Table 2.

Table 2 Smart Learning Adaptability of College Students

	PA	**AA**	**BA**	**EA**	**IA**	**Total Adaptability**
N	247	247	247	247	247	247
Mean	3.7271	3.7672	3.4761	3.6559	3.6447	3.6596
Std. -Deviation	.65855	.63288	.60408	.70494	.65258	.56904
Variance	.434	.401	.365	.497	.426	.324

PA- Psychological Adaptability; AA- Ability Adaptability; BA- Behavioral Adaptability; EA- Environment Adaptability; IA Interpersonal Adaptability

3.3.2 Independent Sample t-Test

In order to further understand the gender differences of smart learning adaptability of college students, the sample data were grouped according to gender, and the statistical method of independent sample T test was adopted to analyze the level differences of learning adaptability of different genders in various dimensions. The statistics are shown in Table 3.

Table 3 T-Test of Smart Learning Adaptability of College Students of Different Genders

	Sex	N	Mean	Std. Deviation	t	sig
Psychological adaptability	male	55	3.6218	.59339	-1.347	.179
	female	192	3.7573	.67448		
ability adaptability	male	55	3.6485	.64603	-1.583	.115
	female	192	3.8012	.62662		
behavioral adaptability	male	55	3.4327	.64379	-.603	.547
	female	192	3.4885	.59340		
environment adaptability	male	55	3.4909	.76067	-1.980	.049*
	female	192	3.7031	.68292		
interpersonal adaptability	male	55	3.4045	.75995	-3.152	.002*
	female	192	3.7135	.60320		
total adaptability	male	55	3.5347	.59117	-1.855	.065
	female	192	3.6953	.55899		

Note: p<0.05

3.3.3 One-Way Anova

In order to understand whether there are significant differences in the adaptability level of smart learning in different types of universities and different types of majors, one-way analysis of variance (ANOVA) is adopted to conduct statistical analysis of the data. Before one-way ANOVA, the homogeneity test of variance was carried out, and the results showed that all the dimensions passed the homogeneity test of variance. The results of one-way ANOVA are shown in Table 4 and Table 5.

Table 4 One-Way Anova of Different Collges Types

		Sum of Squares	df	Mean Square	F	Sig.
PA	Between Groups	2.651	2	1.326	3.109	.046*
	Within Groups	104.037	244	.426		
	Total	106.688	246			
AA	Between Groups	4.209	2	2.104	5.444	.005*
	Within Groups	94.322	244	.387		
	Total	98.531	246			
BA	Between Groups	1.053	2	.526	1.448	.237
	Within Groups	88.716	244	.364		
	Total	89.769	246			
EA	Between Groups	3.707	2	1.854	3.816	.023*
	Within Groups	118.542	244	.486		
	Total	122.249	246			
IA	Between Groups	4.069	2	2.035	4.930	.008*
	Within Groups	100.694	244	.413		
	Total	104.763	246			
total	Between Groups	2.645	2	1.323	4.191	.016*
	Within Groups	77.011	244	.316		
	Total	79.656	246			

PA- Psychological Adaptability; AA- Ability Adaptability; BA- Behavioral Adaptability; EA- Environment Adaptability; IA Interpersonal Adaptability Note: p<0.05

Table 5 One-Way Anova of Different Majors

		Sum of Squares	df	Mean Square	F	Sig.
PA	Between Groups	3.736	2	1.868	4.427	.013*
	Within Groups	102.952	244	.422		

		Sum of Squares	df	Mean Square	F	Sig.
	Total	106.688	246			
	Between Groups	3.971	2	1.986	5.124	.007*
AA	Within Groups	94.560	244	.388		
	Total	98.531	246			
	Between Groups	.690	2	.345	.944	.390
BA	Within Groups	89.079	244	.365		
	Total	89.769	246			
	Between Groups	2.895	2	1.447	2.959	.054
EA	Within Groups	119.354	244	.489		
	Total	122.249	246			
	Between Groups	3.368	2	1.684	4.053	.019*
IA	Within Groups	101.395	244	.416		
	Total	104.763	246			
	Between Groups	2.445	2	1.222	3.863	.022*
total	Within Groups	77.212	244	.316		
	Total	79.656	246			

PA- Psychological Adaptability; AA- Ability Adaptability; BA- Behavioral Adaptability; EA- Environment Adaptability; IA Interpersonal Adaptability Note: $p<0.05$

4 Results

4.1 Descriptive Statistics of Smart Learning Adaptability Level of College Students

The descriptive statistical results show that the average score of 22 items in the smart learning adaptability questionnaire of college students is 3.6596. So, it can be seen that the overall level of smart learning adaptability of college students is at the medium level. Among the five dimensions, the average score of the ability adaptability dimension is the highest (3.7672), and the average score of the behavior adaptability dimension is the lowest (3.4761). In general, the overall level of smart learning adaptability of college students is at the medium level.

4.2 Testing for Sex Significant Difference of Smart Learning Adaptability

According to the data in Table 3, there is no significant difference in the overall level of smart learning adaptability of college students in terms of gender, but there are significant differences in the dimensions of environmental adaptability and interpersonal adaptability between male and female students. From the perspective of *t* value, male students' adaptability level in these two dimensions is slightly lower than that of female students.

4.3 Analyzing the Significant Difference of Different Levels of University and Different Types of Majors

The college students surveyed in this research come from three different levels of schools, including key university, ordinary colleges and higher vocational colleges and the major categories include humanities and social sciences, science and engineering. According to the statistical results of one-way analysis of variance as show in TALBE 4, there are significant differences in the smart learning adaptability of college students from different levels of colleges ($sig=0.016$, $p<0.05$). At the same time, there are significant differences among groups in the dimensions of psychological adaptability, ability adaptability, environment adaptability and interpersonal adaptability. Through the LSD analysis, it is found that there are significant differences in psychological adaptability dimension, ability adaptability dimension, environment adaptability dimension, interpersonal adaptability dimension and overall adaptability level between ordinary undergraduates and higher vocational college students. According to the mean data, the adaptability scores of higher vocational college students in all dimensions are significantly lower than that of undergraduates in ordinary colleges.

As shown in Table 5, there is a significant difference in the overall level of smart learning adaptability among college students of humanities and social sciences, science and engineering ($sig=0.022$, $p<0.05$). Except the dimensions of behavioral adaptability ($sig=0.390$, $p<0.05$) and environ-

mental adaptability (*sig=0.054, p<0.05*), there are significant differences in other dimensions. The LSD results showed that the level of psychological adaptability of liberal arts students was significantly higher than that of science (*sig = 0.011, p <0.05*) and engineering (*sig = 0.032, p <0.05*) students, science and engineering students in psychological adaptability dimension does not exist significant differences. In the dimension of ability adaptability, the adaptability level of liberal arts students was significantly higher than that of science students (*sig=0.02, p<0.05*). In the dimension of environmental adaptability, the adaptability level of liberal arts students is significantly better than that of science students (*sig=0.036, p<0.05*). In interpersonal adaptability dimension, the adaptability level of liberal arts students is significantly better than that of science students (*sig=0.006, p<0.05*). There is no significant difference in the adaptability of science and engineering students in all dimensions.

5 Discussion and Conclusion

In this study, a questionnaire survey was conducted on 279 college students from a key university, an ordinary college and a higher vocational college in 3 provinces who had participated smart learning. Key findings are discussed below.

5.1 Adaptability Level

Under the digital and intelligent environment, the smart learning adaptability of college students is in the medium level, and only less than 12% of college students have fully adapted to the smart learning under the digital and intelligent environment. This shows that there are still many problems in smart learning under the digital and intelligent environment for college students who are accustomed to the traditional learning style. Therefore, the key to the successful implementation of smart learning in colleges is to study the problems, influencing factors and intervention strategies of the smart learning adaptability in the digital and intelligent environment of college students.

5.2 Adaptability and Sex

In terms of the overall adaptability of smart learning, the adaptability level of male students is slightly lower than that of female students, but the difference is not significant, which is consistent with the research results of Yang yanjun, Niu lifeng and others [27, 28]. In the five dimensions of smart learning adaptability, there are significant differences between male and female students both in the dimensions of environmental adaptability and interpersonal adaptability, and the average score of male students is lower than that of female students. This may be because girls are more responsible and self-aware than boys, which may make them more adaptable to smart learning [29-31]. In common sense, we generally believe that male students are usually superior to female students in the operation and use of technology tools. But the survey found the opposite, which is an interesting result. The reason for this result may be that girls are more sensitive to the changes in the external environment than boys, so they can make adjustments to the changes in the smart learning environment more quickly. Therefore, in the process of smart learning, teachers should pay special attention to the cultivation and guidance of learning adaptability of boys, and pay more attention to the cultivation of non-intellectual factors of boys, especially provide them instructions in interpersonal collaborative interaction. And teachers should help boys to correct their learning attitude, and cultivate them self-confidence and sense of responsibility for learning.

5.3 Adaptability and Level of College

There are significant differences in the adaptability of smart learning among students from different college levels, and the adaptability of smart learning in ordinary undergraduate colleges is significantly better than that in higher vocational colleges. After analyzing the reasons, we consider that the students in ordinary undergraduate university usually have good learning habits and strong independent learning ability, and they are better than students of higher vocational colleges in learning motivation and attitude. Therefore, the students in ordinary undergraduate university usually have a clear learning goal in the process of smart learning, and can better plan their own learning time, and then show a better learning adaptability [32] in smart learning. From the results of one-way ANOVA of various dimensions of adaptability, it can also be seen that college students at different levels have significant differences in the dimensions of psychological adaptability, ability adaptability, environmental adaptability and interpersonal adaptability. The average score of undergraduates in university in ability, psychology and interpersonal communication is higher than that of students in higher vocational colleges. In higher vocational colleges, therefore, teachers should give their students

more psychological guidance, trains the students to set up the correct smart learning motivation and attitude [33], and guide them to actively accept smart learning approach, help them improve the ability of autonomic learning under the smart learning environment, and provide them learning guidance and support in time. Meanwhile, teachers in higher vocational colleges should pay attention to cultivating students' ability of communication and cooperation, establish equal teacher-student relationship [34], and help students in higher vocational colleges quickly adapt to the smart learning mode.

There are significant differences in the adaptability level of smart learning among college students of different majors. Liberal arts students are significantly better than science students in four dimensions of psychology, ability, environment and interpersonal relationship, and there is no significant difference between science students and engineering students. We believe that liberal arts students are generally better at acquiring knowledge through independent reading and discussing with each other, so they are more suitable for independent learning in smart learning, and so they are more psychologically receptive to smart learning and more adaptable in behavior. The study of science students usually requires a high degree of concentrated logical reasoning. However, the multi-modal characteristics of the intelligent learning environment, the diversity of intelligent tools, and information overload may lead to problems such as students' distraction, affecting the coherence of logical thinking, and thus, the level of learning adaptability is reduced.

6 Limitations and Future Directions

In the present study, there are several limitations that require discussion. First, the measure instrument need to be further improved. Although this study constructed a theoretical framework before designing the smart learning adaptability questionnaire for college students, the measurement of smart learning adaptability was affected by many factors. Therefore, further improvement of the measurement tool will be conducive to the comprehensive development of research on smart learning adaptability. Second, the sample size was relatively modest. Although this did not prevent significant effects from being revealed, surveys with larger sample sizes and from multiple colleges are important. Third, the study only analyzes the influence of demographic variables such as gender, college and major types on the current situation of smart learning adaptability, and lacks the analysis of the deep factors such as motivation and self-efficacy which influence the adaptability of smart learning. This is important in future research given that motivation and self-efficacy are considered to underpin adaptability and will enable alignment with well-established frameworks of motivation and self-efficacy. Fourth, intervention research, which is also needed in this area, would better inform us about the pattern of psychological–behavioral relations in the smart learning adaptability performance.

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