The Influence Mechanism of Virtual Experiment Teaching on the Behavioral Intention of Distance Learners

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Abstract—Distance education is restricted by the physical isolation of time and space. Without the ability to communicate face-face with teachers, the learning experience of learners is reduced, which has an impact on their behavioural intention. Virtual labs offer students the chance to be free from the constraints of time and place and conduct the required experiments at anytime and anywhere. To explore the influence mechanism of virtual experiment teaching on the behavioural intention of distance learners from three aspects, including self-efficacy, collaborative learning and teacher guidance, a questionnaire is designed, and the mediating effects of perceived ease-of-use (PEOU) and perceived usefulness (PU) on the relationship between virtual experimental teaching and the behavioural intention of distance learners are analysed. Results show that self-efficacy, collaborative learning and guidance from teachers have a notable frontage influence to the behavioural intention of students. PEOU and PU act as different mediators on the relationship between self-efficacy, collaborative learning and guidance from teachers and the behavioural intention of students. Conclusions obtained from this study can be used to improve the design of the learning process of a virtual experimental platform for related subjects and the promotion of the platform. Moreover, these will be of great reference value to the reform and practice of teaching methods for the practical links.

Keywords—virtual experiment teaching, distance learners, learning behavioural intention, influence mechanism

1 Introduction

Information technology comprehensively penetrates the field of education, which has been updating informalisation in education every year. Big data and artificial intelligence, which are considered as representative of information technology, have dramatically changed the mode of education. Owing to the multitude of students in China, the online delivery of courses has become key to the reform in higher education, especially under the impact of the pandemic. Meanwhile, the high integration between information technology and education is inevitable for the development of education. Education departments at all levels in China have increased investment in online

education resources by constructing massive high-quality online course resources and establishing teams of teachers suitable for online teaching methods [1]. Online courses from distance education can hardly provide visualisation for contents of knowledge, while the lack of interactivity during the teaching process, in which course contents are unilaterally passed on to students from lecturers via online course videos, result in no immersion in learning for those studying online courses. The combination of various high and new virtual reality technology and visualisation technology can create a realistic teaching environment via good visualisation technology, which allows distance learners to put more effort in their study and interaction with their teachers through human–computer interaction, hence boosting their learning efficiency. As a result, virtual reality technology acts as a booster to the further development of distance education, which is developed from traditional education, though its role of facilitating educational change is difficult to overestimate. Virtual experiment is one indispensable part of the study process of learners. By carrying out relevant experimental operations in a real subject laboratory in school, students get to consolidate their knowledge in learning and reinforce their operational skills. However, in distance education, due to time and space restrictions, it is difficult for students to practice the required experiments in time, and they have to be gathered at a designated location to conduct experiments on a yearly basis. Both financial and human resources are costly for distance learners, which undoubtedly exposes the disadvantages of distance education in practice in the process of exerting its advantages.

The emergence of the virtual experiment teaching method enables distance learners to fully transcend time and place constraints by allowing them to choose the operation time anytime and anywhere according to their actual situation. The distance learning transition is completed through the guidance of the virtual experiment system, which perfectly remedies the defects in distance education. At the same time, the virtual lab (VL) possesses advantages such as less investment, reduced equipment wear and tear, space saving, easy maintenance, higher security and shortened space–time distance. As a result, a certain level of development and application of VL has been achieved both domestically and internationally. While the good promotion and popularization of VLs do not depend on whether the technology the labs are based on is advanced or not, they depend more on the users' overall perception of the system as well as their behavioural intention (i.e. willingness to continue with the system). Therefore, this study investigates the influencing factors of behavioural intention in distance learning in a virtual experiment environment, which can effectively fill the gap in current research and provide effective suggestions for the implementation of practical teaching and teaching organizations. The study will also play a role in promoting virtual experimental teaching methods that break through professional limitations and space–time isolation while promoting the virtual experiment teaching method suitable for distance education to be fully embedded into daily teaching as well as accelerating the reform of teaching methods in distance education.

2 Theoretical background and hypothesis development

2.1 Theoretical background

Davis created a research model based on rational behaviour theory for user acceptance behaviour in information technology, namely the technology acceptance model (TAM) [2]. Rational behaviour theory is mainly used to explain the process of users understanding and accepting a new technology. The TAM has been fully applied in education. It basically holds that an individual's attitude has more power than one's subjective norms—to some extent—on whether a new technology can be accepted; therefore, subjective norms and other related factors (normative beliefs and compliance motivation) in the theory of rational behaviour can be eliminated [3]. Based on this, one's attitude becomes critical to their behavioural intention, which itself is determined by behavioural belief and result evaluation. The model posits two factors: perceived usefulness (PU) and perceived ease of use (PEOU). PU refers to the subjective perception of users where they believe that using certain technologies can improve the performance of their work. PEOU is defined as the degree to which individuals perceive how easy it is to use the technology. Numerous studies have shown that PU and PEOU have a critical influence on behavioural intention to use information technology. On the basis of Davis's research, aimed at application in various fields, many researchers have been continuously enriching the TAM by adjusting external variables and subjective moderating variables. The TAM presented in this study, which is aimed at virtual experiment systems in universities, considers PU and PEOU as major influencing factors to the behavioural intention of students to learn. TAM believes that one's behavioural intention to use an information technology plays the main role in determining the actual use of the technology by an individual. One's behavioural intention is affected by both their attitude towards using the technology and PU, while one's attitude to use the technology is influenced by the usefulness of the technology itself and their perception of ease of use. At the same time, both PEOU and external factors contribute to PU, where PEOU is determined directly by external factors, which means external factors have a direct impact on the behavioural intention of an individual.

2.2 Hypothesis development

Currently, the TAM has been widely applied to a number of fields and deeply applied in the field of education. It is mainly used in the field of education to analyse the influencing factors on the behavioural intention of learners in terms of new education technology and education information system in the latest educational environment, such as MOOC, mobile learning, distance learning and virtual simulation teaching. The theory has been extensively studied as it has shown exceptional explanation power and suitability in the education industry. With regard to the study on how virtual experiment teaching method impacts the behavioural intention to study of distance learners, Wang [4] mainly proposed a teaching mode of computer distance virtual experiment based on the virtual reality technique, which believes it is the rapid development of information networks that facilitates the emerging growth of new teaching methods and instructional media. Results from studies have shown that such teaching approach is

of practical significance to improve the computer distance teaching mode and promote the smooth development of computer distance teaching. Huo et al. [5] considered virtual experiment teaching to be beneficial to the cultivation of students' practical ability in mechanical majors. The author designed and implemented a mechanical virtual experiment teaching platform by using virtual reality technology and augmented reality technology in a Unity 3D environment. According to results of the questionnaire, a mechanical virtual experiment teaching platform provides multimedia resources and a friendly collaboration of interaction and convenient communication. Reznek et al. [6] found that medical students can improve their diagnosis practice, treatment and operational skills by using virtual reality and computer-enhanced simulation teaching methods. Chamunyonga et al. [7] believed that the application of 3D virtual technology in education can improve the learning motivation of medical students in specific medical teaching projects. Chu et al. [8] set up an interactive virtual teaching (VT) system and another VL system for students studying engineering sub-degree courses. The study results indicate that such VT system makes an excellent complement to traditional classroom and laboratory resources by reducing teachers' workload and improving the academic performance of students. Fagan [9] believed that when learners in a community college accept the influencing factors of mobile learning, assuming that effort expectation and self-management and learning have no significant impact on behavioural intention, other antecedent variables have a positive impact on behavioural intention. Chiu et al. [10] showed the result that performance expectations, effort expectation, computer self-efficacy, achievement value, utility value and intrinsic value are significant predictors of the willingness to continue using the Internet to study. Bag et al. [11] used partial least square method for path modelling and analyses 430 students in higher education institutions in India. The results show that attitude, ease of use and usefulness are significantly related to the students' behavioural intention of using the online education system. An [12] found that the use of digital games in classroom and teachers' involvement in the design of educational games are beneficial to improve the behavioural intention of learners. Park et al. [13] saw a rising trend of e-learning opportunities provided by higher education institutions in South Korea. In applying structural equation modeling techniques, studies have shown that online learning self-efficacy, subjective norms, system accessibility, PU and PEOU have significant effects on the behavioural intentions of learners to use online learning. Endres et al. [14] conducted a survey of 277 online MBA students from a large university in the Midwest of the United States and concluded that satisfaction with teacher practices, learning practices, course materials, student–student interactions and course tools predicts student intentions for each type. Jeong et al. [15] showed that the interface features and system quality of the VT system have a significant impact on PU. Agudo-Peregrina et al. [16] revealed that the wide implementation of the virtual learning system in colleges and universities can improve learners' acceptance of e-learning. Tung et al. [17] showed that self-efficacy, compatibility, PU, PEOU, perceived financial cost and perceived information quality are key factors influencing the behavioural intention of students to use online courses.

Mailizar et al. [18] analyzed the factors that senior teachers use e-learning in mathematics teaching. Studies show that attitudes towards the use of network learning and online learning experience are the two most important structures in predicting the use of online learning. Existing research literature reveals that the embodiment of the virtual experimental teaching platform is very diverse. For example, online learning can be accessed through an online system based on VR and AR technology development or the virtual experiment system developed by Unity 3D and other technologies and experiments can be done based on B/S or C/S architecture technologies. Virtual experiment can completely create a highly immersive and interactive experimental scene, which improves the behavioural intention of learners to learn and perform. Meanwhile, the virtual experimental teaching platform provides convenient and diversified interactive ways that enable learners to visit and study over and over again at any time or place. Thus, it improves the knowledge gain of learners and is beneficial to their knowledge system construction and practical ability transfer. When learners gain higher endogenous motivation after learning based on the platform, they will have a better VL experience and carry out knowledge construction and transfer more easily. Thus, they will have a stronger behavioural intention to use the virtual experimental platform for a longer time. Therefore, based on existing research theories and literature conclusions, this study proposes the following research hypotheses (see Figure 1).

H1: In virtual experiment teaching, self-efficacy can significantly promote the behavioural intention of distance learners.

H2: In virtual experiment teaching, collaborative learning can significantly promote the behavioural intention of distance learners.

H3: In virtual experiment teaching, teachers' guidance can significantly promote the behavioural intention of distance learners.

H4: In virtual experiment teaching, perceived ease of use has a mediating effect on self-efficacy in promoting the behavioural intention of distance learners.

H5: In virtual experiment teaching, perceived usefulness has a mediating effect on self-efficacy in promoting the behavioural intention of distance learners.

H6: In virtual experiment teaching, perceived ease of use has a mediating effect on collaborative learning in promoting the behavioural intention of distance learners.

H7: In virtual experiment teaching, perceived usefulness has a mediating effect on collaborative learning in promoting the behavioural intention of distance learners.

H8: In virtual experiment teaching, perceived ease of use has a mediating effect on teacher guidance in promoting the behavioural intention of distance learners.

H9: In virtual experiment teaching, perceived usefulness has a mediating effect on teacher guidance in promoting the behavioural intention of distance learners.

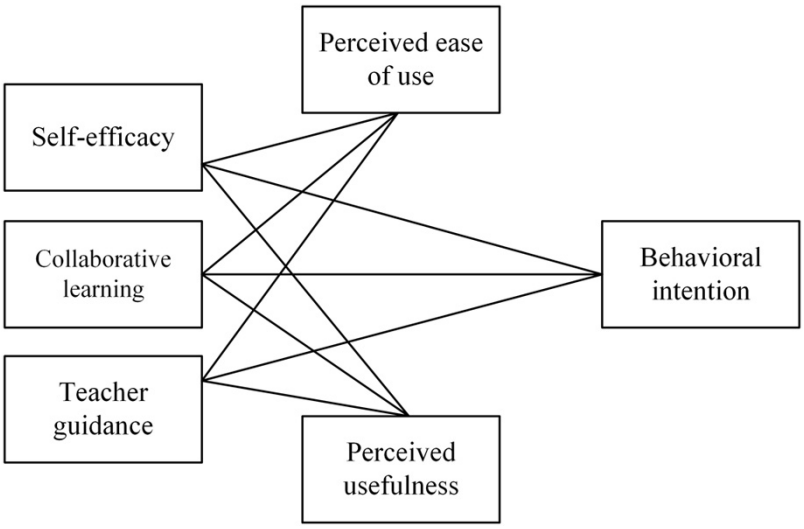

Fig. 1. Research hypothesis path in the study

3 Methodology

3.1 Questionnaire design

This study designs a questionnaire entitled 'The influence mechanism of virtual experiment teaching method on the learning behaviour intention of distance learners', which includes two aspects. The first aspect is the basic information statistics of the respondents, including gender, major and grade. The second aspect is the survey and statistics of core variables. The questionnaire of Fokides [19] was used to measure self-efficacy with four questions. Collaborative learning adopts the research literature of Huang et al. [20], including seven questions for measurement. The research literature of Hner et al. [21] was used for teacher guidance, and four questions are used for measurement. The research literature of Huang et al. [22] was used to measure PEOU, PU and learning behavioural intention with three, five and five questions, respectively. The questionnaire is compiled on the basis of the research model established above, and the questions are measured with a five-level Likert scale.

3.2 Data source

The objects of this study are students of six universities in Henan of China. The subjects are distributed in different places and unevenly distributed by age. Meanwhile, due to the impacts of the pandemic, many students cannot attend campus for offline intensive experimental learning. As a result, the six universities use the virtual experimental platform for students to learn and practice experimental operation in order to master the knowledge and skills related to experimental operation. In the autumn semester of the academic year 2021–2022, the students carried out cross-specialty comprehensive practical training teaching activities of enterprise management by using

the virtual simulation training system (platform) to conduct virtual experimental teaching. A total of 425 questionnaires were collected in this survey, and 369 valid questionnaires were obtained after removing invalid ones, setting an effective recovery of 86.82%. The descriptive statistics of the specific research objects are shown in Table 1.

Table 1. Descriptive statistics

Type	Group	Frequency	Percentage (%)
Gender	Male	222	60.16
	Female	147	39.84
Grade	Freshman	98	26.56
	Sophomore	72	19.51
	Junior year	129	34.96
	Senior year	70	18.97
Subject	Study of Finance	45	12.2
	Study of Accounting	86	23.31
	Business Management	124	33.6
	Administration Management	75	20.33
	Logistics Management	39	10.57
Total		369	100

4 Results analysis and discussion

4.1 Reliability and validity testing

This study uses SPSS 22.0 to test the internal consistency reliability of the questionnaire through Cronbach's alpha reliability coefficient. The larger the Cronbach's alpha reliability coefficient, the better the internal consistency of the questionnaire. The results of the questionnaire reliability analysis are shown in Table 2.

Table 2. Reliability test results

Variable	Number of Questions	Cronbach's α	Overall Cronbach's α
Self-efficacy	4	0.798	0.890
Collaborative learning	7	0.771	
Teacher guidance	4	0.783	
Perceived ease of use	4	0.804	
Perceived usefulness	5	0.869	
Behavioural intention	5	0.881	

As shown in Table 2 above, the overall Cronbach's alpha value of the questionnaire is 0.890, and the Cronbach's alpha value of most subscales is above 0.70, which reaches a good level of reliability. Therefore, the reliability of the questionnaire in this study is high.

In this study, SPSS 22.0 is used to perform the Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity on the data to analyze the overall validity of the questionnaire.

Table 3. Validity test results

KMO		0.919
Bartlett's sphericity test	approximate chi-square	10201.404
	df	378
	p-value	0.000

As shown in Table 3 above, the KMO value of the questionnaire is 0.919, which is greater than 0.9, and the significance Sig value of Bartlett's sphericity test is 0.000, which is less than 0.001, which is significant and indicates that the questionnaire is suitable for further research.

4.2 Hierarchical regression

Table 4 below shows that, in hierarchical model 1, gender, grade and major are used as independent variables and behavioural intention is used as a dependent variable for linear regression analysis. As can be seen from the table, the R-square value of the model is 0.014, which means that gender, grade and major can explain 1.4% of the change in behavioural intention. When conducting the F test on the model, it is found that the model did not pass the F test (F=1.778, p>0.05), which indicates that gender, grade and major had no influence on behavioural intention. In hierarchical model 2, grade has a significant impact on behavioural intention, indicating that learners of different grades have a significant impact on the adoption of virtual experiment teaching in distance education. The main reason may be that different grades need different times to accept distance education. The longer the study time, the easier it is for learners to accept the online virtual experiment teaching method and the more willing they are to take the initiative to accept such teaching method reform.

Table 4. Hierarchical regression results

	Hierarchical Model 1	**Hierarchical Model 2**
Constant	3.996** (24.133)	0.637 (1.666)
Gender	0.146 (1.780)	0.096 (1.324)
Grade	–0.062 (–1.641)	–0.135** (−3.890)
Subject	0.003 (0.078)	0.016 (0.531)
Self-efficacy	–	0.309** (6.088)
Collaborative learning	–	0.221** (3.652)
Teacher Guidance	–	0.352** (5.631)
Sample Quantity	369	369
R^2	0.014	0.24
Adjusted R^2	0.006	0.228
F Value	F (3,365)=1.778, p=0.151	F (6,362)=19.082, p=0.000
$\triangle R^2$	0.014	0.226
△F Value	F (3,365)=1.778, p=0.151	F (3,362)=35.877, p=0.000

(1) Hypothesis H1 is true. The regression coefficient value of self-efficacy is 0.309, and it is significant (t=6.088, p=0.000<0.01). Self-efficacy has been shown to be a key variable affecting the distance learning of learners, and this study supports this notion. The main reason is that self-efficacy reflects that learners can build stronger confidence in the face of various virtual experiment problems in distance learning such that they can complete the distance learning process more efficiently. Faced with a more diverse and personalised virtual experiment system, learners can play a good sense of self-efficacy in the VT environment and promote their learning behaviour intentions to be more obvious. Learners with higher self-efficacy will take the initiative to pay attention to the distance learning process, and they will be more concerned about their learning performance level, which will make them pay more attention to their own learning process. They will also evaluate the usefulness of the VT platform to them as learners. Therefore, learners with higher self-efficacy are more willing to increase input in distance learning, which makes their learning behaviour intention of remote virtual experiment stronger.

(2) Hypothesis H2 is true. The regression coefficient value of collaborative learning is 0.221, and it is significant (t=3.652, p=0.000<0.01). The main reason is that virtual experiments require individual effort and more teamwork. During distance learning, it is more important that learners enhance collaborative learning since they are not clustered together. Collaborative learning is essentially team learning. Under a good team learning system, all learners can maximise their learning potential and learn together by helping one another. At the same time, collaborative learning can meet the emotional needs of learners, which is beneficial to their knowledge construction. In collaborative learning through the virtual experiment platform after good collaborative learning rules are designed by teachers, learners are divided into groups to learn and play different roles in virtual experiments to complete learning tasks together. Therefore, in distance virtual experimental learning, collaborative learning can be fully adopted to increase the interactivity and immersion of learners in the learning system and promote their behavioural intention to be more obvious.

(3) Hypothesis H3 is true. The regression coefficient value of teacher guidance is 0.352, and it is significant (t=5.631, p=0.000<0.01). Teacher guidance is an indispensable link in the process of remote virtual experiment learning. It takes a certain amount of time for learners to become familiar with virtual experimental teaching methods. During this period, teachers need to increase their technical guidance so that learners can reduce low-level activities and achieve more in-depth learning ability processing. Teachers should fully understand and master the operation process of the virtual experiment system and reply to the operation questions and knowledge points raised by students one by one so as to improve the acceptance degree of learners to the VT system. At the same time, teacher guidance can increase the emotional communication of learners, make learners more willing to learn, reduce the sense of alienation from the VT system platform, enhance the overall sense of presence in learning and ultimately improve their learning behaviour intentions.

4.3 Mediation effect

The following can be seen in Table 5.

Table 5. Results of the mediation effect analysis

Item	Test Result	c Effect	a*b Mediation Effect	c' Direct Effect	Effect Percentage
Self-efficacy =>PEOU=> Behavioural intention	Mediation not significant	0.337	0.01	0.181	0%
Self-efficacy =>PU=> Behavioural intention	Partial Mediation	0.337	0.145	0.181	43.193%
Collaborative => PEOU => Behavioural intention	Full Mediation	0.266	0.19	–0.059	100%
Collaborative =>PU=> Behavioural intention	Full Mediation	0.266	0.135	–0.059	100%
Guidance from teachers => PEOU => Behavioural intention	The cover effect	0.263	–0.013	0.242	5.272%
Guidance from teachers =>PU=> Behavioural intention	Mediation not significant	0.263	0.033	0.242	0%

It can be seen from Table 5 that:

(1) Hypothesis H4 is not true. PEOU has no mediating effect on perceived self-efficacy in promoting the behavioural intention of distance learners. The main reason may be that in the face of the more responsible enterprise operation virtual simulation comprehensive training system, learners have insufficient cognition of 'perceived ease of use' in the face of the more complex virtual training system. The learners do not establish a good attitude and perseverance to overcome difficulties, which causes them to resist the mentality of VT experiments.

(2) Hypothesis H5 is true. In virtual experimental teaching, PU has a partial mediating effect on self-efficacy in promoting the behavioural intention of distance learners. It shows that learners' self-efficacy can have a positive impact on the PU of the virtual world by increasing their self-efficacy, making them more willing to increase their learning input and making their learning behaviour intentions more obvious.

(3) Hypothesis H6 is true. In virtual experimental teaching, PEOU has a complete mediating effect on promoting the behavioural intention of distance learners in collaborative learning. Virtual experiment teaching is a relatively unfamiliar learning method for learners in the process of learning. Therefore, learners need to use online collaborative learning to strengthen their emotional and learning skills exchanges, which will help distance learners can perceive the ease of use of the virtual simulation comprehensive training system.

(4) Hypothesis H7 is true. In virtual experimental teaching, PU has a complete mediating effect on cooperative learning to significantly promote the behavioural intention of distance learners. The virtual experiment platform can truly simulate the business operation of the real enterprise, and the training activities can better simulate the business operation or job responsibilities of the enterprise. The platform enables students

to gain a better role experience in virtual social enterprises and service organisations and play different roles, thereby creating more opportunities for collaborative learning, which is widely recognised by schools, teachers and students and improves the behavioural intention of learners.

(5) Hypothesis H8 is true. In the virtual experiment teaching method, PEOU in teacher guidance can significantly promote the behavioural intention of distance learners and there is a masking effect. The main reason is that teacher guidance can significantly improve the 'learning behaviour willingness' of students to participate in virtual simulation comprehensive practical training. The virtual simulation comprehensive training system should give learners a strong sense of presence as much as possible and increase their willingness to learn behaviour. At the same time, the training system requires teachers to be familiar with it in advance in order to provide more effective teaching guidance and significantly improve the willingness to learn in learning.

(6) Hypothesis H9 is not true. In virtual experimental teaching, PU has no mediating effect on teacher guidance in promoting the behavioural intention of distance learners. The main reason is that the virtual simulation comprehensive training system has many functional modules and a large-scale teaching implementation, which is difficult to implement. In addition, the number of students participating in the training is relatively large, and the instructors are relatively few. Insufficient teacher guidance results in learners' insufficient awareness of 'teacher guidance' to improve the 'perceived usefulness' of the virtual training system.

5 Conclusion

The application of virtual simulation technology to practical training has obvious advantages that can break through the limitations of time and space and create a virtual learning environment based on reality. It can also stimulate students to have a strong learning interest and sense of immersion while carrying out modeling and virtual interaction to analyze things in depth and improve learning performance. A variety of high-tech virtual reality technologies combined with virtualisation technology creates a virtual learning environment in which learners' immersion in online learning and the interaction between teachers and students, students and teachers, students and the learning environment can be enhanced by improving visual expression and human–computer interaction. Virtual reality technology plays a role in promoting the further development of distance education developed from traditional education.

This study designs a questionnaire to investigate the influence mechanism of virtual experimental teaching on the learning behaviour intention of distance learners. It analyses the learning behaviour intention of distance learners from three aspects: self-efficacy, collaborative learning and teacher guidance. The study uses PEOU and PU as mediating variables to analyze the mediating effect of virtual experiment teaching methods on the learning behaviour intentions of distance learners. The following research conclusions are obtained: (1) Self-efficacy, collaborative learning and teacher guidance all significantly positively promote the learning behaviour intentions of learners. (2) PEOU and PU have different mediating effects on the learning behaviour intention of distance learners in three aspects: self-efficacy, collaborative learning and teacher guidance.

In the future, in-depth research can be carried out to explore the influencing factors of distance learners' behavioural intention to continue to use the virtual experiment platform as well as promote the VT design of engineering majors that require high practical links in distance education.

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