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# Effect of Virtual Simulation Teaching System on Learning of Students Majoring in Engineering Technology

**Qian Cao[1,2], Ye Huang[1,2], Tingting Luo[2] and Lei Liu[3,*]**

[1]*College of Education, Cavite State University, Indang 4122, Republic of the Philippines*
[2]*Jiangxi Police College, Nanchang, 330044, China*
[3]*School of Economics, Wuhan Textile University, Wuhan, 430000, China*

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***Abstract***

The virtual simulation teaching system combined with computer technology and artificial intelligence has become the key to effectively improving students' learning. This system is an important direction for the development of education informatization. The virtual simulation teaching system constructs real scenes with high simulation degree, effectively realizes the vivid reproduction of real-life scenes in the information system, improves the learning motivation of learners, and increases students' learning. On the basis of constructivism and self-learning theory, this study determines the construction elements of virtual teaching system and conducts a questionnaire on students majoring in engineering technology from seven universities in Jiangxi province of China. The influence of the four aspects of virtual teaching system on students' learning is calculated. Results show that the exceptional reliability and validity of the questionnaire, which can significantly improve learning of students majoring in engineering technology from three aspects of virtual simulation teaching method, virtual simulation teaching resources, and experience of learners. Various resources and platforms did not have a significant difference in the learning effect. This study provides a reference value for improving the application effect of virtual teaching systems, enhancing the teaching incentive mechanism of virtual simulation teaching system participants, and improving the effect of virtual teaching on students majoring in engineering technology.

*Keywords:* virtual simulation teaching system, learning effect, students majoring in engineering technology

## 1. Introduction

With the widespread adoption of information technology into the education sector, integrating virtual reality technology into the education practice has become an inevitable trend, with significant implications for educational reform. During the teaching process, the deep use of multimedia technology, network technology, and communication technology can realize the unification of teachers, teaching materials, and teaching methods, promote the personalized learning development of learners, and enhance the deep reform of teaching methods. As an application form of virtual reality technology, the virtual simulation teaching system has substantial prominent advantages in stimulating learners' learning motivation and improving learning plans and effects. The virtual teaching system creates a more realistic and vivid learning scene to realize virtual sharing teaching. The virtual simulation teaching system effectively overcomes the constraints of realistic objective conditions by integrating virtual characters, virtual equipment, and virtual scenes into the system, which can achieve rapid construction and reduce teaching costs, owing to the deep integration of hardware and software, such as graphics and sensors, and relying on modern digital technology. The virtual teaching system allows shared learning among students in a wider space and more free time to achieve full learning of high-quality teaching resources.

Presently, in the teaching process of China's higher education, many science teachers still use the teaching form of PPT and blackboard writing with poor classroom interaction. Particularly, the classes that require image thinking limits students' time for thinking, thereby making it difficult for students to comprehend the nature of things. As a hot topic in educational technology, the virtual simulation teaching system realizes more convenient maintenance of teaching equipment by adopting a teaching engineering method. It can effectively overcome the dangers of real working scenes in chemical engineering, transportation, physics, and other majors in engineering technology in higher education, for learners to engage in simulation learning in a safer and more realistic environment. Particularly, the development companies and professional teachers of the virtual teaching system cooperate on developing virtual teaching resources and integrating multimedia resources of virtual teaching to realize the visualization of virtual teaching resources, improve the perceived usefulness and ease of use of learners, widely attract users to actively participate in learning tasks, and enhance the learning effect. Therefore, the virtual simulation teaching system has become a new research hot spot in the education industry and has been widely studied and applied in practical teaching in engineering technology.

## 2. Theoretical Basis and Hypothesis Development

*E-mail address: lliu@wtu.edu.cn
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### 2.1 Theoretical Basis

The theories closely related to virtual teaching system are constructivism theory and self-regulated learning theory, which are also the basis for the research hypothesis proposed in this study. In the learning process, constructivism theory believes that learners should be transformed from passive acceptance of knowledge to active processing of information, and learner-first learning mode should be adopted to achieve efficient interaction between teachers and students. Teachers change from traditional simple knowledge teaching to guiders who effectively promote the knowledge construction of learners. During the knowledge construction of learners, teachers must adopt more scientific teaching implementation policies, such as experiential learning, group discussion, problem-oriented learning, project situational teaching, and so on, which can be further extended to the teaching process of the virtual teaching system, granting a significant educational value for the use of a virtual teaching system. The second important theory is self-regulated learning theory. Knowles [1] found that self-regulated learning requires learners to formulate their own learning goals in the process of acquiring knowledge and improving skills, which cannot be simply set by teachers as consistent goals. Teachers must adopt various teaching methods to different learners. Concurrently, learners can also set different learning goals on the basis of their actual situation, grasp their learning process, and scientifically evaluate the learning effect. In the process of self-regulated learning, teachers, as guides, should frequently promote learners to explore knowledge independently and build their knowledge system. During the process of self-regulated learning, learners shall repeatedly process learning information to improve their cognitive level of things and effectively solve practical problems. Especially in the teaching of virtual reality technology, learners must improve self-learning efficacy and effectively realize self-regulated learning. It shall set virtual learning scenarios and different learning difficulties on the basis of the actual situation in which repeated exercises can be implemented when facing more complex learning scenarios to improve the actual effect of human-computer interaction.

### 2.2 Hypothesis Development

Lou [2] proposed a design framework of the virtual teaching system and implemented a comparison analysis on whether the virtual teaching system was adopted, which indicated that a virtual teaching system can significantly improve students' learning. Vollrath et al. [3] implemented web-based virtual education courseware for the C programming language. This system enables students to easily understand the content and programming techniques of the C programming language. It enables lecturers to achieve higher productivity, saving them time and labor. Alfalah et al. [4] demonstrated that the purpose of using virtual reality as a medical training toll is to provide students with additional means of teaching and improve the quality of medical skills, and found that the developed virtual teaching system enhanced their anatomical learning experience and improved their understanding of cardiac anatomy. Khlaisang et al. [5] believe that the use of mobile devices and Three-dimensional (3D) virtual classrooms provides an integrated environment for effective learning. The data analysis using dependency t-test indicated that a significant difference existed in the scores of learning and innovation skills before and after the self-assessment in the 21st century, with a significance level of 0.05. Ray et al. [6] revealed that virtual reality (VR) has reached the pinnacle of computing capability breakthroughs, signifying that using a VR teaching system to improve the teaching process is feasible, and the influence of the system on learning results can improve their cognitive learning and participation. Dobrova et al. [7] demonstrated that the use of VR technology in foreign language learning can improve the learning initiative of learners. Menendez et al. [8] indicated that medical students learning real cases through virtual teaching system can significantly improve the learning effect, and virtual patient tools are conductive to developing the skills needed for pharmaceutical care practice but should be used as supplementary technologies. Dessouky et al. [9] designed a virtual factory teaching system and introduced the VFTS teaching method, prototype development, and its application in advance industrial engineering courses. Kaufmann et al. [10] setup uses a stereoscopic head-mounted display (HMD) and the Personal Interaction Panel (PIP)-a two-handed 3D interaction tool that simplifies 3D model interaction. Means of application in mathematics and geometry education at high school as well as university level are being discussed. The results show that the use of Construct-3D is easy to learn and encourages experimentation with geometric constructions. Freeman et al. [11] designed a flexible modular patient simulation system, which had Three-dimensional 3D, VR and Two-dimensional (2D) tablet user interface for teaching cognitive assessment and treatment skills. Results demonstrated that the virtual teaching system can be deployed to the scene so that trainees can master and maintain these skills. Dickey et al. [12] unveiled that the virtual teaching method can improve the learning motivation of learners. Li et al. [13] believed that VR technology can display 3D materials and their dynamic cutting process and enhance the learning motivation of learners in the context of situational learning. The findings revealed that the scale had high reliability; the design of the virtual situational learning had a significant positive impact on improving the learning effect and performance skills of students, indicating that participants were attracted and willing to use the system, which directly enhanced their positive learning motivation and promoted their academic performance. Ouyang et al. [14] reconstructed the real chemical plant in the virtual environment of the system, demonstrating that the virtual teaching system can strengthen students' understanding of chemical processes and cultivate their operation ability. Dumitrescu et al. [15] pointed out an example of the use of virtual instruments and tools (created by LabView software) in the teaching process of science, which uncovered that using a virtual teaching system in physical knowledge learning can improve students' learning. Xiang et al. [16] suggested students can learn complex experimental process by controlling computers with virtual reality technology and providing a virtual experimental environment. Existing literature shows that a virtual teaching system is a new teaching technology, which can be realized through Virtual Reality, Augmented Reality, Unity-3D, and other technologies. Meanwhile, multimedia technology and communication technology are fully integrated into the virtual teaching system to build a more simulated virtual teaching system and update virtual teaching resources, so that learners can conduct experiments or recognize equipment in the virtual environment, thereby improving their perceptual effectiveness. As a new education technology that better meets educational objectives, the virtual simulation system has a fairly friendly nature and can stimulate the teaching motivation of teachers and learning

motivation of learners. Existing theoretical and empirical research results of the virtual simulation teaching system reveals that the virtual simulation teaching system can improve students' learning in four aspects, including virtual simulation teaching method, virtual simulation teaching equipment, virtual simulation teaching resources, and experience of learners. Therefore, the following hypotheses are proposed.

*H1: Virtual simulation teaching method can significantly improve learning of students majoring in engineering technology.*

*H2: Virtual simulation teaching equipment can significantly improve learning of students majoring in engineering technology.*

*H3: Virtual simulation teaching resources can significantly improve learning of students majoring in engineering technology.*

*H4: Experience of learners can significantly improve learning of students majoring in engineering technology.*

## 3. Methodology

### 3.1 Research Questionnaire

On the basis of the existing virtual teaching simulation system, and combined with the actual needs of this study, it compiled "The influence of virtual simulation teaching system on learning effect of students majoring in engineering technology." The questionnaire included four aspects with a total of 38 questions. Part 1 included the basic information of respondents comprising 6 questions, including gender, grade, subject, platform type (platform and docking instruments), resource types (experiment, instrument), and frequency of using virtual teaching platform and other questions. Part 2 consisted of the survey on virtual teaching simulation system with a total of 15 questions, including virtual simulation method, virtual simulation teaching equipment, virtual simulation resources, and experience of learners. Part 3 involved the survey on learning effect; it used the learning performance questionnaire compiled by Pekrun et al. [17] and Kanetaki et al. [18], and selected 4 problems to re-measure learning performance. All questionnaires were collected through a 7-point Likert scale.

### 3.2 Research Subjects

To strengthen the construction of "Internet+" virtual simulation experiment teaching simulation resource platform and promote online sharing and efficient and intensive application of virtual simulation experiment teaching resources, Jiangxi province of China integrated an existing heterogeneous information platform and virtual simulation experiment teaching projects and data access, constructed a professional virtual simulation experiment teaching sharing platform, realized the inter-school opening of high-quality virtual simulation experiment teaching resources and made it available to the society, and realized the sharing of large-scale online virtual simulation experiment projects. To obtain more objective analysis results, a questionnaire survey was conducted among students majoring in engineering technology from seven universities in Jiangxi province of China. These universities jointly built the virtual simulation experiment teaching platform of colleges and universities in Jiangxi Province in which the virtual simulation experiment teaching platform had various virtual simulation teaching systems in engineering technology. In this study, an online questionnaire survey of students in November 2021, and 357 questionnaires were collected. In addition to the invalid questionnaires and the questionnaires with obvious errors, 285 questionnaires were obtained for analysis, with an effective recovery rate of 79.83%. Specific survey respondents are shown in Table 1.

**Table 1.** Descriptive statistics of research subjects

| Name | Item | Frequency | Percentage (%) | Cumulative percentage (%) |
|---|---|---|---|---|
| **Gender** | Female | 139 | 48.77 | 48.77 |
| | Male | 146 | 51.23 | 100 |
| **Grade** | Freshman | 36 | 12.63 | 12.63 |
| | Sophomore | 108 | 37.89 | 50.53 |
| | Junior | 89 | 31.23 | 81.75 |
| | Senior | 52 | 18.25 | 100 |
| **Platform** | Docking resources | 105 | 36.84 | 36.84 |
| | Platform resources | 180 | 63.16 | 100 |
| **Resources** | Experiment | 83 | 29.12 | 29.12 |
| | Instrument | 202 | 70.88 | 100 |
| **Frequency** | 1 time/week | 28 | 9.82 | 9.82 |
| | 2 times/week | 43 | 15.09 | 24.91 |
| | 3 times/week | 79 | 27.72 | 52.63 |
| | 4 times/week | 58 | 20.35 | 72.98 |
| | 5 times/week | 68 | 23.86 | 96.84 |
| | >5 times/week | 9 | 3.16 | 100 |
| **Total** | | 285 | 100 | 100 |

Results in Table 1 present that no significant difference exists in gender. Sophomore students were more enthusiastic to answer the questionnaire because they are in the critical stage of professional courses. In terms of platform, more platform resources indicated that the college has carried out considerable self-development. Regarding resources, there exist more instruments mainly because the virtual teaching system focused more on cognition and operation of equipment and understanding of mechanical principle of various disciplines. For the frequency of virtual teaching system, more students used it 2-5 times every week, which was more suitable for actual teaching situation.

## 4. Results Analysis

### 4.1 Reliability and Validity Analysis

Reliability detection is mainly to measure the reliability of the questionnaire. Thus, the in this study, SPSS 22.0 software was used to measure Cronbach's α with results shown in Table 2.

**Table 2.** Results of the reliability and validity detection

| Type of variables | Name of variables | Questions | Cronbach's α | Cronbach's α |
|---|---|---|---|---|
| Independent variable | Virtual simulation teaching method | 3 | 0.862 | 0.871 |

| | | | | |
|---|---|---|---|---|
| | Virtual simulation teaching equipment | 3 | 0.909 | |
| | Virtual simulation teaching resources | 3 | 0.926 | |
| | Experience of learners | 6 | 0.810 | |
| Dependent variable | Learning effect | 4 | 0.848 | |

Table 2 exhibits that the Cronbach's α was 0.871, which was more than 0.8, and the Cronbach's α of the five variables was also more than 0.8, indicating that the research data had high reliability. Validity detection is to reflect the extent of the content to be examined. The measurement results mainly demonstrated that the more consistent with the content to be examined, the higher the validity, otherwise, the lower the validity.

**Table 3.** Results of validity detection

| | | |
|---|---|---|
| KMO value | | 0.785 |
| Bartlett sphericity test | Approximate chi-square | 4227.059 |
| | *df* | 210 |
| | *p* | 0 |

Note: The diagonal blue number is the square root of AVE.

**Table 4.** Discriminant validity: Pearson correlation and AVE square root values

| | Factor1 | Factor2 | Factor3 | Factor4 | Factor5 |
|---|---|---|---|---|---|
| **Factor1** | 0.825 | - | - | - | - |
| **Factor2** | 0.322 | 0.877 | - | - | - |
| **Factor3** | 0.444 | 0.258 | 0.901 | - | - |
| **Factor4** | 0.182 | 0.205 | 0.099 | 0.646 | - |
| **Factor5** | 0.336 | 0.221 | 0.248 | 0.392 | 0.766 |

Notes: Diagonal blue numbers are AVE square root values.

Results in Table 3 present that KMP was 0.785 and the corresponding *P*-value was 0.000. Table 4 demonstrates that the square roots of AVE for Factor1-Factor 5 were more than the maximum absolute value of the correlation coefficient between factors. In summary, the validity of the questionnaire in this study is extremely good.

### 4.2 Correlation Analysis

Results in Table 5 present that the Pearson's correlation coefficient was used to represent the condition of the correlation. The analyses are as follows: A significant difference existed between the Factor5 and Factor1, Factor5 and Factor2, Factor5 and Factor3, and Factor and Factor4, the correlation coefficient values were 0.278, 0.148, 0.129, 0.117, and the correlation coefficient values were greater than 0, indicating that a positive correlation existed between them, indicating that the four components of the virtual simulation teaching system had a significant role in promoting learning effect.

**Table 5.** Pearson's correlation coefficient

| | Factor1 | Factor2 | Factor3 | Factor4 | Factor5 |
|---|---|---|---|---|---|
| Factor1 | 1 | - | - | - | - |
| Factor2 | 0.336** | 1 | - | - | - |
| Factor3 | 0.251** | 0.301** | 1 | - | - |
| Factor4 | 0.251** | 0.460** | 0.201** | 1 | - |
| Factor5 | 0.278** | 0.148* | 0.129* | 0.117* | 1 |

Note: *$p$<0.05, **$p$<0.01

### 4.3 Regression Analysis

Table 6 exhibits that the model passes the *F* test ($F$=16.711, $p$=0.000<0.05), and the VIF values of model in the multi-collinearity were all less than 5, indicating no collinearity problem. Moreover, D-W value was close to 2, indicating that no autocorrelation between the sample data, so the model was good.

**Table 6.** Regression analysis results

| Variables | Standardized coefficient | *t* | *p* | VIF | *F* |
|---|---|---|---|---|---|
| Constants | - | 6.299 | 0.000** | - | $F$ (4,280)=16.711, $p$=0.000 |
| Factor1 | 0.218 | 3.482 | 0.001** | 1.355 | |
| Factor2 | 0.098 | 1.612 | 0.108 | 1.279 | |
| Factor3 | 0.217 | 3.971 | 0.000** | 1.033 | |
| Factor4 | 0.138 | 2.431 | 0.016* | 1.114 | |

Notes: D-W=1.720; * $p$<0.05, ** $p$<0.01.

Hypothesis H1 is valid. The virtual simulation teaching method can significantly improve students' learning, which may be because the virtual reality technology has been widely recognized in the education industry as an emerging technology, and many teachers are willing to adopt such teaching methods. The virtual simulation teaching method can overcome the difficulties that traditional teaching methods have in terms of implementing experiments and equipment recognition. By improving the immersive virtual learning and interactive friendliness of virtual teaching methods in teaching, learners can better master experimental knowledge and improve their experimental skills. The virtual simulation teaching method can create a good learning interactive atmosphere, realize human-computer interaction, and improve learners' innovative ability and high-order thinking ability. Facing good virtual teaching environment, teachers can utilize virtual experimental resources and use multimedia technology to assist teaching. Teachers can develop a scientific virtual experiment teaching method that can exercise and improve the independent completion of some virtual simulation experiments and implement more personalized exercise on the basis of the ability of different learners. The virtual simulation teaching method overcame the limitation of passive acceptance of learners in traditional classroom, which more adapted to the rapid development of knowledge update so that everyone can become the operator of virtual simulation experiment, provide learners more powerful imagination space and obtain higher student's learning.

Hypothesis H2 is invalid. The virtual simulation teaching equipment cannot significantly improve students' learning, which main reason may be that the virtual teaching system paid more attention to the use of more teachers at the beginning of the design, and did not realize the importance of learning operation of learners and other issues. At present, college students, as learners, have pretty good information literacy, especially with the increase in the frequency of using teaching simulation equipment; they are more familiar with the operation of equipment after understood virtual simulation teaching equipment well, so that they prefer to operate the virtual simulation equipment. However, it is also easy to feel tired and lack of the initial sense of novelty with

the increasing use of virtual devices. Meanwhile, there is a potential reason that the virtual teaching system needs the corresponding higher professional knowledge; therefore, learners with higher professional quality can obtain better learning effect through more in-depth system operation exploration in the learning process of virtual simulation system. For some learners who are not very good at virtual teaching methods, their learning effect was greatly reduced due to the lack of good human-computer interaction experience, which also inspired our virtual teaching teachers to design virtual teaching contents with different difficulties and different contents according to different learning foundation to improve students' learning.

Hypothesis H3 is valid. The virtual simulation teaching resources can significantly improve students' learning. The virtual simulation teaching resources were the core resources of virtual teaching, which were key variables affecting learning experience of learners and improving students' learning. At present, more colleges and universities in China are extremely willing to develop or purchase high-quality virtual teaching resources. Many colleges and universities have established standards for the design and development of virtual teaching resources to make them more scientific and reasonable, which has an obvious role in stimulating professional learners. By strengthening the construction of virtual teaching resources team, professional teachers can cooperate with professional companies to improve skills of virtual teachers and customize virtual teaching resources suitable for teaching, thereby serving virtual simulation teaching effectively. With the help of virtual simulation technology or software, the school improved the immersion, interactivity, and conception of virtual teaching resources by increasing the functions of interaction and demonstration, making students perceive that they are in the situation, which improved the reduction of virtual classroom to the real environment, fundamentally enhanced the participation of learners, and ultimately improved students' learning.

Hypothesis H4 is valid. The experience of learners can significantly improve students' learning, which is mainly because the learning experience was the process of learners participating in activities, and obtaining emotional input simultaneously. Learning experience is the cognition and response of learners to the learning process and learning results of online courses, which directly impacts the improvement of students' learning. Therefore, the positive learning experience of learners can significantly stimulate learners' interests in learning and motivate learners to engage in deep learning behaviors. The experience generated from dynamic learning activities is the experience of curriculum activities. Learners produce deeper cognition and emotion through curriculum activities, which will directly affect learners' willingness and encourage them to continuously participate in curriculum learning. The good learning experience of virtual teaching system can stimulate learners to build their own knowledge system. Learners who use virtual education products extensively can gain first-hand experience by fully utilizing them, which is conducive to evaluating their previous experience, thereby filling their perceived professional skills that they have not obtained and promoting learners' high-quality understanding and absorption of professional knowledge. After gradually improving their learning experience, learners will build a learning knowledge system in which they are more willing to share their own learning experience with other learners, stimulate learners to reflect and share, and efficiently connect their learning views with knowledge in textbooks, resulting in more efficient and interesting learning.

### 4.4 Difference Analysis

Table 7 demonstrates that different resources and platforms had no significant difference in learning effect. Moreover, as a unified platform, the virtual teaching system was consistent with the learning outcomes of learners. From the resource perspective, the main reason may be that although there were docking resources from other colleges and universities and platform resources independently developed by the research universities, it had a very strict review and examination of various resources in the platform as a sharing platform in Jiangxi Province given that the virtual teaching system platform had a high construction platform. Thus, learners can learn more actively by improving the quality of virtual teaching system resources to ensure the learning initiative and enthusiasm of learners, thereby obtaining higher learning performance. In terms of platform, experiments and instruments were main types of virtual teaching system, therefore, virtual teaching put more emphasis on the experiments of engineering and science and the virtual application of advance teaching equipment and instruments, meanwhile, experiments and instruments were fully integrated in many courses, so that there was no significant difference in students' learning.

**Table 7.** Differences between sources and platforms on learning effect

| | Resources (average value ± standard deviation) | | *t* | *p* |
|---|---|---|---|---|
| | Docking resource (*n*=83) | Platform resource (*n*=202) | | |
| **Learning effect** | 4.08±1.35 | 3.94±1.38 | 0.804 | 0.422 |
| | Platforms (average value ± standard deviation) | | *t* | *p* |
| | Experiments (*n*=105) | Instruments (*n*=180) | | |
| | 4.01±1.34 | 3.97±1.39 | 0.254 | 0.799 |

Note: **p*<0.05, ***p*<0.01

## 5. Conclusion

The level of education informatization has been improved year by year with the development of communication technology, artificial intelligence, and other technologies. The virtual simulation teaching system has significantly improved the teaching effect, improved teaching quality, and increased learner motivation. The virtual simulation teaching system has good interactivity and reliability of repeated operation, which can be maintained more conveniently. It can complete a variety of experimental projects that are impossible to complete in real life and provide learners with a high level of learning performance of students majoring in engineering technology. In this study, a questionnaire about the influence of virtual simulation teaching system on learning was designed for students majoring in engineering technology from seven universities in Jiangxi province of China who use a virtual simulation teaching platform. The

questionnaire was used to measure the influence of the four components of virtual simulation teaching system on learning of students majoring in engineering technology. The following conclusions are obtained: (1) virtual simulation teaching method, virtual simulation teaching resources, and learners' experience can significantly improve learning of students majoring in engineering technology. (2) No significant difference existed in the learning effect in terms of different resources and platforms. (3) The use of virtual simulation teaching system can significantly improve the learning effect of students majoring in engineering technology.

Thus, further research should be carried out on the differences of students' learning influenced by different intermediary variables—whether different majors can affect students' learning of the virtual simulation teaching system and can enrich the conceptual elements of virtual simulation teaching system.



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