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Application Analysis of Virtual Simulation Experiment Combined with Picture Archiving and Communication System in the Practical Teaching of Medical Imaging

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Abstract: *Objective:* To explore the application effect of virtual simulation experiment combined with picture archiving and communication system (PACS) in medical imaging practical teaching. *Methods:* 97 students from the medical imaging class of 2022 were divided into two groups; the control group (n = 48) was taught by the traditional teaching method, whereas the research group was taught by virtual simulation experiment combined with PACS (n = 49). The teaching achievements and teaching effects of the two groups were compared to define the advantages of the two teaching modes. *Results:* Initially, there were no significant differences in the basic theory, image analysis, report writing, and differential diagnosis scores between the two groups of students ($P > 0.05$); however, after 16 weeks of teaching, the scores of the research group were better than those of the control group ($P < 0.05$); the pass rate of students in the study group (93.88%) was higher than that in the control group (81.25%); the scores of students in the research group in terms of clinical inquiry skills, X-ray/computed tomography/magnetic resonance imaging (X-ray/CT/MRI) operation skills, and doctor-patient communication skills were significantly higher than those in the control group ($P < 0.05$). *Conclusion:* In medical imaging practical teaching, the application of virtual simulation experiment combined with PACS can effectively address several problems in the traditional teaching mode, including the single teaching method, the single teaching content, and the lack of innovation, and, at the same time, improve students' basic theoretical knowledge, X-ray/CT/MRI operation skills, consultation skills, and doctor-patient communication skills, thereby effectively improving the teaching quality and learning effect.

Keywords: Medical imaging; Virtual simulation experiment; PACS system; Teaching effect

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1. Introduction

Medical imaging is a discipline with strong practicality and applicability. It functions to provide information on the internal shape and function of the human body in the form of images and to use the features observed for clinical diagnosis and treatment. This discipline includes imaging inspection techniques, imaging principles, image processing and diagnostic analysis, and many other aspects. The teaching of traditional medical imaging is mainly based on theoretical lectures, and students often do not understand what they have learned. With the rapid development of modern medical imaging, teaching methods are constantly being updated and improved [1]. Virtual simulation is a new type of educational technology that has gradually matured following the development of internet technology. With the application of this technology, the real clinical scene is displayed with three-dimensional (3D) animation, thus realizing "Internet + education." Through this, the theoretical basis and operation skills of medical imaging can be better cultivated to meet the actual needs in the process of medical imaging education [2]. The application of virtual simulation experiment combined with PACS in medical imaging practical teaching can improve students' autonomous learning ability and their interest in learning, as well as help teachers to reform the content of practical teaching. This discussion mainly focuses on the application of virtual simulation experiment combined with PACS in medical imaging practical teaching.

2. Materials and methods

2.1. General information

A total of 97 students from the medical imaging class of 2022 were selected as research subjects. They were divided into two groups, the control group (n = 48) and the research group (n = 49), by the random number table method. The students in the control group were taught by the traditional teaching method, whereas those in the research group were taught by the virtual simulation platform combined with PACS. The duration of the study was 16 weeks. There was no significant difference in the general data of the two groups of students ($P > 0.05$).

2.2. Methods

The control group was taught by the traditional teaching method: (i) a combination of heuristic teaching method and medical record teaching method; (ii) a systematic transfer of theoretical basic knowledge to students, and an explanation of classic cases to students with questions and answers.

The research group was taught by virtual simulation experiment combined with PACS. This practical teaching method includes four stages.

The first stage includes a systematic teaching of the principles of X-ray/CT/MRI imaging, equipment performance, detection methods, inspection safety, and image characteristics, with the use of an online virtual platform to release the virtual simulation experiment of X-ray/CT/MRI imaging principles. Through X-ray/CT/MRI examination operation of virtual patients, students can achieve the goal of fully understanding the work content of each link in clinical imaging examination and diagnosis. At the same time, through individual practice, students' medical imaging-related theoretical knowledge can be further consolidated, thereby becoming high-quality medical talents with strong theoretical and practical skills.

The second stage includes a virtual simulation test operation of the corresponding disease case arranged on the PACS after gaining basic knowledge about medical imaging examination technology, image appearance, and lesion appearance of a certain type of disease. The selection of virtual simulation cases must be driven by real cases, and medical imaging content should be integrated into situational problems, so as to ensure that students develop mature medical imaging clinical thinking [3].

The third stage includes the selection of multiple cases through the PACS to further consolidate learning and enable students to have a comprehensive understanding of a systemic disease. This allows students to summarize the imaging features of the same type of disease in continuous learning and research, thereby developing systematic medical imaging clinical diagnosis thinking.

The fourth stage includes the use of PACS for examination after completing a certain amount of teaching hours. Students will first fill in the case report according to the imaging data and clinical information of the virtual simulation case; thereafter, teachers will evaluate their virtual simulation practice and test results to keep abreast of students' learning state, so that they can adjust and optimize their teaching plan.

2.3. Observation indicators

(i) The professional imaging ability of the two groups of students before and after teaching, including basic theory, image analysis, report writing, and differential diagnosis.
(ii) The pass rate of the students in the two groups, pass rate = (excellent + good + fair)/total number × 100%.
(iii) The ratings of students' consultation skills, X-ray/CT/MRI operation skills, and doctor-patient communication skills between the two groups.

2.4. Statistical analysis

SPSS 22.0 was used for data analysis; measurement data were expressed as mean ± standard deviation, and *t*-test was used to compare the data between groups and within groups; chi-square (χ^2) test was used to compare count data expressed as n (%). $P < 0.05$ indicates statistically significant difference.

3. Results

3.1. Professional imaging ability before and after teaching

Initially, there was no significant difference in basic theory, image analysis, report writing, and differential diagnosis scores between the two groups of students ($P > 0.05$); after 16 weeks of professional teaching, the scores of the two groups showed significant improvement, although the research group scored significantly higher than the control group ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of professional imaging ability between the two groups before and after teaching

Group		Before teaching	After teaching	*t*	*P*
Control group (n = 48)	Basic theory	56.47 ± 2.15	79.69 ± 3.35	40.4145	0.0000
Research group (n = 49)		57.02 ± 2.13	82.44 ± 3.36	44.7282	0.0000
t		1.2656	4.0361		
P		0.2087	0.0001		
Control group (n = 48)	Image analysis	52.26 ± 2.19	76.69 ± 4.12	36.2752	0.0000
Research group (n = 49)		52.31 ± 2.02	88.15 ± 3.98	56.2099	0.0000
t		0.1169	13.9340		
P		0.9072	0.0000		
Control group (n = 48)	Report writing	60.58 ± 1.22	83.65 ± 2.11	65.5778	0.0000
Research group (n = 49)		60.95 ± 1.12	89.78 ± 2.13	83.8600	0.0000
t		1.5565	14.2374		
P		0.1229	0.0459		
Control group (n = 48)	Differential diagnosis	56.41 ± 1.95	82.58 ± 2.12	62.9458	0.0000
Research group (n = 49)		56.36 ± 1.87	90.23 ± 2.54	75.1682	0.0000
t		0.1289	16.0869		
P		0.8977	0.0000		

3.2. Pass rate

Under different teaching modes, there was statistically significant difference in the pass rate between the two groups of students; the pass rate of students in the research group (93.88%) was higher than that of students in the control group (81.25%) ($P < 0.05$). See **Table 2** for details.

Table 2. Comparison of pass rate between the two groups of students

Group	Excellent	Good	Fair	Poor	Pass rate
Control group (n = 48)	9 (18.75)	12 (25.00)	17 (35.42)	10 (20.83)	39 (81.25)
Research group (n = 49)	15 (30.61)	18 (36.73)	13 (26.53)	3 (6.12)	46 (93.88)
χ^2					4.5213
P					0.0335

Data are given as n (%).

3.3. Scores of students' consultation skills, X-ray/CT/MRI operation skills, and doctor-patient communication skills

The consultation skills, X-ray/CT/MRI practical skills, and doctor-patient communication skills of the students in the research group were scored as 81.36 ± 3.01, 84.96 ± 3.14, and 86.06 ± 4.02, respectively, which were significantly higher than those of the students in the control group (71.36 ± 2.36, 75.45 ± 3.45, and 77.01 ± 3.49) ($P < 0.05$), as shown in **Table 3**.

Table 3. Comparison of scores between the two groups of students in terms of consultation skills, X-ray/CT/MRI operation skills, and doctor-patient communication skills

Group	Consultation skills	X-ray/CT/MRI operation skills	Doctor-patient communication skills
Control group (n = 48)	71.36 ± 2.36	75.45 ± 3.45	77.01 ± 3.49
Research group (n = 49)	81.36 ± 3.01	84.96 ± 3.14	86.06 ± 4.02
t	18.1838	14.2034	11.8296
P	0.0000	0.0000	0.0000

4. Discussion

4.1. Disadvantages of the traditional teaching method in the practical teaching of medical imaging

(i) Single teaching content

Traditional medical imaging teaching is mainly based on theory and has a relatively single content. Most students only have a basic understanding of theoretical knowledge, which is disconnected from clinical work, and lack enthusiasm and initiative in learning. Students do not really understand what they have learned and are unable to use what they have learned in clinical work.

(ii) Single teaching method

Due to the practicality of medical imaging, it is necessary to increase students' hands-on operation in the practical teaching, combine theoretical knowledge with practical operation, and cultivate students' independent learning ability and innovative consciousness. However, traditional medical imaging teaching methods such as theoretical lectures and demonstrations are often used in practical teaching. Such methods are not conducive to cultivating students' independent learning ability and innovative consciousness and may even cause students to lose interest in the course.

(iii) Lack of cultivation of students' innovative ability

Although many medical schools have begun to pay attention to the cultivation of students' innovative ability, they have yet to implement it as an important link in practical teaching. Although medical imaging is a highly practical subject, teachers tend to focus on basic theoretical education, with less emphasis on the cultivation of students' hands-on practical ability and innovative ability in traditional teaching practice.

4.2. Advantages of virtual simulation platform combined with PACS

(i) In the application of virtual simulation technology, clinical scenes can be truly presented with the help of 3D animation. Students can complete the imaging inspection process through mouse, virtual reality (VR) glasses, and controllers, thus addressing practical difficulties such as insufficient imaging equipment in practical teaching. The development of medical education has opened up new ideas [4].

(ii) Virtual simulation experiments are closer to the real environment. They stimulate students' interest and make up for the lack of understanding of imaging equipment and principles among students in traditional teaching. Improving students' hands-on ability in a virtual simulation environment is one of the problems that need to be addressed urgently.

(iii) With the purpose of expanding the breadth and depth of experimental teaching content and breaking the limitations of experimental space and time in virtual simulation experimental teaching with students as the center as well as to provide students with more experimental environments for independent learning and diversified development, various forms of terminal devices such as desktop computers, notebooks, iPads, and smart phones can be used to carry out practical training operations anywhere covered by the network. Other issues that need to be addressed include how teachers can effectively provide experimental guidance and teaching feedback, how to ensure the quality of teaching so that teaching and learning are not limited by time and space, and how to realize functions that are not available or difficult to complete in real experiments.

(iv) How to organically and deeply integrate VR and PACS in the practical teaching of medical imaging, so as to ensure the applicability of theory to practice, the combination of practice with theory, and the continuity from theory to practice? The interaction and integration between theory and practice create a sense of interaction and fun, stimulate the interest of students in learning, return to the essence of education, and help students to gain an immersive experience through online learning and realize that experiments will not stop. At the same time, the interaction and integration can also address the disconnection between teaching and application in the teaching of medical imaging [5].

(v) Through virtual simulation technology combined with PACS practical teaching, taking the combination of engineering and learning as the starting point and learning how to improve the acceptance and technical content of training through the virtual simulation network platform, how to use the PACS platform to improve students' ability in summarizing and reading diagnostics, and how to use the network platform to realize the integration of teaching, learning, examination, and practice enable students majoring in medical imaging to achieve homogeneous teaching, which would improve students' clinical reasoning and practical skills.

4.3. Application effect of virtual simulation experiment combined with PACS in medical imaging practical teaching

In this study, we compared and analyzed the professional imaging ability, pass rate, consultation skills, X-ray/CT/MRI operation skills, and doctor-patient communication skills of students in both the control group and the research group under different teaching modes. We found that all indicators of the research group were significantly better than those of the control group. At commencement, there were no significant differences in the basic theory, image analysis, report writing, and differential diagnosis scores between the two groups of students ($P > 0.05$); however, after 16 weeks of professional learning, the scores of the two groups of students showed significant improvement, although the scores of the research group were significantly higher than those of the control group ($P < 0.05$), indicating that the two teaching modes are effective in improving students' medical imaging knowledge and ability, but the virtual simulation platform combined with PACS was better. In addition, the total number of students in the research group with excellent, good, and fair grades was 46, and the pass rate was 93.88%, which was significantly higher than the pass rate of the control group (81.25%; 38/48). The scores of the research group in terms of clinical inquiry skills, X-ray/CT/MRI operation skills, and doctor-patient communication skills were 81.36 ± 3.01, 84.96 ± 3.14, and 86.06 ± 4.02, respectively, which were significantly higher than those of the control group (71.36 ± 2.36, 75.45 ± 3.45, and 77.01 ± 3.49) ($P < 0.05$).

5. Conclusion

In the practical teaching of medical imaging, the application of the virtual simulation platform combined with PACS helps students gain familiarity with the components of the imaging equipment, provides opportunities to students to exercise their hands-on skills, and improves students' independent learning ability and innovative consciousness. As a large-scale medical imaging information management system, the PACS is open and comprehensive. We anticipate that it will be further improved in future medical imaging practice teaching, so as to play a greater role.

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Disclosure statement

The authors declare no conflict of interest.

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