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Application of Virtual Simulation Technology in Surgical Practice Teaching for MBBS Students

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ABSTRACT

Objective: To explore the application effect and advantages of virtual reality (VR) surgical simulation technology in surgical teaching for MBBS international students, and provide reference for the innovation of medical education mode. Methods: A total of 20 MBBS international students were selected as the research subjects. The application of VR and traditional teaching modes in surgical internship courses was investigated. Student satisfaction data were collected across nine dimensions, including content relevance, theoretical understanding, operational skills, and teacher-student interaction. Descriptive statistics and inter-group comparison methods were used to analyze the differences in effectiveness. Results: VR teaching is superior to traditional methods in all teaching dimensions, especially in terms of practical skills improvement, teaching pace control, and teacher-student interaction. VR not only provides students with highly simulated practical environments and abundant opportunities for repeated practice, but also reduces language barriers through visual expression, significantly enhancing foreign students' learning confidence and active participation. At the same time, VR places higher demands on educational resources and capabilities in terms of teacher curriculum design, software and hardware support, and the training of soft skills such as clinical communication and emergency response also needs to be strengthened. Conclusion: VR surgical simulation technology provides effective support for skill training and theoretical consolidation of international students, and is a beneficial attempt to promote surgical teaching innovation and improve the quality of international medical education. In the future, the VR teaching system can be continuously improved by expanding the sample size, enriching simulation scenarios, and strengthening soft skill training, and its long-term educational effectiveness can be continuously tracked and evaluated.

KEYWORDS

MBBS; Virtual Reality (Vr) Surgical simulation technology; Medical education; Teaching innovation

1 Introduction

1.1 The Importance and Challenges of Surgical Practical Teaching, Especially the Difficulties in Teaching MBBS International Students (Language, Medical Background, Limited Practical Opportunities, Etc.)

Surgical practical teaching plays a central role in medical education, serving as a crucial component in cultivating medical students' clinical thinking abilities, operational skills, and team collaboration awareness. Compared to theoretical courses, surgical practical teaching places greater emphasis on the integration of hands and mind, as well as on-the-spot clinical decision-making skills, which are essential for future physicians to independently address complex patient issues. In recent years, with the increasing frequency of international medical education exchanges, more and more international students have chosen to pursue their MBBS (Bachelor of Medicine & Bachelor of Surgery) degrees in China. However, surgical practical teaching for international students faces many unique challenges.

Firstly, language barriers are the primary factor affecting international students' effective participation in surgical practice. There are significant differences between medical terminology and everyday language, and it is difficult to understand and grasp some details of clinical operations and doctor-patient communication in a non-native language environment. Secondly, international students generally have uneven knowledge of basic medical knowledge. Due to differences in medical education models in their respective countries, some international students have a certain gap in theoretical level, operational skills, and thinking mode compared to local students when entering the clinical probation stage. In addition, due to medical safety regulations and hospital management regulations, international students have limited opportunities to obtain practical operations in the front line of clinical practice, often only participating in observation or role-playing, making it difficult to repeatedly practice and accumulate independent operational experience.

The interplay of multiple factors mentioned above leads to problems such as inadequate understanding, unskilled operation, and lack of confidence among international students during surgical practice learning. Therefore, how to innovate surgical practice teaching models and create a more friendly and effective learning and training environment for international students has become one of the important issues that need to be addressed in current medical education.

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1.2 The Emergence and Advantages of Virtual Reality (vr) Technology in Medical Education

In recent years, virtual simulation (Virtual Reality, VR) technology has developed rapidly in the global medical education field as a cutting-edge information teaching tool. With the help of computer modeling, interactive perception and immersive experience, VR can create highly simulated three-dimensional medical scenes, providing an unprecedented learning platform for medical students and clinicians. Compared with the traditional "see-tell-practice" mode, virtual simulation technology allows learners to conduct immersive training in surgical operations, diagnostic reasoning, and team collaboration, significantly enhancing the initiative and practicality of learning.

The advantages of VR medical teaching are prominent. Firstly, VR breaks through the constraints of time and space, allowing students to repeatedly practice skills in a virtual operating room without worrying about resource constraints or patient safety risks. Secondly, VR platforms can simulate various complex and rare clinical scenarios, helping students accumulate valuable practical experience and enhance their emergency response capabilities. At the same time, VR technology also features visualization, strong interactivity, and traceability of processes, enabling students to promptly identify and correct errors, deepening the integration of theory and practice. For international students with weaker language foundations or lacking hands-on opportunities, VR lowers the learning threshold through visual operation and scenario reproduction, helping to compensate for the deficiencies of real-world clinical teaching and significantly improving cognitive efficiency and skill mastery.

With the continuous popularization of VR hardware and the enrichment and improvement of software ecosystem, virtual simulation technology is gradually becoming an indispensable and important means in medical education, bringing more possibilities for medical talent cultivation.

1.3 Research Objective: To Explore the Application Effect of VR Technology in Surgical Teaching for Foreign Medical Students and Compare it with Traditional Methods

This study aims to explore the application effect of virtual reality (VR) technology in surgical teaching for foreign medical students, and assess its practical role in enhancing students' learning enthusiasm, theoretical understanding, and clinical skill mastery. The digital surgical environment constructed through VR technology not only provides a safe, controllable, and repeatable training platform for international students, but also offers new solutions to traditional teaching challenges such as language barriers and limited practical opportunities. To comprehensively evaluate the effectiveness of VR surgical teaching, this study targets MBBS international students, designs a comparative survey, and systematically analyzes the performance and student satisfaction differences between VR and traditional teaching methods (such as ward rounds, interactive explanations, etc.) in multiple key teaching dimensions. It is hoped that this study will provide practical evidence and theoretical references for medical educators to optimize surgical teaching models for international students and enhance the quality of international medical talent cultivation.

2 Research Methods

This study employs a self-designed structured questionnaire to comparatively evaluate the effectiveness of VR-based teaching and traditional surgical teaching. The questionnaire encompasses nine core dimensions, covering clinical relevance of teaching content, understanding of theoretical knowledge, mastery of practical operational skills, instructor's teaching preparation, instructor's teaching attitude, teaching pace and difficulty, teaching methods and styles, teacher-student classroom interaction, and overall evaluation of teaching quality. These dimensions not only reflect the basic requirements of surgical teaching but also fully consider the actual learning needs of international students and their focus on teaching innovation.

For each dimension, students use a five-level satisfaction evaluation method based on their own experiences to score, specifically including "very satisfied", "satisfied", "fair", "dissatisfied", and "very dissatisfied". This grading system can comprehensively and meticulously reflect students' subjective feelings and overall recognition of different teaching modes, facilitating subsequent quantitative analysis and data comparison, and objectively evaluating the practical application effect of VR technology in surgical teaching from multiple perspectives.

2.6 Data Collection and Analysis Methods (Descriptive Statistics, Inter-Group Comparison)

After students completed the surgical internship course, this study collected data through anonymous questionnaires. All 20 MBBS international students participated in both VR teaching and traditional teaching modes, and evaluated their satisfaction with nine dimensions for each teaching method. The data collection process was guided uniformly to ensure the authenticity and validity of questionnaire responses.

The satisfaction data obtained from the survey were organized and analyzed using descriptive statistical methods. Specifically, the calculation of the proportions of different satisfaction levels (very satisfied, satisfied, general, dissatisfied, and very dissatisfied) across various dimensions was conducted to comprehensively describe the overall evaluation trend of students. On this basis, a comparison was made between the score distributions of VR teaching and traditional

teaching, visually presenting the advantages and disadvantages of the two teaching modes across various dimensions. For core results, tables and charts were used to assist in the presentation, thereby more clearly revealing the potential effect enhancement and practical significance of VR technology in surgical teaching.

3 Results and Data Analysis

3.1 Summary of Comparative Data Between VR Teaching and Traditional Teaching

Use tables or graphics to concisely display the percentage distribution of results across nine dimensions.

3.2 Brief Analysis of Data for Each Item

In the core data analysis of this survey, the VR teaching group outperformed the traditional teaching group in most dimensions. The detailed results are as follows:

3.2.1 Relevance of Teaching Content To Clinical Practice(fag1-A)

In the dimension of "the close correlation between teaching content and clinical practice," 40% of students in the VR teaching group selected "very satisfied," a figure significantly higher than the 20% in the traditional teaching group. This outcome demonstrates that virtual simulation technology, by recreating authentic clinical scenarios, helps students better grasp the link between their learning and real-world practice, thereby enhancing the clinical orientation and practical value of the course. In contrast, traditional methods such as ward rounds and lectures tend to confine students to passive observation in content delivery, making it challenging to fully depict dynamic and varied surgical settings.

3.2.2 Improvement in the Ability to Understand Theoretical Content(fag1-B)

The combined proportion of students who chose "satisfied" and "very satisfied" in the VR teaching group reached 65%, compared to only 45% in the traditional teaching group. This indicates that the virtual simulation learning environment helps overcome language barriers and challenges in understanding abstract concepts. By utilizing three-dimensional models and interactive operations, it promotes the visualization and intuitiveness of theoretical knowledge, enabling international students to better grasp key medical principles and surgical procedures.

3.2.3 Mastery of Practical Operational Skills(fag1-C)

In terms of "mastery of practical skills", the combined proportion of satisfaction and very satisfaction among the VR group is 65%, significantly higher than the 40% in the traditional group. This highlights that VR can create opportunities for repeated and safe practice for students, effectively compensating for the limited opportunities for real-world clinical practice. However, it is worth noting that a portion of students in the VR group still expressed dissatisfaction, which may be related to factors such as individual students' insufficient adaptation to new technologies and differences in their starting points in practical abilities. This suggests a need for enhanced individualized counseling and practical guidance in the future.

3.2.4 Teachers' Teaching Preparation and Teaching Attitude(fag1-D)

Regarding teachers' preparation of teaching content, the satisfaction rate and above for the VR group is 70%, compared to 45% for the traditional group. In terms of teaching attitude and seriousness, the satisfaction rate and above for the VR group is 75%, while the traditional group only has 40%. This reflects that in the new teaching process using VR simulation technology, teachers have invested more time and energy in course design and technical preparation, showing a stronger sense of responsibility and innovation, which helps enhance students' learning trust and enthusiasm.

3.2.5 Rationality of Teaching Pace and Difficulty(fag1-E)

The satisfaction distribution of the VR group is more concentrated in the aspect of "teaching pace and difficulty", with a high proportion of students believing that the pace and difficulty are moderate. Compared with traditional teaching, VR courses can often flexibly adjust the progress according to students' levels, and help students independently control their learning pace through real-time feedback, which enhances the sense of achievement and learning efficiency of students with different foundations.

3.2.6 Satisfaction with Teacher-Student Interaction and Teaching Style(fag1-F)

In terms of satisfaction with teacher-student interaction and teaching methods and styles, the VR teaching group generally performed slightly better. In the VR environment, students actively participated in virtual operations and exchanged ideas with each other, which helped stimulate teamwork and thinking collisions. At the same time, the innovative teaching style also enhanced the overall classroom experience of students, maintaining their higher interest and attention to the course content.

3.2.7 Overall Evaluation of Teaching Quality(fag1-G)

In terms of overall satisfaction with the course, the proportion of students in the VR group who were satisfied or above was 70%, compared to only 55% in the traditional group. This result fully demonstrates that virtual simulation technology can bring a better learning experience and higher teaching recognition while ensuring teaching quality, providing strong support for promoting the modernization and internationalization of surgical education in the future.

In summary, virtual reality (VR) teaching outperforms traditional teaching methods in all teaching dimensions covered by this survey. Especially in terms of enhancing practical skills, controlling teaching pace and difficulty, and facilitating teacher-student interaction, VR technology demonstrates particularly prominent advantages. Specifically, the VR environment provides students with high-frequency, low-risk opportunities for operational practice, allowing them to repeatedly practice and master key skills proficiently. At the same time, the teaching pace is more flexible, allowing dynamic adjustments based on students' actual situations, helping learners of different levels to keep up with the progress and achieve effectiveness. Furthermore, the immersive and interactive characteristics of VR make communication and collaboration between teachers and students, as well as among classmates, more proactive, effectively enhancing classroom atmosphere and overall participation. Overall, VR surgical teaching not only comprehensively improves teaching effectiveness but also provides innovative ideas for addressing pain points and challenges existing in traditional practical teaching processes.

4 Discussion

4.1 Advantages of VR Technology

The application of virtual reality (VR) technology in medical education offers significant advantages in multiple aspects. Firstly, VR can highly replicate the real surgical environment and clinical scenarios, providing students with an immersive learning experience through three-dimensional visualization and detailed interactive operations. This highly simulated digital environment allows students to intuitively perceive every detail of the surgical process, bridging the gap between cognition and practice, and aligning more closely with the actual needs of future clinical work.

Secondly, VR technology provides medical students with tremendous opportunities for repeated practice. Unlike traditional teaching methods that rely excessively on observing manuals or limited practical operations, students can practice and learn key skills infinitely in a virtual environment, without worrying about consuming clinical resources or increasing patient risks. This high-frequency, low-cost practice mode helps to solidify basic skills, improve operational proficiency, and significantly accelerate skill development.

In addition, the VR teaching mode actively stimulates students' initiative in learning and classroom participation. Digital interaction and situational re-enactment arouse students' curiosity and desire for exploration, transforming their passive "listening" into active "learning by doing". Through self-control and team interaction, they gain a stronger sense of achievement and participation.

Addressing the language communication barriers commonly faced by international students, VR technology employs a plethora of images, animations, and 3D models for graphical representation, effectively mitigating the high demands on oral and auditory comprehension abilities. Through visual manipulation and dynamic demonstrations, students can overcome language barriers and gain a more intuitive understanding of abstract medical concepts and operational procedures, significantly lowering the learning threshold.

Most importantly, after multiple rounds of simulated training in the VR environment, foreign medical students have become increasingly confident in their grasp of operational skills. They are able to practice repeatedly and correct mistakes without psychological pressure, gradually overcoming nervousness and technical unfamiliarity, and personally experiencing the improvement of their abilities. This enhanced confidence is not only beneficial to learning outcomes but also lays a solid psychological foundation for their future participation in clinical work.

In summary, VR technology, with its advantages such as high simulation, multiple practice opportunities, active participation, and visual expression, effectively enhances the comprehensive learning experience and skill mastery level of foreign medical students.

4.2 Existing Deficiencies and Challenges

Firstly, based on the feedback from learning experiences, a small number of students still express general or even dissatisfied experiences regarding the "improvement of practical skills" in the VR teaching environment. The reasons for this phenomenon may be complex. On the one hand, some students may require a certain adaptation period to master the operation methods and interaction logic of VR equipment proficiently. The initial discomfort affects learning efficiency and sense of achievement. On the other hand, students' skill levels vary, and it is difficult for international students with weaker foundations to achieve a leap in skills through virtual simulation in a short period of time. In addition, some individual students may lack interest in digital learning methods themselves or feel insufficiently immersed in the "reality" of the simulated environment, thus failing to fully utilize the potential of VR. To address these issues, curriculum design should strengthen early guidance, add adaptation training, and provide tiered coaching and targeted practice based on individual differences among students to enhance the overall experience.

Secondly, the application of VR technology poses new challenges in terms of cost and subsequent maintenance. High-quality virtual simulation software and hardware equipment are expensive, and they have high requirements for network, computing, and other infrastructure. In the actual promotion process, equipment depreciation and renewal, technical support, and system maintenance also require continuous investment. For some universities or training institutions, the large-scale popularization of VR teaching in the short term still faces certain economic pressures. In addition, teachers have previously conducted teaching in traditional modes, and the existing teaching staff's adaptability to new VR teaching tools varies greatly. To ensure teaching quality, it is necessary to strengthen technical training for teachers, improve their course design and system operation abilities, and achieve deep integration of software, hardware, and teaching content.

Furthermore, although VR can effectively enhance operational skills, there are still limitations in the design and complexity of current virtual simulation scenarios when it comes to non-technical "soft skills" training, such as clinical communication, patient scenario empathy, and emergency handling between doctors and patients. For instance, the language variations, emotional expressions, and environmental suddenness in real clinical doctor-patient communication are often difficult to fully replicate through virtual models. Although students can practice standard procedures in simulations, it is challenging for them to fully hone their adaptability and humanistic qualities. Therefore, it is still necessary to explore the integration of VR with various teaching methods such as scenario reproduction and role-playing, gradually enhancing the support level of virtual teaching environments for comprehensive soft skills.

In summary, the application of virtual simulation technology in medical education is still in a continuous improvement stage. It requires in-depth optimization in terms of individual student differences, equipment resource allocation, and soft skill cultivation, laying a more solid foundation for its healthy and sustainable development in the field of medical teaching.

4.3 Suggestions for Improvement and Optimization

In response to the current deficiencies and challenges of VR technology in medical surgical teaching, the following improvement and optimization suggestions are proposed to further enhance teaching effectiveness and students' comprehensive quality.

Firstly, it is recommended to fully leverage the respective advantages of VR and traditional internship teaching, implementing a blended teaching model. By combining virtual simulation technology with clinical practical internships, not only can the shortcomings of VR in soft skills training such as clinical communication be compensated for, but it can also create more authentic interpersonal interactions and diverse clinical experiences for students. Blended teaching enables students to proficiently practice basic skills in a safe and free virtual environment, and then further experience comprehensive abilities such as patient communication and emergency handling in real-life scenarios, maximizing skill transfer and knowledge internalization, and achieving the organic unity of theory and practice.

Secondly, it is recommended to establish a regular mechanism for collecting student feedback and iterating teaching content. Teachers and administrators should regularly gather students' genuine evaluations of VR course content, technical experience, and learning outcomes through various methods such as questionnaires and classroom discussions, promptly identifying and addressing issues that arise during the teaching process. At the same time, dynamically adjust teaching designs based on student needs and feedback, continuously enrich and improve VR scenario content, making teaching more targeted and adaptable, thereby continuously enhancing student satisfaction and learning outcomes.

Furthermore, it is essential to enhance the training of teachers' digital literacy and technological application skills. By organizing specialized technical workshops, demonstration observations, and experience exchanges, teachers can be assisted in mastering the operational methods of VR platforms and the skills of developing teaching resources. This encourages them to actively participate in teaching reforms and innovations. Additionally, schools and relevant departments should promote the construction of diversified simulation scenarios, continuously expanding the types of clinical situations covered by virtual simulation platforms. For instance, modules such as complex cases, emergency

situations, and doctor-patient communication simulations can be added to further refine the VR teaching system and meet the multi-level and multifaceted learning needs of students.

In summary, by combining blended course models, dynamic feedback mechanisms, and diverse scenario development, we provide strong support for the widespread application and continuous optimization of VR in medical surgical teaching. At the same time, it is also expected to open up new paths for the modernization and internationalization of medical education.

5 Conclusion

The results of this study indicate that the application of virtual reality (VR) surgical simulation technology in surgical teaching for international students exhibits significant advantages in both skill training and theoretical reinforcement. Firstly, the VR environment highly replicates clinical operation procedures, providing students with opportunities for repeated practice, effectively enhancing their practical ability, spatial imagination, and knowledge transfer. Compared to traditional teaching methods, VR can more intuitively demonstrate complex surgical operation steps, helping students achieve efficient transformation from theory to practice in a short period of time. In most teaching dimensions (including content relevance, operational skills, teacher-student interaction, etc.), the satisfaction and self-evaluation of the VR group are significantly higher than those of the traditional group, further verifying the teaching effectiveness of virtual simulation technology.

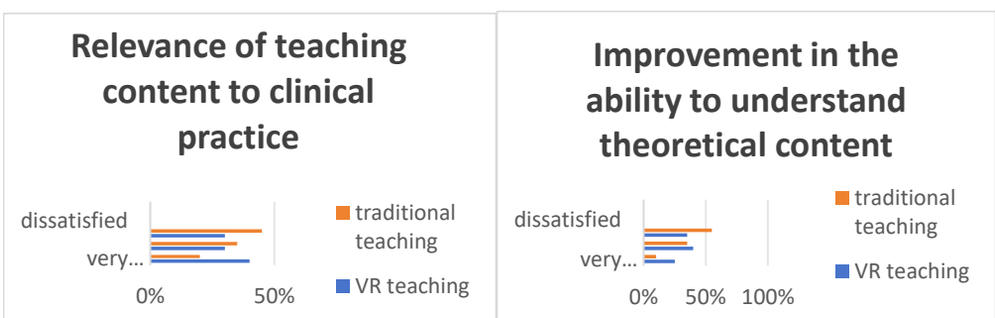
Meanwhile, this project provides a beneficial exploration path for promoting innovation in surgical teaching models and enhancing the quality of international medical education. By introducing advanced educational technology, it actively responds to the diverse learning needs of international students, achieving an organic integration of teaching content, methods, and evaluation methods. It has accumulated valuable experience for the modernization and internationalization of medical education in China, and has positive significance for promoting the cultivation of global medical talents.

6 Prospect

Looking ahead, VR technology holds vast potential for development in the field of medical education. Future research could consider expanding the sample size to include more batches of international students, thereby enhancing the representativeness and statistical power of the results. Additionally, multi-round and phased skill training and teaching evaluations could be designed to more scientifically and systematically assess the long-term effects and short-term achievements of VR teaching at different learning stages.

In terms of content development, we can continuously enrich and expand virtual simulation scenarios in the future, covering more types of surgical operations with varying levels of difficulty. At the same time, we should strengthen the simulation training of soft skills such as clinical communication, team collaboration, and emergency response, further improving the comprehensive ability training system. At the same time, it is also recommended to combine diversified evaluation methods such as qualitative interviews and practical operation assessments to provide a more comprehensive and objective verification of the effectiveness of VR teaching.

Finally, it is recommended to conduct long-term follow-up studies to investigate the true impact of VR teaching on students' subsequent clinical internships, independent operations, and professional development, providing a solid theoretical and practical basis for the reform of medical education informatization and the continuous optimization of surgical talent cultivation models.



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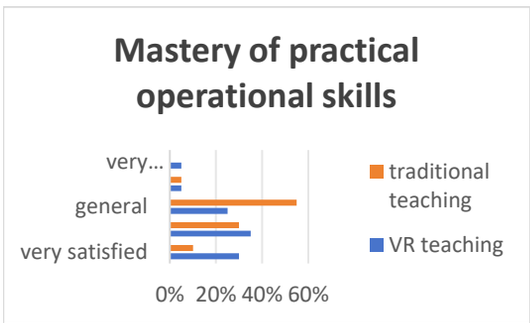

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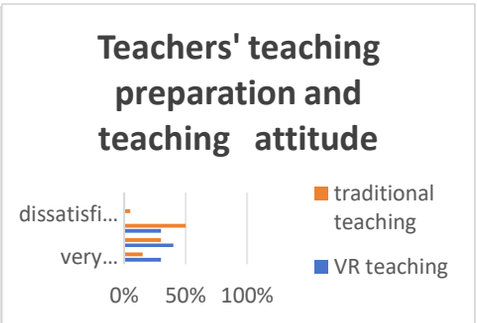

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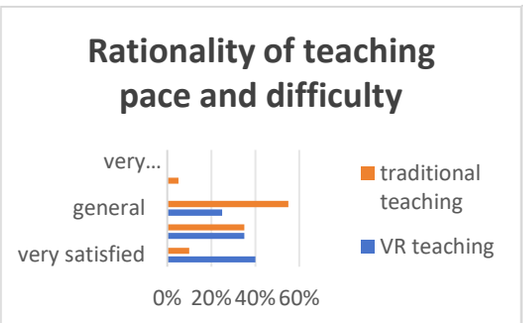

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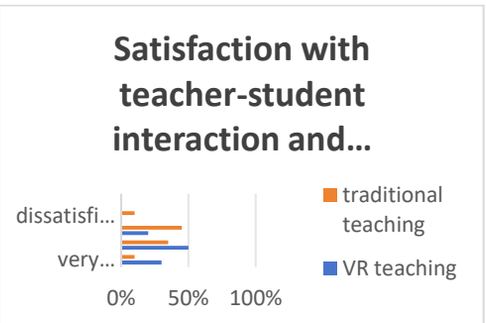

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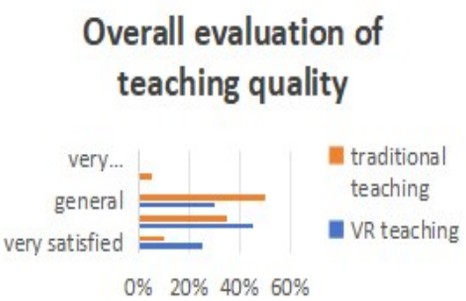

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