

Exploration and Application of Virtual Reality Technology in Mechanical Manufacturing Teaching

<https://doi.org/10.3991/ijet.v17i15.31927>

Maoquan Xue

Changzhou Institute of Industry Technology, Changzhou, China
xuemaq@163.com

Abstract—Virtual reality technology has been effectively applied in many fields and is also emerging in the field of education. It has the characteristics of interactivity and provides a new method for teaching. There are some problems in mechanical manufacturing teaching in the past. The introduction of virtual reality technology is conducive to solve relevant problems, optimize the teaching process and create an interactive learning situation for students. This new mechanical manufacturing teaching method can effectively enhance students' interest and motivation in learning, and then improve the teaching effect.

Keywords—virtual reality technology, mechanical manufacturing, distance education

1 Introduction

Science and technology has brought about great changes in people's lives, as well as changes in the media and mode of information dissemination. Virtual reality technology has been integrated into people's daily life and work. It creates an immersive interactive environment for people based on computable digital information. With computer technology as the core, it converts and generates virtual scenes with realistic audiovisual and emotional effects in a specific range [1-3]. With the characteristics of interactivity, perceptibility and high fidelity, virtual reality technology injects new vitality and provides new resources for the reform of teaching methods. Virtual reality technology can comb and analyze knowledge points in multiple dimensions, simulate and restore scenes, expand teaching contents, enrich teaching activities, and improve students' understanding and mastery of knowledge. Especially for practical courses, compared with the flat presentation of knowledge in previous education, virtual reality technology can present learning materials more three-dimensional, and change the reading mode of plane images into immersive experience [1]. At the same time, it can improve students' learning interest and help students effectively deepen their knowledge structure [4-6].

2 Application of virtual reality technology in teaching

The introduction of virtual reality technology in the field of education can break through the limitations of previous learning methods, enable students to interact in a virtual environment, and make up for the shortcomings of interactivity, situational and immersion in the past classroom [7-8]. In this teaching form, the role of teachers has changed from the disseminator of previous knowledge to participants and collaborators, teaching students new learning methods, guiding them to use new technologies to learn knowledge, master the tools to acquire new knowledge, and learn to explore and master relevant knowledge through new tools. Classroom teaching has changed from teacher-centered to student-centered mode, so that students have more autonomy and choice in the learning process, which can consciously improve learning efficiency, enhance learning initiative, and realize personalized and free development. With the change of interaction methods, classroom teaching methods are more flexible and diverse, and more targeted, which better solves the problem of the impact on the overall teaching effect due to the individual differences of students. In daily teaching practice, some learning materials are difficult to present in front of students for various reasons, resulting in some practical teaching is difficult to carry out, and this kind of problem can be solved through virtual reality technology. Teachers can use the virtual practical teaching platform to simulate the real environment and things, and bring more intuitive experience to students. For example, some science and engineering disciplines in Colleges and universities will carry out metal smelting teaching practice activities, but there are often problems such as scarce resources and high risk of field teaching. Teachers can make students familiar with the environment and learning tasks in advance by using virtual reality technology, and can also let students who do not have practical conditions experience the whole process of practice through virtual reality technology to improve students' professional level [9].

2.1 Applying the styles to an existing paper

In the field of special education, the introduction of virtual reality technology into special education can enable students to obtain perceptual and rational knowledge, so as to achieve the purpose of Education [10]. For example, using virtual reality gloves to translate commands and actions such as sign language into sound, so that the deaf and dumb people can communicate with others in time, and so on. Virtual reality technology is of great help to the education and daily life of special social groups.

2.2 Professional practical training

Professional practical training often needs the support of some material conditions. In this kind of practical training, operators often need to have high professional ability and technical level. Using virtual reality technology to build a training platform can not only reduce the risk, but also allow the operator to carry out repeated training and improve the operator's operation skill level [11]. For example, in high-speed railway driving training, the use of simulation High-speed Railway Cab for training can simulate

the virtual space environment in the real state. Under the condition of ensuring safety, the driving trainees can carry out multiple training operations. In the teaching of these advanced and sophisticated fields, the introduction of virtual reality technology can better promote the development of professional fields. In recent years, in Higher Education in the field of mechanical manufacturing, virtual reality technology can help teachers use innovative teaching methods to sort out, simulate and restore abstract knowledge points in multiple dimensions, so that students can experience and receive knowledge and information through sight, hearing, touch and other senses.

3 Analysis of traditional teaching mode of mechanical manufacturing

The teaching of mechanical manufacturing combines theory with practice to cultivate relevant talents. Although the course has formed a complete teaching system, there are still some problems such as backward teaching methods. On the one hand, in the process of machinery manufacturing teaching, some schools adopt the classroom teaching method dominated by teachers to transfer knowledge, while students practice through exercises. In this mode, it is difficult for students to master all the contents of the course, the learning effect is poor, and the teaching purpose of teachers is difficult to achieve. On the other hand, due to the imperfect teaching facilities, it is difficult for teachers to explain the relevant knowledge about mechanical manufacturing in depth, and it is difficult for students to effectively master the specific methods of actual mechanical manufacturing and understand the technical core of the latest mechanical manufacturing [12].

In the teaching of mechanical manufacturing, some students are often difficult to concentrate for a long time. It is difficult to improve their attention to the course content and enhance their learning enthusiasm. The purpose of mechanical manufacturing teaching is to enable students to have strong process planning and practical ability. Therefore, it is imperative to use new teaching methods and means to enhance students' enthusiasm, organize classroom teaching more reasonably, construct teaching resources and design teaching activities more effectively.

4 Theoretical basis of the application of virtual reality technology in mechanical manufacturing teaching

4.1 The necessity of applying virtual reality technology in mechanical manufacturing teaching

The progress of science and technology has greatly improved the mechanical manufacturing technology. The previous mechanical manufacturing teaching materials and teaching models are difficult to match the current mechanical manufacturing teaching content and students' learning needs. It is imperative to expand the mechanical manu-

facturing teaching platform. Mechanical manufacturing based on virtual reality technology integrates new knowledge in relevant fields, and the expressiveness of the classroom can also be extended. At the same time, the integration of new technology and knowledge also enriches the methods of mechanical manufacturing. The curriculum design also needs to show more comprehensive machinery manufacturing resources. Different from the previous paper resources, it contains more network resources and virtual resources. Students can carry out independent learning here [13].

In mechanical manufacturing teaching, practical teaching is an important part. Integrating virtual reality technology can greatly improve the efficiency of practical teaching and enhance students' enthusiasm to participate in mechanical manufacturing practical teaching. In the process of practice, teachers can guide students to understand and master the abstract contents such as process and operation process through the teaching virtual platform. They can also conduct online interactive communication with students through the construction of virtual laboratory, enhance students' classroom participation and interactive experience, innovate teaching ideas and improve teaching quality.

4.2 Four aspects of the application of virtual reality technology in the teaching of mechanical manufacturing

In terms of curriculum content, teachers should expand the teaching content horizontally and break through the constraints of existing teaching materials; Vertically integrate new knowledge and new manufacturing technology, and absorb new research achievements in the manufacturing field, such as additive manufacturing, digital manufacturing technology, etc, Try to combine the teaching with the actual product manufacturing of enterprises, so as to make the teaching content keep pace with the times. In the construction of curriculum and teaching resources, teachers should present virtual resources in an all-round and three-dimensional way, break the current situation dominated by paper resources, and form a teaching resource system dominated by network virtual resources and supplemented by electronic and paper teaching materials. Students can learn independently through the virtual platform, ask questions or put forward feedback. Teachers can analyze students' relevant opinions through the platform big data, and gradually determine the rhythm and focus of classroom teaching. For the practical link in the teaching of mechanical manufacturing, students can not only observe the teacher's demonstration in class, but also carry out simulation training and repeated research through the virtual platform after class, but also put forward the problems encountered in the practical link and suggestions on practical operation. Teachers can give necessary guidance to students' feedback, so as to improve the quality of practical teaching.

Virtual reality system can vividly show knowledge, including natural phenomena and the change process of things that are difficult to present in classroom teaching in the past or difficult for students to observe in real life. At the same time, it can provide students with realistic observation environment and perceptual learning materials to help students better understand the key and difficult points in learning. For example, in the process of chip deformation and formation in metal cutting, through the virtual reality platform, students can enter the simulation space for immersive observation to

understand the chip characteristics in the process of metal cutting. For another example, in the application teaching of turning, when studying the surfaces suitable for machining with different kinds of turning tools, students can use the virtual platform to "simulate" the whole process of machining different surfaces with various turning tools, so as to make the static change into motion and the discontinuity change into continuity. Using virtual reality technology to display knowledge can make abstract concepts more intuitive and vivid. Through virtual display, students can better understand and master knowledge.

In the process of mechanical manufacturing teaching, practical teaching is particularly important. The introduction of virtual reality technology into practical teaching expands the teaching methods and ways. Teachers and students can obtain a vivid practical environment and more convenient practical tools in the virtual practice space. The introduction of virtual reality technology into practical teaching can not only improve the quality of practical teaching, but also help students understand knowledge and deepen their memory. The virtual practice platform has the characteristics of interactivity, which can help students cooperate and complete practical projects through the platform. The virtual platform can not only enable students to carry out virtual practice on the project, but also enable students to face the processing effect after setting different situational parameters more intuitively according to different assumptions, so as to stimulate their interest in exploring knowledge and cultivate students' creativity [14].

The spread of global COVID-19 makes distance online teaching widely adopted by schools, and promotes the development of distance education [15]. Compared with the previous face-to-face model, the use of distance teaching model can carry out educational activities in a wider range. Teachers can make full use of educational resources and let more students participate in teaching, so as to promote the development of education [16]. However, this distance learning system lacks teaching interaction. Due to the limitations of space, some disciplines are difficult to carry out distance teaching effectively, especially the practical course of mechanical manufacturing. The introduction of virtual reality technology into mechanical manufacturing course can make the teaching environment more humanized. Virtual campus environment and virtual classroom environment can create a dynamic learning atmosphere for students, break through the limitations of space, so that teachers and students can discuss, study and make progress together [17].

5 Curriculum design of applying virtual reality technology in mechanical manufacturing teaching

5.1 Basic elements and main functions of virtual platform

The realization of virtual reality depends on the virtual environment. Teachers can add and integrate the resources required for curriculum teaching in the virtual environment, and then carry out virtual teaching activities. Taking the construction of virtual teaching environment based on PC as an example, the virtual teaching platform environment needs to have the following main functions and basic elements.

First, the main functions: the virtual teaching platform is divided into virtual teaching practice platform and virtual teaching resource inventory storage platform. By simulating the virtual design of the physical environment, students can learn and practice. In this environment, students can query information, interact with peers and learn from each other; Teachers can carry out curriculum design, resource management, practical guidance and exchange. Second, basic elements: on the premise of main functions, the virtual teaching platform needs to build management module, teaching module, resource module, communication module, counseling module and evaluation module, including authority setting, registration and login, basic information statistics, learning statistics, curriculum management, information receiving and sending management and other functions, so as to ensure the smooth progress of teaching. Teachers should establish an all-round and diversified information resource database in the platform to meet the changing teaching needs. In order to highlight the advantage of strong interaction of virtual reality technology, teachers and students can use virtual avatars to enter the teaching environment for practical operation, mutual discussion and cooperation. According to the feedback of teaching information and the grasp of teaching quality, teachers can establish corresponding evaluation system to promote the development of machinery manufacturing teaching.

5.2 Teaching scheme practice taking metal cutting and machine tool module as an example

In the teaching of "metal cutting and machine tools", many phenomena are invisible or have little visibility. In this way, it is difficult for students to clearly understand and master the process of metal cutting, which will make students feel boring and unimaginable, reduce students' interest in learning and affect the quality of teaching. The interactivity of virtual reality technology can make people get a strong sense of immersion. Using this characteristic, teachers can develop a virtual platform suitable for teaching, use the platform to solve the key and difficult points in machinery manufacturing teaching, and constantly improve and innovate machinery manufacturing teaching.

5.3 Construction of virtual platform

Teachers can use vocational education cloud, Chinese University MOOC and other teaching platforms to build teaching platforms, comprehensively use video, audio, images, animation and other materials, divide teaching contents according to modules, and use animation, video and games matching the teaching contents to enhance students' learning motivation, change students from passive learning to active learning, and gradually master important and difficult knowledge in the process, Teachers can create a virtual teaching platform according to the teaching content of the course, which is divided into the basic parts of course introduction module, metal technology module, machining process module, common parts machining module and testing module.

6 Conclusion

The introduction of virtual reality technology into machinery manufacturing teaching can change teachers' teaching mode and teaching concept, enhance the interaction and initiative of curriculum teaching, and help students better understand and master knowledge. Under the guidance of different teaching means and with the help of relevant knowledge and teaching platform, students can make the teaching content of mechanical manufacturing richer, more innovative and practical. Students have changed from passive learning to active learning and achieved all-round development. At the same time, teachers have also broken the "full house filling" mode in the previous teaching, made the teaching forms more diversified and vivid, and improved the teaching quality of the course.

7 References

- [1] Li, Y., Deng, K. (2021). Application of virtual reality technology in the health field based on the background of big data. *Journal of Physics: Conference Series*, 1883(1), 012175 (6pp). <https://doi.org/10.1088/1742-6596/1883/1/012175>
- [2] Santos, F. V., Yamaguchi, F., Buckley, T. A., & Caccese, J. B. (2020). Virtual reality in concussion management: from lab to clinic. *Journal of Clinical and Translational Research*, 5(4). <https://doi.org/10.18053/jctres.05.2020S4.008>
- [3] Lengenfelder, J., Schultheis, M. T., Al-Shihabi, T., Mourant, R., & Deluca, J. (2002). Divided attention and driving: a pilot study using virtual reality technology. *Journal of Head Trauma Rehabilitation*, 17(1), 26-37. <https://doi.org/10.1097/00001199-200202000-00005>
- [4] Geng, J., & Wu, X. (2021). Application of virtual reality technology in university education. *Journal of Physics: Conference Series*, 1972 (1), 012023 (5pp). <https://doi.org/10.1088/1742-6596/1972/1/012023>
- [5] Park, J. S., Sim, G. C., Kim, J. H., Kim, H. S., & Park, Y. C. (2002). Research of application the virtual reality technology in chemistry education. *Journal of the Korean Chemical Society*, 46(5), 450-468. <https://doi.org/10.5012/jkcs.2002.46.5.450>
- [6] Klopfer, E., & Sheldon, J. (2010). Augmenting your own reality: Student authoring of science-based augmented reality games. *New directions for youth development*, 2010(128), 85-94. <https://doi.org/10.1002/yd.378>
- [7] Li, H. (2019). Discussion on the teaching of mine course from the perspective of virtual reality technology. *Advances in Higher Education*, 3(3), 196. <https://doi.org/10.18686/ahe.v3i3.1500>
- [8] Ibáñez, M. B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers & Education*, 123, 109-123. <https://doi.org/10.1016/j.compedu.2018.05.002>
- [9] Ji, Y. (2021). Use of Virtual Reality Technology in Animation Course Teaching. *International Journal of Emerging Technologies in Learning (iJET)*, 16(17), pp. 191–208. <https://doi.org/10.3991/ijet.v16i17.25337>
- [10] Powers, D. A., & Melissa, D. (1994). Special education and virtual reality: Challenges and possibilities. *Journal of Research on Computing in Education*, 27(1), 111-121. <https://doi.org/10.1080/08886504.1994.10782120>

- [11] Wong, S. F., Yang, Z. X., Cao, N., & Ho, W. I. (2010). Applied rfid and virtual reality technology in professional training system for manufacturing. IEEE. <https://doi.org/10.1109/IEEM.2010.5674534>
- [12] Tortorella, G., & Cauchick-Miguel, P. (2018). Combining traditional teaching methods and pbl for teaching and learning of lean manufacturing. IFAC-PapersOnLine, 51(11), 915-920. <https://doi.org/10.1016/j.ifacol.2018.08.465>
- [13] Ma, J., Jaradat, R., Ashour, O., Hamilton, M., & Dayarathna, V. L. (2018). Efficacy investigation of virtual reality teaching module in manufacturing system design course. Journal of Mechanical Design, 141(1). <https://doi.org/10.1115/1.4041428>
- [14] Sun, G., & Wang, X. (2021). Application of computer virtual reality technology in practical teaching of construction engineering survey. Journal of Physics Conference Series, 1915(3), 032072. <https://doi.org/10.1088/1742-6596/1915/3/032072>
- [15] Tsekhmister, Y., Konovalova, T., Tsekhmister, B., Agrawal, A., & Ghosh, D. (2021). Evaluation of virtual reality technology and online teaching system for medical students in Ukraine during COVID-19 pandemic. International Journal of Emerging Technologies in Learning (IJET), 16(23), 127-139. <https://doi.org/10.3991/ijet.v16i23.26099>
- [16] Wang, F. (2018). Computer Distance Virtual Experiment Teaching Application Based on Virtual Reality Technology. International Journal of Emerging Technologies in Learning, 13(4). <https://doi.org/10.3991/ijet.v13i04.8472>
- [17] Penland, J. L., Laviers, K., Bassham, E., & Nnochiri, V. (2019). Virtual learning: A study of virtual reality for distance education. In Handbook of Research on Blended Learning Pedagogies and Professional Development in Higher Education (pp. 156-176). IGI Global. <https://doi.org/10.4018/978-1-5225-5557-5.ch009>

8 Author

Maoquan Xue is an associate professor in Changzhou Institute of Industry Technology, Changzhou, China. He obtained his PhD degree from the Jiangsu University. His research interests include educational management, mechanical manufacturing theory and practical education (email: xuemaq@163.com).

Article submitted 2022-04-24. Resubmitted 2022-05-28. Final acceptance 2022-05-29. Final version published as submitted by the author.