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Article

Application of the Metaverse in Vocational Education: Scenario Innovation, Skill Development Needs, and Practical Pathways

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Abstract: Modern vocational education reform prioritizes the cultivation of interdisciplinary, applied, skilled, and innovative talents. However, traditional vocational education faces limitations due to its single teaching scenario and a significant disconnect between skill development and job requirements, which adversely affects the employment prospects of vocational school students. The metaverse, as a "parallel space" to the real world, integrates technologies such as virtual reality, blockchain, and artificial intelligence. It can provide customized digital twin scenarios for vocational education and deliver digitalized, personalized skill training programs, enabling precise talent cultivation based on job skill matrices. This paper examines the application of the metaverse in vocational education by defining its core concepts, elaborating on the theoretical foundations for its integration with vocational education, and discussing scenario innovation, skill development needs, and practical pathways. The aim is to offer new perspectives for the advancement of vocational education in the era of the metaverse.

Keywords: Metaverse; Vocational Education; Scenarios; Skills

1. Introduction

Traditional vocational education has long emphasized a skill–centered talent cultivation model. For a considerable period, vocational education has faced numerous challenges, such as the lack of teaching scenarios and outdated skill training mechanisms, which have become key factors hindering its high–quality development. With the advent of the metaverse era, virtual teaching platforms have been widely adopted in vocational education. This not only addresses the issue of missing teaching scenarios but also establishes a demand–driven vocational skill training model.

The deep integration of the metaverse and vocational education is essentially an in–depth practice of technology empowering education. Its core value lies in addressing key challenges in traditional vocational education–such as shortage of practical training resources, difficulties in practicing high–risk scenarios, uneven distribution of cross–regional resources, and insufficient personalized training–by constructing teaching environments where virtual and real worlds coexist. This transformation shifts skill development from "theoretical indoctrination" to "practical empowerment," from "uniform teaching" to "personalized adaptation," and from "geographical constraints" to "global coverage." At this stage, the metaverse is reconstructing the skill cultivation system of vocational education with its unique technological advantages, injecting new vitality into the high–quality development of vocational education.

In this context, systematically exploring the innovative application scenarios, skill development needs, and practical pathways of the metaverse in vocational education, while deeply analyzing the prominent issues in its current application process, holds significant theoretical value and practical importance for advancing the digital transformation of vocational education, enhancing the quality of skill–based talent cultivation, and promoting effective integration of the education chain and talent chain with the industry chain and innovation chain.

From the current state of domestic and international research, the application of the metaverse in the field of education has become an academic hotspot in recent years. Exploration in vocational education, in particular, has gradually deepened, but overall, it remains in its early stages, with issues such as imbalanced research perspectives and practical research lagging behind theoretical studies. In foreign research, the development of metaverse–related technologies started relatively early. Developed countries like the United States, Japan, and South Korea took the lead in practical explorations of integrating the metaverse with vocational education. Their research focuses primarily on constructing virtual training scenarios, innovating skill cultivation models, and adapting and applying relevant technologies.

Foreign scholars often approach from the perspective of technological application, exploring the effectiveness of technologies such as virtual reality and artificial intelligence in vocational education training scenarios. For instance, by constructing environments like virtual factories and virtual operating rooms, they aim to enhance students' practical skills and job adaptability. These studies emphasize the precise alignment between technology and occupational requirements, resulting in replicable practical cases. For example, American scholars Hampton, K., & Keys, B., in their work *Virtual Reality for Nursing Education: A Systematic Review* (2017), provided a detailed introduction to the application of virtual reality technology in nursing education and proposed the integration of application scenarios with practical training, offering insights for the digitalization of medical vocational education. Spanish renowned educator Garcia, R. et al., in their article *Augmented Reality in Automotive Vocational Training: A Case Study*(2018), discussed the application of virtual reality technology in automotive vocational schools. By overlaying scenarios such as fault diagnosis and maintenance training, they achieved a substantial increase in fault detection efficiency and a notable improvement in maintenance efficiency, representing early quantifiable validation of the metaverse in vocational education. Serbian scholars Jovanović, M., & Milosavljević, M., in *Gamified Collaborative Learning in Metaverse Platforms* (2022), completed the design of vocational education application scenarios using the VoRetex platform and proposed a "task–driven + virtual social interaction + immediate feedback" model, providing practical cases for interactive teaching innovation in metaverse–based vocational education. German scholars Jacquemin, P. H. et al., focusing on assembly tasks as an application scenario, compared real–world settings, traditional computer–based training environments, and virtual reality scenarios in *Evaluating the Metaverse as an Environment for Training: Impacts on Performance, Cognitive Effort and Enjoyment* (2025). They affirmed the effectiveness of virtual reality scenarios, offering key empirical support for the large–scale promotion of metaverse–based vocational education.

Nevertheless, research on the application of the metaverse in vocational education, both domestically and internationally, has clear limitations. Most studies focus on the technical application level, lacking in–depth exploration of the underlying logic of integrating the metaverse with vocational education and the intrinsic demands of skill development. These limitations are evident in five key areas: technical support, resource provision[1], industry–education collaboration, talent security, and risk prevention. The metaverse possesses a relatively complete technological system, with related technologies such as virtual reality, blockchain, and artificial intelligence serving as its "foundation," forming a relatively open and collaborative "digital space." Unlike traditional digital space technologies, the digital space constructed by the metaverse features immersion, interactivity, scalability, and flexibility, laying the groundwork for its integration and application across multiple fields.

2. Research Methods

Based on the overall trend of integrating the metaverse with vocational education and the practical needs of combining scenario innovation and skill development, this paper addresses the current implementation status of vocational education and the evolving talent demands in related industries. Through methods such as field visits and case analysis, it selects typical cases for in–depth examination to accurately identify the specific applications, existing challenges, and lessons learned from the metaverse's implementation in vocational education. This approach provides solid practical support for the research conclusions. Aligned with the research theme, the paper establishes three core criteria for case selection to ensure the chosen cases are representative, targeted, and researchable, thereby effectively supporting the achievement of the research objectives.This study is an exploratory qualitative and conceptual analysis rather than a statistically validated empirical study.

First, typicality criterion. The selected cases should reflect the application models, scenario innovations, and prominent issues of the metaverse in vocational education. Whether they are mature cases with exemplary effects or early–stage applications with numerous challenges, all must possess distinct typical characteristics to provide valuable analytical samples for the study.

Second, targeted criteria. The selected cases are closely aligned with the research focus of this paper, concentrating on five core issues: technological support, resource provision, industry–education collaboration, talent assurance, and risk prevention and control. This ensures that the cases can provide specific practical materials for analyzing these five key aspects.

Third, the criterion of research feasibility. The selected case must have complete practical documentation, enabling the collection of sufficient research data through methods such as questionnaires, interviews, and field investigations. The case organization should actively cooperate with the research, providing authentic and detailed application scenarios, data materials, and relevant documents. This ensures an in–depth analysis of the case, uncovering underlying issues and internal logic, while avoiding cases with incomplete documentation that hinder thorough investigation.

This study used 33 vocational colleges as samples and conducted a full process survey using online literature search method. In the data collection stage, firstly, based on the division standards of the eastern, central, and western regions, combined with the economic level of each province and the development level of metaverse vocational education applications, target universities are screened in layers to determine the sample size of 15 universities in the eastern region, 10 universities in the central region, and 8 universities in the western region. Further screening will be conducted based on three dimensions: public/private, vocational/secondary, and popular application majors. Six practical majors, including mechanical manufacturing, nursing, and e–commerce, will be identified. 2–3 universities will be selected for each major. At the same time, basic information such as the school's educational attributes, levels, metaverse application scenarios, and construction achievements will be collected through channels such as the school's official website, education department announcements, industry reports, and virtual training project announcements. The original data will be sorted and verified to ensure sample coverage and authenticity.

The data analysis stage mainly uses statistical analysis methods to classify and input the collected information, create four types of statistical tables including regional, educational nature, institutional level, and professional distribution, and conduct cross dimensional comparisons. Quantify the sample structure by calculating the number and proportion of each type of sample; Combining regional economic and vocational education resource differences, comparing the application levels of different groups of metaverse, sorting out the development gradient and distribution characteristics, and mining the causes and laws behind the data.

Conclusion deduction relies on comprehensive analysis of data results and industry background. Based on the proportion data, clarify the regional development pattern of strong in the east, flat in the middle, and weak in the west, and judge that public colleges are the main force of metaverse applications and vocational colleges are the main landing carriers according to the educational structure data; Based on the distribution characteristics of majors, it is concluded that practical majors are more suitable for metaverse training scenarios. Based on quantitative data, objective current situation, and industry logic, the final conclusion is formed to ensure that the research results are reasonable and well founded, and can truly reflect the overall situation of metaverse applications in domestic vocational colleges.

3. Results and Discussion

3.1 Application Challenges of the Metaverse in Vocational Education

Technical Support: Insufficient Collaboration and Inadequate Adaptation Hinder Large–Scale Implementation. The deep integration of the metaverse and vocational education relies on the synergistic application of multiple technologies such as virtual reality, artificial intelligence, and big data. However, the current technical support system still has numerous shortcomings, which have become the core obstacle to its large–scale application. The maturity of core technologies is insufficient; most metaverse–related technologies are still in the exploratory stage and have not yet formed stable and efficient application models. Moreover, the high cost of technology application makes it difficult for most vocational institutions with limited budgets to equip themselves with high–performance terminal devices in bulk. This significantly compromises students' immersive practical training experience and prevents the full release of the practical value of metaverse scenarios. The adaptability of artificial intelligence technology is inadequate; its application in areas such as personalized learning plan recommendations and virtual training guidance is not deep enough. The intelligence level of virtual interactive characters is relatively low, making it difficult to accurately capture students' real–time learning needs and promptly answer operational questions. The application scope of digital twin technology is narrow; most virtual training scenarios can only simply replicate equipment and processes, failing to achieve real–time linkage with actual enterprise production scenes. The simulation fidelity of these scenarios significantly deviates from real job requirements, directly affecting the effectiveness of skill development. Additionally, the lack of unified technical standards leads to poor compatibility and difficult data interoperability among metaverse teaching systems developed by different institutions and enterprises. This makes it challenging to form a large–scale, standardized application system, further exacerbating the fragmentation of technology application and hindering the deep integration of the metaverse and vocational education.

Taking vocational schools and ordinary vocational schools in the central and western regions as an example, only 1–2 small virtual training rooms can be built on campus, which cannot meet the needs of whole class teaching. The duration of student rotation experience is insufficient, and the immersive training effect is greatly reduced. The problem of artificial intelligence adaptation is widespread, and many universities' virtual training systems only pre–set fixed operation processes. Virtual teachers cannot identify students' operational errors, nor can they push personalized exercises based on learning weaknesses, resulting in intelligent guidance being merely a formality. In majors such as mechanical manufacturing and auto repair, the application of digital twins only stays at static equipment modeling, and cannot synchronize and connect with production line data of cooperative enterprises. The difference between virtual scenes and real job operations is obvious, and the practical training results are difficult to directly transform. At the same time, different universities use teaching platforms from different vendors, and the system interfaces are not unified, making it impossible to exchange and share training data and teaching resources. The welding virtual training systems of two universities in the same region are incompatible with each other, making it difficult to carry out joint teaching between regions. The problem of fragmented technology application is prominent, seriously hindering the large–scale promotion of the metaverse teaching mode.

Resource Supply: Overall Shortage and Uneven Quality, Difficult to Align with Diverse Needs. The quality and quantity of vocational education resources in the metaverse directly determine their application effectiveness. The current resource supply system suffers from issues such as insufficient overall volume, uneven quality, and poor sharing mechanisms, making it difficult to meet the diverse learning needs of different majors and students. In terms of total resources, high–quality metaverse teaching resources are overly concentrated in popular majors like mechanical manufacturing and nursing, while virtual training scenarios and course resources for niche and specialized majors are extremely scarce. This fails to satisfy the skill development demands across various disciplines, creating an imbalanced pattern where "popular majors are resource–crowded, while niche majors face resource gaps." Regarding resource quality, some resource development falls into the trap of "prioritizing technology over education," featuring crude scenario designs and unsystematic content. The training components are severely disconnected from vocational education curricula and job skill requirements, failing to effectively support the achievement of skill development objectives. Additionally, the high threshold for resource development requires substantial investments in manpower, materials, and finances. Most vocational institutions lack the capability for independent development, and corporate participation in resource development is insufficient, further exacerbating the shortage of high–quality resources. Moreover, the resource sharing mechanism is underdeveloped, hindering the flow of resources between regions and institutions. Redundant development and resource wastage are prominent, and the absence of unified resource evaluation standards prevents the scientific definition and standardized management of resource quality, significantly reducing the overall efficiency of resource supply.

Taking the layout of professional resources in various vocational colleges as an example, popular majors such as mechanical manufacturing, nursing, and e–commerce have rich metaverse training courses and virtual scenes, while niche specialty majors such as modern funeral technology, traditional handicrafts, and animal husbandry and veterinary medicine have little supporting digital teaching resources, and practical training still relies on traditional methods.

Industry–Education Collaboration: Inadequate Mechanisms and Weak Linkages Hinder Alignment with Industry Needs. Industry–education collaboration is a critical pathway for the metaverse to empower vocational education. However, the current application of the metaverse in vocational education faces challenges such as underdeveloped collaboration mechanisms and insufficient school–enterprise linkages, making it difficult to achieve seamless integration between education and industry. Enterprises lack sufficient motivation to participate, with most focusing their core technologies and high–quality resources on their own production and operations, resulting in limited investment in metaverse scenario development, curriculum design, and practical training guidance for vocational education. There is a lack of intrinsic drive for active involvement. Even among enterprises that do participate in collaborations, many engage only superficially, without deep involvement in key areas such as talent training program design and virtual training scenario construction. This leads to a disconnect between metaverse–based educational content and actual job requirements, making it difficult for students to acquire skills that meet workplace demands. Communication and coordination between schools and enterprises are inefficient, hampered by the absence of effective collaboration mechanisms and benefit–sharing systems. Responsibilities and rights in areas such as metaverse technology application, resource development, and talent cultivation are unclear, resulting in partnerships that lack long–term stability and are prone to becoming "merely formalities, difficult to sustain." Furthermore, industry associations have not fully leveraged their role as bridges, failing to effectively coordinate resources between educational institutions and enterprises. This impedes the collaborative application of metaverse technology in vocational education and industrial development, causing a misalignment between metaverse scenario innovation and actual industry needs. As a result, the goal of "integrating industry and education, and fostering school–enterprise collaboration" in talent development remains unachieved.

Taking manufacturing leading enterprises as an example, their focus is on production and research and development, with very few technical personnel being selected to participate in the development of metaverse training courses in universities. They only occasionally conduct short–term visits and exchanges, without deeply intervening in the entire process of talent cultivation. Taking the automotive repair major in multiple vocational colleges as an example, school enterprise cooperation only stays at the establishment of joint bases, and enterprises have not combined the latest job standards to build virtual maintenance scenarios. The teaching content lags behind the industry's practical requirements.

Talent Support: Supply Shortage and Lagging Cultivation Form Development Bottlenecks. The practical application of the metaverse in vocational education relies on the support of interdisciplinary talent proficient in both technology and education. However, the current talent support system faces issues such as supply shortages, delayed cultivation, and severe brain drain, which have become significant constraints on its development. Insufficient Supply of Interdisciplinary Talent: Metaverse vocational education requires professionals who possess expertise in metaverse–

related technologies (e.g., VR/AR development, digital twins, AI applications) as well as an understanding of vocational education principles and industry demands. Yet, the overall scarcity of such talent makes it difficult to meet the practical needs of institutional teaching, resource development, and practical training guidance. Lagging Competence of Teaching Staff: Most current vocational school teachers lack the necessary technical background in metaverse–related technologies, making it challenging for them to effectively conduct teaching and practical training in metaverse scenarios. The absence of systematic technical training further hinders their digital literacy and professional competence from aligning with the demands of metaverse education, creating a weak link in talent cultivation. Inadequate Talent Cultivation Mechanisms: Metaverse–related disciplines are relatively new, with long cultivation cycles and underdeveloped curriculum systems that often prioritize theoretical instruction over practical training. This weak practical component makes it difficult to produce interdisciplinary talent with hands–on skills. Additionally, brain drain is a prominent issue, as metaverse industry talent tends to concentrate in first–tier cities. The limited salary prospects and career development opportunities in regions where most vocational schools are located lead to significant outmigration of cultivated talent. Coupled with the lack of clear talent standards and comprehensive talent recruitment policies, it becomes challenging to attract high–end talent to vocational education, resulting in a vicious cycle of "insufficient cultivation, difficulty in recruitment, and severe brain drain."

Taking the construction of relevant majors in vocational colleges as an example, majors in the metaverse direction are offered for a short period of time, with a focus on theoretical learning and a lack of school enterprise joint practical training, resulting in students with weak practical abilities. Taking local grassroots colleges as an example, due to salary and development platform restrictions, the trained and introduced technical talents have flowed to science and technology enterprises in first tier cities, and the phenomenon of talent loss is widespread. In addition, due to the lack of unified talent evaluation standards and specialized talent introduction policies, universities have long been trapped in the dilemma of "difficult recruitment, weak education, and limited retention", which continues to constrain the implementation of metaverse teaching.

Risk Prevention and Control: The system is incomplete and awareness is weak, harboring multiple application risks. The application of the metaverse in vocational education involves risks across various domains such as technology, ethics, and security. Currently[2], the risk prevention and control system is underdeveloped, and awareness of risk management is insufficient, making it difficult to effectively guard against potential hazards, which hinders its healthy and orderly development. Inadequate technological risk prevention: Metaverse systems heavily rely on networks and digital technologies, making them prone to issues such as network lag, system crashes, and data breaches, which directly disrupt the normal conduct of teaching activities. Additionally, the rapid pace of technological advancements makes it challenging for educational institutions to keep up, leading to the quick obsolescence of existing equipment and resources, significantly increasing application costs and risks. Lack of ethical risk supervision: The openness and interactivity of virtual environments in the metaverse may lead to students becoming addicted to the virtual world, adversely affecting their real–world learning and physical and mental health. Moreover, the absence of well–established ethical norms in virtual scenarios can result in the spread of false information and inappropriate interactions, misguiding students' value formation. Weak data security controls: The metaverse teaching process collects vast amounts of student data, including learning records, practical training data, and personal information. Many institutions lack robust data security management systems and technical safeguards, increasing the risk of data breaches and misuse, thereby infringing on students' privacy rights. Furthermore, there is a shortage of risk prevention policies and standards: Policies addressing risk prevention and control for the metaverse's application in vocational education are underdeveloped, with a lack of clear regulatory standards and guidelines. Institutions themselves often have weak risk prevention awareness and have not established effective risk early–warning and emergency response mechanisms, making it difficult to address sudden risks effectively. This lays the groundwork for potential hazards in the application of the metaverse in vocational education.

Taking the virtual training experience of students as an example, the open metaverse interaction scene lacks strict control, and some students are addicted to virtual training scenes, neglecting offline practical training, and even exhibiting inappropriate behavior in virtual interaction, which is not conducive to physical and mental health and the shaping of correct values. Taking the data management work of universities as an example, most universities have not established a special data security protection mechanism, and the data collected by metaverse teaching, such as student training records and personal information, lack encryption protection, which easily leads to data leakage and abuse problems. Taking the management work of grassroots vocational schools as an example, most colleges lack specialized risk control standards and emergency plans for metaverse applications, and teachers and students have weak risk control awareness. They are unable to deal with sudden problems such as technical failures and data risks in a timely manner, which poses multiple hidden application risks.

3.2 Scenario Innovation in the Integration of the Metaverse and Vocational Education

The integration of the metaverse with vocational education exhibits diversified and scientifically grounded innovations in scenarios, thereby providing comprehensive coverage across the entire process of "teaching, practical training, assessment, innovation and entrepreneurship, and cross–domain collaboration." In practical implementation[3], it is essential to clarify the objective of "leveraging scenarios to empower skills development," focus on bridging the gap between vocational education and industry demands, and advance the integration of the metaverse in vocational education through the following five core scenarios.

Virtual Training Scenarios: Overcoming Shortages and High–Risk Challenges in Practical Training. Virtual training scenarios represent the most fundamental and core application of the metaverse in vocational education. They address key pain points in traditional vocational training, such as scarce resources, high costs, and difficulties in practicing high–risk scenarios. By leveraging virtual reality technology, these scenarios create 1:1 replicas of real workplace environments, equipment, processes, and standards tailored to specific professions and roles. This allows students to engage in hands–on practice within virtual settings, achieving training objectives characterized by "low cost, high safety, and high adaptability." The innovation of virtual training scenarios is primarily reflected in three aspects: the precision of scenario replication, the flexibility of training processes, and the immersive nature of the training experience.

The Metaverse virtual training environment also supports one–click reset and repeated practice. Students can immediately restore the scenario and retry after making mistakes, eliminating concerns about equipment wear or safety risks. Through repeated practice, they can reinforce skill retention and improve proficiency. Additionally, interactive elements such as virtual classmates or corporate mentors can be incorporated into the virtual training scenarios. Students can collaborate with these virtual characters to complete tasks, fostering teamwork and communication skills.

Taking automobile maintenance professional training as an example, traditional training is limited by the number of actual vehicles and the cost of maintenance parts, making it difficult to ensure sufficient mobile phone skills for each student. The metaverse virtual scene accurately replicates the overall structure, maintenance stations, and maintenance processes of different vehicle models, and all aspects such as disassembly, inspection, and assembly can be repeatedly simulated. After an operation error, simply reset with one click to restart without consuming parts or wearing out the vehicle. By adding interactive roles such as virtual maintenance apprentices and technicians to the scene, students can cooperate to complete collaborative tasks such as vehicle maintenance and fault diagnosis. With low cost and zero loss, they can efficiently improve their practical maintenance skills and teamwork abilities.

Personalized Training Scenario: Adapting to the educational goal of "teaching students according to their aptitude." The core of vocational education lies in tailoring instruction to individual needs. Leveraging artificial intelligence, the metaverse collects real–time data on students' learning and practical training–such as study duration, mastery of knowledge points, frequency of operational errors, and skill gaps. Through data analysis, it precisely identifies students' learning needs and weaknesses, formulating customized learning plans (**Table 1**), this plan is a research example based on preliminary research and combined with the actual situation faced by vocational colleges at present. Additionally, the virtual teaching environment within the metaverse can recommend relevant extended learning content based on students' interests, thereby enhancing their motivation to learn.

Table 1. Metaverse Personalized Cultivation Design Table

Session	Core Technologies/Carriers	Collected/Processed Content	Achieve goals
Data Collection	Metaverse Virtual Learning Space + AI	Study duration, knowledge point mastery, operational errors, skill gaps, learning interest	Comprehensive recording of the entire learning process
Data Analysis	Artificial Intelligence Algorithms	Learning Profiles, Competency Assessment, Weakness Diagnosis	Precise positioning of individual differences
Plan Formulation	Intelligent Recommendation System	Personalized learning paths and customized practical training content	Truly achieving personalized education tailored to individual aptitudes
Performance Improvement	Immersive Virtual Environment	Expanding Content Recommendations and Stimulating Interests	Enhancing Learning Motivation and Skill Proficiency

In this personalized training scenario, students can receive real–time guidance and have their questions answered, addressing the issue in traditional teaching where "teachers cannot attend to all students simultaneously." The virtual assistant can provide real–time reminders of key operational points and correct mistakes based on students' performance. It also tracks their learning progress, issuing timely alerts to adjust learning pace when lagging progress or excessive errors occur, and contacting teachers for targeted guidance when necessary. Additionally, through AI–driven evaluation methods, it comprehensively assesses students' learning outcomes across multiple dimensions—such as theoretical knowledge, practical skills, and professional quality—using data from their learning and training activities. This approach provides objective evaluation scores and improvement suggestions, avoiding the subjectivity and delays inherent in traditional assessment methods.

Taking the cultivation of students majoring in preschool education as an example: preschool education teaching covers multiple skills such as child interaction, classroom organization, emergency response, etc. The strengths and weaknesses of different students vary greatly, and traditional classrooms are difficult to achieve personalized cultivation. The metaverse teaching space can collect real–time data on students' simulated teaching duration, number of interactive language errors, accuracy in handling sudden problems for young children, and weaknesses in classroom rhythm control. Through intelligent analysis, it can accurately locate students' ability deficiencies, such as insufficient emotional comfort for young children and a single form of classroom interaction. Based on the analysis results, the platform customizes learning plans for students, adding targeted training courses such as emotional counseling and fun classroom interactions for young children. At the same time, according to students' interests, it pushes creative classrooms and characteristic early childhood education activity designs for young children to expand learning content and stimulate learning enthusiasm. In virtual simulation teaching and practical training, virtual teaching assistants provide real–time Q&A guidance throughout the entire process, correct students' rigid communication skills and improper classroom handling methods in a timely manner, dynamically track learning progress, timely warn students who are lagging behind in learning and have frequent practical problems, and coordinate with teachers to provide accurate guidance. After the course ends, artificial intelligence completes a comprehensive evaluation from multiple dimensions such as theoretical knowledge, simulated practical operations, professional competence, and educational service awareness, providing accurate scores and specialized improvement suggestions, avoiding the drawbacks of traditional teachers' subjective evaluation, and adapting to the growth pace of each student.

Cross–domain collaboration scenarios: Breaking down resource barriers to achieve high–quality resource sharing. In traditional vocational education, high–quality resources are heavily concentrated in first–tier cities, key institutions, and large enterprises. Students in remote areas and small to medium–sized institutions struggle to access cutting–edge skills and quality teaching resources, leading to imbalanced development of vocational education across regions and institutions. The metaverse leverages technologies such as blockchain to create cross–domain collaboration scenarios[4], eliminating spatial and resource barriers. This enables the sharing of high–quality vocational education resources across regions, institutions, and enterprises, promoting balanced development in vocational education. Practical training based on cross–regional collaboration scenarios facilitates "inter–school cooperation and complementary advantages." Institutions from different regions can jointly develop metaverse training resources based on their respective disciplinary strengths, sharing teaching plans and training outcomes (**Figure 1**).

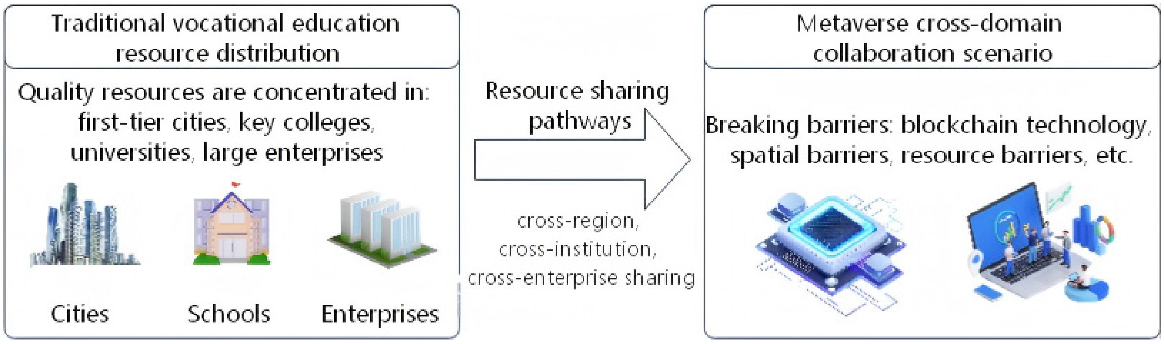

Figure 1. Schematic Diagram of Cross–Domain Collaborative Scenarios

The cross–domain collaborative scenario of the metaverse can break down spatial barriers between educational institutions and enterprises, establishing a "virtual industry–education collaboration platform" that enables enterprises to deeply engage in the entire process of talent cultivation[5]. Enterprises can replicate real production processes, job standards, equipment parameters, and production tasks into the virtual space. Educational institutions can design teaching content and practical training modules based on enterprise needs, allowing students to participate in real enterprise production tasks within the virtual environment—effectively achieving "learning at school as practicing on the job." Enterprise technicians can provide real–time guidance and technical training to students in the virtual space, while institutional teachers can optimize teaching plans according to job requirements, forming a talent development model characterized by "industry–institution collaboration, co–construction and sharing, and mutual benefit."

Taking mechanical manufacturing as an example, local manufacturing enterprises have fully replicated workshop production lines, numerical control equipment parameters, and job operation specifications on the metaverse virtual industry education collaboration platform. Cooperative vocational schools design practical training courses based on enterprise standards, and students can access virtual production lines to complete practical training on campus; Enterprise engineers provide real–time online Q&A guidance, and the school synchronously optimizes the curriculum system, truly achieving a seamless connection between learning and job practice.

Skill Competition Scenario: Promoting Learning through Competition to Enhance Skill Levels. Vocational skill competitions serve as a crucial vehicle for vocational education, embodying the principle of "promoting learning, teaching, and reform through competition." However, traditional vocational skill competitions face challenges such as limited venues, expensive equipment, low participation rates, and inconsistent evaluation standards, making it difficult to fully leverage their educational value. By leveraging technologies like virtual reality and artificial intelligence, the metaverse constructs virtual skill competition scenarios that break the constraints of physical venues, equipment, and participant numbers. This enables "anyone to participate and compete anytime," while simultaneously enhancing the fairness and effectiveness of competitions.

The relevant achievements from the Metaverse skills competition scenarios can be rapidly transformed and applied. On one hand, outstanding students in the competition can receive virtual skill certificates, which can be mutually recognized across institutions and enterprises through blockchain technology, serving as a key reference for student employment. On the other hand, exceptional works and innovative solutions emerging from the competition can be adopted by companies, achieving the goal of "promoting production through competition and fostering innovation through competition."

Taking the industrial robot vocational skills competition as an example, relying on the metaverse to build a virtual competition arena, there is no need to build physical venues or purchase expensive real equipment. A large number of participants from all over the country can participate online at the same time. The system relies on artificial intelligence for unified scoring, avoiding human judgment bias and allowing more teachers and students to participate in the competition, truly achieving the goal of promoting learning and teaching through competition.

Innovation and Entrepreneurship Scenarios: Unleashing Innovative Potential and Cultivating Entrepreneurial Skills. Vocational education should not only equip students with job–specific skills but also ignite their innovative potential and foster their entrepreneurial capabilities, supporting their diversified development. Leveraging its characteristics of virtual–real integration and intelligent collaboration, the metaverse constructs innovation and entrepreneurship scenarios, providing students with a low–cost, low–risk, and highly adaptable platform for practical experience. This allows students to engage in innovation and entrepreneurship activities within virtual spaces, accumulate entrepreneurial experience, and enhance their innovative and entrepreneurial abilities. By establishing virtual entrepreneurial incubation platforms, it offers students one–stop services including entrepreneurial spaces, resources, and guidance, thereby reducing their entrepreneurial costs and risks (**Table 2**), The relevant conclusions in this table are for reference only, and the specific situation should be analyzed in depth based on the actual situation of each vocational college.

Table 2. Comparative Analysis of College Students' Entrepreneurial Abilities

Comparison Dimension	Traditional Entrepreneurial Practice Models	Metaverse–Enabled Entrepreneurship Practice Model	Core Improvement
Startup costs	High (significant investment in venues, equipment, and materials)	Low (zero physical cost, virtual supply)	Significant cost reduction
Entrepreneurial risk	High (high trial–and–error costs, prone to losses)	Low (virtual trial and error, no actual loss)	The risk is substantially reduced
Entrepreneurship Scenario	Single, low fit	End–to–end process, virtual–real integration	Significant improvement in adaptability
Resource Acquisition	Limited, narrow channels	One–stop, convenient and efficient	Significant improvement in efficiency
Skill Enhancement	Lack of practical application, difficult to implement	Practice repeatedly, iterate quickly	Innovation implementation efficiency increased
Student engagement	Narrow coverage and low motivation	All members can participate with high motivation.	Participation rate increased

The metaverse innovation and entrepreneurship environment can invite corporate startup mentors, industry experts, and academic faculty to provide real–time guidance for students' innovative projects, helping them address challenges encountered during the entrepreneurial process and enhancing the practicality and creativity of their initiatives. Additionally, the metaverse innovation and entrepreneurship setting can establish a platform for project exchange, facilitating collaboration and communication among students, between students and enterprises, and between students and experts. This enables the sharing of innovative ideas and entrepreneurial experiences, thereby sparking further inspiration for innovation.

Taking the innovation and entrepreneurship practice of vocational school e–commerce majors as an example, students can rely on the metaverse virtual entrepreneurship incubation platform to carry out entrepreneurship training such as online store operation and live streaming e–commerce. They do not need to rent physical stores or purchase hardware equipment, and can complete the entire process of store construction, product selection, marketing promotion, order processing, etc. at low cost and zero risk in the virtual space. They can accumulate complete entrepreneurial practical experience and effectively hone their innovative thinking and entrepreneurial practical abilities.

3.3 Skill Development Needs for Vocational Education in the Metaverse Context

Modern industrial development has placed higher demands on vocational education. The integration of the metaverse with vocational education can better address the adaptability issues between job requirements and vocational training. Based on the technological composition of the metaverse and the talent development goals of vocational education, the skill cultivation needs in vocational education within the metaverse context primarily manifest in four dimensions: core job skills, digital technical skills, innovation and collaboration skills, and professional competence.

Core professional skills: adhering to the essential orientation of vocational education. The ultimate goal of vocational education is to cultivate talents that meet job requirements, making the core of vocational education the development of students' core professional skills [6]. The metaverse can provide skill training scenarios tailored to the differentiated needs of enterprises, this is a great attempt at modern vocational education reform. This can be achieved through the following aspects.

First, precisely align with the skill standards required for corporate positions. Vocational education's skill development should revolve around the skill standards of corporate positions. The metaverse can develop application scenarios tailored to different skill standards, enabling students to better master relevant job skills and achieve the goal of "seamless integration between learning and job requirements." In practice, the core skill demands vary depending on the specialization and position. While strengthening the cultivation scenarios for core skills, it further solidifies the skill standards for corporate positions to meet the differentiated requirements of various roles for students' vocational skills.

Second, enhance practical skills and emergency response capabilities. Vocational education emphasizes the cultivation of applied, interdisciplinary, and innovative talents, among whom practical skills and emergency response capabilities are essential competencies [7,8]. Considering cost and safety factors, traditional vocational education often cannot provide extended practical and emergency response training. However, in the metaverse environment, students can engage in immersive job skill training and simulate various complex and hazardous emergency situations. As a result, students' practical and emergency response abilities will be significantly improved.

Taking the inspection and maintenance of new energy vehicles as an example, current new energy vehicle companies have established standardized job skill requirements for maintenance positions, such as high–voltage battery testing, motor fault diagnosis, and on–board electronic control system debugging. There are subtle differences in equipment parameters, maintenance processes, and technical specifications among different car companies. Relying on metaverse technology, customized virtual maintenance training scenarios can be developed based on the differentiated job skill standards of various large vehicle enterprises, accurately matching the enterprise's on–the–job assessment standards. Students can repeatedly complete standardized operations such as battery fault diagnosis, line testing, and system calibration according to the actual operating standards of the enterprise in the corresponding virtual scene, avoiding the problems of outdated traditional training materials and single training scenarios. They can accurately benchmark the skill requirements of enterprise positions, truly achieve seamless connection between campus learning and enterprise job needs, and consolidate students' core skills in their positions.

Digital Technology Skills: Adapting to the demands of metaverse technology applications. The metaverse is supported by digital technologies such as virtual reality, artificial intelligence, and blockchain. Vocational education requires students to master at least one digital technology, which creates opportunities for the integration of the metaverse and vocational education. In the context of the metaverse, vocational skills training enables students to understand and master digital technologies, allowing them to adapt to the application needs of metaverse technologies. This reflects the mutually reinforcing relationship between the metaverse and vocational education.

First, skills related to operating metaverse devices and systems. The integration and application of the metaverse in vocational education involve a wide range of hardware devices and operating systems, such as virtual reality display terminals, motion capture equipment, and virtual simulation training systems. Students must not only correctly operate these devices and systems but also master relevant development tools like UE and Unity to create simple training scenarios and design various interaction logics. This is a crucial component of skill development in vocational education in the metaverse era.

Second, the application skills of metaverse technology in job positions. In recent years, metaverse technology has achieved comprehensive penetration across multiple industries. Leveraging technologies such as virtual reality, artificial intelligence, and blockchain to assist in job tasks has become another objective in the skill development of vocational institutions. At the same time, students in vocational institutions must possess a high level of digital literacy to identify application risks associated with metaverse technology, thereby implementing safety measures and preventing its misuse in the workplace.

Taking the cultivation of metaverse related equipment and system operation skills as an example, virtual simulation teaching in vocational colleges such as intelligent manufacturing, digital media, and automotive repair training has fully implemented the practical training of this skill. In vocational education practical teaching, colleges generally introduce metaverse hardware devices such as virtual reality display terminals, full body motion capture devices, immersive virtual simulation training systems, and carry out teaching and practical training with mainstream development tools such as UE and Unity. For students majoring in numerical control technology, they not only need to proficiently wear VR virtual training equipment and operate motion capture instruments accurately, but also complete basic practical training such as debugging, operation, and shutdown of virtual machine tools to avoid equipment loss and operational risks in offline physical training; We also need to use Unity development tools to independently build a simple virtual training scene for CNC machining, design human–machine interaction logic for part processing and equipment troubleshooting, adjust virtual scene parameters and optimize interaction experience according to different training needs, and independently create lightweight virtual training courseware. Through a complete set of practical training, students have not only mastered the standardized operation ability of metaverse hardware equipment, but also acquired basic metaverse scene development ability, fully adapting to the application needs of the metaverse virtual training system, and consolidating the practical foundation of the integration of metaverse and vocational education.

Innovation and Collaboration Skills: Adapting to the demands of industrial transformation and upgrading. Vocational education emphasizes the holistic development of students. The integration of the metaverse in vocational education should not only strengthen students' practical skills but also require them to possess certain innovation and collaboration skills, which align with the needs of industrial transformation and upgrading in the new era. Leveraging the technical advantages of the metaverse and considering the current state of students' comprehensive competencies in vocational institutions, innovation and collaboration skills training will become a key focus in the next phase of talent development in vocational education, supported by scenarios such as crossdomain collaboration and innovation–driven entrepreneurship.

First, fostering innovation capability. Innovation capability is the core competitiveness in the process of modern industrial transformation and development. Therefore, in the context of the metaverse, vocational education needs to focus on cultivating students' innovation ability, inspiring their creative ideas, and enabling them to engage in collaborative innovation within relatively open metaverse scenarios. At the same time, efforts should be made to strengthen the development of students' cross–boundary innovation skills, integrating theoretical knowledge and applied skills to solve various problems encountered in learning, daily life, and work.

Second, the cultivation of collaborative skills. Enterprises' demands for job skills also include interdepartmental coordination, as collaborative capabilities directly impact the efficiency of completing complex tasks. The application of the metaverse in vocational education can provide cross–role, interdisciplinary collaborative training scenarios, allowing flexible design in coordination logic. This represents another crucial adaptation to the needs of industrial transformation and upgrading.

Taking the training of talents in the field of new energy vehicle technology as an example, in the current context of the automotive industry's transformation and upgrading towards new energy, intelligence, and digitization, traditional single maintenance and assembly skills are no longer suitable for the job demands of enterprises. Innovation ability has become the core employment competitiveness of vocational college students. Based on the virtual training scenario of the metaverse, vocational colleges can build an open virtual platform for the research and development of new energy vehicles and fault optimization, breaking the limitations of traditional classroom training equipment and scenarios. Students can break through common technical pain points in the existing new energy vehicle battery cooling, in vehicle intelligent system adaptation, charging pile compatibility, and other industries in the virtual environment of the metaverse. Combined with theoretical knowledge of vehicle construction and electronic control principles learned in class, they can independently try to optimize equipment structure, improve control programs, and design new adaptation solutions. At the same time, students can leverage the advantages of cross domain resource integration in the metaverse, integrate cross–border knowledge such as electronic technology, artificial intelligence, and new materials, and carry out innovative exploration of practical industry problems such as insufficient low–temperature range of new energy vehicles and misjudgment of intelligent assisted driving, effectively exercising their own innovative thinking and cross–border innovation ability, and meeting the core requirements of modern industrial transformation for technological talents' innovation literacy.

Professional Competence: The Foundation for Skilled Talents. In the context of the metaverse, the skill development needs in vocational education can be divided into broad and narrow aspects. Narrowly defined skill development includes the aforementioned core job skills, digital technology skills, and innovation and collaboration skills, while professional competence falls under the category of broadly defined skill development [9]. Strong professional competence helps students better adapt to their job roles and serves as the foundation for their personal growth.

First, professional ethics and sense of responsibility. The formation of good professional qualities requires a relatively long cycle. Integrating the metaverse into vocational education can shorten this process by innovating virtual scenarios. In virtual job roles, students can gain a deeper understanding of their responsibilities and gradually develop a correct professional outlook. Additionally, virtual scenarios can incorporate various interactive logics to guide students through interactive choices, thereby enhancing the quality and effectiveness of vocational education.

Second, service awareness and dedication. In modern professional competence, service awareness and dedication are fundamental requirements that enterprises have for talent. Integrating the metaverse into vocational education can provide more innovative career service scenarios, and the design of service components in virtual teaching can strengthen students' service awareness through targeted training. Meanwhile, using the metaverse to create immersive job experiences and understanding the importance of their roles from a third–person perspective can ignite students' sense of dedication.

Taking the practical training teaching of intelligent manufacturing professional workshop positions as an example, in the traditional vocational education model, students only understand job responsibilities through theoretical explanations, video observations, and shallow practical operations, making it difficult for them to deeply establish a sense of job responsibility. The cultivation cycle of professional values is long and the effect is weak. After integrating metaverse technology, a highly simulated intelligent workshop virtual work scene can be built, which fully replicates the real job content such as equipment operation, production process, safety regulations, and job responsibilities. Students participate in immersive job positions as virtual practitioners. In virtual production assignments, if irresponsible behaviors such as violating regulations, perfunctory work, or missing processes occur, the system will immediately trigger chain virtual consequences such as equipment failure, product scrapping, production line stagnation, and safety hazards. At the same time, the metaverse scene can set up multi branch interactive selection logic. When students face choices such as lazy homework, perfunctory handling, and ignoring safety rules, the system will display corresponding job losses, enterprise losses, team influence, and other results in real time, guiding students to actively correct erroneous professional behaviors. Through repeated immersive experiences and interactive training, students can intuitively and deeply perceive the safety responsibility, production responsibility, and job responsibility of intelligent manufacturing positions, quickly abandon their scattered professional mentality, gradually establish a rigorous and responsible professional outlook, significantly shorten the cultivation period of professional ethics and responsibility awareness, and effectively improve the quality of professional ethics cultivation.

4. Practical Pathways for Applying the Metaverse in Vocational Education

Based on the principle of industry demand orientation and centering on the dual needs of scenario innovation and skill development, the integration goals of the metaverse in vocational education have been clarified. Therefore, by aligning with the principles of talent cultivation within the vocational education system and leveraging the technical characteristics of the metaverse, a practical pathway that is both feasible and forward–looking can be constructed across five dimensions: technological support, resource provision, industry–education collaboration, talent assurance, and risk prevention. This approach will drive the high–quality development of vocational education in the era of the metaverse.

4.1 Technical Support Dimension

Vocational education talent cultivation is a systematic project that requires consideration not only of traditional academic teaching content but also of the differentiated skill demands across various industries and positions. The metaverse, supported by core technologies such as virtual reality, artificial intelligence, and blockchain, can provide vocational institutions with scalable, personalized teaching environments to meet diverse educational and practical training needs. Therefore, the application of the metaverse in vocational education necessitates open application scenarios. By introducing metaverse technology, it is essential to address the alignment between technology and requirements, optimize the technical operational architecture, enhance technical response speed and stability, and refine interactive logic within application scenarios to ensure the effectiveness and reliability of virtual teaching environments[10].

At the current stage, vocational education should establish a multi–stakeholder collaborative technology–sharing platform. With the support of leading universities, research institutions, and enterprises, it is essential to overcome technical limitations and lower the barriers for vocational colleges in adopting metaverse technologies. Meanwhile, the technology iteration mechanism should be optimized to address technical challenges encountered in practical applications, thereby providing robust support for the implementation of the metaverse in vocational education.

4.2 Resource Supply Dimension

The application of the metaverse in vocational education requires substantial resource investment. To reduce costs for vocational institutions and ensure effective resource provision, it is essential to build a personalized, professional, and standardized resource system aligned with the characteristics of relevant disciplines and skill development objectives. This system should also demonstrate strong iterative capabilities and practicality, thereby minimizing resource waste to some extent. Taking vocational education application scenario resources as an example, while screening existing products, personalized needs in vocational education should be met. By promoting diversified resource provision and integrating resources from governments, institutions, enterprises, and other stakeholders, institutions are encouraged to collaborate with enterprises in developing metaverse–based teaching resources. These efforts should focus on core vocational skills, creating virtual teaching resources that cover various disciplines and levels, including virtual courses, virtual training scenarios, and virtual teaching aids. Simultaneously, a joint innovation mechanism should be established to dynamically update metaverse application scenarios based on evolving skill requirements, providing comprehensive resource support for the deep integration of the metaverse and vocational education.

To ensure the quality of metaverse resource supply in vocational education, it is essential to strengthen the development of resource standard systems and improve the quality supervision mechanisms for these resources. Through scientific evaluation, it can be guaranteed that metaverse resources meet the skill development requirements of vocational education[11]. Under this mechanism, the behavior of metaverse resource providers can be effectively regulated, ensuring the sustained and stable application of the metaverse in vocational education.

4.3 Industry–Education Collaboration Dimension

The ultimate goal of vocational education is to cultivate talent that aligns with industry needs. Traditional single–track training mechanisms lack enterprise–level participation, which compromises the quality and effectiveness of vocational education. Industry–education collaboration addresses this by increasing corporate involvement. The application of the metaverse in vocational education requires enterprises to play a leading role, enabling education and industry to resonate in harmony. First, enterprises must propose comprehensive planning for application scenarios and organize the development of metaverse–based scenario design resources and skill standards. This integrates cutting–edge industry technologies and core job requirements into the metaverse teaching process, ensuring precise alignment between skill development and occupational demands. Second, a joint talent training mechanism should be established, with active participation in metaverse application scenario training and evaluation. This achieves seamless integration from scenario development to practical training and provides a comprehensive understanding of the actual impact of metaverse applications on student skill cultivation[12].

Under the dimension of industry–education collaboration, the application of the metaverse in vocational education also includes virtual training and on–the–job internships. However, innovation in metaverse application scenarios cannot fully replace practical workplace experience. Therefore, guided by the collaborative development principle of "joint construction by schools and enterprises, complementary advantages, and mutual benefit," companies should provide diverse internship positions for students to facilitate the transition from the virtual to the real world. This approach also helps address, to some extent, the limitations of applying the metaverse in vocational education.

4.4 Talent Support Dimension

Talent support is the fundamental foundation for the deep integration of the metaverse and vocational education. It is necessary to build a composite talent team that possesses both metaverse technical capabilities and vocational education teaching abilities, based on the application of metaverse technology and the development needs of vocational education. Efforts should be made to strengthen the teaching faculty by establishing a skill training system related to the metaverse. Regular training sessions on metaverse technology and virtual teaching design should be organized for vocational school teachers to enhance their technical application skills and teaching innovation capabilities, promoting the transition from traditional teaching methods to metaverse–based virtual teaching models. At the same time, the talent introduction mechanism should be improved, with a focus on recruiting composite talents who have both a background in metaverse technology and experience in vocational education, thereby enriching the teaching team and optimizing its structure. Additionally, a talent cultivation and incentive mechanism should be established to encourage teachers to engage in teaching research and practical innovation related to the integration of the metaverse and vocational education. Outstanding teachers should be recognized and rewarded to stimulate their teaching enthusiasm and innovative vitality. Furthermore, it is essential to strengthen the cultivation of students' metaverse–related skills by incorporating metaverse technology application abilities into the vocational skill evaluation system. Students should be guided to proactively learn metaverse–related knowledge and skills, enhancing their digital literacy and job adaptability, thereby providing solid talent support for the deep integration of the metaverse and vocational education.

4.5 Risk Prevention and Control Dimension

Risk prevention and control is a crucial safeguard for the deep integration of the metaverse and vocational education. It is necessary to build a comprehensive, multi–level, and regular risk prevention and control system based on the unique characteristics of metaverse technology and the public welfare nature of vocational education, in order to prevent and mitigate various risks arising from the integration process. Strengthening technical risk prevention and control involves establishing a safety management system for the application of metaverse technology, enhancing technical safety monitoring and emergency response capabilities, and preventing technical risks such as system failures, cybersecurity threats, and data breaches, thereby ensuring the safety and stability of the virtual teaching environment. At the same time, content risk prevention and control must be reinforced by implementing a review mechanism for metaverse teaching content, strictly examining resources such as virtual courses and practical training scenarios to prevent harmful or false information from entering the teaching process, and ensuring the scientific integrity and positive impact of the educational content. Additionally, ethical and legal risk prevention and control should be enhanced by clarifying ethical norms and legal boundaries within metaverse–based teaching, guiding teachers and students to use metaverse technology appropriately, and preventing issues such as ethical misconduct and copyright infringement, thereby safeguarding the legitimate rights and interests of all parties. In addition, establishing an expert committee, improving the multi–dimensional risk early warning and handling mechanism, regularly organizing experts to conduct risk assessments, promptly identifying and addressing risks in the integration process, and formulating comprehensive emergency plans are crucial to ensuring the healthy and orderly advancement of the deep integration of the metaverse and vocational education, providing a safe and stable environment for skills training.

4.6 Overall Assessment

The evaluation of the application and implementation pathways of the metaverse in vocational education should revolve around five core dimensions: technological support, resource provision, industry–education collaboration, talent assurance, and risk prevention and control, focusing on three core objectives: feasibility, effectiveness, and sustainability. The implementation of these pathways has achieved significant results, effectively addressing the core challenges of traditional vocational education and comprehensively enhancing the quality of talent cultivation and teaching effectiveness. At the teaching level, the implementation of virtual training and personalized cultivation scenarios has substantially reduced training costs, mitigated risks associated with high–risk operations, and significantly improved students' practical proficiency and skill acquisition efficiency, achieving "seamless integration of learning and workplace roles." In terms of resource utilization, a co–constructed and shared resource system has broken down regional and institutional barriers, expanding the reach of high–quality vocational education resources and effectively alleviating issues of resource scarcity and uneven distribution. At the industry–education collaboration level, virtual industry–education platforms have deepened school–enterprise cooperation, increasing opportunities for students to engage in real production tasks and markedly enhancing their job adaptability and employment competitiveness.

5. Conclusion

The metaverse, as an integrated platform for next–generation digital technologies, is characterized by immersive interaction, virtual–real integration, intelligent collaboration, and global connectivity. It provides crucial technical support and innovative pathways for the digital transformation of vocational education in the new era. This paper systematically explores the innovative scenarios, skill development needs, and practical approaches of the metaverse in vocational education. The findings indicate that the metaverse effectively addresses key challenges in traditional vocational education, such as insufficient training resources, difficulties in implementing high–risk scenarios, weak alignment between courses and job requirements, and regional development disparities. Through diverse applications–including virtual simulation training, personalized education, cross–domain collaboration, skill competitions, and innovation and entrepreneurship–the metaverse significantly enhances the relevance, safety, and efficiency of skill development.

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