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RESEARCH ON THE INTEGRATION OF MODERN APPRENTICESHIP SYSTEMS AND EDUCATIONAL LARGE MODELS: A PERSPECTIVE BASED ON LITERATURE REVIEW AND CASE ANALYSIS

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Abstract— The modern apprenticeship system, which serves as a vital link between education and employment, faces challenges such as insufficient dual-teacher teaching capabilities, a limited assessment system, and communication barriers between schools and enterprises. To address these issues, Education Large Models (ELMs), powered by artificial intelligence, offer innovative solutions for reform. ELMs enhance teaching quality through personalized training, intelligent teaching assistance, and the creation of communication platforms for teachers, addressing disparities in teaching capabilities. For assessment, ELMs introduce dynamic, diverse, and personalized evaluation metrics, improving the scientific accuracy of apprenticeship evaluations and overcoming the limitations of traditional methods. Furthermore, ELMs establish a unified platform to bridge the communication gap between schools and enterprises by intelligently interpreting industry needs and educational feedback, facilitating effective collaboration. Some Institutes and colleges which have taken in developing a vocational education-specific large-scale model, using new technologies such as artificial intelligence to empower large-scale personalized talent cultivation. However, challenges remain, such as data privacy concerns and algorithmic bias. Future research should focus on enhancing data security measures, addressing algorithmic fairness, and developing accessible technological solutions to broaden the applicability of ELMs across various educational contexts.

Index Terms—Educational Large Models, Modern Apprenticeship, Artificial Intelligence, Vocational Education, Intelligent Transformation

I. INTRODUCTION

The apprenticeship training model is an important way to effectively combine education and employment. There are many successful cases worldwide. The dual-track education system in Germany is particularly renowned. Through close cooperation between schools and enterprises, it enables students to acquire valuable practical experience while learning theoretical knowledge, thereby cultivating highly skilled talents. Employer-led vocational training ensures the content closely aligns with industry demands and enhances the adaptability of the labor market in Switzerland.

The apprenticeship system registered in the United States is a nationwide system officially certified by the federal or state government. Under this framework, various specific models have been formed, such as the community apprenticeship system, which specifically serves the residents of local communities and places particular emphasis on providing equal career development opportunities for disadvantaged groups such as the low-income population.

Due to the differences in economic and social backgrounds, different countries adopt different apprenticeship models, which not only meet the demand for highly skilled talents but also promote social equity. As pointed out in [1] and [2], apprenticeship systems create more career development opportunities for disadvantaged social groups and promote economic growth. [3] further emphasizes that apprenticeship systems play a crucial role in increasing employment rates and enhancing economic vitality. For example, the registered apprenticeship system in the United States significantly improves youth employment rates and economic development levels through a multi-level degree apprenticeship framework and effective government regulation. The common feature of these models is to value the participation of industries and enterprises, closely integrating apprenticeship with market demands, and providing strong human resource support for economic development.

In recent years, China has also been piloting modern apprenticeship programs, deepening industry-education integration and school-enterprise cooperation. Compared with the apprenticeship models of other countries, China's modern apprenticeship system is led by the government, oriented towards industry needs, and aims to cultivate skilled talents who can adapt to industrial upgrading [4]. These practices not only provide career development support for young people but also inject new vitality into economic development. As stated in [5], a successful apprenticeship system can effectively link education with employment, laying the foundation for social and economic development.

As the digital transformation of education continues to advance, educational large models are emerging as an innovative solution, providing strong support for the implementation of modern apprenticeship systems. The traditional dual-teacher teaching model often faces issues related to differences in teacher capabilities, while educational large models, through intelligent technologies, can provide real-time teaching guidance and training for teachers, enhancing their teaching abilities and thereby achieving higher quality dual-teacher instruction. Furthermore, the singularity of assessment systems also limits students' diverse development. Educational large models, through big data analysis, are able to establish a more comprehensive and personalized assessment system, helping students improve holistically in skills and qualities. The difficulties in communication between schools and enterprises have also been effectively addressed, as educational large models promote information sharing and cooperation between schools and businesses through digital platforms, ensuring that course offerings are closely aligned with industry needs. These innovative measures not only enhance the efficiency of the connection between education and employment but also cultivate more high-quality technical and skilled talents for economic development, meeting the urgent societal demand for vocational talents. In this context, the combination of the digital transformation of education and educational large models will have a profound impact on the future of vocational education, driving a comprehensive upgrade and development of the educational system.

II. LITERATURE REVIEW

A. Issues Related to Dual Teacher Instructional Ability

The dual-teacher teaching model plays an important role in today's educational reform, but there are still some capability gaps in its implementation process. The theories of scholars such as Schwille, Lave, and Wenger provide strong support for teachers' professional development, emphasizing that teachers not only need solid subject knowledge but also must continuously enhance their dual-teacher abilities. In this process, corporate mentors need to play the roles of both technical experts and educational designers to ensure that students gain real skill experiences in practice. At the same time, school teachers should be transformed into promoters of practical application to help students combine theoretical knowledge with practice. In addition, in school-enterprise cooperation, the concept of legitimate peripheral participation is particularly important, and the roles of teachers and enterprise mentors should be clearly defined to avoid confusion due to ambiguous responsibilities. The conclusion of a contract of rights and obligations can clarify the obligations and responsibilities of the parties to cooperation and improve the efficiency and effectiveness of cooperation. In addition, the ability of multi-specialty translation is increasingly the key to the success of the “duel-teacher” teaching model. Teachers and enterprise mentors need the ability to effectively translate knowledge from different fields into teaching content in order to promote the all-round development of students. In short, by strengthening the professional development of teachers and perfecting the cooperation mechanism between schools and enterprises, the teaching effect of “double-teacher” teachers will be significantly improved [6], [7].

According to a study by [8], 73% of business mentors lack systematic instructional design skills and 58% have unclear evaluation criteria. This phenomenon is also present in China's vocational education system, with a study by the [9] revealing that some teachers in vocational colleges spend less than 15 days a year in business practice, resulting in more than three years of disconnection between curriculum content and industry practice. To address these issues, [9] emphasizes the importance of jointly signing the "Competency Matrix Table" by dual instructors, aimed at recording apprentice skills and enhancing the practicality and relevance of vocational education. Additionally, in China's '1+X' certificate system, corporate mentors and school teachers are responsible for practical assessments and academic credit conversion rules, reflecting a commitment to the quality of vocational education. Through these measures, it is hoped that the gap between enterprises and vocational colleges can be narrowed, promoting the deep integration of education and industry, and improving apprentices' professional capabilities and employment competitiveness.

According to [10] the "Digital Portrait of a Duel Teacher" project, developed in collaboration with Huawei and Shenzhen Polytechnic, supports the effective implementation of dual teacher teaching by collecting multidimensional data on teacher interaction frequency and technology patent contributions, among others, to establish dynamic early warning mechanism. This innovative initiative aims to improve the teaching ability of teachers and students' learning outcomes. In addition, the BIBB system of the German Federal Institute for Vocational Education and Training further optimizes the allocation of dual teacher resources by using block chain technology to automatically match apprenticeship growth record certification and smart contracts. These international experiences and technology applications demonstrate how the education sector can use advanced technology to drive the development of vocational education, improve the overall quality of the teaching workforce and improve the accuracy of apprentice training, providing valuable lessons for vocational education worldwide.

B. Training Evaluation Issues

At present, the content of apprentice training cannot meet the needs of enterprises, and it is hard for apprentice to adapt to actual work environments. Many studies showed that courses of training were being updated slowly and inflexibly. This is a problem also in some colleges of China where the practical content of the apprenticeship system does not get updated in a timely manner..

This situation affects the effectiveness of apprenticeship programs and further increases training expenses for enrerprises [5]. Therefore, enrerprises need to think more about the usefulness and adaptability of the curriculum in choosing apprenticeship programs, to assure that apprentices can develop abilities for which industry needs. Furthermore, educational institutions must renew their syllabi to better adapt to market shifts and demands, which can improve the apprentices' ability effectively and better adapt to future work.

There are several limitations in the current assessment system of apprenticeship, the assessment methods being s simple, which is difficult to measure the apprentices' overall abilities. [11] point out that the main factors which affect the effectiveness of the assessment are unclear evaluation criteria. It hinders the apprentices capturing theoretical knowledge, practical skills, and professional qualities. Take Switzerland's assessment system of apprenticeship as an example, it adopts a more multidimensional approach, which is capable of comprehensively assessing professional proficiency in terms of knowledge and skills, etc. By learning from the Swiss model, the researcher needs to enhance the comprehensiveness and effectiveness of the evaluation of apprenticeship in China. By relying on the Educational Large Model (ELMs), researchers can conduct in-depth analysis of apprentices' learning data, work performance and skill assessment, and generate detailed reports on their learning progress and working environment. This system effectively enhances the accuracy and effectiveness of the assessment from three dimensions:

In terms of the accuracy of the assessment, ELMs can integrate multi-source data for cross-validation. It combines the practical operation data of apprentices (such as the completion degree of processes) with their theoretical examination results, precisely identifying weak points. This significantly reduces the deviation of the traditional single assessment standard and makes the assessment conclusion more objective.

In terms of the completeness of the assessment, ELMs transform the assessment from a single-dimensional model to a comprehensive and integrated system. It not only focuses on the output results of skills, but also captures the performance of apprentices in soft skills such as teamwork and problem-solving. This ensures that the assessment content covers both basic skills and professional qualities as well as the application of cutting-edge technologies, avoiding assessment blind spots.

In terms of the dynamics of the assessment, this automatic assessment system can achieve real-time monitoring of the apprentice's progress. It provides timely and practical feedback and gives personalized improvement suggestions. The system can automatically update the assessment focus based on the phased growth data of the apprentice, forming a "assessment-feedback-improvement" closed-loop management.

C. Service Management Issues

Apprenticeship programs often face issues due to disjointed administration, insufficient policy backing, and lack of a consistent management system, restricting their execution. Studies within the country reveal that they comprise various departments and are without a cohesive management structure, resulting in subpar management [12]. Conversely, Australia has developed an effective apprenticeship management mechanism via cooperation among the government, sector, and educational institutions. As an instance, Australia's apprenticeship system management is under the government's leadership, involving the industry and schools actively, establishing a cooperative, multi-party support system [12]. This cooperative approach not only boosts management efficiency but also bolsters the success of apprenticeship execution.

Protecting the rights of apprentices remains a significant challenge within apprenticeship program. The current apprenticeship system is deficient in areas such as career development guidance and fair pay, which is detrimental to the professional growth of apprentices. [13] Highlighted the inequity of apprentices in terms of pay, social security and career development. In the UK, the rights of apprentices are firmly guaranteed through a well-developed legal and policy framework. The apprenticeship system in the UK not only provides comprehensive social security for participants, but also offers professional career guidance services to help them plan and develop their careers [5]. This system effectively protects the rights of apprentices while also significantly enhancing the competitiveness of the entire labor market.

Meanwhile, many challenges faced by modern apprenticeship management have been addressed through the use of an apprenticeship management system. The intelligence of educational management can significantly enhance the efficiency of daily tasks such as scheduling, attendance, and performance tracking [12]. More importantly, this system can provide highly personalized guidance and career planning suggestions based on the interests, skills, and career goals of the apprentices [14]. These intelligent service and management strategies not only greatly improve the training experience of the apprentices but also inject strong impetus into their future career development potential.

III. THE APPLICATION PATH OF EDUCATIONAL LARGE MODELS IN MODERN APPRENTICESHIP SYSTEMS

A. AI-empowered "Teaching-Technology" Composite Mentor Training

Artificial intelligence technology enables the dynamic update of industry database knowledge and skills. Mentors can promptly obtain the latest industry information, thereby closely linking the teaching content with job requirements. This real-time update mechanism not only supplements the mentors' professional knowledge but also enhances the targeted and effective nature of their teaching. In addition, a personalized teaching ability diagnostic system can help each apprentice grow by tailoring his or her learning plan according to his or her characteristics and needs. The apprentice feedback mechanism provides important support for teachers to improve their teaching. By collecting feedback from apprentices, teachers can continuously optimize teaching strategies and improve teaching results. More importantly, the application of the ELMs promote the development of cross-professional collaboration skills, enabling mentors from different professional backgrounds to share knowledge and expertise in solving complex real-world problems. This collaborative approach not only enriches the mentoring experience of the mentors, but also facilitates the learning of the apprentices, thus helping them to develop fully and make them more competitive in the future job market.

The ELMs play an important role in enhancing the collaborate ability of enterprise and school educators, the model provides a comprehensive knowledge and ability map for both colleges and enterprises. Through the integration of teaching concepts and technologies, education methods are tailored to different learners to help educators improve teaching methods and develop teaching strategies. In addition, by analyzing teaching outcomes and real-time feedback from students help evaluate teaching effects, which provide empirical data for educators to adjust teaching methods. Customized training programs promote the continuous development of schools and businesses, which enable them to update and expand their skills in an ever-changing educational environment. This model not only improves the teaching skills of school and corporate educators, but also increases their confidence and efficiency in interdisciplinary collaboration.

B. Intelligent Training and Assessment

In fast-moving fields such as emerging energy and manufacturing, knowledge and technology are evolving rapidly, and the requirements for practitioners' competence are constantly increasing [15]. ELMs innovatively integrate intelligent training and assessment into it [16], dynamically updates course content, quickly captures industry trends and business needs, and automatically refreshes training materials to ensure that students learn and synchronize with the forefront of the industry and acquire the latest knowledge. In the training of battery management and industrial robot maintenance, the modular course design fully considers the individual needs of students, so that they can choose their own learning modules. At the same time, the combination of virtual simulation and immersive teaching allows students to deeply participate in the actual scene, improve the learning experience and practical skills, and cultivate practical talents for the industry.

With the rapid development of science and technology, intelligent training is becoming a key means for enterprises to train talents, adapt to market changes, and improve employees' skills. Among them, VR and AR technology is favored in the field of education, especially medical and industrial training. ELMs use these technologies to build a highly realistic work environment and significantly improve training efficiency. In a precision manufacturing company in Switzerland, for example, the integration of ELMs with VR has improved the success rate in the evaluation of complex equipment operation by 35%. In industrial fields such as circuit board welding and equipment maintenance, apprentices can repeatedly practice in nearly realistic simulation environments and obtain immediate feedback through data analysis. Augmented reality technology can also provide real-time guidance during actual operations, helping them master complex equipment. For example, in culinary training, apprentices use ELM to conduct comprehensive automated evaluations, real-time assessing the quality of their dishes and providing accurate feedback. This not only enhances the objectivity of the assessment and the efficiency of scoring, but also provides timely insights for apprentices when they encounter problems during their learning process, helping to improve their learning methods. An apprenticeship training program of an American IT company shows that ELM feedback has increased apprentices' skills by 50%, and this innovative teaching model has greatly promoted the all-round development of apprentices.

C. Intelligent Management and Services

In the vocational education system, ELMs are playing an increasingly important role. Currently, some higher vocational colleges have already implemented the localization of ELMs, intelligently managing teaching tasks, covering core areas such as course schedule generation, attendance management, and resource allocation optimization. By integrating artificial intelligence technology, the efficiency of academic management has significantly improved, while the labor cost has been greatly reduced [12]. By optimizing the teaching management process using the educational big model, the workload of administrative staff and teaching personnel can be reduced, and they can focus more on key tasks that can enhance the quality of education. The educational big model can also play a crucial role in reducing the risk of student dropout, enabling educational institutions and schools to make wise and scientific decisions [2]. By analyzing students' daily behaviors and conditions, it can accurately detect potential dropout risks and take practical measures to enhance their academic performance and confidence. In addition, by integrating recruitment trend analysis to help apprentices create more targeted resumes, it can help apprentices improve their competitiveness in the job market and provide them with more targeted career development suggestions. Research [11] shows that incorporating labor market information into consideration can enable apprentices to quickly discover new employment opportunities and provide strong support for their career development trajectories towards mechanical engineers, electronic engineers, intelligent manufacturing engineers, or industrial robot maintenance experts.

In terms of employment interviews, through simulated interview scenarios and with the help of ELMs, mentors can objectively evaluate the performance of apprentices and provide them with comprehensive and professional training to help them overcome practical obstacles during the interview preparation process. [5] and [17] studies show that cutting-edge technologies such as speech recognition and sentiment analysis can significantly improve the efficiency of internship interviews, enhance job seekers' confidence, and help them stand out in the highly competitive job market.

IV. THE APPLICATION OF EDUCATIONAL LARGE MODELS IN MODERN APPRENTICESHIP PROGRAMS

The overall promoting effect of educational large model application on the operation of modern apprenticeship system is quite obvious. Through data analysis, apprentices can achieve personalized learning, thereby enhancing their practical and professional abilities. Virtual reality (VR) and augmented reality (AR) technologies provide immersive learning experiences for apprentices. Students can have an immersive learning experience in the model. The research team has established an "embedded" dual-teacher teaching team based on this and formulated the best educational strategies [11]. This model not only improves learning efficiency but also effectively stimulates the apprentices' exploratory spirit and innovative consciousness, helping them to specifically enhance their practical abilities and professional skills. On the other hand, VR and AR technologies have constructed immersive learning scenarios. Apprentices can practice complex operations safely and solve practical problems through role-playing in simulated environments [13]. This not only helps them quickly adapt to future work requirements but also simultaneously cultivates key professional abilities such as teamwork.

The cooperation practice between Shenyang Institute of Technology collaborated with Huawei has also proved that such integrated models can accurately capture the real difficulties and challenges faced by apprentices in practical work [17], laying a solid foundation for the efficient implementation of modern apprenticeship systems and the solid growth of apprentices. By collecting and analyzing real-time data, it is possible to continuously monitor the performance of the apprentices, enabling teachers and enterprise mentors to provide immediate feedback and targeted guidance, helping them solve practical problems and thereby effectively enhancing their practical skills. At the same time, as the apprentices continuously improve their skills and self-capacity, their confidence has also been greatly enhanced.

With the continuous advancement of technology, educational models combined with VR and AR technologies [19] provide apprentices with an unprecedented learning experience, especially in specialized fields such as automotive repair. Taking Shanghai Automotive Vocational and Technical College as an example, the school, supported by educational models, uses virtual reality and augmented reality technologies to offer apprentices opportunities to simulate real operations, enabling them to undergo practical training in a safe environment, thereby effectively enhancing their practical abilities and professional qualities [20]. Furthermore, the implementation of modern apprenticeship programs, particularly the deep collaboration between certain IT companies and universities, demonstrates the significant application of educational models in soft skills analysis. For instance, Guangdong Polytechnic Institute in Science and Technology supported by educational models, not only helps students improve their technical skills but also cultivates communication skills and teamwork spirit through collaboration.

Educational Large Models have become an important support for modern apprenticeship systems by offering highly personalized teaching materials and learning strategies. The educational large model can dynamically adjust according to the individual interests and academic progress of the apprentices. For instance, Guangzhou Institute of Technology adopts learning modules to enhance the practical teaching. This ensures that apprentices can effectively apply theoretical knowledge to real situations, significantly improving practical skills [14]. Through modular learning, apprentices not only acquire professional technical knowledge but also cultivate key abilities such as teamwork, communication, and problem-solving. At the same time, simulation training reduces the risks of actual operations and consolidates and improves skill levels through repeated practice.

In conclusion, the introduction of the educational large model injects new vitality into the modern apprenticeship system, enabling it to play a greater role in vocational education and promoting the overall improvement of educational quality [2], [18]. This model has enhanced learning efficiency, cultivated highly skilled talents that better meet the demands of enterprises, and established a virtuous cycle that promotes the development of vocational education. Therefore, the successful implementation of modern apprenticeship system depends not only on the close cooperation between enterprises and vocational schools, but also on the intelligent support provided by the educational framework [2].

V. CHALLENGES AND FUTURE DIRECTIONS

ELMs play a significant role in enhancing educational quality and achieving personalized learning. However, their wide application still faces several key challenges, such as data privacy issues and algorithmic bias problems.

Data privacy challenges. Educational AI models require a large amount of user data for precise analysis, including learning behaviors and personal backgrounds, etc. However, the process of data collection and storage can easily lead to privacy leakage. To address this issue, the introduction of blockchain technology can be considered. It ensures data ownership through a distributed ledger and achieves complete traceability. For example, smart contracts can be used to manage data access rights, thereby protecting sensitive information and improving transparency.

Algorithmic bias problems. The logic of decisions made by large educational models is limited by the inherent biases in the training data, which can affect the accuracy of their outputs. For instance, if the training data of the model fails to adequately cover different cultural backgrounds or groups with special needs, this may exacerbate educational inequality. Future research should focus on improving algorithms, establishing indicators for evaluating fairness, and adopting dynamic calibration methods to reduce errors. Additionally, a multi-party ethical review framework must be established to ensure that model design can meet the actual needs of various apprenticeship training programs.

The sustainable development of ELMs require a balance between technological innovation and ethical practices, constructing a trustworthy intelligent education ecosystem through interdisciplinary collaboration (such as educational science, data security, and algorithm ethics). Only by balancing efficiency with fairness, and technological empowerment with inclusive accessibility, can the educational large model transform from "tool enhancement" to "value creation".

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