A Review of Research on the Transformation of Scientific and Technological Achievements in Higher Vocational Colleges in China

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Abstract

The article places particular emphasis on the review of research on the transformation of scientific and technological achievements in Chinese higher vocational colleges. The analysis indicates that existing literature primarily focuses on exploring the pathways for achievement transformation, investigating practical dilemmas and corresponding countermeasures, innovating evaluation mechanisms and developing collaborative models for industry-education integration. Key challenges identified in the transformation process include issues related to financial management, incentive systems, intellectual property protection, and the insufficient depth of school-enterprise cooperation. Moreover, the review provides targeted proposals informed by the principles of industry-education integration, scientific research and education synergy, and the innovation value chain. Additionally, the paper also draws attention to new research applying contemporary techniques such as machine learning and Principal Component Analysis (PCA) to assess technological outcomes and talent. The study also examines broader macro-level issues, including the distribution of technological talents, the involvement of young scientific and technological personnel in transformation activities, and reforms to the classification and evaluation systems for such achievements. To sum up, under the unique background of China's higher vocational education sector, the direction of improving the efficiency of scientific and technological achievements transformation is proposed while consolidating existing knowledge.

Keywords

Higher vocational colleges, Transformation of scientific and technological achievements, Industry-education integration, School-enterprise cooperation

Introduction

Constituting an integral component of China's higher education system, vocational colleges play a unique role in the promotion of regional industrial upgrading and the facilitation of industry-education integration through the transformation of scientific and technological achievements [1]. Nevertheless, the current practices of technology transfer in this domain remain confronted with a range of practical challenges, including inadequate institutional mechanisms and a lack of sufficient incentives [2]. Therefore, systematically reviewing the connotation, current status, influencing factors, and improvement strategies of scientific and technological achievements transformation in vocational colleges is of great significance for promoting the development of theory and practice in this field [3].

This article provides a comprehensive examination of research on the transformation of scientific and technological achievements in vocational colleges. Firstly, it will elucidate its core connotation, unique characteristics, and multidimensional value orientation. Secondly, it will analyze the overall current status of transformation, the practical dilemmas faced, and the key constraints. Next, it will explore the key factors that affect transformation efficiency and the related evaluation system. Then, it will summarize and generalize diversified transformation paths, modes, and mechanism innovations. Finally, it will propose strategies and countermeasures to enhance transformation efficiency from macro, meso, and micro levels. It also systematically identifies existing research gaps and future directions to facilitate theoretically grounded and practically actionable improvements in technology transfer practices within vocational

education.

Connotation, characteristics, and multidimensional value

Connotative and characteristics

The transformation of scientific and technological achievements in higher vocational colleges is defined as the process in which practical outcomes generated through scientific research and technological development are deployed into real-world production and service activities. Such implementation ultimately gives rise to novel technologies, processes, products, or professional services. Its connotation entails not only the direct transfer of technology but also a complex ecosystem involving innovation, entrepreneurship, talent cultivation, and industrial services. Currently, most studies on the transformation of scientific and technological achievements in higher education institutions tend to focus on holistic discussions at the macro level, lacking detailed differentiation and in-depth analysis of higher vocational colleges as a specific object [4]. This gap has given rise to an inadequate recognition of the distinctive connotations and pathways inherent in technology transfer within vocational colleges. Therefore, an in-depth analysis of the connotation of scientific and technological achievement transformation in higher vocational colleges requires a holistic perspective. Key dimensions to be considered include the construction of external ecosystems, constraints of internal capabilities, and the design of evaluation and incentive mechanisms. Its type also needs to evolve from a single linear model to a diversified and collaborative ecosystem model [5].

With regard to features, the transformation of scientific and technological achievements in higher vocational colleges that exhibits distinct application orientation and regional embeddedness [6]. It is intricately linked to local industrial needs, with a particular emphasis on applied fields such as cultural creativity, e-commerce, information technology, and new materials. However, some higher vocational colleges still lack substantial competitive advantages in the transformation of scientific and technological achievements. Therefore, it is critical to strengthen their transformation mechanisms and capabilities to effectively underpin technological upgrading and sustainable development in regional industries. Improving the transformation rate of scientific and technological achievements has become the top priority for the development of higher vocational colleges [7]. In terms of types, the transformation of scientific and technological achievements in higher vocational colleges goes beyond conventional technology transfer and licensing. It also includes the development of a full-chain incubation model that integrates incubation and acceleration services. This model helps to build a collaborative innovation ecosystem featured by the integration of achievement transformation, entrepreneurship incubation, and talent cultivation.

Multidimensional value

The value of the transformation of scientific and technological achievements in higher vocational colleges is a multifaceted complex encompassing economic and industrial drive, educational talent cultivation, and innovative ecosystem construction.

Firstly, at the level of economic and industrial value, the transformation of scientific and technological achievements serves as a critical enabling vocational colleges to directly contribute to local industries and foster the high-quality development of the regional economy [8]. Through the application of technological achievements to specific industries such as cultural creativity and e-commerce, vocational colleges can assist enterprises in technological upgrading and product innovation, thereby promoting the improvement and enhancement of the industrial chain. This necessitates that the transformation work must closely align with regional industrial development plans, forming precise technology supply. However, a study points out that some vocational colleges have not yet developed this transformation advantage, resulting in a gap between their technical support capabilities and the needs of regional industries.

Secondly, from the perspective of educational and talent value, the process of transforming scientific and technological achievements exhibits deep integration and mutual interconnection with talent cultivation and innovation and entrepreneurship education [9]. It offers students authentic project practice scenarios and serves as an essential element in cultivating applied technical talents. In the meantime, the transformation activities themselves serve as an important carrier for nurturing

the spirit and ability of teachers and students in innovation and entrepreneurship. The evaluation of scientific and technological achievements transformation in higher vocational colleges should go beyond purely economic indicators. It should also integrate contributions to the development of teachers' and students' innovative and practical capabilities into its value framework, so as to establish a more scientific and development-oriented talent incentive and evaluation system.

Finally, in terms of the value of the innovation ecosystem and system, the transformation of scientific and technological achievements in higher vocational colleges is oriented toward the establishment of an open, collaborative, and sustainable innovation ecosystem [10]. This positioning goes beyond the transformation of individual technology projects, emphasizing the integration of resources from multiple parties such as the government, industry, schools, and research institutions through the development of entrepreneurship parks and the creation of collaborative innovation platforms. For example, building a scientific and technological achievements evaluation system based on machine learning which coupled with image feature retrieval to improve the flexibility and scientificity of evaluation.

Current situation and predicaments

Current situation

The conversion of scientific and technological achievements in higher vocational colleges serves as a key driver for fostering local economic and social development, enabling industry-education integration, and augmenting the technical service capacity and brand equity of these institutions. Concerning output, the scientific and technological achievements of higher vocational colleges mainly revolve around the technological development, innovation, and application needs of regional industries, formed through industrial teaching and scientific research activities. Compared to the achievements of ordinary undergraduate colleges, they are widely regarded as offering greater benefits in the realms of technological transformation and application potential [11]. However, research to date has highlighted that this potential advantage has not been fully demonstrated in practice. The transformation rate of scientific and technological achievements in higher vocational colleges remains persistently low. This rate presents a substantial gap compared with that of large enterprises, thereby inadequately meeting the urgent demands of industry-education integration reforms and the industrial transformation and upgrading at the regional level.

As observed in regional contexts, this transformation dilemma is universal [12]. For instance, in Guangdong Province, although higher vocational education has developed rapidly and the number of technological achievements has increased significantly, the transformation rate remains subject to multiple constraints and has improved only gradually. Higher vocational colleges in Shandong Province also exhibit prominent problems, such as impediments to the conversion of technological achievements, low transformation rates, and a single transformation model. These phenomena collectively reflect a core contradiction. Higher vocational colleges serve as a vital pillar for cultivating applied technical and skilled talents and advancing regional technological innovation. Nevertheless, their efficiency in transforming scientific and technological achievements still lags significantly behind the expectations of regional economic development. Some professional undergraduate colleges, as an advanced tier of higher vocational education, likewise demonstrate shortcomings in the transformation of technological achievements, characterized by inadequate technical support for such transformation and an urgent need to strengthen the upgrading of the regional economy. Therefore, identifying and mitigating the constraints within the transformation process have become pivotal to achieving high-quality development in the transformation of technological achievements in higher vocational colleges.

Predicaments

The low transformation rate of scientific and technological achievements in higher vocational colleges is caused by a series of interrelated and intricate constraints and "blockages". Through a systematic review of the extant body of literature, the aforementioned key constraints can be distilled into four primary aspects: institutional mechanisms, subject capabilities, resource channels, and environmental ecology. Their specific manifestations and correlations are shown in Table 1 below.

Table 1. Analysis of key constraints on the transformation of scientific and technological achievements in higher vocational colleges.

Constraint level	Specific manifestations
Systems and mechanisms	The evaluation and incentive system are not sound. The intellectual property system lags behind. Weak financial management system. The internal management system is unreasonable.
Subject and ability	Insufficient quality and practicality of achievements. Lack of professional talent team. Limited motivation and ability of scientific researchers.
Resources and channels	Information channels are obstructed. Capital investment and financing remain insufficient. The construction of the transformation platform lags behind.
Environment and ecology	A diversified and collaborative ecosystem has not yet been formed. The market's driving effect is not strong. The regional transformation environment is not ideal.

Table 1 systematically uncovers the complexity and multidimensional inherent in the dilemma of transforming scientific and technological achievements in higher vocational colleges.

Firstly, the "blockages" at the institutional and mechanism levels are fundamental obstacles [13]. An unsound scientific and technological evaluation system - for instance, one that prioritizes academic papers over technology transfer - directly causes research priorities to deviate from market needs. A backward intellectual property regime also fails to provide researchers with stable expectations about benefits and risks, thereby dampening their motivation to engage in transformation activities. The imperfections in internal management systems such as financial management further restrict the standardization and efficiency of transformation activities at the operational level [14].

Secondly, issues at the subject and capability levels are related to the foundation of transformation. The quality of achievements is the prerequisite for transformation, and currently, some achievements are "of low value" and "disconnected from the training objectives of applied technical and skill talents", reducing their market appeal. At the same time, the severe shortage of professional transformation talents - namely, technical managers - prevents even potentially valuable achievements from crossing the "valley of death", owing to a lack of professional evaluation, negotiation, and operational capabilities.

Furthermore, obstructions at the resource and channel levels directly affect the transformation process [15]. Information asymmetry stands as one of the foremost obstacles to collaboration between schools and enterprises, as both supply and demand sides are dispersed and an efficient matching platform is lacking. The shortage of funds, especially the lack of market-oriented venture capital for early-stage achievements, makes it difficult for many projects to cross the "funding gap" from the laboratory to pilot testing. Ultimately, shortcomings in environmental and ecological dimensions exacerbate the above-mentioned issues. The cultivation of a sound transformation ecosystem necessitates joint participation from governments, enterprises, universities, and intermediary institutions.

However, in practice, the driving role of the government, the dominant role of enterprises, the facilitating function of the market, and the bridging role of intermediaries have not been fully exerted. This hinders policy implementation and interest coordination among multiple stakeholders, thereby disrupting the overall transformation chain. These four levels are intertwined and collectively constitute the core dilemma of the transformation of scientific and technological achievements in higher vocational colleges.

Path optimization and strategy innovation

Core mechanism construction

The effective construction of a mechanism for the

transformation of scientific and technological achievements constitutes a pivotal hub linking technological innovation to regional industrial development.

The motivation and incentive mechanism aim to address the inherent driving force issues faced by vocational colleges and their scientific researchers in the transformation of scientific and technological achievements [16]. Existing research has identified divergent focuses and potential frictions in incentive orientation and institutional design. On the one hand, studies emphasize stimulating vitality by refining internal scientific research management systems and establishing value recognition mechanisms. For example, Shanxi National Defense Industry Vocational and Technical College has effectively enhanced its scientific and technological innovation vitality by optimizing its scientific research management system. Conversely, relevant studies also highlight the prevalent dilemmas inherent in current incentive mechanisms, especially in the field of horizontal cooperation. Theoretical divergence lies in whether incentives should focus primarily on internal system optimization and value guidance, or prioritize addressing practical obstacles such as external market linkage and achievement quality to establish effective feedback. The two complement each other, but the choice of policy focus may lead to different practical paths.

The mechanism of collaboration and integration focuses on breaking down organizational and domain barriers to build an efficient network for technology transfer. Most studies emphasize the construction of collaborative platforms and carriers involving multiple stakeholders. Through the establishment of academic-local technological cooperation platforms, targeted services can be directly delivered to regional SMEs in accordance with their actual production demands, thereby realizing precise matching.

In terms of the depth of collaboration, research shows a theoretical trend towards development from “project matching” to “system integration”. A deep level of integration is reflected in the synergy between technology transfer and talent cultivation. For example, by designing pathways such as “famous teachers and doctoral students in the classroom” and “student research assistants”, the scientific research process is effectively integrated into the core educational link. Based on the integrated analytical framework of Technology-Organization-Environment (TOE), it is further argued that innovations in organizational mechanisms are required to enhance the collaboration between research outcome transformation and talent cultivation [17].

Professional talent cultivation

Talent serves as the core driving force for the transformation of scientific and technological achievements, and its evaluation and incentive mechanisms directly affect the efficiency of the transformation process [18]. As the core actors in the transformation process, the participation of young scientific and technological talents in universities exerts a direct impact on the implementation effectiveness of the innovation-driven power strategy. Currently, the scientific research evaluation criteria for this group are often inconsistent with the needs of scientific and technological achievement transformation. This inconsistency has led to a “career development paradox”, as the traditional academic evaluation system fails to fully acknowledge their contributions to transformation practices. Consequently, these individuals lack sufficient intrinsic motivation to participate in achievement transformation activities. This highlights the importance of reconstructing diversified research evaluation criteria and optimizing the structure of the rights and interests distribution mechanism. At the same time, a regional imbalance exists in the distribution of scientific and technological talents in China, and the resulting risk situation is not optimistic. This uneven distribution may further widen the disparity in innovation capability and economic development levels across regions. Research shows that only by coordinating talent cultivation and economic development can we promote the healthy, stable, and balanced development of regional society and economy. To this end, it is necessary to adopt measures such as optimizing industrial structure, ensuring population size and quality, strengthening technological innovation, and enhancing talent introduction and support.

For higher vocational colleges, building an in-house scientific and technological talent team also constitutes an important approach to advancing the transformation of research achievements, which necessitates the

integration of talent “introduction and cultivation” [19]. The cultivation of technology transfer talents must consider the “stickiness” to projects, and internalized cultivation is a good implementation path. For instance, universities may develop and nurture internal technology transfer intermediaries, including research secretaries, key team leaders, and core platform staff. This approach not only lowers the costs associated with recruiting external intermediaries but also enhances the institution’s own capacity to support the transformation of scientific and technological achievements. The primary objective is to deploy a contingent of professional and vocational technology transfer talents to the forefront of advancing the transformation of scientific and technological achievements in institutions of higher education, truly playing the role of identifying achievements and matching needs. A greater number of professionals with an understanding of the industrial value of scientific and technological achievements can foster the creation of more research outcomes that align with industrial demands.

Resources and channels

Resources and channels serve as the fundamental conditions for providing continuous support and empowerment for the transformation of scientific and technological achievements [20]. The core support lies in cultivating technological innovation capabilities. This involves constructing a variety of technological innovation platforms, nurturing skilled technical personnel, and organizing research teams to enhance original innovation capabilities. Meanwhile, strengthening intellectual property management and improving patent application quality serve as key initiatives to solidify the legal and value foundation for achievement transformation.

Providing professional services across the entire chain is an important supporting means. Beyond the aforementioned full-chain “incubation-acceleration” service model, specific service forms include converting scientific and technological achievements into teaching resources, jointly delivering technical training with enterprises, carrying out demand-driven technological Research and Development (R&D) for enterprises, and promoting on-site transformation through technology docking. These services are designed to mitigate friction and costs in various transformation links. Current scholarly debates center on whether the development of support mechanisms should prioritize investing in enhancing internal R&D capabilities and the quality of outcomes, or whether it should focus on building a comprehensive external service network and transformation channels.

Ecological advancement

Given the significant differences in school positioning, professional characteristics, and regional industrial environments among higher vocational colleges, a blanket “one-size-fits-all” transformation strategy yields limited effectiveness, and it is thus imperative to adopt an ecological promotion strategy. The theoretical underpinning of this strategy rests on the recognition that technological achievements across diverse professional fields and with varying levels of maturity feature distinct transformation models, resource demands, and constraints.

Engineering technological achievements that are closely associated with regional leading industries require targeted development strategies. For such achievements, efforts should focus on deepening industry-education integration with key enterprises and co-constructing industrial colleges or collaborative innovation platforms. Through customized Research and Development (R&D) and embedded collaboration, these efforts can effectively promote technological upgrading and productization. For some original achievements with great market potential but still in the laboratory stage, the strategy should focus on providing early-stage incubation support, including concept verification, seed funding support, and connecting with venture capital. This requires the establishment of a flexible achievement disposal mechanism within the school and an external diversified funding support system.

The ecological promotion strategy is also reflected in the definition of roles for different participating entities. Policy makers need to recognize that the government, enterprises, schools, and intermediary organizations should play different yet collaborative roles in transforming the ecosystem. The government ought to enhance the policy guarantee system, deliver stable support in funding, taxation, and intellectual property allocation, and eliminate institutional impediments. Enterprises should participate deeply as demand proposers, collaborative R&D partners, and outcome

recipients. Higher vocational colleges ought to strengthen their transformation-oriented awareness, advance technological innovation capabilities, and refine internal mechanisms for the transfer of research outcomes.

Conclusion

This paper systematically reviews the research trajectory in relevant fields, with its main analysis conducted from two perspectives: macro-level evaluation and support mechanisms, and micro-level practices and dilemma resolution. Macro-level research emphasizes the construction of an evaluation system and support framework that integrate multifaceted elements such as talent cultivation, financial investment, and intermediary services. Micro-level research, by contrast, focuses on the specific institutional barriers and practical challenges encountered by individual institutions in the process of transforming scientific and technological achievements. Existing research generally acknowledges that the key to enhancing transformation efficiency lies in constructing an innovative ecosystem with multi-party collaboration and well-established mechanisms. By optimizing internal management and deepening external cooperation, bottlenecks in transformation can be overcome, thereby better serving regional industries and economic development.

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Conflicts of Interest

The authors declare no conflict of interest.

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