

ORIGINAL ARTICLE

Precise institutional supply pathways to address faculty shortages in German vocational schools

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ABSTRACT

This study aims to explore Germany's systemic experience in addressing vocational education teacher shortages, to provide insights for developing China's "dual-qualified" teaching workforce and tackling the global shortage of vocational instructors. Employing a literature analysis method, the research systematically examines Germany's institutional reform pathways since the late 20th century. The findings reveal that Germany effectively alleviated teacher shortages through an integrated institutional approach combining "entry system innovation-training system optimization-incentive system reconstruction". This approach formed a model vocational teacher supply system. However, the study also identifies persistent challenges within the German model: balancing vocational and academic values, coordinating short-term demands with long-term standards, and effectively integrating cross-state collaboration mechanisms. The conclusion emphasizes that continuous institutional optimization is necessary to address these issues.

Key words: Germany, vocational schools, faculty shortage, institutional supply

INTRODUCTION

Vocational education and training systems play a crucial role in preparing young people for employment, cultivating vocational skills, and meeting the demands of social and economic development for high-quality technical and skilled talents. Among these systems, vocational education teachers have a positive impact on learners' skill improvement, employment competitiveness, and career development. However, the marginalized position of vocational education in modern education systems has become an increasingly widespread reality worldwide. Behind this phenomenon lies the cognitive deviation of society toward the value of vocational education, which has triggered a deep-seated crisis through the shortage of vocational education teachers. According to a survey by the Organization for Economic Cooperation and Development (OECD) in South Korea, between 2015 and 2019, the supply of

vocational education teachers reached approximately only 70% of the demand (OECD, 2021a). In 2017, the retention rate of vocational education and training teachers in the UK was only 79%—lower than the average retention rate of the country's labor force, at 83% (OECD, 2021a). Sweden predicts that during the period from 2019 to 2033, the supply of vocational education and training teachers will not reach half of the demand (OECD, 2021a). Half of the states in the United States and one-third of vocational education and training principals in Denmark, Portugal, and Turkey have reported a shortage of teachers (OECD, 2021b). Due to a lack of support or incentives as well as conflicts with teachers' work schedules, vocational education teachers often face obstacles in obtaining training (OECD, 2021b). How to effectively deal with the challenge of a shortage of vocational education teachers and ensure the continuous and stable supply of vocational education teachers have become an important issue that all

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countries urgently need to solve. Even Germany, where the vocational education system is highly developed, has not been spared from a shortage of vocational education teachers, especially in terms of the supply of teachers in vocational schools. Since the end of the 20th century, Germany has intensively implemented a series of targeted measures to actively address the shortage of teachers in vocational schools and has accumulated valuable experience. This study finds that Germany starts mainly from three key dimensions—the reform of the access system, the optimization of the training system, and the reconstruction of the incentive system to precisely construct the institutional supply system, effectively break the deadlock regarding the shortage of teachers in vocational schools, and provide a governance solution that can be referred to around the world.

RESEARCH DESIGN

This study employs document analysis to systematically examine the institutional supply pathways adopted by Germany to address the shortages of vocational school teachers. The research integrates multi-source data and conducts cross-validation to establish a comprehensive chain of evidence, specifically including: (1) Resolutions concerning vocational school teachers issued by the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (Kultusministerkonferenz, KMK) from the late 20th century to 2024. (2) Legal documents related to vocational school teachers published on the official websites of the German federal states (Länder). (3) Teacher training programs published on the official websites of higher education institutions responsible for training vocational school teachers. (4) Relevant authoritative academic studies and research reports. (5) Data from the German Federal Statistical Office (Statistisches Bundesamt).

The literature screening criteria were closely aligned with the institutional design of vocational school teachers in Germany across three dimensions: access, training, and incentives. Typical cases were selected for in-depth analysis.

Building on this, the research first clarifies the current situation and underlying causes of the teacher shortage in German vocational schools. It then conducts a detailed analysis of the specific measures and characteristics of Germany's institutional design for vocational school teachers, focusing on the aforementioned three core dimensions. Finally, it reveals the effectiveness of the relevant German institutions in alleviating the teacher shortage and the challenges the country will continue to face in the future.

To enhance the applied value of this research, we

summarize and distill the German experience, aiming to provide potential lessons for the institutional development of "dual-qualified" teachers in China. This is intended to contribute valuable insights to the governance of international vocational education.

It should be noted that this study has certain limitations: The accessibility of some German-language literature was restricted, and the collection of educational policy details across the Länder might be incomplete. This may have somewhat affected the representativeness of the sample. Future research could consider expanding the sample size or employing diverse research methods to further validate the findings of this study.

STRUCTURAL DILEMMA: CURRENT STATUS AND CAUSES OF FACULTY SHORTAGES IN GERMAN VOCATIONAL SCHOOLS

Germany has established a diverse large-scale secondary vocational education system and has formed a systematic training model through the process of professional development for vocational school faculty. However, since the late 20th century, German vocational schools have faced increasingly severe faculty shortages. This predicament not only constrains the sustainable development of vocational education but also poses a potential threat to Germany's proud dual vocational education model.

Distribution characteristics of German vocational schools

As is widely known, the dual vocational education and training system is Germany's secret weapon for economic takeoff, and the stable operation of this system relies on its diversified vocational school system. According to the latest data for the 2023/24 academic year from the German Federal Statistical Office, Germany's 8315 vocational schools form a collaborative development pattern of 10 major types. Among these, specialized vocational schools (Berufsfachschulen), which account for 26%, with 2172 institutions; part-time vocational schools (Teilzeit-Berufsschulen), which represent 18%, with 1469 institutions; and technical schools (Fachschulen), which constitute 17%, with 1442 institutions, form the main framework. These are complemented by distinctive educational systems, such as the vocational preparatory year (Berufsvorbereitungsjahr), the full-time basic vocational education year (Berufsgrundbildungsjahr in Vollzeitschulischer Form), and vocational advancement schools (Berufsaufbauschulen; Statista, 2024c), creating a complete training chain from vocational preparation services to advanced studies. In terms of spatial distribution, vocational education resources have demonstrated a significant

clustering effect. Fifty-one percent of the country's vocational schools are concentrated in the three economically strong states of Baden-Württemberg (1578 schools), North Rhine-Westphalia (1550 schools), and Bavaria (1056 schools), which undertake 55% of vocational faculty training tasks (Statista, 2024b). This symbiotic model of industrial highlands-educational clusters effectively supports the economic development of various states. Germany's dual system provides standardized training for secondary vocational students in 86 officially certified professional fields. Nearly 1.29 million trainees have completed dual-system training (Bundesinstitut für Berufsbildung, 2022), which continuously supplies high-quality, technically skilled talent for Germany's industrial transformation and upgrading. Through a dual training mechanism that combines enterprise practical training and theoretical learning, graduates become an important cornerstone for guaranteeing the quality of German manufacturing.

Current status of faculty shortages in German vocational schools

The continuous and stable operation of dual vocational education in Germany relies on a sound supply mechanism for vocational schoolteachers. However, since the end of the 20th century, the quality of dual vocational education has gradually been threatened by an insufficient supply of qualified teachers in vocational schools. The development of teaching staff in German vocational schools is confronted with the following outstanding issues. First, the ratio of teachers to students in vocational schools is unbalanced. With the number of teachers having long remained at around 110,000 (Statista, 2025) and the number of students enrolled being approximately 2.3 million (Statista, 2024a), the student-teacher ratio is approximately 1 : 21. This is higher than the average student-teacher ratio of 1 : 15 in vocational education and training in OECD countries (OECD, 2023). Due to the sharp increase in Germany's birth rate since 2010, the number of students enrolled in primary and secondary schools has increased significantly in recent years. It is estimated that the total number of students in the 2030/31 academic year will reach 11.7 million, which will increase to 11.8 million in the 2035/36 academic year (Geis-Thöne, 2022), which will bring greater challenges to the supply of vocational schoolteachers. Second, the aging of vocational schoolteachers is relatively serious because the proportion of teachers over the age of 50 has long remained above 45% (Brinkmann *et al.*, 2017). In the 2015/16 academic year, the proportion of teachers aged 50 and above in German vocational schools was as high as 49.09% (Zorn, 2017). Third, the retention rate of vocational school faculty training is insufficient. Of the approximately 52,500 first-year vocational school faculty trainees nationwide each year, only approximately half

(approximately 28,300) complete bachelor's degree training (Brand, 2024). Fourth, the proportion of faculty with teaching qualifications in vocational schools is relatively low. According to data for the 2022/23 academic year, of the nearly 770,000 full-time and part-time faculty members working in general and vocational schools, fewer than 115,000 taught in vocational schools (Klinger, 2024). On average, only 41.70% of faculty members in vocational schools possess vocational teaching qualifications, with West Germany accounting for 41.55%, East Germany accounting for 34.35%, and city states accounting for 56.65% (Klinger, 2024). Fifth, there is a structural shortage in the vocational teaching workforce. Vocational school faculty trainees are primarily distributed in larger technical subject areas, such as business, metal technology, nutrition, electrical engineering, and health, which account for more than two-thirds of all trainees (*e.g.*, 81% in Berlin and 70% in Bavaria; Rackles, 2020). At the same time, there is a severe shortage of faculty trainees in technical subjects, such as electrical engineering, automotive technology, mechanical engineering, and computer science (Rackles, 2020).

According to the German ministers of education and culture, there was a shortage of approximately 700 vocational school faculty members in Germany in 2020 (Kesper, 2025). The report "Faculty Recruitment Needs and Supply in Germany 2023-2035—Comprehensive Model Calculations of the Federal States", published by the Secretariat of the Standing Conference of the Ministers of Culture in 2023, which predicted recruitment needs and supply for the next 12 years, stated that the supply situation for secondary education (vocational subjects) and vocational school faculty is very tight nationwide (KMK, 2023). It is estimated that from 2023 to 2035, the total number of graduates prepared for secondary education (vocational subjects) and vocational school faculty will reach 36,200, while the number of faculty members needed to be recruited during the same period will be 58,300 (Table 1; KMK, 2023). Therefore, throughout the entire forecast period, the number of vocational school faculty members available for recruitment will be severely insufficient.

Causes of faculty shortages in German vocational schools

Since the end of the 20th century, the supply system of vocational schoolteachers in Germany has faced multiple challenges, which can be summarized by three core issues: the high-cost predicament of the entry threshold, the structural defects of the training model, and the constraints of the vocational environment. These deep-seated problems are intertwined and accumulated, not only exacerbating the shortage of teachers in vocational schools but also posing a severe challenge to the

Table 1: Forecast model of the demand for and supply of secondary education (vocational) and vocational school faculty members (2023-2035)

Year	Number of faculty members required	Number of faculty members supplied	Shortage of faculty members
2023-2025	12,800	8000	4800
2026-2029	16,200	11,200	5000
2030-2035	29,400	16,900	12,500
Total	58,300	36,200	22,100

Compiled and analyzed from the data presented in the KMK (2023).

sustainable development of the dual vocational education system in Germany.

Regarding the high-cost predicament of the entry threshold, Schultz (1961) pointed out that the formation of human capital requires long-term and high-cost investment, but its returns may not match the investment cost due to policy or market restrictions. Educational investment has become almost a synonym for human capital theory (Bluag, 1976). When individuals decide whether to invest in education, they weigh the cost against the expected returns. However, the high complexity and regional fragmentation of the access system for vocational schoolteachers in Germany pose significant obstacles to this investment. From a vertical process perspective, obtaining teaching qualification in Germany follows an extended multi-phase pathway: It commences with a three-year bachelor's degree, followed by a two-year master's program or successful completion of the First State Examination, then proceeds to 12-24 months of preparatory service (Vorbereitungsdienst), and culminates in passing the Second State Examination. Generally speaking, the entire training period lasts as long as seven years. Such a high investment in time exposes potential teachers to a high opportunity cost. If the salary or social status of the teaching profession cannot match this investment, rational individuals will turn to other, more attractive fields. Furthermore, educational autonomy under the federal framework leads to differences in admission standards among states, forming barriers to cross-state teacher mobility. Schultz (1961) emphasized that the specificity of human capital would suppress its mobility and that regional policy barriers in Germany further strengthen this effect, making teacher human capital a state-exclusive asset and weakening the elasticity of teacher supply. The superimposition of such high time costs and regional policy barriers not only reduces the investment willingness of potential teachers but also hinders the optimal allocation of teaching staff, ultimately leading to the inefficiency and shortage of the system supplying teaching staff.

Regarding the structural flaws in the training model, the first is that vocational school teacher training institutions

are relatively single. For a long time, the training of vocational schoolteachers in Germany has relied on comprehensive universities as a supply channel. This single model makes it difficult to achieve large-scale training to meet the huge demand for teachers in the vocational school system. The second issue is that the curriculum system is poorly connected. Driven by the Bologna process, although higher education in Germany has completed the transformation from the traditional two-level degree system to the internationally recognized three-level degree system of bachelor's, master's, and doctoral degrees, there are still problems such as loose course connection at the undergraduate and postgraduate stages and a lack of modular design in the training of vocational schoolteachers in some federal states. The curriculum system shows fragmented characteristics that deeply restrict the systematicity and professionalism of teacher training. The third point is that there is an obvious imbalance in the curriculum structure. Germany has established a continuous training program of "undergraduate courses + master's courses" based on the European Credit Transfer and Accumulation System (ECTS). The proportion of school internships in the course study is relatively low, and a linear training model of "theory first, practice later" is generally adopted. This curriculum structure, which emphasizes theory over practice, highlights the academic tendency and contradicts the essential requirement of vocational education that stresses teaching practice ability.

Regarding the systematic constraints of the professional environment, at the level of professional identity, a higher professional status is crucial for the self-identity of professionals (Liu *et al.*, 2014), since people with a higher professional status are more likely to receive respect. On the contrary, a lower professional status leads to the insufficient professional identity of individuals (Anderson & Kilduff, 2009). The traditional academic atmosphere in Germany has exacerbated the marginalization of vocational education. Teaching industrial technology is often regarded as a career alternative for those who have failed to become engineers. Meanwhile, at the career development level, some vocational schoolteachers in federal states are

confronted with issues such as blocked promotion channels, the increasing complexity of teaching tasks due to digital transformation (Seifried, 2023), and insufficient career security. Under this combined influence, according to a survey by Guo (2024), 36% of teachers indicated that they felt emotionally exhausted every week, and 12% even felt exhausted every day, which further exacerbated the teacher turnover rate.

GERMANY'S INSTITUTIONAL SUPPLY PATH TO DEAL WITH THE SHORTAGE OF VOCATIONAL SCHOOLTEACHERS

Innovation of access mechanism: a paradigm shift from standardized selection to flexible supply

Facing the high-cost predicament of the entry threshold for vocational schoolteachers, Germany has relaxed both the academic and vocational access systems and established a cross-state coordination mechanism. This series of reforms has presented an important shift in the German vocational schoolteacher education system—namely, a paradigm transformation from standardized selection to flexible supply, which not only effectively broadens the channels for talent absorption but also promotes the rational flow of teacher resources.

Academic access flexibility reform: flexible horizontal admission paths

Traditional vocational schoolteacher education courses in Germany have high requirements for learners' academic backgrounds and practical experience. To further expand the student source, attract more talents with a professional background and work experience to join the teaching staff, and increase the stock of vocational schoolteachers, Germany has relaxed the admission conditions for teacher education and launched a horizontal admission plan. Horizontal enrollment refers to the entry of students not majoring in teacher education into teacher education majors for study. Through this unconventional path, learners are incorporated into preparatory teams of vocational schoolteachers. In the traditional training path, vocational schoolteachers need to complete teacher education courses at the undergraduate and master's levels, strictly following the two-subject principle (Zwei-Facher-Prinzip)—that is, having the qualifications to teach in two professional fields. The "Recommendations on Addressing the Shortage of Teachers" issued by the SWK (Ständige Wissenschaftliche Kommission) in 2023 clearly stipulate that students entering the field horizontally need to complete a preparatory service period that includes theoretical study and practical teaching, usually over 1-2 years, and pass a second national examination before they can obtain the teaching qualification (SWK, 2023). It is worth noting that the

"Measures for Attracting More Teachers and Structurally Supplementing Teacher Training" issued by the KMK in March 2024 achieved a policy breakthrough (KMK, 2024a). This document establishes a "single-subject teacher qualification certification" system, allowing those who meet the following conditions to enter the preparatory service period: (1) possessing a university degree not related to education and (2) completing a single-subject master's program. This move not only breaks through the traditional framework of teacher education but also significantly broadens the admission channels through the diversification of qualification certifications.

Under this guidance, the horizontal admission paths implemented by federal states mainly include the following three models. First, the regular horizontal admission model allows graduates of university master's degree programs and equivalent degrees to participate in regular preparatory courses, which are also completed by teacher candidates with undergraduate qualifications. The degrees obtained from these courses are usually equivalent to or recognized as teacher-related degrees (Trampe, 2024). Second, the part-time horizontal enrollment model allows graduates of university master's programs and equivalent degrees to participate in preparatory courses. However, such preparatory courses are qualification certification measures specifically established for the target group, and preparatory services are completed concurrently with school service activities (Trampe, 2024). Third, the horizontal admission model with a specific subject-learning background allows students who have completed a bachelor's degree program in the field of engineering at any university to enter through horizontal enrollment. They can choose to pursue a master's degree program at either a comprehensive university or an applied science university that cooperates with a normal college. Before starting a master's degree program in education, it is possible to restudy and supplement the missing content in the modules of vocational disciplines, school practice, and education within the framework of the bachelor's degree program.

Empowerment of professional entry standards: formation of diversified faculty supplementation pathways

Based on expanding the stock of vocational schoolteachers in the reform of the access mechanism, Germany has expanded the growth of teachers by exploring diversified vocational access channels. Since the beginning of the 21st century, the KMK has gradually constructed a flexible and open faculty entry mechanism, with the core focus on absorbing talents with professional backgrounds not in faculty education into the teaching profession. In 2001, the term "lateral

entry" (Seiteneinsteiger) was first used in faculty recruitment statistics published by the KMK to refer to those who enter the teaching profession with university qualifications not in faculty education and without going through a preparatory internship period (*der Kultusministerkonferenz, 2001*). In 2009, the KMK formulated a demand-based training capacity management goal, "Joint Guidelines for Meeting Faculty Needs", which required "ensuring qualifications for horizontal and lateral (Quer- und Seiteneinsteigern) entry into the teaching profession" (KMK, 2009). Here, horizontal entry refers to entering preparatory service directly without passing the first state examination or obtaining a relevant master's degree in education. After completing preparatory service and passing the second state examination, these individuals have the same qualifications as education graduates. Lateral entry refers to entering school service without passing either the first or second state examinations. This type of entry usually adopts alternative qualification certification paths, such as modular courses or training during actual teaching work (Driesner & Arndt, 2020). In 2013, the KMK passed "Design Special Measures to Obtain Faculty Resources to Meet Teaching Needs", which proposed that "Special measures for faculty recruitment can be established for each state ... usually based on the corresponding valid versions of faculty training standards and joint agreements adopted by the KMK" (KMK, 2013a). In 2020, the KMK issued the "Agreement on the Common Basic Structure of the School System and the Overall Responsibility of the States in Central Education Policy Issues", Article 38 of which requires that "If, despite appropriate measures taken by the states, the need for faculty still cannot be met, the states may recruit and employ university graduates who have not received appropriate faculty training" (KMK, 2020a). Despite various variants and subtle differences in the KMK's recruitment requirements across different periods, they all indicate that states enjoy flexible recruitment authority.

Under the guidance of relevant KMK policies, German state governments have adopted flexible recruitment approaches to increase the number of vocational school faculty members, mainly through the following four methods. The first concerns the direct recruitment of part-time substitute faculty members with relevant subject backgrounds. According to the position requirements published by vocational schools in federal states, personnel with backgrounds in certain subjects can be directly hired as part-time substitute faculty members without going through the horizontal entry application procedure of the state education department. If applicants wish to become formal faculty members, their learning experience must cover at least two subjects that can be taught in vocational schools. The second

concerns special recruitment models for urgently needed subject areas that are in shortage. According to the position requirements published by vocational schools in the federal states, in areas with severe faculty shortages, such as physics and electrical engineering, applicants can enter vocational schools to teach through special channels, even if they have not obtained university degrees. Such applicants generally need to meet the following three conditions: obtain a master craftsman title, complete at least 1 year of subject knowledge training in their professional field, and participate in a 2-year preparatory service period. The third concerns recruitment models without restrictions on learning backgrounds. If applicants not only lack teaching methodology, educational subjects, and teaching knowledge in vocational subjects but also not take the national faculty qualification examination, they can enter the teaching field after undergoing qualification examinations and faculty training and passing the second state examination (Trampe, 2024). The fourth concerns qualified horizontal entry models for those with bachelor's/master's degrees. Graduates who have obtained bachelor's degrees or diplomas from universities of applied sciences and have completed university master's degree courses or equivalent degrees can be hired as faculty members and requalify in the fields of education, educational sciences, and teaching subjects in specific disciplines. If necessary, they requalify for a second subject according to their previous qualifications, after which they take the second state examination.

Through the above flexibility measures, federal states have effectively alleviated the vocational school faculty shortage while ensuring educational quality and have provided diversified pathways for talents with practical experience and professional backgrounds to enter the education industry. According to the Federal Statistical Office of Germany (Statistisches Bundesamt, 2024), in the 2022/23 academic year, of the 724,800 faculty in general education schools in Germany, approximately 71,100 entered schools through horizontal entry pathways, while of the 123,500 faculty in vocational schools, approximately 26,200 were horizontal entrants—a proportion twice that of general education schools.

Regional collaborative governance innovation: establishment of a cross-state faculty mobility support system

Due to the uneven distribution of vocational schools and teaching resources among the federal states of Germany, while taking as many measures as possible to ensure an adequate supply of teachers in each state, Germany is also committed to establishing a cross-state coordination mechanism for teaching supply to counter

the administrative barriers to the cross-state flow of vocational schoolteachers. This mechanism takes "federal coordination under a unified framework" as its core principle and, based on respecting the educational sovereignty of each state, realizes the optimal allocation of teacher resources. As early as 1999, the KMK issued the "Mutual Recognition Agreement on Teacher Qualification Examinations and Teacher Qualifications" (KMK, 1999), which stipulates that vocational schoolteachers who have passed the first and second national examinations must have their qualifications mutually recognized among states and that they can apply to enter the preparatory service period in other states after completing the first national examination. This means that applicants can apply to teach at vocational schools in other states after completing the preparatory service period and the second national examination, laying the foundation for the mutual recognition of qualifications for cross-state mobility. In 2009, the KMK first formulated its demand-based training capacity management objective, the "Joint Guidelines for Meeting the Needs of Teachers", which stipulates that "Each state will at least maintain the expected capacity of preparatory services to meet medium-term needs, or coordinate efforts with other states through cooperation to enhance their respective preparatory service capabilities as needed" (KMK, 2009). In 2013, the KMK passed the "Rules and Procedures for Improving Teacher Mobility and Quality" (KMK, 2013b), which states that states should mutually recognize secondary school Level 2 (vocational subjects) and vocational schoolteacher qualifications and allow vocational schoolteacher applicants to enter the preparatory service period and obtain teaching positions in other states. This measure further strengthens the legal guarantee of the cross-state mobility of teachers. In 2023, the KMK adopted the "Proposal on Addressing the Shortage of Teachers", further proposing that the recruitment procedures for teachers need to be coordinated among states, that cross-state transfers should be carried out, and that a unified qualification certification standard should be implemented. This will help promote the dynamic allocation of teacher resources. In 2024, the KMK successively released the "Tenth Report on the Implementation of Rules and Procedures for Enhancing Teacher Mobility and Quality-Federal State Joint Implementation Guidelines", which is used to adjust the rules and procedures for preemployment and school services (KMK, 2024b). The "Recognition of Learning and Examination Results in Teacher Education Courses" proposes ensuring, respectively, that flexible subject combinations can be recognized in preparatory services in each state and that vocational schoolteachers possess at least one occupation-related subject covering vocational fields such as technology, business, and handicrafts (KMK, 2024b). To ensure that the qualific-

ations of vocational schoolteachers are mutually recognized in principle among the states of Germany, this measure has upgraded from the mutual recognition of qualification examination results to the compatibility of the training process and has reduced administrative barriers by unifying preparatory services and onboarding procedures. This series of support policies indicates that the KMK, while respecting the autonomy of each state in teacher recruitment and subject requirements, provides a relatively unified policy framework for the cross-state mobility of vocational schoolteachers. This helps promote the cross-regional mobility of vocational schoolteachers and ensures that the vocational education needs of each state are met.

Training mechanism optimization: breaking the path dependency of traditional training models

It is widely believed in the German education circle that the root cause of the shortage of teachers in vocational schools lies in the fact that the existing training model is not designed to meet the teaching needs of vocational schools and that it cannot satisfy the actual teaching requirements. To this end, Germany has achieved systematic breakthroughs in training institutions, curriculum systems, and teaching models. Mainly through measures such as exploring cooperative training models, optimizing the structure of the curriculum system, and introducing the dual teaching model, it has overcome problems such as traditional single institutions training vocational schoolteachers, the loose connection between undergraduate and master's courses, and the separation of theory and practice in the training model and has comprehensively enhanced the ability to align teacher training with job requirements.

Cooperative training model innovation: supply breakthrough for technical subject faculty

The cooperative training model for vocational schoolteachers refers to German universities of applied sciences and comprehensive universities or normal colleges jointly offering courses, jointly conferring degrees, and cooperating in training vocational schoolteachers. This model expands training institutions for vocational schoolteachers. Traditionally, vocational schoolteachers in Germany have been independently trained by comprehensive universities. The cooperative training model for vocational schoolteachers began when applied science universities were officially incorporated into legal institutions for vocational schoolteachers. Since the late 20th century, Germany has faced increasingly severe faculty shortages in technical engineering fields. To meet the urgent demand for faculty in technical subject areas in vocational schools, Germany gradually emphasized the role of universities of applied sciences in vocational school faculty training.

In 1995, the KMK's "Framework Agreement for Training and Examination of Secondary Level II Faculty Qualifications (Vocational Subjects) or Vocational Schools (Faculty Qualification Type 5)" proposed that "studies and examination results obtained at universities of applied sciences can be credited as part of recognized bachelor's or master's degree programs" (KMK, 2018), thereby marking the formal inclusion of graduates from universities of applied sciences into the vocational faculty training system. In 2010, the German Federal Science Council proposed that universities of applied sciences expand their range of subjects and provide practical and professional study courses in all subject areas in which there is demand for corresponding vocational school faculty (Wissenschaftsrat, 2010), further establishing the legitimate basis for universities of applied sciences to participate in vocational faculty training. In the early 21st century, German universities of applied sciences successively cooperated with comprehensive universities and faculty colleges to conduct vocational school faculty training. By 2021, Germany had 52 vocational school faculty training centers, of which 23 had adopted cooperative training models, that were distributed across 11 states, including Bavaria, Lower Saxony, and Berlin. Training centers using cooperative models accounted for 44% of the total (Porcher & Trampe, 2021), making cooperative training models an important component of Germany's vocational school faculty training system.

In the long-term exploration of vocational school faculty cooperative models, three types of higher education institutions fully leveraged their respective resource endowments and formed diversified cooperative training models. According to classifications by scholars such as Silke Lange, Germany's vocational school faculty training models are mainly divided into seven types, with cooperative training models categorized as Models 2, 4, and 5 based on specific implementation characteristics, corresponding to the basic continuous rule cooperation model (Das grundständig-konsekutive Regelmodell in Kooperation), the dual lateral entry model (Das duale Quereinstiegsmodell), and the multifunctional supplier model (Das polyvalente Zulieferermodell; Lange et al., 2023). These three cooperative training models differ in course articulation, cooperation mode, learning integration method, applicable objects, and additional requirements, as shown in Table 2. The above models evolved autonomously based on institutional resource endowments and differences in faculty demand, optimizing the integration paths of vocational and education courses through the division of labor and collaboration. Models 4 and 5, in particular, have effectively alleviated the shortage of vocational faculty in technical fields by shortening training cycles and lowering entry thresholds, thereby providing a

sustainable talent supply mechanism for Germany's vocational education system.

Structural optimization of the curriculum system: enhancement of professionalization in faculty training

Following the Bologna Process, Germany began implementing a bachelor's + master's curriculum structure reform for faculty education students to enhance the professionalization of faculty training and establish a unified foundation for cross-state faculty mobility. On June 2, 2005, the KMK adopted the "Key Points on Mutual Recognition of Bachelor's and Master's Degrees in Faculty Education Programs", with the core content being the reorganization of curriculum content and the standardization of faculty education program structures. Specifically, both undergraduate and master's stages should include at least two professional subjects and educational subjects; The proportion of school practical learning should significantly increase; and educational subjects, professional subjects, and their teaching methodologies should be more closely interconnected to better adapt to the job requirements of the teaching profession and to ensure the quality and consistency of faculty education across states. Based on the requirements of this document, federal states successively carried out curriculum system structure reforms. For example, in 2016, Baden-Württemberg formulated the "Decree of the Ministry of Education and Cultural Affairs of April 29, 2016, on the Conversion of Higher Faculty Education Degree Programs for Vocational Schools to Graduate Degree Program Structures". The University of Heidelberg's Health and Social (Nursing) degree program was renamed Gerontology, Health, and Nursing, and along with the University of Tübingen's Social Education and Education degree programs, it was converted to a tiered degree program structure (Baden-Württemberg Landesrecht BW, 2024). The new curriculum structure covers professional subjects, general education, teaching methodology, vocational education, and other content and strengthens practical school internship components, as shown in Table 3. This reform broke the previous separation between vocational subjects, educational subjects, and teaching methodology in the undergraduate and master's stages, placing more emphasis on a training model oriented toward vocational teaching practice and helping enhance the professionalization of prospective vocational school faculty.

Pilot exploration of the dual teaching model: deep integration of theory and practice

The dual-system vocational schoolteacher training model refers to a teaching mode in which vocational school normal students simultaneously alternate theoretical learning and vocational internships during the bachelor's

Table 2: Characteristics of German vocational school faculty cooperative training models

Characteristics/models	Type 2: basic continuous cooperation model	Type 4: dual-system horizontal entry model	Type 5: multifunctional supplier model
Course articulation	Undergraduate and master's courses are closely connected with coherent content	Master's courses are adapted to undergraduate courses	Master's courses do not fully match undergraduate courses in structure and content but are based on education-related undergraduate courses
Collaborative division of labor	Two universities cooperate to provide undergraduate and master's courses	Two universities cooperate to provide master's courses	Undergraduate courses must be completed at specific cooperative schools, with a single university providing master's courses
Internship integration	-	The preparatory service phase can be shortened after the master's course ends or even fully integrated into the master's course	-
Target	Students seeking coherent faculty education at undergraduate and master's stages	Students with relevant professional bachelor's degrees who wish to transition to the teaching profession	Students entering faculty education from different professional backgrounds
Additional requirements	-	-	Students need to supplement courses in pedagogy and subject teaching methodology upon admission

Source: Compiled from Lange *et al.* (2023).

Table 3: Study scope of the conversion learning program for gerontology, health and nursing, educational sociology, and education as vocational subjects in Baden-Württemberg

Gerontology, health and nursing, educational sociology, and education	Credits (n)
Two levels	Total 230
Professional subjects (first level)	Total 200
Professional subject	At least 125
General education (second subject)	At least 63
Subject teaching methodology (second level)	Total 30
Professional subject	15
General education (second subject)	15
Vocational education, educational subjects	33
School internship semester	16
Bachelor's and master's theses	21
Total	300

Source: Baden-Württemberg Landesrecht BW (2024).

or master's course stage and closely combine theory with practice. Compared with the traditional model, it significantly increases practical content. To address the longstanding problem of the separation between theory and practice in vocational education faculty training, eight federal states in Germany (including Baden-Württemberg and Bavaria) launched an innovative dual vocational faculty training program in the 2024/25 winter semester. This program established a contractual training mechanism that enables students to form employment relationships with vocational schools at the undergraduate stage, which achieves deep binding between educational settings and professional fields and forms three distinctive training paradigms. First, the integrated dual training model, by constructing an integrated curriculum system that connects bachelor's and master's studies, enables students to establish stable

practical relationships with designated vocational schools from the beginning of their undergraduate studies, thereby achieving spiral integration of theoretical teaching and practical experience through alternating learning. Second, the enhanced master's training model focuses on professional deepening at the master's stage by organically integrating the preparatory service period with course learning, adopting a dual-track approach of "theoretical learning-practical application", and significantly compressing the training cycle. Third, the in-service enhancement program model targets in-service personnel who already hold teaching positions, designing on-the-job training programs that ensure that faculty members can complete professional advancement without leaving their teaching positions through school cooperation agreements. This system innovatively constructs a tripartite contractual

relationship among "faculty training institutions-vocational schools-trainees". Relying on institutionalized cross-institutional collaboration mechanisms, it not only ensures the effective transfer of educational theory to practical scenarios but also achieves dual improvements in training efficiency and professional standards through standardized quality control, thereby providing a solution to the problem of weak teaching practical abilities among vocational education faculty.

Restructuring incentive mechanisms: strategies to enhance occupational attractiveness and social status

Facing the challenges of insufficient teacher training and professional attractiveness in vocational schools, Germany has constructed a full-chain support system covering teacher training, career development, and rights protection through systematic institutional restructuring—that is, through institutional arrangements such as organizational innovation, rights protection, financial support, and differentiated management—driving the dual improvement of the social status and professional attractiveness of vocational teachers and optimizing the implementation environment of the supply mechanism for teachers in vocational schools.

Organizational leadership and project support: empowering enhancement of the influence of vocational faculty training

First, the concept of building an organizational innovation network leads to the development of vocational education teachers. The Vocational School Teachers' Innovation Training Association (Innovation-snetzwerk Lehramt an Beruflichen Schulen), led by the Wilo Foundation in 2016, integrates resources from multiple parties, including government, industry, academia, and research. The "Innovating Teacher Training for Vocational Schools: 12 Requirements for Teaching of Vocational School Innovation Associations" has paradigm innovation significance, proposes conducting image promotion activities, providing lessons for future skilled workers, creating monetary incentives and reliable financing models for teacher training courses for shortage subjects, allowing part-time learning, integrating practical work into learning, achieving full coupling of large professional disciplines and small professional fields, providing horizontal entry points for comprehensive engineers, and readjusting learning plans (Stifterverband, 2017). Through initiatives such as professional relevance, creating new forms of subject teachers, targeted promotion of innovative methods, and political strengthening of vocational education, the Vocational School Teachers' Innovation Training Association has continuously provided targeted solutions to address the structural shortage of teachers,

thereby enhancing the social recognition of vocational schoolteacher training.

Second, Germany has implemented specialized funding programs to enhance the attractiveness of faculty training through project clusters. Relying on the Faculty Training Quality Offensive program launched by the Federal Ministry of Education and Research in 2014, Germany has directly invested in 38 vocational faculty specialized projects since 2020, forming three major capacity-building modules. The first of these modules is a three-in-one training system that integrates curriculum development, platform construction, and tool application. For example, RWTH Aachen University has built a cross-school virtual research room and developed a teaching resource library for emerging fields such as smart construction and electronic healthcare. The second is an interdisciplinary talent transformation project implementing a professional restructuring and academic support transformation plan. For example, the LeBiAC project has achieved the targeted transformation of talent in fields such as mechanical engineering into vocational faculty training through modular course reorganization and personalized career navigation. The third is the innovation of immersive training models. This project employs extended virtual reality technology to construct a virtual training system. The intelligent feedback system developed by the LEBUS Project can analyze the teaching behaviors of preservice faculty in real time, generating personalized competency development profiles. These projects not only compensate for shortcomings in traditional educational resources but also strengthen vocational school faculty members' professional abilities to handle diverse classroom situations through a combination of virtual and real models.

Construction of a dual-track driving mechanism: synergistic empowerment through economic incentives and rights protection

To solve the structural contradiction in the supply of vocational education teachers, Germany has enhanced the attractiveness of teacher training programs through economic incentives and rights protection. On the one hand, to attract more students to switch to the teacher training track, the German Association for Innovation in Vocational Schoolteacher Training suggests providing a monthly scholarship of 1000 euros for master's students to achieve full coverage throughout the entire process (Chen & Sun, 2024). Under this advocacy, the states of Germany have formulated corresponding incentive measures for teacher training. For instance, in 2021, the Hesse Ministry of Education and Cultural Affairs, in collaboration with a teacher training college, developed a funding program for vocational schools in areas of shortage in metal and electrical engineering, chemical

engineering, computer science, and health. During their master's studies, students can receive a salary agreed upon collectively and an additional 1000 euros in funding. On the other hand, Germany provides a full-process guarantee mechanism for the implementation and promotion of teacher training programs. For instance, in 2024, Baden-Württemberg issued the "Decree on Pilot Programs for Master's Degree Courses Related to Dual-System Teachers and Subsequent Preparatory Services for Higher Education Services in Secondary Teaching Specialties, Grammar Schools or Vocational Schools", which established an innovative four-dimensional security system for trainees that included living security, social security, vacation security, and privacy security. By embedding economic incentives into the process of human capital accumulation and simultaneously constructing a multidimensional guarantee system to reduce occupational risks, this institutional design helps enhance the relative attractiveness of the teaching profession.

Optimization of professional treatment: granting civil servant status and implementing differentiated teaching management

In Germany, the social status and basic rights of vocational school faculty members are emphasized to enhance the retention rate and attractiveness of the vocational school teaching workforce. This situation is further exacerbated by the fact that approximately 0.6% of young teachers in Germany leave the profession prematurely and permanently each year (Geis-Thöne, 2022), worsening the already existing shortage of vocational school teachers. To improve the retention rate and attractiveness of vocational school faculty, Germany increasingly emphasizes the social status and basic rights protection of vocational school faculty members.

First, by reconstructing career advancement systems based on civil servant status, Germany systematically enhances the social status and professional security of vocational school faculty by incorporating them into the civil service system. Most states classify public vocational school faculty members at the "higher service" (höherer Dienst) level within the civil servant system, granting them the same rank benefits as academic secondary school faculty. For example, issued in 2022, Berlin's Faculty Retention Law explicitly incorporates vocational school faculty aged under 52 years into the civil servant system (Senatsverwaltung für Bildung, Jugend und Familie, 2024), ensuring career stability through tenure. Regarding salary structure, a three-level, eight-tier advancement system has been implemented for vocational school faculty members that consists of three ranks—Research Assistant Professor (A13), Senior Research Assistant Professor (A14), and Research

Director (A15)—corresponding to differentiated salary standards (KMK, 2017), with eight advancement steps within each rank. For example, the entry-level A13 sequence starts at 5526 euros monthly (level 3) and can gradually advance to a maximum of 6427 euros at level 8 through biennial performance evaluations (Beamtenbesoldung, 2024), forming a continuously attractive salary growth mechanism. This institutional design, which deeply binds professional status, salary treatment, and professional development, significantly strengthens the professional identity of vocational education faculty members.

Second, Germany has implemented differentiated teaching load management systems. Since the faculty shortage problem has exacerbated issues of faculty health and professional burnout, a dynamic adjustment mechanism has been established according to age and teaching hours through legislative means. According to the KMK's "Overview of Compulsory Working Hours for Faculty in General and Vocational Schools in the 2020/21 School Year-Discounts for Full-Time and Part-Time Faculty in Specific Age Groups", published in 2020, various states have established differentiated "step-by-step load reduction" systems for full-time and part-time vocational school faculty members. For example, North Rhine-Westphalia stipulates that those over the age of 58 are exempted from 1 h of teaching obligations per week, those over the age of 60 are exempted from 2 h per week, and those over the age of 63 are exempted from 3 h per week. For part-time faculty members aged over 58, if their part-time teaching time reaches 75% of the weekly teaching obligation hours of full-time faculty members, they can be exempted from 1 h, and if it reaches 50%, they can be exempted from 0.5 h (KMK, 2020b), thereby extending the professional life cycle of senior faculty members through gradual adjustments. At the same time, vocational school faculty members in North Rhine-Westphalia, Saxony, and Schleswig-Holstein can apply for a "working time account" (Arbeitszeitkonto), which allows them to flexibly adjust their weekly compulsory teaching hours within a certain period. This flexible work system, which takes into account age differences and teaching characteristics, both ensures teaching quality and effectively enhances job attractiveness.

CONCLUSION

Evaluation and reflection on the effectiveness of institutional supply in Germany

In addressing the shortage of teachers in vocational schools, Germany has established an innovative systematic and collaborative governance model. This model mainly takes the KMK as the coordinating body, with state governments, vocational schoolteacher

training institutions, and social organizations working in coordination and implementing it specifically. The theory of historical institutionalism holds that the meaning and function of institutions themselves have internal conflicts over time, and these struggles and conflicts may overflow beyond the institutions and trigger new changes (Weir, 1989). In the practice of responding to the shortage of vocational schoolteachers, Germany has formed a trinity institutional system of innovation of access mechanism, optimization of training mechanism and reconstruction of incentive mechanism. This reform path of the vocational schoolteacher supply system has gradually broken the path dependence of the traditional system and introduced more flexible and practice-oriented institutional innovations. Meanwhile, it also reflects the characteristics of institutional isomorphism. The states of Germany have gradually converged in terms of teacher access, training, and incentive systems, forming a relatively unified institutional framework. This practice of institutional organization convergence does not stem from competition or efficiency demands but is driven by external institutional pressure, leading organizations to imitate similar organizations to obtain legitimacy and form structural similarities within the field (DiMaggio & Powell, 1983). Under the unified consultation mechanism of the KMK, the isomorphism of the system not only enhances the stability of the system but also promotes the flow of teaching staff and resource sharing among the states, achieving a systematic breakthrough and sustainable development in the construction of teaching staff. The practical experience of Germany not only demonstrates outstanding institutional effectiveness but also highlights the profound social value of its vocational education governance. Specifically, in the dimension of institutional effectiveness, Germany has achieved the efficient realization of policy goals through demand-oriented top-level design, the innovative implementation of the dual-system vocational schoolteacher training program, and the precise implementation of the Teacher Training Quality Offensive project, among others. In terms of the dimension of social equity, Germany has established a rights protection mechanism covering the training process, career development, salary and benefits, and social security, effectively safeguarding the professional dignity and development rights of vocational schoolteachers. In terms of inclusiveness, Germany has established an open and diverse access mechanism for teacher training and professional access, providing multiple development channels for talent with different professional and practical experience backgrounds. This not only optimizes the structure of the teaching staff but also enhances their overall vitality. This comprehensive governance model, which takes into account efficiency, fairness, and inclusiveness, provides a practical model

with reference significance for the construction of global vocational education teaching staff.

However, Germany still faces challenges in dealing with the shortage of teachers in vocational schools. First, at the level of value orientation, the opposition between vocational and academic aspects is a deep-seated contradiction in institutional reform. Germany's academic efforts have a long history, dating back to the early 19th century, with the aim of enhancing the status of vocational schoolteachers (Rebmann, 2021). The current introduction of the dual-system project has once again triggered conflict between the academic and vocational aspects of teacher training in vocational schools. The academic training path of the long-term education system has significantly reduced its professional attractiveness, while the implementation of the dual-system program has raised questions in the education field about the professional theoretical level of teachers. How to balance theoretical knowledge and practical experience to ensure that graduates meet the standards of qualified teachers still requires further exploration. Second, at the institutional logic level, the conflict game between short-term emergency measures and long-term quality assurance is becoming increasingly prominent. Although Germany can alleviate the shortage of teachers through short-term measures, such as large-scale recruitment of lateral entrants, and the lateral admission path eliminates a large number of learning courses related to teachers for quick use in vocational schools, this may reduce the overall quality of the teaching staff and more likely shake society's professional recognition of vocational schoolteachers by lowering the occupational threshold. This predicament essentially reflects the institutional conflict between the demand for flexibility in the labor market and the maintenance of professional autonomy. How to adhere to high standards of access while meeting the demand for teaching staff is an urgent problem to be solved. Third, at the governance structure level, the tension between federal coordination and local autonomy continuously restricts the effectiveness of the cross-state cooperation mechanism. The teacher shortage crisis in Germany reflects institutional fragmentation in educational planning under its federal structure, not natural contingencies (Rackles, 2020). The vocational schoolteacher training and supply systems in the 16 states of Germany are relatively fragmented. Although the federal government is committed to establishing a cross-state mobility mechanism and has shown a certain trend toward convergence, this convergence is not thorough. There are still some institutional differences that make it difficult for the supply of teachers to fully cover the demands of each state. For instance, compared to other states that require a shorter period, Bavaria requires a probationary service period of 24 months, which may result in some

applicants being unable to enter the Bavarian civil service system immediately. The vocational school-teacher market is national rather than regional, and it is crucial to establish a cross-state cooperative training and supply mechanism. In conclusion, the governance proposition of the teacher supply system in German vocational schools is essentially a process of seeking a dynamic balance point among multiple values, such as efficiency and quality, unity and diversity, and flexibility and stability. The experience of Germany shows that any single-dimensional policy adjustment is difficult to solve in this complex proposition. Future reforms need to build a more inclusive institutional framework that can not only expand supply through differentiated paths but also maintain professional standards through quality assurance mechanisms. It is necessary to both strengthen strategic coordination at the federal level and retain the institutional flexibility of each state in responding to regional demands. This exploration is not only related to the sustainable development of the German vocational education system but also provides an important theoretical reference for the reform of the global vocational education teacher supply system.

Implications for optimizing the supply system of "dual-qualified" teachers in China

Vocational education teachers in China are also confronted with the problem of insufficient job appeal. In particular, the shortage of dual-qualified teachers has restricted the high-quality development of vocational education in China. The concept of "dual-qualified" teachers was introduced to address the situation in China's vocational education where faculty members often had limited expertise beyond theoretical knowledge and lacked hands-on industry experience (Lu, 2002). The adaptive transformation of the German system can provide the following important inspirations for optimizing the institutional supply of dual-qualified teachers in China. First, the professional access mechanism for dual-qualified teachers should be optimized. In the recognition standards for dual-qualified teachers, the academic requirements should be relaxed. Enterprise technicians who are willing to become vocational education teachers and have rich practical experience in enterprises but lack theoretical knowledge of education are allowed to learn through flexible education courses and certification systems. Teachers from higher education institutions who have teaching experience in relevant vocational courses but lack practical experience in enterprises are allowed to obtain the dual-qualified qualification through flexible enterprise practice courses and enter the teaching staff of vocational schools through part-time or full-time employment. In addition, a collaborative governance system for dual-qualified teachers comprising the

national, provincial, and municipal levels should be established. There is a gap in the connection between some provincial and school-level standards in China, and the provincial standards cannot fully meet the diverse development needs of vocational colleges in various cities within the province (Xu *et al.*, 2025), thereby reducing their certification efficiency. The establishment of a dual-qualified teacher development committee could unify and refine the recognition standards layer by layer, promote the cross-regional mobility of dual-qualified teachers, and coordinate vocational education teacher resources. Second, the training mechanism for dual-qualified teachers should be improved. This can be done by promoting cross-institutional cooperation in the cultivation of dual-qualified teachers; encouraging vocational and technical normal universities, application-oriented universities, and comprehensive universities to jointly cultivate teachers; and releasing the advantages and effectiveness of various universities in the cultivation of dual-qualified teachers, teaching, and course resources. In addition, a comprehensive training path can be established for the undergraduate + master's curriculum system before dual-qualified teachers enter service, the stratified training of educational theory and professional theory can be promoted, and a spiral ascent of the curriculum system can be achieved. It is also necessary to balance the alternating rhythm of theoretical learning and practical training for dual-qualified teachers, avoid academic tendencies, and enhance the comprehensive quality of teacher training. Third, social members should be encouraged to join the dual-qualified teaching staff. Dual-qualified teachers in China have faced multiple issues regarding their professional attributes and identity, such as being considered "outsiders", "one-sided people", and "tool people" (Li & Mao, 2022), and it is necessary to enhance their professional attractiveness. Publicity should be enhanced, an association should be established for the innovative training and research of dual-qualified teachers, and targeted solutions to issues such as the recognition, training, and supply of dual-qualified teachers should be proposed to promote the formation of wide social recognition. Meanwhile, in response to the digital development demands of vocational education, a dual-qualified teacher training program has been established to enhance the quality of teacher training and the attractiveness of the training. In addition, the professional treatment and social status of dual-qualified teachers should be enhanced. By breaking down the barriers between the professional title series of dual-qualified teachers, smoothing their career advancement path, and supplementing this path with salary incentives and bonus incentives, the professional happiness of dual-qualified teachers can be enhanced, thereby encouraging more social members to join the dual-qualified teacher team and promoting the maturity and development of

China's vocational education teacher system.

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Author contributions

Liu ZW: Conceptualization, Writing—Original draft, Methodology, Validation, Supervision, Project administration, Funding acquisition. Wang L: Writing—Original draft, Data curation, Writing—Review and Editing, Formal analysis, Resources. All authors have read and approved the final version.

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The authors have no conflicts of interest to declare.

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