ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

Research on the Master's Training Model of Mechanical Engineering in Central and Western China: Based on Comparison with the Pearl River Delta Region

Yunze Yang[1,a,*], Huiqi Liu[1,b], Yinghong Zhang[1,c,*]

[1]School of Mechanical and Electrical Engineering, Guilin University of Electronic Science and Technology, Guilin, China
[a]yangyz@guet.edu.cn, [b]1366861860@qq.com, [c]yh_zhang@guet.edu.cn
**Corresponding author*

Abstract: *This article takes the master's program in mechanical engineering in the central and western regions as the research object. Based on the needs of regional industrial transformation and upgrading, it analyzes the practical status and core issues of the "regional adaptability" training path, and proposes improvement strategies such as "deep integration of industry and education, dynamic optimization of courses, and collaborative guarantee of resources". Research has found that the central and western regions have advantages in serving local industries and integrating characteristic resources, but still face challenges such as insufficient practical ability cultivation, lagging curriculum system, and limited quality of student sources. Through case analysis and policy recommendations, this article provides theoretical support for optimizing the cultivation of high-level applied talents in mechanical engineering.*

Keywords: *Mechanical Engineering Education; Advanced Manufacturing; Talent Training System; Industry-Academia Collaboration; Curriculum Optimization*

1. Introduction

With the promotion of national strategies such as "Made in China 2025" and "New Engineering Construction", the demand for high-level applied talents in the field of mechanical engineering continues to grow. As an important base for equipment manufacturing, new energy vehicles, agricultural machinery and other industries in China, the master's program in mechanical engineering in the central and western regions needs to balance the dual goals of regional economic transformation needs and technological innovation capability enhancement. However, due to factors such as resource endowment and insufficient depth of industry education integration, there is still a gap in the quality of talent cultivation between universities in the central and western regions and developed regions in the east. Data shows the average annual growth rate of the equipment manufacturing industry in central and western China has reached 8.5% (according to data from the Ministry of Industry and Information Technology in 2023), but the gap in high-level talents in the field of mechanical engineering in the region continues to widen. According to the "China Manufacturing Talent Development Report (2023)", the supply and demand gap for mechanical master's degree talents in the central and western regions has reached 37%, significantly higher than that in the eastern region (15%). This contradiction is manifested by a structural mismatch between the training model and regional industrial demand.

Based on this, this article is based on the actual training system of mechanical engineering master's degree in the central and western regions, and analyzes the problems existing in the training mode of mechanical engineering master's degree from multiple dimensions such as policy support, industry demand, education foundation, and resource guarantee. It proposes an optimization plan for the training mode of mechanical engineering master's degree, systematically solves the adaptability problem between the training of mechanical engineering master's degree in the central and western regions and the development needs of advanced manufacturing industry, and provides a demonstration sample for the integration of industry and education in underdeveloped western regions.

The research significance of this topic mainly lies in the following aspects: Firstly, relying on the adaptability of regional characteristic industries, promoting innovation in the integrated education model

ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

of industry and education. Research can deepen the theoretical framework of "industry education collaborative education", combined with the characteristics of manufacturing clusters in central and western China (such as automobiles, engineering machinery, new energy equipment, etc.), explore the mode of deep integration between professional master's degree training and regional industrial demand, supplement the existing research gap in the adaptability of industry education integration theory to regional characteristic industries, propose an educational theoretical model that adapts to the development of advanced manufacturing industry, and provide theoretical support for professional degree education in local universities.

Secondly, establish a talent cultivation framework guided by industrial demand and enrich the theory of regional characteristic talent cultivation. The research focuses on the practical innovation ability cultivation of high-end talents in the fields of forestry machinery, agricultural equipment, intelligent robots and other mechanical engineering in the central and western regions of China. A systematic analysis of the requirements of manufacturing industry clusters for talent knowledge structure and skill level can inject new connotations into engineering education theory, promote the construction of theoretical models for the coordinated development of education chain, industry chain and innovation chain, and improve the theory of progressive development of mechanical engineering talent ability.

Thirdly, improve interdisciplinary and technological innovation, and deepen research on the interaction between higher education and regional economy. This article focuses on the demand for composite talents in advanced manufacturing industries in the central and western regions, and studies the integration of interdisciplinary theories in mechanical engineering, materials science, intelligent control, and other fields. It proposes an optimization path for the curriculum system of "multidisciplinary knowledge embedding+technological innovation driven", strengthens the theoretical connection between technology research and industrial upgrading, and provides theoretical support for the mechanism of "higher education serving regional economy".

2. Literature review

Scholars widely agree that as the Made in China 2025 strategy advances, the manufacturing sector’s shift toward intelligence, sustainability, and servitization urgently demands high-level applied talents with interdisciplinary knowledge, engineering practice capabilities, and innovative thinking [1-2]. Engineering machinery clusters, plagued by homogeneous competition and reliance on imported core technologies, require education system optimization to improve talent alignment [3-4]. The root causes of this mismatch include: (1) Disconnect between training models and industry needs: Current mechanical engineering master’s programs suffer from "convergence between academic and applied orientations" and "insufficient corporate engagement," resulting in graduates failing to meet the demand for multidisciplinary engineers [5-7]. (2) Curriculum homogenization: Most universities retain academic-focused frameworks, lacking specialized modules for advanced manufacturing (e.g., intelligent manufacturing, new energy equipment) [8-9]. Due to technological confidentiality and funding constraints, enterprises struggle to provide hands-on training in core technologies, rendering practical components superficial [10-11]. (3) Fragile industry-academia collaboration: Divergent priorities—enterprises focus on short-term gains, while universities emphasize talent development and research—hinder stable cooperation [12-13]. Limited participation incentives for enterprises and overburdened external mentors, coupled with insufficient engineering experience among academic mentors, weaken the "dual-mentor" system [14-15]. (4) Overly simplistic evaluation systems: Current assessments prioritize academic papers while neglecting practical metrics like engineering problem-solving and technology commercialization [16], undermining the applied orientation of professional master’s programs. Scholars thus advocate resolving the talent mismatch by reconstructing training systems, implementing modular curriculum designs, deepening industry-education integration, and strengthening practical innovation capabilities [17-19].

The aforementioned studies provide a solid foundation for this research. However, we identify the following limitations in existing research: First, insufficient attention to regional particularities: Current research predominantly focuses on developed eastern regions (e.g., the Yangtze River Delta and Greater Bay Area), lacking targeted analysis of industrial characteristics in western provinces (autonomous regions).Second, absence of dynamic adjustment mechanisms: Existing mechanical engineering master’s training frameworks exhibit prolonged update cycles (typically over five years), failing to rapidly adapt to the technological iteration demands of Guangxi’s aluminum-based new materials, new energy vehicles,and related industries. Third, underutilized policy synergies: Prior studies inadequately integrate policy incentives such as Guangxi’s Measures to Promote Industrial Revitalization and Special Programs

ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

for Industry-Education Integration and University-Enterprise Collaboration, leaving unclear the mechanisms through which policies influence training systems. This limits their practical guidance value.

3. Comparative Analysis of Master's Degree Training Models in Mechanical Engineering between Central and Western China and the Pearl River Delta Region

3.1 Target positioning and regional adaptability

Central and Western regions. Focusing on regional characteristic industries: Taking a university in Guangxi as an example, its mechanical master's program focuses on the layout of regional pillar industries such as new energy vehicles and aluminum based new materials, relying on the joint laboratory of provincial-level "strong leading" enterprises to promote the integration of industry and education.

Policy driven: Based on the "Several Policy Measures for Promoting Industrial Revitalization in Guangxi", emphasis is placed on the integration of professional master's degree training with characteristic industries such as aluminum processing and forestry machinery.

Pearl River Delta region. Facing intelligent manufacturing and internationalization: For example, universities in the Greater Bay Area, in combination with the pilot policy of "Made in China 2025", have positioned the training direction in high-end fields such as intelligent connected vehicles and industrial Internet, and the curriculum system has been embedded in enterprise technical standards such as Huawei.

Interdisciplinary innovation: Deep integration of mechanical engineering and intelligent control, new materials and other disciplines, such as the establishment of dynamic course modules in the direction of intelligent robots in universities in southern China.

3.2 Curriculum system and cultivation of practical innovation ability

Central and Western regions. Modular course design: Specialized courses such as aluminum based material processing and new energy equipment maintenance are offered to meet the needs of regional industries, enhancing students' ability to solve regional technical problems.

Practice platform: Based on provincial-level graduate practice bases (such as 11 provincial-level bases of a certain university in Guangxi), promote students' participation in practical projects such as automotive lightweight technology research and development.

Pearl River Delta region. Dynamic curriculum update: For example, Shenzhen universities adjust the curriculum content according to the intelligent manufacturing technology iteration every year, embedding intelligent driving algorithm, industrial Internet and other cutting-edge directions.

High end scientific research platform: Establish an intelligent manufacturing collaborative innovation center, connect with international technological frontiers, and promote students' participation in technological breakthroughs of enterprises such as DJI and BYD.

3.3 School enterprise collaboration and resource integration mechanism

Central and Western regions. Government led cooperation: For example, Guangxi Yuchai Machinery and Liugang Group have established school enterprise alliances with universities, guided by the demand for industrial chain supplementation and focusing on regional technology transformation.

Resource bottleneck: Relying on policy subsidies and special funds, insufficient motivation for enterprise participation, and in the dual mentor system, enterprise mentors are mostly limited to assisting practical activities.

Pearl River Delta region. Market driven collaboration: Huawei, DJI and other enterprises jointly design and develop research and development projects with universities, and school enterprise mentors participate in technical breakthroughs throughout the process, forming a closed loop of "education industry innovation".

Flexible resource guarantee: Through venture capital and enterprise R&D funds to support technological breakthroughs, with strong liquidity, students can directly participate in commercial projects.

ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

3.4 Evaluation system and dynamic adjustment capability

Central and Western regions. Academic orientation is the main focus: the evaluation is still centered on academic papers, and practical achievements (such as technological transformation benefits) lack quantitative standards. The training program update cycle is as long as 5 years.

Pearl River Delta region. Application oriented evaluation: Introduce indicators such as enterprise patent authorization rate and product iteration contribution, establish an annual evaluation mechanism, and quickly adjust the training direction (such as modular updates of intelligent automotive technology)

4. Matrix Analysis of Master's Degree Training Models in Mechanical Engineering in Central and Western China and the Pearl River Delta Region

Based on the regional industrial characteristics and differences in educational resource allocation, this article will conduct a matrix analysis of the master's degree training mode in mechanical engineering in the central and western regions of China and the Pearl River Delta region from four aspects: target positioning and regional adaptability, curriculum system and practical innovation ability cultivation, school enterprise collaboration and resource integration mechanism, and evaluation system and dynamic adjustment mechanism:

4.1 Comparison of Target Positioning and Regional Adaptability

Table 1 shows the differences in target positioning and regional adaptability of mechanical engineering master's programs in universities in the central and western regions and the Pearl River Delta region.

Table 1: Comparison of Target Positioning and Regional Adaptability

Dimension	Central and Western regions	Pearl River Delta region
Core orientation	Focus on regional characteristic industries (such as Guangxi new energy vehicles, aluminum based new materials, Chongqing petroleum machinery)	Emphasis on intelligent manufacturing, high-end equipment and international needs (such as intelligent networked vehicles, precision manufacturing).
Policy synergy	Relying on local policies (such as "Several Policy Measures for Promoting Industrial Revitalization in Guangxi") to strengthen the integration of industry and education and the docking of industrial demand	Integrate industrial upgrading policies in the Greater Bay Area (such as the "Made in China 2025" regional pilot), promote technology transformation and talent internationalization
Interdisciplinary intersection	Focus on "mechanical+regional characteristic technologies" (such as forestry machinery, agricultural equipment)	Deep integration of "machinery+intelligent control/new materials", highlighting digitization and cross disciplinary scientific and technological innovation

4.2 Comparison of Industry Education Integration Models

Table 2 shows the differences in industry education integration models of mechanical engineering master's programs in universities in the central and western regions and the Pearl River Delta region.

Table 2: Comparison of Industry Education Integration Models

Dimension	Central and Western regions	Pearl River Delta region
School enterprise cooperation mechanism	Mainly based on the "dual mentor system" and relying on provincial-level practical bases (such as the "Obstetrics Teaching and Competition Integration" model of Chongqing University of Science and Technology)	Deepen the "School Enterprise Joint Laboratory" and "Industry Research Institute", and jointly build platforms with leading enterprises (such as the Intelligent Automotive Industry College)
Resource integration	Integrate regional characteristic industrial resources (such as coal equipment, petroleum machinery)	Rely on national scientific research platform and industrial chain resources (such as State Key Laboratory and intelligent manufacturing equipment
Cultivating path	Practice oriented model of "enterprise proposition - dual mentor guidance - team research and development"	The "2+2" mechanism of "theoretical training+innovative practice" strengthens technological research and development capabilities

4.3 Comparison of Practice Platform and Curriculum System

Table 3 shows the differences in practice platform and curriculum system of mechanical engineering

ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

master's programs in universities in the central and western regions and the Pearl River Delta region.

Table 3: Comparison between Practice Platform and Curriculum System

Dimension	Central and Western regions	Pearl River Delta region
Practice Platform	Provincial graduate joint training base as the main focus	National level industry education integration base and virtual simulation platform
Course Features	Set up courses based on local needs (such as automotive lightweight technology, precision measurement technology)	Strengthen cutting-edge technology modules (such as intelligent manufacturing, mechatronics, and intelligent driving)
Internationalization level	Less mention of international courses, focusing on localized applications	Introducing an international curriculum system to serve the "the Belt and Road" strategy

4.4 Comparison of research direction and achievement transformation

Table 4 shows the differences in *research direction and achievement transformation* of mechanical engineering master's programs in universities in the central and western regions and the Pearl River Delta region.

Table 4: Comparison of research direction and achievement transformation

Dimension	Central and Western regions	Pearl River Delta region
Focus Areas	Provincial graduate joint training base as the main focus	National level industry education integration base and virtual simulation platform
Path of Achievement Transformation	Serve local enterprises through horizontal projects	Relying on national level scientific research projects and joint research and development with enterprises
Social services	Emphasis on technology promotion and industrial poverty alleviation	Focusing on collaborative innovation in the high-end equipment industry chain

5. Analysis of the Shortcomings in the Master's Training System for Mechanical Engineering in the Central and Western Regions

5.1 Insufficient cultivation of practical abilities

5.1.1 Weak practical link

There are problems with the low proportion of practical courses and insufficient participation of enterprises in the master's program of mechanical engineering in central and western universities. Some universities still focus on theoretical teaching, with practical projects mostly staying at the level of simulation experiments or simple operations, lacking training in real engineering scenarios that match the needs of regional industries.

5.1.2 Insufficient depth of school enterprise cooperation

Despite the implementation of the "dual mentor system", the participation of enterprise mentors is limited, and some school enterprise cooperation projects have become mere formalities, failing to form a normalized collaboration mechanism of "enterprise proposition team research and development".

5.2 The curriculum system is disconnected from industry demand

5.2.1 Course content lags behind

Some curriculum settings were not updated in a timely manner, which still focused on traditional mechanical design and manufacturing technology, and lacked the coverage of emerging fields such as intelligent manufacturing and industrial Internet, which made it difficult for students' knowledge structure to match the needs of regional industrial upgrading.

5.2.2 Insufficient interdisciplinary integration

The weak integration of mechanical courses with interdisciplinary fields such as information technology and materials science limits students' innovation ability in complex engineering problems.

5.3 Contradiction between the quality of student sources and the positioning of cultivation

5.3.1 Single source structure of students

The main source of mechanical master's students in the central and western regions is undergraduate

ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

students from local ordinary universities, and the proportion of high-quality students with interdisciplinary backgrounds and international perspectives is relatively low, which affects the improvement of research and innovation capabilities.

5.3.2 Fuzzy training objectives

Some universities have unclear distinctions between professional master's degrees (such as mechanical engineering master's degree) and academic master's degrees, and still use academic oriented assessment standards, which makes it difficult to achieve the goal of cultivating applied talents.

5.4 Imperfect quality assurance system

5.4.1 The assessment mechanism is rigid

The assessment of practical activities often relies on reports or simple defenses, lacking quantitative evaluation standards for engineering practical abilities.

5.4.2 Missing dynamic feedback

The adjustment of training programs lags behind industrial development, and a dynamic feedback mechanism for school enterprise cooperation has not been established, making it difficult to optimize curriculum or practical content in a timely manner according to regional industrial changes.

6. Strategies for Enhancing the Master's Degree Training Model in Mechanical Engineering in the Central and Western Regions

6.1 Deepen the mechanism of integrating industry and education

Strengthen the collaboration between schools and enterprises in educating students. Universities in the central and western regions should promote the "enterprise proposition dual mentor guidance team research and development" model, integrating the actual technical needs of enterprises into the training process (such as Guangxi University establishing research and development projects based on regional industries). In addition, universities in the central and western regions can establish provincial-level industry education integration training bases and cooperate with regional leading enterprises (such as Chongqing University of Science and Technology and Honghua Company jointly building petroleum machinery laboratories) to enhance the authenticity and technological frontiers of actual scenarios.

Optimize resource integration path. Universities in the central and western regions should integrate regional characteristic industrial resources (such as forestry machinery in Guangxi and petroleum equipment in Chongqing), and promote the sharing of school enterprise equipment, platforms, and research funds through mixed ownership pilot projects.

6.2 Optimizing the curriculum system and cultivating practical abilities

Dynamically adjust course content. Universities in the central and western regions can add cutting-edge technology modules such as intelligent manufacturing, industrial Internet, and digital twins, gradually eliminate backward courses, and enhance their adaptability to regional industrial upgrading. Promote interdisciplinary integration, such as the combination of mechanical and information technology, materials science, and cultivate composite engineering talents.

Strengthen practical ability assessment. Universities in the central and western regions can introduce quantitative evaluation criteria for enterprise participation in practical activities, such as using horizontal project achievements, patent conversion, or engineering problem-solving abilities as evaluation indicators. In addition, universities in the central and western regions can also promote segmented training of "theory+practice", such as the "2+2" model (2 years of theoretical study+2 years of enterprise practice), to ensure that the proportion of practical credits is not less than 30%.

6.3 Improving the quality of teaching staff and student sources

Improve the construction of the mentor team. Universities in the central and western regions should establish a joint training mechanism for school enterprise mentors, clarify the responsibilities and rights of enterprise mentors, and enhance their enthusiasm for participating in the entire training process (such as Xijing University strengthening mentor responsibilities through evaluation and reward systems).

ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

Universities in the central and western regions can also introduce high-level talents with industry experience through the "dual employment system" and attract enterprise experts to join their teaching teams.

Optimize the structure of student sources. Universities in the central and western regions should expand the proportion of recommended students from enterprises, prioritize the selection of in-service personnel with engineering practice experience, and strengthen targeted training. Universities in the central and western regions can also attract high-quality undergraduate students and strengthen the selection of students with interdisciplinary backgrounds through policies such as "comprehensive master's and doctoral programs" and "comprehensive bachelor's and master's programs".

6.4 Strengthen policies and resource guarantees

Intensify policy tilt. The state should tilt resources such as discipline construction funds and graduate enrollment indicators towards universities in the central and western regions, and support their construction of provincial key laboratories and engineering research centers. The government should also actively promote the implementation of the "Western Special Project" scientific research projects, encourage universities to cooperate with regional enterprises to apply for national level scientific research projects (such as the National Key Research and Development Program).

Building a dynamic feedback mechanism. Universities in the central and western regions should establish a school enterprise joint "training quality tracking platform", regularly collect employment feedback from enterprises, and dynamically adjust training plans and course offerings. In addition, universities in the central and western regions with conditions can also establish a regional industrial talent demand database to provide data support for training directions.

7. Conclusion

The research has found that the Pearl River Delta region has formed a market-oriented collaborative education mechanism based on the advantages of industrial clusters, while the central and western regions are limited by resource endowments and industrial foundations, and have problems such as a disconnect between training goals and regional demand, and insufficient practical innovation capabilities. Based on this, this article believes that the optimization of the master's program in mechanical engineering in the central and western regions should be based on regional industrial characteristics, and through strengthening demand matching, resource integration, and mechanism innovation, a differentiated education ecosystem should be constructed. This is not only related to improving the quality of talent cultivation, but also a key support for promoting the transformation and upgrading of the manufacturing industry in the central and western regions.

Acknowledgements

Supported by the Exploration and Practice of Project based Teaching Reform in the Course of "Principles and Applications of Single Chip Microcontrollers" under the Background of New Engineering in Guangxi Higher Education Undergraduate Teaching Reform Project (Grant No. 2023JGA182)

References

[1] Colabianchi S, Costantino F, Sabetta N. Assessment of a Large Language Model Based Digital Intelligent Assistant in Assembly Manufacturing[J]. Computers in Industry, 2024, 162: 104129.

[2] Broo D G, Kaynak O, Sait S M. Rethinking Engineering Education at the Age of Industry 5.0[J]. Journal of Industrial Information Integration, 2022, 25: 100311.

[3] Gan W, Qi Z, Wu J, et al. Large Language Models in Education: Vision and Opportunities[C]//2023 IEEE International Conference on Big Data (BigData). IEEE, 2023: 4776-4785.

[4] Padovano A, Cardamone M. Towards Human-Ai Collaboration in the Competency-Based Curriculum Development Process: The Case of Industrial Engineering and Management Education[J]. Computers and Education: Artificial Intelligence, 2024, 7: 100256.

[5] Hamadeh L. Integrating Python into Mechanical Engineering Undergraduate Curriculum[C]. Aalborg University Press, 2023.

ISSN 2522-6398 Vol. 8, Issue 7: 29-36, DOI: 10.25236/FER.2025.080705

[6] Li C Q. Teaching Mechatronics to Non-traditional Mechanical Engineering Students-An Adaptive Approach[J]. International Journal of Engineering Pedagogy, 2021, 11(3).
[7] Huber S E, Kiili K, Nebel S, et al. Leveraging the Potential of Large Language Models in Education through Playful and Game-Based Learning[J]. Educational Psychology Review, 2024, 36(1): 25.
[8] Husain S S, Kadhim M Q, Al-Obaidi A S M, et al. Design of Robust Control for Vehicle Steer-By-Wire System[J]. Indonesian Journal of Science And Technology, 2023, 8(2): 197-216.
[9] Johri A, Katz A S, Qadir J, et al. Generative Artificial Intelligence and Engineering Education[J]. Journal of Engineering Education, 2023, 112(3).
[10] Udeozor C, Toyoda R, Russo Abegão F, et al. Digital Games in Engineering Education: Systematic Review and Future Trends[J]. European Journal of Engineering Education, 2023, 48(2): 321-339.
[11] Nandiyanto A B D, Al Husaeni D F. Bibliometric Analysis of Engineering Research Using Vosviewer Indexed By Google Scholar[J]. Journal of Engineering Science and Technology, 2022, 17(2): 883-894.
[12] Situmorang H, Purba S, Situmorang M. Implementation of Innovative Digital-Based Learning Resources for Teaching Occupational Safety and Health in Mechanical Engineering[C]//Proceedings of the 5th International Conference on Innovation in Education, Science, and Culture, ICIESC. 2023, 24.
[13] Bernabei M, Colabianchi S, Falegnami A, et al. Students' Use of Large Language Models in Engineering Education: A Case Study on Technology Acceptance, Perceptions, Efficacy, and Detection Chances[J]. Computers and Education: Artificial Intelligence, 2023, 5: 100172.
[14] Miranda J, Navarrete C, Noguez J, et al. The Core Components of Education 4.0 in Higher Education: Three Case Studies in Engineering Education[J]. Computers & Electrical Engineering, 2021, 93: 107278.
[15] Nikolic S, Daniel S, Haque R, et al. Chatgpt versus Engineering Education Assessment: A Multidisciplinary and Multi-Institutional Benchmarking and Analysis of This Generative Artificial Intelligence Tool to Investigate Assessment Integrity[J]. European Journal of Engineering Education, 2023, 48(4): 559-614.
[16] Álvarez-Marín A, Velazquez-Iturbide J A. Augmented Reality and Engineering Education: A Systematic Review[J]. IEEE Transactions on Learning Technologies, 2022, 14(6): 817-831.
[17] Grodotzki J, Upadhya S, Tekkaya A E. Engineering Education amid A Global Pandemic[J]. Advances in Industrial and Manufacturing Engineering, 2021, 3: 100058.
[18] Martin M J, Diem S J, Karwat D M, et al. The Climate Is Changing. Engineering Education Needs to Change as Well[J]. Journal of Engineering Education, 2022, 111(4).
[19] Chen J, Kolmos A, Du X. Forms of Implementation and Challenges of Pbl in Engineering Education: A Review of Literature[J]. European Journal of Engineering Education, 2021, 46(1): 90-115.