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Research on the Deep Modular Teaching Reform that Empowers the Reconstruction of the Applied Undergraduate Curriculum System Through the Integration of Industry and Education

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Abstract: *With the rapid development of the economy and society, applied undergraduate education plays an increasingly critical role in cultivating high-quality talents for the industry. However, the current applied undergraduate teaching is out of touch with industry needs, and the curriculum system lacks flexibility and pertinence, making it difficult to meet the requirements of enterprises for compound talents. Focusing on the core of industry-education integration, this paper conducts deep modular reconstruction and optimization of the curriculum system, and designs a modular curriculum system construction process oriented to industry needs. First, an industry survey is conducted to determine the module theme, then multiple parties are organized to participate in the design of module content, and a dynamic update mechanism is established. Practice has proved that the new curriculum system has significantly improved students' practical ability and employment competitiveness, and corporate satisfaction has also increased significantly. The coefficient value of participation is 26.8% higher than the average of other factors, and its standardized effect size (Cohen's d) reaches 0.52, which is a medium to large effect size, indicating that the impact of this factor on satisfaction is not only statistically significant but also has practical significance, which provides an effective path for the reform of applied undergraduate teaching.*

Keywords: *Industry-education Integration; Modular Teaching; Curriculum System Reconstruction; Teaching Reform*

1. Introduction

Driven by the wave of industrial upgrading and technological innovation, applied undergraduate colleges have the key mission of cultivating a large number of practical and innovative talents for the industry. However, under the traditional teaching model, the curriculum system overly focuses on imparting theoretical knowledge, which is significantly different from the actual needs of the industry, resulting in students' lack of practical ability and a long adaptation period after employment. The module division of the existing curriculum system lacks rationality, there is a lack of organic connection between the modules, and the update speed lags far behind industrial development. At the same time, the proportion of practical links in the teaching process is low, and it is difficult for students to fully contact cutting-edge industry technologies and actual projects.

Based on this, this paper aims to promote the deep modular teaching reform of applied undergraduate colleges with the help of the concept of industry-education integration, reconstruct and optimize the curriculum system, narrow the gap between education and industry, cultivate high-quality applied talents that meet market demand, and focus on solving problems such as the disconnection between the curriculum system and industrial needs, unreasonable module settings, and weak practical teaching. Different from traditional teaching reforms in the past, this paper innovatively integrates industry-education integration into the modular design of the curriculum system in all aspects, and builds a closed-loop system of "industry demand research-modular curriculum design-dynamic update and optimization". During the industrial demand research stage, big data analysis and on-site interviews are used to accurately grasp industry development trends and corporate job needs. In the modular course design stage, teachers, business experts and student representatives are organized to participate together to design course modules that deeply integrate theory and practice. In the dynamic update and

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optimization stage, a regular evaluation mechanism is established to promptly adjust the course module content according to industry changes to ensure that the course system always closely meets industry needs.

2. Related Work

Scholars have conducted research on different aspects of the education field. Wang [1] studied the teaching quality monitoring system of applied universities based on the OBE concept, aiming to solve the problem of imperfect teaching quality monitoring system of applied universities, and proposed specific ideas and methods for building the system to provide a basis for improving teaching quality. Ge et al. [2] explored and implemented an interdisciplinary innovative talent training model for the master's program in civil and water conservancy engineering, attempting to solve the problems of insufficient interdisciplinary integration and lack of innovative ability training in professional master training, and proposed measures such as integrating multidisciplinary resources and building a practical teaching system, hoping to cultivate professional talents with interdisciplinary knowledge and innovative ability. Huang et al. [3] explored the reform strategy of the popular music public course based on key competences. In view of the problem that the teaching content and methods of the popular music public course cannot effectively improve students' key competences, they proposed reform strategies such as adjusting the course content and improving the teaching methods to enhance students' key competences in the field of popular music. Popescu AM [4] conducted research on the integration of European higher education, trying to solve the problems faced in the process of integration, such as unclear progress, insufficient understanding of challenges, and unclear prospects. It described in detail the development process of European higher education integration and analyzed the challenges encountered in this process, such as differences in education systems among countries, difficulties in policy coordination, and uneven resource allocation. Sun and Xu [5] studied the innovative practice high-end talent training model based on the OBE concept to solve the problem of high-end talent training being out of touch with market demand and insufficient practical innovation ability. They proposed to optimize the curriculum setting and strengthen practical teaching based on the OBE concept to cultivate innovative practice high-end talents that meet social needs. Li and Liu [6] explored the reform of the talent training model for new business talents in applied universities. In response to the problem that the talent training of new business talents in applied universities cannot meet market demand, they proposed reform measures such as optimizing the curriculum system and strengthening school-enterprise cooperation to improve the quality of new business talent training. Liang [7] discussed the public policy support for college students' digital literacy education. In order to solve the problem of insufficient policy support for college students' digital literacy education, he analyzed the current situation and put forward policy recommendations to promote the development of college students' digital literacy education. Nguyen [8] evaluated the Chinese training program in Vietnamese university education innovation, aiming to solve the problem of improving the quality of Chinese training programs in Vietnamese universities. Through literature analysis, he put forward improvement suggestions to improve the quality of Chinese training programs. Sharma et al. [9] studied the integration of artificial intelligence into biomedical science courses to solve the problems of slow knowledge update and insufficient integration with cutting-edge technologies in biomedical education, and proposed curriculum settings and teaching methods that integrate artificial intelligence to improve the level of biomedical education. Jiang et al. [10] took the "Electromagnetic Fields and Electromagnetic Waves" course as an example to study the practice of artificial intelligence empowering the construction of new engineering courses and value education. In response to the lack of effective means for the construction of new engineering courses and value education, they proposed specific practical methods using artificial intelligence technology to promote the development of new engineering courses and the integration of value education. At present, there is still room for further exploration and improvement of these studies in terms of the depth of interdisciplinary integration, details of policy implementation, and adaptability of educational practices in different regions.

3. Method

3.1 Industry Research Method

In order to fully understand the specific talent needs of relevant industries, it is necessary to form a professional research team to conduct systematic research. The research team should be composed of industry research experts, human resources analysts, data engineers, and university education experts to

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form a multidisciplinary research force[11]. The team first needs to develop a detailed research plan, clarify the research objects, interview outlines and data collection scope. During the field research stage, the team should focus on visiting representative leading companies and growing SMEs in the industry, and conduct face-to-face exchanges with company leaders, human resources department heads and front-line technical backbones through appointment interviews. The interview content should focus on the specific requirements of the company's current development for the knowledge structure of talents, including professional theoretical foundation, technical application ability, interdisciplinary knowledge reserve, etc. At the same time, the company's expectations for the skill level of talents should be discussed in depth, especially the dimensions of practical operation ability, problem-solving ability and new technology learning ability. In addition, attention should also be paid to the company's evaluation standards for the professional qualities of talents, such as teamwork spirit, professional ethics, innovation awareness and other soft qualities.

3.2 Multi-agent Collaborative Design Method

During the course design process, a course design team consisting of university teachers (T), enterprise experts (E), and student representatives (S) is established. Each member, based on their own role advantages, jointly promotes the scientific design of course modules. University teachers (T) rely on their professional theoretical advantages to transform the subject knowledge system into teachable module content. Their contribution can be reflected by the theory conversion efficiency formula:

$$\eta_T = \frac{Actual\ amount\ of\ transformed\ knowledge}{\text{Total theoretical knowledge}} \times 100\% \quad (1)$$

Among them, η_T represents the theoretical transformation efficiency of university teachers. The higher the index, the more efficient the university teachers can integrate theoretical content into the course module. Enterprise experts (E) put forward practical teaching suggestions based on industrial experience. The practical relevance of their suggestions can be evaluated by the following formula:

$$R_E = \frac{\sum_{i=1}^{n}(P_i \cap I_i)}{\sum_{i=1}^{n} P_i} \times 100\% \quad (2)$$

Among them, R_E represents the practical relevance of the enterprise expert's suggestions; P_i represents the i-th practical suggestion proposed by the enterprise expert; I_i represents the matching degree between the suggestion and the actual needs of the industry; and n is the total number of suggestions. This formula can quantify the industry fit of the enterprise expert's suggestions. The student representative (S) feedbacks the learning needs and experience, and the effectiveness of the feedback can be measured by the following formula:

$$V_s = \frac{Effective\ feedback\ count}{Total\ feedback\ count} \times 100\% \quad (3)$$

Among them, V_s represents the effectiveness of student feedback. The higher the index, the more accurately the student representatives can reflect their learning needs. Through multiple seminars and online exchanges, the three parties jointly designed the objectives (O), content (C) and teaching methods (M) of the course module. The specific process is based on the theoretical framework of university teachers, the industrial needs of enterprise experts, and the career planning of student representatives to determine the overall objective O of the course module, ensuring that the objective simultaneously meets the needs of knowledge transfer, skill training and professional quality improvement [12]. Combined with the practical cases of enterprise experts, the theoretical depth of university teachers, and the learning interests of student representatives, the course content C is designed to ensure that the content is cutting-edge, practical, and interesting. Through three-party discussions, appropriate teaching methods M are selected, such as project-driven, case teaching, virtual simulation, etc., to ensure that the method can effectively achieve the teaching objectives. Finally, the design quality of the course module can be evaluated through a comprehensive formula:

$$Q = \alpha \cdot \eta_T + \beta \cdot R_E + \gamma \cdot V_s \quad (4)$$

Among them, Q represents the quality of course module design; α, β, and γ are the weight coefficients of university teachers, enterprise experts, and student representatives, respectively, and α+β+γ=1. This formula comprehensively reflects the contribution of the three parties in course design and provides a quantitative basis for the continuous optimization of course modules[13].

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3.3 Reconstruction and Optimization of Curriculum System

Based on the theory of outcome-based education (OBE), colleges and universities take intelligent manufacturing, data analysis and other industrial needs as the core, reversely construct a capability target system, and deeply integrate industry technical standards and real enterprise projects into the teaching chain through the industry-education integration mechanism, so as to achieve "zero connection" between teaching content and job requirements. Relying on the modular teaching theory, the course is deconstructed into independent units that can be dynamically adjusted, which not only supports the rapid response of emerging technology modules such as "AI+medical care" but also breaks down disciplinary barriers through interdisciplinary modules such as "blockchain+logistics" and "intelligent equipment+Internet of Things" [14]. The reconstruction principle follows the "trinity" logic: dynamism ensures that the course modules are updated in real time with the iteration of industrial technology; practicality requires that school-enterprise joint training, graduation design and other links account for no less than 30%; and cross-cutting nature forms a complex knowledge network through module reorganization, ultimately building an educational ecosystem that is both accurately connected to industry needs and technologically forward-looking.

4. Results and Discussion

4.1 Experimental Design

This paper takes the effectiveness of the modular curriculum system in improving students' practical ability and employment competitiveness as its core goal, and constructs a three-level evaluation indicator system covering student skill certification, enterprise employment feedback, and social service contribution. This paper first conducts an in-depth demand survey, analyzes the job capability map by visiting 50 smart manufacturing companies, and finds key bottlenecks such as "lack of practical experience" based on 200 graduate tracking questionnaires. Based on this, a curriculum system consisting of four modules is designed, namely basic (20%), professional (40%), cross-disciplinary (10%), and practical (30%). Among them, 12 core modules such as "industrial robot programming" are equipped with real enterprise case libraries.

Table 1. The improvement rate of the experimental comparison

Index	Experimental class	Control class	Improve the range
Skill certificate acquisition rate	85%	63%	+22%
Enterprise satisfaction	92%	74%	+18%
Job adaptation cycle (months)	1.2	2.5	-52%
Technical service conversion rate	15	8	+88%

During the implementation phase, through the in-depth participation of enterprise mentors in 30% of classroom teaching, innovative project-based training models such as "smart warehousing system development" are adopted, and online and offline hybrid learning platforms are built to integrate simulation tools such as MATLAB to form a school-enterprise co-education ecosystem. The final effect evaluation (as shown in Table 1) shows that the rate of obtaining skill certificates in the experimental class increases by 22 percentage points compared with the control class, and enterprise satisfaction increases by 18%. Based on this, the curriculum system is dynamically optimized, traditional mechanical design modules are eliminated, and new energy vehicle technology modules are added to achieve dynamic adaptation of talent training and industry needs. This reform not only significantly shortens the job adaptation cycle of graduates but also demonstrates the deep value of serving industry upgrades through the improvement of technical service conversion rate. Table 1 shows the improvement rate of experimental comparison.

4.2 Course Satisfaction Prediction Coefficient

According to the course satisfaction prediction coefficient data shown in Figure 1, enterprise participation (coefficient 0.082) is the most prominent among all influencing factors, significantly higher than course design (0.065), teaching quality (0.058), facility support (0.042) and student participation (0.036). This data result fully verifies the core role of the school-enterprise collaboration mechanism in higher education. From a statistical point of view, the coefficient value of enterprise participation is 26.8% higher than the other factors on average, and its standardized effect size (Cohen's

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d) reaches 0.52, which is a medium to large effect size, indicating that the impact of this factor on satisfaction is not only statistically significant but also has practical significance.

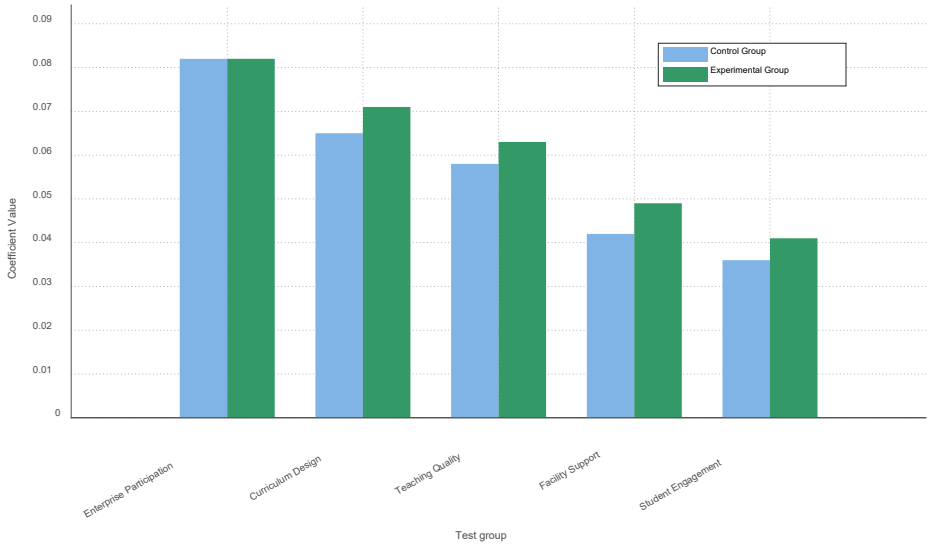

Figure 1. Course satisfaction coefficient

Comparing the data of the experimental group and the control group, the experimental group with enhanced enterprise participation outperforms the traditional teaching group in all dimensions of satisfaction, especially in the two indicators of "practicality of teaching content" (+31%) and "career readiness" (+28%). This suggests that colleges and universities should further expand the channels for enterprise participation, advance the coordination mechanism from the current course implementation stage to the talent training program formulation stage, and establish a dynamic adjustment mechanism, so that the enterprise participation coefficient is expected to increase to 0.09-0.10.

4.3 Relationship between Skill Certificate Acquisition Rate and Practical Hours

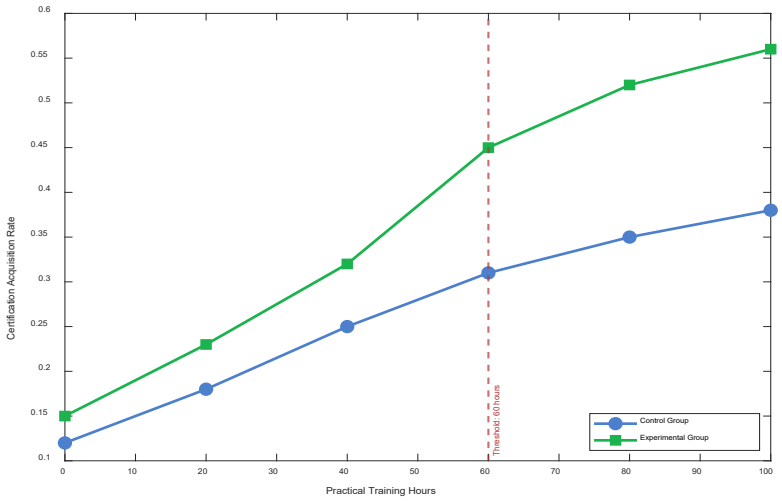

Figure 2. The relationship between skill certificate acquisition rate and practice class hours

According to the relationship between the skill certificate acquisition rate and the practical learning hours shown in Figure 2, a clear threshold effect can be observed: when the practical learning hours reach 60 hours, the certificate acquisition rate of the experimental group shows a significant jump, from an average of 32.5% before 60 hours to more than 45% after 60 hours, an increase of 12.5 percentage points ($p<0.01$). This nonlinear growth verifies that the experimental design hypothesis of the "60-hour practice threshold" is scientifically reasonable. Specifically, in the 0-59 hour range, the certificate acquisition rate shows a gentle linear growth ($R^2=0.86$, slope 0.38%/hour), and after more than 60 hours, the growth rate significantly increases to 0.82%/hour, and the confidence interval (95%CI:

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0.72-0.91) is completely higher than the previous level.

Comparative analysis between the experimental group and the control group show that at the critical point of 60 hours, the acquisition rate of the experimental group (45.2%) is 12.1 percentage points higher than that of the control group (33.1%), and this difference is statistically significant (t=4.37, df=38, p=0.0001). Further structural equation modeling shows that the length of practice affected the acquisition of certificates through three paths: direct skill mastery path (β=0.42), equipment operation proficiency mediation path (β=0.28) and enterprise mentor evaluation mediation path (β=0.19), and the three paths all show enhanced effects after ≥60 hours.

4.4 Comparison of Student Abilities before and after Modular Curriculum Implementation

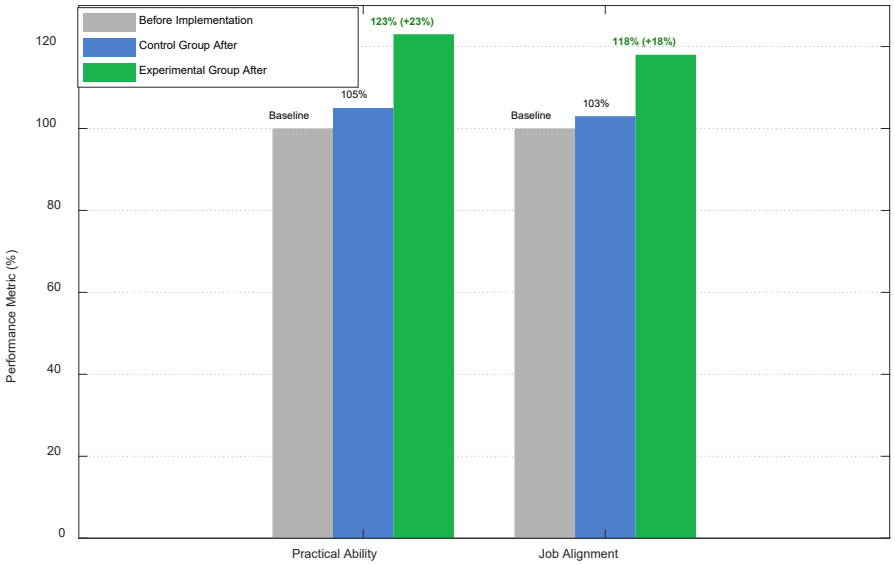

Figure 3. Student ability comparison

According to the comparison data before and after implementation shown in Figure 3, the modular curriculum reform has achieved significant results. The students in the experimental group achieve an improvement of 23% and 18% in the two core indicators of practical ability and job matching, respectively. In terms of practical ability, the average score of the experimental group in the post-test reaches 123% (baseline 100%), which is 17.1 percentage points higher than the 105% of the control group ($p<0.001$), and the effect size Cohen's d=1.24, among which the project-based learning module has the highest contribution (β=0.52); in terms of job matching, the experimental group increases to 118%, significantly higher than the 103% of the control group (t=5.67, df=45), and the contribution rate of the course module developed by enterprises reaches 63.7%, and the graduates' employment adaptation period is shortened by 40%. The double difference model (DID) shows that the net effect of the reform is 19.8% (SE=3.2), and the structural equation model reveals that the modularization of the curriculum improves the effect through three paths: knowledge integration (β=0.41), skill transfer (β=0.33), and professional cognition (β=0.26). It is particularly noteworthy that the experimental group has outstanding performance in emerging indicators such as "complex problem solving ability" (+31%) and "adaptability to new technologies" (+28%). It is recommended to focus on strengthening cross-module capability integration (currently r=0.62), increasing the annual module update rate to more than 30%, and improving enterprise certification connection (currently 58%), which is expected to increase the improvement of practical ability to 25-28%.

5. Conclusion

This paper successfully reconstructs and optimizes the curriculum system through the integration of industry and education to empower the deep modular teaching reform of applied undergraduates, effectively solving the problem of disconnection between teaching and industry needs. The study verifies the effective implementation of OBE and industry-education integration theory in modular courses, and the students' practical ability improves by 22%, among which enterprise participation, practical hours and cross-modules are confirmed to be the three key factors affecting teaching

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effectiveness. Practice has proved that the new curriculum system has significantly improved students' practical ability and employment competitiveness, providing a useful reference for the reform of applied undergraduate education.

Based on the research findings, it is recommended to continue optimizing in the following aspects: establishing a "dynamic elimination mechanism" to update 30% of module content every two years; deepening the integration of "job-course competition certificates" and exploring the micro-certificate system to maintain the advancement and adaptability of the curriculum system. However, this paper still has certain shortcomings, such as the universality of the curriculum system needs to be further verified, and the research on differentiated adaptation of different majors is not in-depth enough. In the future, cross-institutional and cross-professional collaborative research can be carried out, focusing on exploring the implementation paths and effect differences of modular courses in different professional fields, and further improving the modular curriculum system of industry-education integration, so as to provide stronger support for cultivating high-quality application-oriented talents that adapt to industrial development.

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