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Construction of Engineering Education Quality Assurance System in Applied Undergraduate Colleges Under the Background of Emerging Engineering Education

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Abstract: The establishment of Emerging Engineering Education is not only a new type of talent cultivation system, but also the world's largest-scale engineering education reform in the contemporary world. Within the process of transitioning from nurturing research-oriented talents to application-oriented talents, application-oriented undergraduate institutions are interwoven with the transformation brought about by the Emerging Engineering Education development. Their quality assurance system for talent cultivation faces greater challenges. Addressing the practical issues in engineering education at application-oriented undergraduate institutions under the backdrop of Emerging Engineering Education, this article proposes a stable and effective engineering education quality assurance system that ensures and enhances the quality of engineering education. It supervises and regulates the teaching system to accomplish the predetermined goals of cultivating applied talents and exceptional engineers. The construction of the engineering education quality assurance system in application-oriented undergraduate institutions within the context of Emerging Engineering Education development should adhere to the scientific developmental concept of being "student-centered, output-oriented, and continuously improving." This article provides a profound interpretation of the essence of this concept and systematically discusses the entire process of establishing and implementing the quality assurance system, addressing the questions of who will provide assurance, what needs assurance, and how assurance will be ensured. The thoughtful construction of the engineering education quality assurance system in application-oriented undergraduate institutions will not only contribute to enhancing the quality of education and cultivating exceptional engineering talents but also facilitate the development and elevation of the school's reputation. It will meet the needs of society and industries, propelling continuous innovation and advancement in engineering education.

Keywords: Emerging Engineering Education, Talent Cultivation, Engineering Education Quality Assurance, System Construction

1. Introduction

In recent years, in order to proactively respond to the new wave of technological revolution and industrial transformation, the country has been actively promoting the construction of "Emerging Engineering Education" presenting new requirements for the quality of talent cultivation in higher education institutions [1]. For application-oriented undergraduate institutions that have just undergone transformational development, the transition from cultivating research-oriented talents to applied talents is intertwined with the reforms brought by the "Emerging Engineering Education" construction. The quality assurance system for talent cultivation faces greater challenges. The construction of "Emerging Engineering Education" is not only a novel talent cultivation framework but also the

largest-scale educational reform in engineering worldwide [2]. As a vital component of the higher education system, application-oriented undergraduate institutions are the main force behind the construction of "Emerging Engineering Education" and the vanguard of engineering education reform [3]. Promoting the improvement of education quality through evaluation and certification is a common experience of higher education development and quality construction in various countries around the world [4]. Within the context of "Emerging Engineering Education", based on the actual circumstances of application-oriented undergraduate institutions, establishing a new quality assurance system that aligns with the new concepts, models, and standards in engineering education can lead the direction of reform in engineering education for these institutions. This endeavor holds significant importance in accelerating the progress of engineering education reform.

After several years of active exploration, most application-oriented undergraduate institutions in various provinces and cities have established their own educational quality assurance systems and developed unique methods for conducting educational quality evaluations. Zhang et al. [5], from Hetao College, established a safeguard system composed of fundamental classroom teaching indicators under the context of "Emerging Engineering Education", tailored to the practical situation of newly established local application-oriented undergraduate institutions in Inner Mongolia. They combined diverse evaluation methods to promote diversified talent development. Li et al. [6] analyzed the practical aspects of experiential teaching in application-oriented colleges under the backdrop of "Emerging Engineering Education". They constructed an experiential teaching quality assurance system based on the CIPP model, with regulatory measures put in place by the administration to standardize the management of experiential teaching. This resulted in a closed-loop system for evaluating the quality of experiential teaching. Zhao et al. [7] considered the interdisciplinary integration, forward-looking nature, and innovation characteristics of "Emerging Engineering Education". They selected 26 indicators from six aspects, including curriculum design, infrastructure, and faculty input. They preliminarily constructed a safeguard system for innovation and entrepreneurship education in universities within the context of "Emerging Engineering Education". However, due to the relatively short period of transformation and development, the construction of "Emerging Engineering Education" is still evolving. While the educational quality assurance systems established by various application-oriented undergraduate institutions can supervise and control various aspects of the education process and outcomes, there still exists a certain gap between the objectives of cultivating innovative and excellent engineering talents and the essence of engineering education reform in the context of "Emerging Engineering Education". For instance, the current assurance system lacks monitoring in terms of "ideological and political education within the curriculum" [8, 9]; classroom teaching is separated from experiential teaching [10]; there is limited process-oriented assessment and continuous monitoring of students [11]; and there is insufficient involvement from industry employers [12].

This paper addresses practical issues in engineering education at applied undergraduate institutions within the context of "Emerging Engineering Education". It organically connects teaching and management activities that significantly impact engineering education. This establishes a stable and effective quality assurance system that ensures and enhances the quality of engineering education. The system supervises and controls the teaching process, ensuring the achievement of designated goals in cultivating applied talents and outstanding engineers. The paper systematically discusses the entire process of constructing and implementing the quality assurance system from various aspects, including those responsible for ensuring it, what is being ensured, and how the assurance is carried out.

2. The Concept of Constructing a Quality Assurance System

The construction of a quality assurance system for engineering education in applied undergraduate institutions under the context of the development of Emerging Engineering Education should adhere to the scientific development concept of "student-centered, outcome-oriented, and continuous improvement". The schematic diagram of this concept is illustrated in Figure 1.

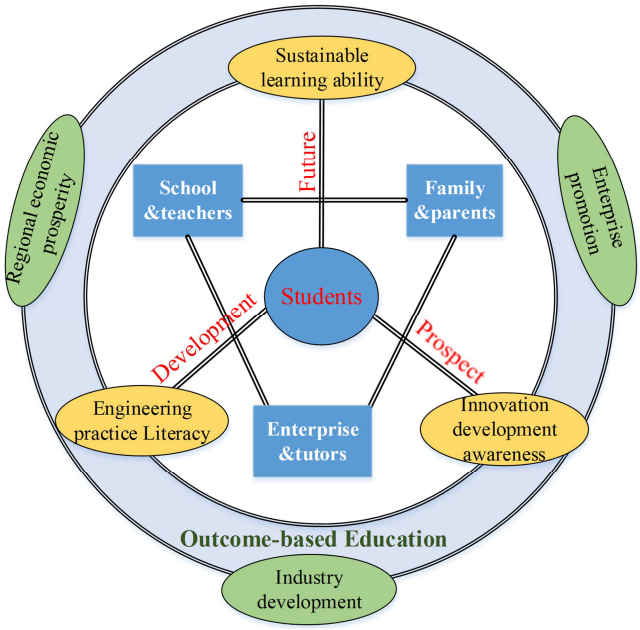

Figure 1. *The concept of constructing a quality assurance system.*

2.1. Student-Centered

Higher engineering education bears the significant responsibility of nurturing engineers who drive national and societal technological advancement, serving as a vital platform for cultivating technology innovation talents [13]. In

the context of the "Emerging Engineering Education", applied undergraduate institutions need to consistently deepen engineering education reforms and cultivate talents in emerging fields of engineering and technology. Therefore, it is crucial to uphold a student-centered philosophy. Being student-centered implies placing students' futures, development, and prospects at the core, fostering sustainable learning capabilities, engineering practical competence, and an awareness of innovative development to enhance students' core competitiveness.

2.2. Outcome-Oriented

In the context of the "Emerging Engineering Education", engineering education at applied undergraduate institutions bears a dual responsibility. On one hand, it is tasked with cultivating students into outstanding engineers who are not only application-oriented but also possess technological innovation capabilities and a well-rounded development encompassing ethics, knowledge, physical fitness, aesthetics, and practical skills. On the other hand, it is expected to serve regional industries and businesses, promoting regional economic prosperity and leading the development of industry enterprises. Outcome-oriented, this means organizing, implementing, and evaluating engineering education with anticipated learning outcomes at the core. These outcomes encompass two parts: talent output and service output. The former aligns logically and inseparably in practice with the student-centered approach's goals of nurturing talents with sustainable learning capabilities, engineering practical competence, and innovative development consciousness. The latter involves contributing to regional economies, industry development, and business enhancement. Talent output supports service output, and service output reciprocally nourishes talent output. These two parts of output rely on each other, mutually propelling one another. They not only serve as the objectives of applied undergraduate engineering education but also act as the driving forces behind it.

2.3. Continuous Improvement

The fundamental mission of the quality assurance system in engineering education is continuous improvement. By establishing effective quality monitoring and continuous improvement mechanisms, it ensures the ongoing tracking of improvement outcomes and uses them to drive the continuous enhancement of the quality of professional talent cultivation. The concept of continuous improvement in engineering education highlights that it is a dynamic and progressive process. The closed-loop feedback mechanism of "monitoring-evaluation- feedback-improvement" ensures the practicality and continuous development of the quality assurance for engineering education at applied undergraduate institutions. This approach dynamically adapts to the industry's evolving demands for talents, ultimately achieving a comprehensive elevation in the level of cultivating new types of engineering talents.

3. The Process of Constructing a Quality Assurance System

In the context of the "Emerging Engineering Education", applied undergraduate institutions implementing engineering education need to establish an adapted quality assurance system to facilitate the enhancement of engineering education quality and respond to society's practical demand for the quality of new engineering talents. The quality assurance system for engineering education involves the participation of all faculty members, students, and staff members engaged in engineering education. With a student-centered approach, this system employs various quality management methods to conduct comprehensive and all-encompassing quality management activities throughout the entire process of nurturing innovative engineering talents. These activities aim to promote continuous improvement in educational activities and the ongoing enhancement of talent cultivation quality, ensuring the management and operation of a system that guarantees the achievement of outstanding engineer cultivation quality goals.

The construction of the quality assurance system must clarify three points: who ensures, what is ensured, and how the assurance is carried out.

3.1. Who Ensures — Organizers and Managers of the Quality Assurance System

In the construction of a quality assurance system for engineering education at applied undergraduate institutions, it is necessary to clarify who ensures, namely the organizers and managers of the quality assurance system. These organizers and managers are engaged throughout the entire process of quality assurance, determining the goals, progress, and outcomes of engineering education quality assurance efforts. Within the school, organizational managers encompass a three-tier structure: school-department-major, and each level should ensure clear delineation of roles and responsibilities and collaborate effectively. This structure involves both decision-makers and implementers of quality assurance, establishing efficient feedback channels between them, thereby achieving the engagement of all members of the school and comprehensive quality management throughout the entire process. The organizational management structure within the school is illustrated in Figure 2 below.

Engineering education in applied undergraduate colleges should not only cultivate innovative engineering talents, but also serve local industry enterprises. Therefore, unlike traditional quality assurance systems that are only organized and managed by internal personnel within the school, the quality assurance system also needs to supplement and add external participants, including local employers, school enterprise cooperation units, enterprise mentors, student parents, etc., to form a comprehensive, multi-level, and three-dimensional organizational management model, as shown in Figure 3. Local employers, as the main employers of applied undergraduate universities, provide real-time

feedback on employment needs, job satisfaction, etc., evaluate the engineering adaptability of graduates, guide schools in formulating talent cultivation goals, and adjust talent cultivation plans. School enterprise cooperation units monitor students' professional internships and training activities, and provide periodic feedback on their engineering practical abilities. Corporate mentors and student parents also assess the achievement of outstanding engineers in monitoring engineering education from aspects such as professional competence and moral character.

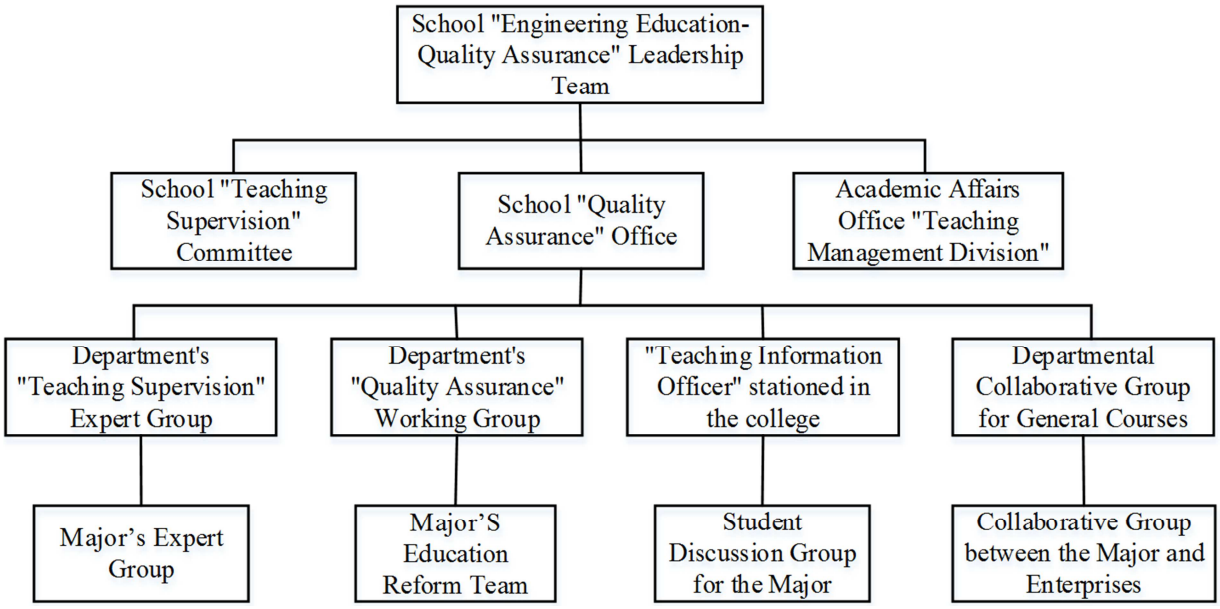

Figure 2. *Organizational Management Structure within the School.*

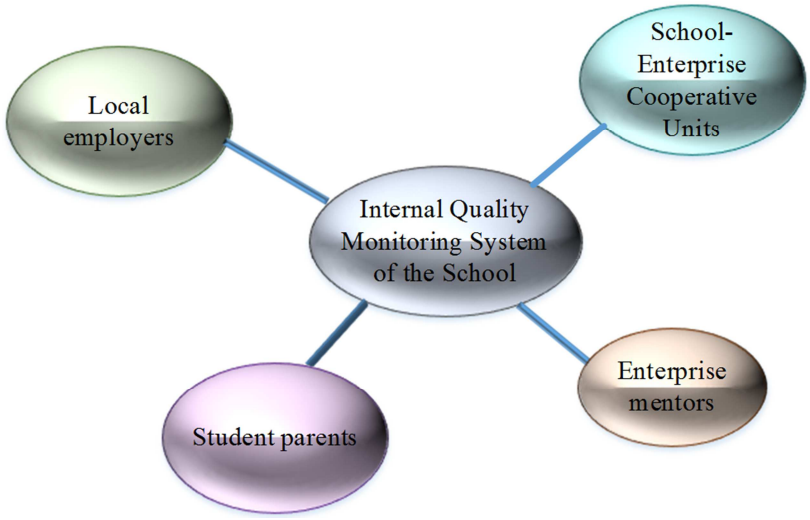

Figure 3. *Collaborative Organizational Model for School-External Joint Management.*

3.2. What Is Ensured — The Monitoring Subject of the Quality Assurance System

The reform of engineering education in applied undergraduate institutions is not merely implementing ordinary educational reform projects; it involves a series of educational innovations and transformations encompassing aspects such as talent cultivation orientation, discipline and major determination, professional cultivation plans, faculty development, and the internationalization of engineering education. Correspondingly, the monitoring scope of the quality assurance system for engineering education should also encompass these elements. The key stages include the monitoring of day-to-day teaching, assessment of teaching outcomes, and the employment of graduates; the involved components comprise the school, teachers, students, and enterprises. Furthermore, this quality monitoring system should be grounded in the foundation of applied undergraduate institutions, grasping the new characteristics of engineering education in the modern era. Special attention should be paid to the following aspects:

(1) Breaking through the limitations of traditional quality assurance systems that lack attention to "Curriculum Ideology and Politics". This system not only focuses on the quality of

"teaching" but also places special emphasis on the "education" aspect, which involves fostering individuals for the Party and nurturing talents for the country. The construction of "Emerging Engineering Education" requires being guided by the principle of "cultivating virtue and talent," demanding that applied undergraduate institutions shoulder the integrated educational responsibilities of value shaping, skill development, and knowledge transmission in the process of engineering education. As a result, the corresponding quality assurance system must pay particular attention to and ensure the integration and effectiveness of "Curriculum Ideology and Politics" in teaching activities. Through this approach, engineering education with a soul is realized, fostering outstanding engineers with patriotic sentiments and innovative practical abilities.

(2) Changing the conventional operation of traditional quality assurance systems in monitoring processes that tend to emphasize "teaching" over "learning". Overemphasizing the evaluation of teachers' "teaching" while neglecting the assurance and evaluation of students' "learning" can lead to situations where information is "poured in but not absorbed" and "triggered but not cultivated" [14]. Constructing a quality assurance system in alignment with the "Emerging Engineering Education" concept of "student-centered" places the students' active engagement and individual development in educational activities as the core safeguard, thus reshaping the monitoring and assurance priorities based on a "student-centered" approach. Expanding beyond the traditional standalone paper-based examination methods, the quality assurance system adapted to the "Emerging Engineering Education" philosophy, which focuses on students, encompasses forms such as student discussions, assessment of professional competence, and tracking graduates' employment. Through these methods, real-time insights into students' learning progress, professional skills, and employability are gained during their everyday learning process. The identified issues are then fed back into frontline teaching, thereby establishing a student-centered quality assurance system that is attentive to student development.

Table 1. *The reference assessment standards of Digital Circuit.*

Key Steps	Specific Measures
Establish Quality Assurance Planning	1. Establish a Quality Assurance Committee or similar body responsible for organizing and coordinating engineering education quality assurance activities. 2. Develop quality assurance policies, objectives, and strategies to clarify the direction and positioning of engineering education.
Course and Teaching Quality Assurance	1. Design and review curriculum offerings to ensure a scientifically reasonable curriculum system that meets engineering education requirements. 2. Develop course syllabi, defining teaching objectives, content, teaching methods, and assessment approaches. 3. Conduct teaching quality assessments, including student evaluations, peer reviews, and teaching observations, and adjust teaching strategies as needed.
Faculty Development	1. Regularly assess faculty structure and levels, provide training and development opportunities, ensuring teachers possess the required professional knowledge and educational capabilities for engineering education. 2. Encourage teachers to engage in research and engineering practices to stay updated on the forefront of the discipline and practical experiences.
Practical Teaching Assurance	1. Organize internships, practical training, and projects that allow students to apply theoretical knowledge to practical engineering problems. 2. Appoint practical guidance teachers or internship mentors to provide guidance and evaluation during internship processes.
Teaching Resource Development	1. Provide necessary teaching facilities, laboratories, and engineering practice spaces to support experimental and practical teaching activities. 2. Update teaching resources, including textbooks, multimedia materials, etc., to remain synchronized with engineering advancements.
Student Evaluation and Feedback	1. Regularly collect student evaluations and feedback on courses, teachers, and the learning environment to enhance teaching quality. 2. Establish student consultation and support mechanisms to assist students with academic and personal issues.
Quality Monitoring and Evaluation	1. Establish a quality monitoring system to regularly assess and monitor engineering education quality, including teaching effectiveness and student employment indicators. 2. Based on evaluation results, adjust educational plans and quality assurance strategies promptly.
Continuous Improvement and Innovation	1. Encourage teachers and management teams to participate in educational research and reform, continuously exploring new educational models and methods. 2. Establish improvement mechanisms to integrate evaluation results and feedback into a continuous improvement cycle.
Social Recognition and Collaboration	1. Collaborate with companies, industry associations, and others to establish mechanisms for internships, practical training, and employment, ensuring the integration of education with actual engineering needs. 2. Regularly communicate with society and share educational experiences to enhance the social recognition of engineering education.

(3) Reversing the previous awkward situation of the quality assurance system's emphasis on theory over practice. Practical teaching primarily cultivates students' abilities to analyze and solve engineering problems, communicate and coordinate, and engage in hands-on practice. It is a crucial component in nurturing engineering talents with practical applications. The quality of practical teaching directly impacts the quality of cultivating applied and engineering-oriented talents [15]. Practical teaching is one of the weak links in current engineering quality assurance. Within the context of the Emerging Engineering Education, engineering problems are more comprehensive, diverse, and interdisciplinary, requiring students to flexibly apply theoretical

foundations from subjects like mathematics, physics, natural sciences, and engineering fundamentals. They should use appropriate engineering techniques, online resources, modern engineering tools, and information technology tools to design experiments, analyze and interpret data, and arrive at rational and effective conclusions through integrated information. Hence, both theoretical and practical teaching are equally vital and complementary for engineering education within the context of the "Emerging Engineering Education". Constructing a quality assurance system tailored to applied undergraduate institutions' engineering education involves incorporating diverse practical teaching components, such as course experiments, professional internships, social practices, and student innovation and entrepreneurship activities, into the scope of assurance. This creates a model of collaborative assurance between theory and practice.

3.3. How to Ensure — The Implementation Process of the Quality Assurance System

The specific implementation process of quality assurance for engineering education in applied undergraduate institutions follows a bottom-up and inside-out approach. As the main body of quality assurance, universities need to enhance their awareness of quality and autonomy, placing significant emphasis on the establishment of internal educational quality assurance mechanisms. The implementation process can be divided into the following key steps, as shown in the Table 1 above.

In summary, quality assurance in engineering education is a continuous process that requires the collective efforts and participation of all faculty and students within the institution. This is to ensure the cultivation of applied talents with excellent engineering qualities.

4. Conclusion

Building an engineering education quality assurance system ensures effective monitoring and management of "Emerging Engineering Education" quality, thereby enhancing the overall quality and standards of education. This aids in cultivating more outstanding and socially adaptable engineering talents, offering high-quality educational services. Through the quality assurance system, applied undergraduate institutions can better understand societal and industry demands for engineering talents, adjust curriculum designs, teaching methods, and practical components, making education more aligned with practical needs and producing graduates with enhanced engineering application capabilities. High-quality engineering education equips students with richer knowledge and practical experiences, enhancing their competitiveness in the job market. The establishment of a quality assurance system contributes to producing graduates with solid engineering qualities, thereby increasing their employability and earning potential. Similarly, exceptional engineering education and the remarkable performance of graduates contribute to elevating the reputation and visibility of the institution. This not only attracts more students to enroll but also enhances the institution's influence in the industry and society. The establishment of a quality assurance system requires continuous assessment and improvement by the institution, encouraging innovation in educational methods and curriculum designs. This progress-oriented approach aligns education with the evolving needs of the times. The construction of the quality assurance system promotes collaboration among various departments within the institution and fosters communication and cooperation with external partners such as industries and enterprises. This facilitates the sharing and exchange of educational resources.

In conclusion, the construction of an engineering education quality assurance system in applied undergraduate institutions not only improves educational quality and nurtures exceptional engineering talents but also drives the institution's development and reputation enhancement. It meets societal and industry demands, propelling continuous innovation and advancement in education.

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