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Undergraduate Learning Ability and Career Cognition in Emerging Engineering Fields: A Systematic Review

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Abstract: Against the backdrop of new-quality productivity driving rapid iteration in emerging industries, the interdisciplinary integration and swift technological advancement characteristic of new engineering fields have set higher standards for undergraduate students' learning capabilities and career awareness. This paper systematically reviews relevant research findings, focusing on the current status of core learning competencies and career cognition among undergraduate students in new engineering disciplines. The paper conducts an in-depth analysis of structural issues in talent development and clarifies the intrinsic bidirectional relationship between these two aspects. The study reveals that students commonly face rigid learning patterns, deficiencies in higher-order skills, fragmented career understanding, and weak alignment in career planning—factors that mutually constrain each other and result in suboptimal talent development outcomes. To address these challenges, this paper proposes improvement measures from three dimensions: competency cultivation, cognitive development, and industry-education collaboration, offering insights for reforming undergraduate education in new engineering fields and enhancing the alignment between talent development and industrial needs.

Keywords: Emerging engineering fields; Undergraduate students; Learning ability; Career cognition; Talent cultivation

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1. Introduction

With new-quality productivity empowering industrial transformation, emerging engineering industries including artificial intelligence, integrated circuits, low-altitude technology, and new energy have achieved rapid development, which has completely reshaped the job structure, technical standards, and talent requirement system of the engineering community. Different from the standardized and fixed talent demand of traditional engineering disciplines, emerging engineering industries attach greater importance to candidates' cross-boundary learning, dynamic adaptation, innovative practice, and sustainable career development capabilities, which brings disruptive challenges to the cultivation of undergraduate talents in

emerging engineering programs in colleges and universities. As the main component of the reserve talent for emerging industries, undergraduates' learning ability determines the updating and matching speed of knowledge and technology, while their career cognition affects employment choice, the pace of career development, and job retention. At present, there are a growing number of academic studies on the learning ability and career cognition of engineering students, but most of them focus on isolated research on a single major or a single aspect, and no systematic analysis has been conducted on these two fundamental competencies of undergraduates in the emerging engineering field. Based on the relevant academic research outcomes over the past decade, this paper summarizes the development status and existing problems of emerging engineering undergraduates' learning ability and career cognition, as well as the interaction between the two dimensions, accurately aligns with the employment demand of emerging industries, proposes approaches for the synergistic improvement of the two competencies, and promotes the formation of an interactive synergistic development pattern between vocational education and the development of new emerging industries.

2. Current status and shortcomings of core learning competencies of undergraduate students in emerging engineering fields

2.1. Basic learning competencies meet standards while high-order integrative capabilities are weak

At the current stage, most undergraduate students in emerging engineering disciplines possess solid theoretical foundations and are capable of completing basic learning tasks such as in-class knowledge memorization, application of fundamental formulas, and routine experimental operations, which satisfies the basic academic requirements for undergraduate studies. However, from the perspective of industrial adaptability, students have obvious deficiencies in high-level learning capabilities, which are mainly manifested as the lack of systematic mastery of knowledge points and insufficient interdisciplinary comprehensive application capabilities. Most emerging engineering technologies are products of interdisciplinary integration, covering multiple fields including mechanics, electronics, information technology, and materials science. Nevertheless, the majority of students still study in accordance with the traditional siloed teaching and isolated knowledge acquisition mode in science and engineering, leading to severe disciplinary segmentation. As a result, they are unable to integrate basic mathematical and physical knowledge, professional technologies, and practical engineering scenarios [1]. Relevant studies indicate that only approximately 30% of engineering undergraduates can quickly adapt to technological updates in enterprises, while most students apply knowledge in a rigid manner and cannot rely on their acquired knowledge to solve complex and open-ended emerging engineering problems. The main causes of this issue are the lack of critical thinking and systematic knowledge integration capabilities. Furthermore, with the rapid development of new technologies, students have poor capabilities for independent knowledge updating, retain a strong habit of passively accepting knowledge in classrooms, and cannot keep up with the latest industrial technologies and the development requirements of new quality productive forces.

2.2. Formalized practical learning with insufficient innovation and adaptation capabilities

Practical learning constitutes a critical link in the cultivation of core competencies for undergraduate students

majoring in emerging engineering disciplines. However, the current practical teaching system in Chinese universities remains underdeveloped, which leads to unsatisfactory practical learning outcomes for students. Most existing practical courses are dominated by simulated training and fixed-procedure experiments, while the proportion of comprehensive and innovative practical content that is closely aligned with real job scenarios and cutting-edge technology applications in emerging industries is relatively low [2]. The majority of students engage in practical learning merely to fulfill academic requirements, lacking the awareness of active exploration and innovative trial and error; thus, their practical operation capabilities, scheme optimization capabilities, and system integration capabilities are relatively weak. Positions in the emerging engineering industry require talents to possess full-chain practical capabilities from theory to product development, and to be competent for the entire workflow, including demand demonstration, scheme design, debugging, and optimization. Nevertheless, most undergraduate students only master scattered practical skills, fail to form systematic engineering practice thinking, and cannot meet the requirements of interdisciplinary positions in emerging industries. In addition, students' digital learning capabilities and intelligent technology application capabilities are uneven, and their mastery of emerging tools such as artificial intelligence, simulation design, and system control is insufficient, which leads to a mismatch between students' learning capabilities and industrial demands [3].

3. Characteristics and major problems of undergraduates' career cognition development in emerging engineering fields

3.1. Shallow career identity and insufficient industrial sense of belonging

Career identity serves as the fundamental intrinsic motivation for students to engage in the industry and commit to their positions in the long term. However, a prevailing surface-level career identity issue is commonly observed among current emerging engineering undergraduates. On the one hand, as an emerging field, the emerging engineering industry has not yet fully established mature development patterns, post systems, and promotion paths. During their schooling, students lack access to systematic industrial cognition channels, leading to a vague understanding of the job responsibilities, technical value, and industrial prospects of emerging engineering positions, which prevents them from establishing clear professional value recognition. On the other hand, some students hold cognitive biases: they one-sidedly believe that emerging engineering positions are characterized by high work intensity, high technical threshold, and high employment uncertainty, overemphasize superficial factors such as salary and working environment, while neglecting the strategic value and development potential of the industry. Referring to the research findings on undergraduate career identity in majors such as medicine and social work, students in emerging science and engineering majors are more prone to the chain reaction of academic burnout and lack of career identity. Shallow career identity weakens students' learning motivation and makes it difficult for them to form professional beliefs for long-term commitment to the industry [4].

3.2. Static career planning and lack of dynamic adaptability

Dynamic adaptive career planning is a core requirement for talent career development in emerging engineering fields. Nevertheless, most current undergraduates' career planning presents obvious characteristics of staticity and blindness. The majority of students' planning only stays at the low-level stage, such as immediate employment after graduation or postgraduate entrance examinations, and few of

them develop medium- and long-term plans based on their own capabilities, industrial changes, and job demand. Some students choose careers or pursue postgraduate study blindly following peers, without a clear understanding of the prospects of their industry and their own shortcomings, thus failing to make timely adjustments corresponding to technological progress and job requirement changes. Most prominently, students from private undergraduate universities and non-key undergraduate institutions tend to hold utilitarian employment concepts and are prone to the problem of overestimating their own abilities. They are unwilling to take root in grassroots technical positions, while at the same time failing to meet the job requirements of high-end R&D positions [5]. It can be seen that the higher the alignment between an individual's career development path and industrial development and the student's actual situation is, the better the career development outcome will be; otherwise, it will lead to incoordination or conflicts in career planning. Most of the career guidance provided by colleges and universities is general-oriented, rarely involves the cultivation and development of professional knowledge or skills related to emerging industrial fields, which further narrows students' development paths and deprives them of various options they should have had.

3.3. One-sided employment cognition and cognitive bias in supply-demand matching

At the level of employment cognition, emerging engineering undergraduates generally have cognitive biases in supply-demand matching. Most students have insufficient understanding of the employment criteria, capability requirements, and job gaps of the emerging industry. They only focus on the popularity of employment, while neglecting the degree of match between positions and their own capabilities. Some students overestimate their professional capabilities, lack understanding of actual job requirements, and feel pressure from technical updates, which makes it difficult for them to quickly adapt to job requirements after entry. Another group of students underestimates the development potential of the emerging engineering field, worries about the pressure brought by technological innovation, and proactively avoids core technical positions and turns to positions unrelated to their major, resulting in a waste of professional human resources. From the perspective of collaborative education, there is a disconnect between the output standards of talent cultivation in colleges and universities and the employment demand of emerging industries. Students lack first-hand industrial cognition and on-the-job training experience during schooling, which leads to a disconnect between their employment cognition and industrial reality, resulting in insufficient scientificity and accuracy of employment choices.

4. The internal coupling mechanism between learning ability and career cognition

Through systematic collation of relevant studies, it can be found that the learning ability and career cognition of undergraduate students majoring in emerging engineering are not independent of each other. Instead, they constitute an interrelated internal connection characterized by mutual influence and mutual promotion, and together determine the quality of talent cultivation and the effectiveness of employment development. On the one hand, learning ability serves as the core foundation for the deepening of career cognition. The stronger students' capabilities in cross-border integration, innovative practice, and independent iterative learning are, the more accurately they can grasp the technical characteristics, job requirements, and future development direction of the emerging engineering industry, clarify the matching degree between themselves and target positions, thereby form scientific and in-depth career cognition, and improve the accuracy of

career identification and career planning. Conversely, students with weak learning ability cannot correctly understand the professional value and industry development prospects, and are prone to problems such as vague career cognition, low career identification, and confused career planning.

On the other hand, career cognition acts as the intrinsic driving force for the improvement of learning ability. Clear career cognition and definite career development goals can guide students to targetedly compensate for their learning shortcomings, proactively align with job requirements, improve higher-order learning ability as well as practical and innovative ability, and form a positive cycle of "cognition guides learning, learning empowers employment." Students with biased career cognition and vague career goals generally suffer from insufficient learning motivation, confused learning direction, and negative participation in practical activities, which further exacerbates their weakness in learning ability. At present, the core problem in the talent cultivation of emerging engineering undergraduates lies in the coupling imbalance between the two dimensions, which is manifested in the disconnection between learning cultivation and cognitive shaping. As a result, the output of talents cannot meet the requirements for the coordinated development of emerging industries.

5. Collaborative enhancement and optimization strategies for undergraduate competencies in emerging engineering fields

5.1. Focus on industrial demand and reconstruct a high-order learning ability training system

Based on the characteristics of rapid technological updates and a high degree of cross-boundary integration in the emerging engineering industry, higher education institutions should break through the traditional segmented teaching mode and form an interdisciplinary and dynamic learning ability training system. It is necessary to optimize the curriculum system by offering courses in cutting-edge technologies and cross-boundary integration, break down knowledge barriers between basic disciplines and emerging engineering majors, and focus on cultivating students' capabilities in knowledge integration, complex problem decomposition, and systematic thinking. In terms of practical teaching, the mode should be innovated by aligning with real engineering scenarios of enterprises, adding practical contents such as comprehensive innovation training, project-based teaching, and university-enterprise joint research, so as to strengthen students' whole-chain engineering practice ability and innovative adaptability. Meanwhile, students should be guided to change their learning approaches: get rid of the inertia of passive exercise-based and exam-oriented learning, cultivate the awareness of independent iterative learning, take the initiative to track cutting-edge industrial technologies, and adapt to the pace of technological updates under the development of new quality productivity.

5.2. Strengthen targeted empowerment and establish a dynamic professional cognition training system

A normalized dynamic professional cognition cultivation mechanism should be established to address the problems of superficial and static professional cognition among students. According to the characteristics of industries in emerging engineering fields, higher education institutions should carry out professional cognition education. By means of cutting-edge industry lectures, enterprise visits, post-awareness internships, experience exchanges with outstanding practitioners, and other approaches, institutions can help students

fully understand industrial development trends, post-employment standards, and career growth paths, and enhance students' professional identity. Career planning guidance services should abandon the general guidance mode and provide personalized phased guidance based on the needs of new industrial posts and individual characteristics of students, so as to help students form a development-oriented employment concept and eliminate the problems of overestimating one's own abilities and blind employment. Students should be guided to establish correct professional values, unify the interests of short-term employment with long-term career development, focus on improving their own professional competence, and expand their space and sustainability for career development.

5.3. Deepen industry-education integration and build an integrated education platform for competence and cognition

Relying on the collaborative education mechanism between vocational undergraduate education and emerging industries, it is necessary to promote industry-education integration and university-enterprise cooperation, and break down the connection barriers between learning ability cultivation and professional cognition shaping. It is necessary to promote universities and enterprises to jointly develop talent training programs, co-research curriculum systems, and share training platforms, and integrate enterprise post-competence standards and technological iteration requirements into daily teaching, so that students can align with industrial demands synchronously during professional learning, and realize the precise adaptation between learning ability cultivation and post requirements. A two-way exchange platform between universities and enterprises should be established: invite enterprise engineers to campus for teaching and practical guidance, and organize students to take on-the-job internships in enterprises and participate in real engineering projects. In this way, students can deepen their understanding of the industry in practical operations, identify their own competence deficiencies, form a three-dimensional growth path, and comprehensively improve the quality and industrial adaptability of undergraduate students in emerging engineering fields.

6. Conclusion

The learning ability and career cognition of undergraduate students in emerging engineering fields are core competencies that adapt to the development of new quality productivity and support the high-quality development of emerging industries. The coordinated development of the two is the key to improving the quality of talent cultivation and addressing the problem of supply-demand mismatch in employment. At present, undergraduate students in emerging engineering face such problems as insufficient higher-order learning ability, low practical adaptability, one-sided career cognition, and delayed career planning; the unbalanced coupling between learning ability and career cognition also hinders the high-quality development of talents. Colleges and universities should base themselves on the development demands of emerging industries, focus on ability cultivation, take cognition shaping as an approach, and use industry-education collaboration as support to reconstruct the talent cultivation system, so as to achieve the simultaneous improvement of students' learning ability and career cognition. This will enable the continuous delivery of innovation-driven talents that meet industrial demands to emerging engineering sectors, and further promote the formation of a benign mutual development pattern between vocational undergraduate education and emerging industries.

Disclosure statement

The authors declare no conflict of interest.

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