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Curriculum Reform and Practice of Engineering Geology under the Concept of Integrating Five Educations

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Abstract: Promoting the integration of moral, intellectual, physical, aesthetic and labor education ("Five Educations") in professional courses is the goal and mission of talent training in colleges and universities in the new era endowed by China's education modernization. As a professional basic course for civil engineering majors in ordinary colleges and universities, Engineering Geology still has the problem of paying attention to the teaching of professional knowledge and ignoring the excavation and infiltration of "physical, aesthetic and labor education" in the course in terms of professional ability training orientation. Taking the engineering geology course with intensive interdisciplinary knowledge points, strong engineering application and field practice as the reform object, this paper excavates the "Five Educations" elements and values of engineering geology, deeply explores the implementation path and landing mechanism of "Five Educations Integration" in engineering geology, and constructs a "value-knowledge-ability-quality" four-in-one teaching mode by reconstructing the four-stage progressive teaching chain of "classroom intensive explanation-problem discussion-industry collaboration-field training," to promote curriculum construction and comprehensively improve the quality of talent training, and provide a universal reference for the reform of engineering foundational courses under the background of Emerging Engineering Education (3E) .

Keywords: Five-Education elements; Five-Education integration; Engineering geology; Field practice; Teaching model

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1. Introduction

The talent training concept in different periods contains different value concepts. From the "three educations" theory of morality, intelligence and physique [1], the parallel "four educations" of morality, intelligence, physique and aesthetics [2], to the "simultaneous development of five educations" [3], and then to the "integration of five educations" of morality, intelligence, physique, aesthetics and labor in the new era [4–6], it reflects the adjustment and change of China's talent training concept. Colleges and universities in China are important cultivation bases for the "integration of five educations", and the professional courses they offer are important

carriers for the "integration of five educations". Although most professional courses have begun to pay attention to the "integration of five educations", the "five educations" are often implemented in isolation and separated. Teachers are often used to sticking to the boundaries of disciplines in teaching activities, and do not fully excavate the elements and values of the "five educations," which is not conducive to the cultivation of talents with all-round development of morality, intelligence, physique, aesthetics and labor. Therefore, ways to promote the integration of morality, intelligence, physique, aesthetics and labor in professional courses is an important issue in curriculum teaching reform.

As a compulsory basic course for civil engineering, water conservancy engineering, transportation engineering, road and bridge engineering and other majors in ordinary colleges and universities, Engineering Geology is characterized by rich content, wide knowledge, abstract theory and strong practical ability [7,8]. In order to complete the complicated teaching tasks, there are still problems of attaching importance to intellectual education, neglecting moral education and lacking innovation in professional ability training. At present, the employment situation of civil engineering majors in China presents a pattern of "challenges and opportunities coexisting." Under this background, exploring the implementation path and landing mechanism based on the actual situation, promoting the "integration of five educations" and promoting the coordinated development of professional quality and morality, intelligence, physique, aesthetics and labor has become an urgent teaching problem to be solved in curriculum reform.

2. Teaching status and cause analysis

The Engineering Geology course is characterized by its strong professionalism and practicality, covering content, such as rocks, geological structures, soil, groundwater, adverse engineering geological phenomena, and engineering geological surveys. Under the talent training requirements of Emerging Engineering Education, students are required not only to fully and systematically master theoretical knowledge and have strong practical operation capabilities, but also to meet and adapt to the development requirements of a new round of scientific and technological revolution and industrial transformation [9–11]. Continuing to base on traditional teaching contents, models and methods makes it difficult to achieve such teaching objectives, which are mainly reflected in the following problems.

2.1. Emphasis on intellectual education, neglect of moral education, and lack of innovation

In the teaching of Engineering Geology, the prevalent overemphasis on professional knowledge imparting has caused a severe disconnection from physical education, aesthetic education, and labor education. The cultivation of "physical, aesthetic, and labor" literacy is significantly weakened, constrained, or even absent in the curriculum. Some hold the view that "physical, aesthetic, and labor education" solely belong to the responsibility of PE teachers and humanities/art educators, with little relevance to science and engineering courses. This fragmented mindset has led curriculum designers and instructors to overlook the necessity and feasibility of proactively exploring and artfully integrating the elements of "physical, aesthetic, and labor" into the disciplinary content of Engineering Geology. Due to the lack of integration of "physical, aesthetic, and labor" elements in the curriculum itself, students are deprived of diversified learning experiences and incentives, thus prone to losing interest and motivation in classroom participation, which hinders the cultivation of their comprehensive literacy.

2.2. Disconnection from physical, aesthetic and labor education

In the teaching process of Engineering Geology, there is a common problem of overemphasizing the imparting of professional knowledge, leading to a serious disconnection from physical education, aesthetic education, and labor education. The "physical, aesthetic and labor" education is significantly weakened, suppressed or even absent in the curriculum. Some views hold that "physical, aesthetic and labor education" belongs to the responsibility of physical education and humanities and art teachers, and there is little relevance to science and engineering professional courses. This fragmented thinking makes curriculum designers and implementers ignore the necessity and possibility of actively excavating and skillfully infiltrating the elements of "physical, aesthetic and labor education" in the content of engineering geology. Precisely because the curriculum content itself lacks the integration of "physical, aesthetic and labor education," students can hardly obtain diversified experiences and incentives in the learning process, and naturally tend to lose interest and motivation in class, which is not conducive to the cultivation of their comprehensive qualities.

2.3. "Five Educations" fragmentation and the lack of integration

From an overall educational perspective, knowledge in all disciplines embodies the educational values of "morality, intelligence, physical education, aesthetics, and labor". Professional courses serve as the critical carriers for advancing the "integration of the Five Educations". However, a review of the current practice of the "Five Educations" in engineering geology courses reveals a prominent issue: isolated implementation and mutual fragmentation. Teaching activities rigidly adhere to traditional disciplinary boundaries, failing to effectively uncover, explore, and systematically demonstrate the inherent "Five Educations" values within professional knowledge, nor to establish an organically integrated "Five Educations" curriculum cultivation system. The current curriculum construction and training objectives still fall short of fully reflecting the advanced educational philosophy of "Five Educations Integration," a state that constrains the cultivation of comprehensively developed talents. It is essential to recognize that the "Five Educations" are not independent entities but exist in profound relationships of mutual promotion and collaborative transformation; the full realization of any educational goal relies on the effective support and supplementation of the other "Four Educations." Therefore, the fragmented implementation model of the "Five Educations" in engineering geology courses urgently needs to shift toward deep integration and interconnection to align with the fundamental requirement of fostering virtue through education.

3. Implementation pathways and mechanisms

Based on the above analysis of the teaching status, under the concept of "integration of the Five Educations," this paper explores practical implementation paths and operational mechanisms to promote the "integration of the Five Educations" and facilitate the coordinated development of professional competencies with morality, intelligence, physical fitness, aesthetics and labor from the following aspects.

3.1. Integrating moral education: Cultivating ethics and responsibility

In the instructional design of the Engineering Geology course, the curriculum knowledge system is analyzed, and ideological and political topics are discussed through heuristic, discussion-based, and case-driven teaching methods to evoke students' empathy and resonance, thereby accomplishing the ideological and political teaching task of "nourishing silently." Super projects and the stories behind them, such as the Five-hundred-

meter Aperture Spherical Radio Telescope (FAST), the Three Gorges Dam, the Qinghai-Tibet Railway, and the Hong Kong-Zhuhai-Macao Bridge, are introduced to cultivate students' qualities of dedication, perseverance, focus, and innovation, and to strengthen their "Four Spheres of Confidence." By integrating the spirit of craftsmanship of a great nation, China's speed, and the rescue capabilities of a great nation, students are guided to develop a sense of patriotism and strengthen their social responsibility. The application of industrial solid waste in foundation treatment is introduced to encourage students to actively respond to national strategic goals and contribute to carbon peaking and carbon neutrality. Geological disaster cases, such as the Wenchuan earthquake and the Zhouqu catastrophic debris flow, are used as vehicles to cultivate students' sense of social responsibility and mission. Engineering accident cases, such as the settlement of the central hall of the Shanghai Exhibition Hall and the subgrade settlement of the Nanning-Kunming Railway, are used as vehicles to establish students' awareness of project quality, safety, industry standards, and the law. The application of aviation engineering, geological surveys and remote sensing technology is introduced to stimulate students' pioneering spirit and innovative consciousness.

3.2. Innovating intellectual education: Enhancing expertise and creativity

Based on the development needs of emerging engineering education, while imparting professional knowledge, we should focus on cultivating students' innovative awareness and integrate innovative awareness education into the entire process of professional course teaching. Adopt the teaching model of "case analysis-intensive training," establish a course case database, assign open-ended assignments, allow students to form groups freely and give group reports, and guide students to use the knowledge they have learned to solve practical engineering problems. Construct a formative assessment and evaluation system, pay attention to process assessment, increase the proportion of usual grades, incorporate online classroom activities into the assessment of usual grades, and stimulate students' enthusiasm for participation. Set up interest groups, guide students to independently design experiments, participate in innovation and entrepreneurship competition projects, cultivate innovative achievements relying on projects, and improve students' innovative and practical abilities. Introduce typical innovation and entrepreneurship cases in the classroom, drive students to brainstorm, inspire students' innovative thinking, and achieve the deep integration of professional education and innovation and entrepreneurship education.

3.3. Strengthening physical education: Building resilience

The purpose of physical education is to enhance comprehensive qualities and serve the comprehensive development of students. The high-intensity work in civil engineering requires graduates to have a healthy body. In the process of theoretical teaching, students should be constantly reminded to develop a healthy lifestyle, adhere to physical exercise, and use it to enrich their extracurricular life and relieve psychological pressure. At the same time, discussing hot sports events in class can narrow the distance with students and guide their fighting spirit and sense of rules. During the engineering geology internship, students can participate in outdoor mountain climbing while conducting field internships to exercise the body, please the body and mind, and create a good atmosphere while completing the internship.

3.4. Enriching aesthetic education: Inspiring creativity

Aesthetic education constitutes a vital component of quality-oriented education, and civil engineering courses can serve as primary channels for its infiltration. By fully excavating the aesthetic elements within the

curriculum, students can experience the artistic conception of beauty, enhancing their imagination, creativity, and aesthetic cultivation while stimulating learning interest. The edification of beauty helps regulate academic pressure, improve mental states, and alleviate study fatigue.

In Engineering Geology, aesthetic elements should be deeply explored and integrated into both theoretical classes and field internships. When teaching geological landforms, animated videos, short films, and landscape photography can showcase the magnificence of China's natural landscapes, such as Zhangye's Colorful Danxia landform, Guilin's karst mountains, and Hezhou's stone forests, allowing students to appreciate the geological beauty created by nature. During field internships, guiding students to observe typical geological phenomena in natural settings not only reinforces professional knowledge but also enables them to embrace the grandeur of the motherland's landscapes, integrating aesthetic perception with scientific exploration.

3.5. Deepening labor education: Honoring practical skills

Internship serves as an extension of theoretical teaching and a crucial approach for students to master labor skills and enhance practical capabilities. The engineering geology internship program leads students into nature, where they identify geological phenomena such as rocks, strata, geological structures, and adverse geological conditions, allowing them to experience fieldwork environments firsthand. Carried out in groups, the internship cultivates students' teamwork skills through mutual assistance and collaboration.

During the internship, distinctive activities such as specimen collection and field photo shooting are organized, encouraging students to share their work achievements on the Xuexitong platform. By adopting a peer evaluation system, where students vote and comment on the most popular works, it motivates active participation and the sharing of labor outcomes. Additionally, lectures by enterprise engineers are invited to present practical engineering cases, new technologies, and innovative concepts, enabling students to feel the dedication of frontline engineers, thus guiding them to love labor and take pride in it.

4. Five-educations integrated teaching model

Based on the current status, implementation paths, and implementation mechanisms of engineering geology courses, guided by the "integration of five educations" (morality, intelligence, physique, aesthetics, and labor education), this paper reconstructs a four-stage progressive teaching chain of "classroom intensive teaching-problem discussion-industry collaboration-field training." It systematically integrates elements of moral education for soul-casting, intellectual education for foundation-consolidation, physical education for strength-building, aesthetic education for infiltration, and labor education for tempering, to build a new teaching paradigm of "value-knowledge-ability-quality" integration.

4.1. Classroom lectures

The classroom assumes a pivotal role in the instructional framework of engineering geology courses. It is imperative to comprehensively excavate the elements of the "Five Educations" (morality, intelligence, physical education, aesthetics, and labor), clarify the inherent logic of integrating these five educational components (**Figure 1**), and deliver classroom-based professional knowledge instruction with emphasis on consolidating foundational understanding and providing value-oriented guidance. Transcending the listing of geological facts, an integrated knowledge system should be constructed along the trajectory of "basic geology-engineering geological issues-evaluation methodologies-engineering countermeasures."

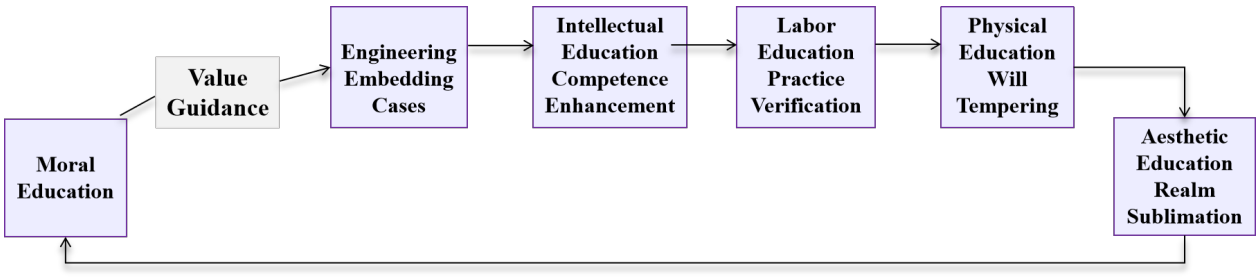

Figure 1. Integration model of the five education elements.

Enhancing the synergy with engineering practice remains critical. For example, the mechanical properties of rocks are contextualized with tunnel support design during instruction, while groundwater dynamics are linked to foundation pit dewatering and foundation settlement scenarios. By selecting paradigmatic domestic and international engineering cases (both successful and failed), such as reservoir-induced seismicity, slope instability incidents, and building tilting due to uneven foundation settlement, analyses of their geological origins, decision-making rationales, and ethical responsibilities (with moral education integration) aim to stimulate academic curiosity and problem-awareness.

Advanced technologies, including GIS, 3D geological modeling, and VR/AR are leveraged to visualize geological structures and the evolutionary processes of engineering geological problems, translating abstract concepts into tangible representations to enhance spatial cognition and cultivate appreciation for the aesthetic dimensions of geological formations (aesthetic education infiltration). Timely integration of geological challenges and technological advancements in emerging engineering frontiers, such as deep-earth/ocean exploration, urban underground space utilization, and intelligent monitoring of geological disasters, serves to advance intellectual education. Furthermore, by contextualizing the geological complexities and problem-solving ethos embedded in national megaprojects (e.g., Sichuan-Tibet Railway, Three Gorges Project, Hong Kong-Zhuhai-Macao Bridge), the instructional framework reinforces scientific spirit and engineering professionalism, deepening moral education objectives.

4.2. Problem seminars

Problem design constitutes the linchpin of issue-oriented seminars, necessitating the establishment of open-ended and challenging complex engineering geology scenarios. Examples include "Formation, Impacts, and Prevention of Earthquakes," "Landslide Geological Disaster Mitigation and Response," and "Causes, Types, and Control Measures for Uneven Settlement." The seminar workflow unfolds as follows.

During pre-class preparation, instructors provide foundational material packages (geological maps, fragmented survey reports, code specifications, etc.), while students conduct literature reviews and data analysis in groups. Teams engage in intensive internal discussions to formulate preliminary solutions or reports. For in-class deliberations, methodologies like the "Jigsaw Learning Method" [12] facilitate cross-group knowledge exchange in teams of 3 to 6 members. Instructors assume the role of facilitators and interrogators, encouraging critical inquiry and debate.

For results presentation and defense, each group showcases solutions via PPT, defending their proposals against peer and faculty questioning. Evaluation prioritizes logical coherence, innovativeness, feasibility, and teamwork. The assessment framework employs multi-source feedback, including teacher evaluation, inter-group peer review, and intra-group self-assessment, focusing on process participation, depth of critical

thinking, and collaborative efficacy. This model not only enhances disciplinary competence but also cultivates systems thinking, engineering ethics, and problem-solving agility in authentic contexts.

4.3. Industry collaboration

Engineers serve not only as technical instructors but also as demonstrators of professional ethics and guides for engineering practice. Inviting engineers into the classroom establishes industry-academia connectivity, integrates theory with practice, expands intellectual education, models moral cultivation, and enhances understanding of labor education.

Senior engineers from partner companies are carefully selected, with pre-class communication to align their shared focus with course content and the "Five Educations" objectives. Students are guided to prepare questions and engage actively. Engineers share firsthand experiences in engineering projects, emphasizing how geological knowledge addresses real-world challenges, decision-making processes, and lessons learned, particularly the "live" knowledge beyond standard codes. They introduce cutting-edge industry technologies (e.g., InSAR monitoring, ground-penetrating radar, UAV aerial surveying), design software, and construction techniques applied in geological engineering.

The session highlights engineers' social responsibility, safety imperatives, lifelong quality accountability, and professional ethics, such as the integrity of engineering geological reports and prudence in risk assessment. A Q&A session allows students to inquire about industry trends, career planning, and skill requirements, fostering direct dialogue between academic learning and professional practice. This initiative bridges the gap between classroom theory and industry reality, embedding vocational spirit and practical competencies within the educational framework.

4.4. Field practice

Engineering geology fieldwork stands as the core of curricular reform for engineering geology courses [13], serving as a comprehensive testing ground for the integration of the "Five Educations" (morality, intelligence, physical education, aesthetics, and labor). The goal is to enable students to "measure the earth with their feet, touch rocks with their hands, observe structures with their eyes, and think through problems with their minds." The internship design is detailed in **Table 1**.

Table 1. Field practice framework

Stage	Tasks	Competencies cultivated	Five-education integration
Preparation	Literature review, route planning, safety training	Planning, risk awareness	Intellectual, Moral (Responsibility)
Field survey	Rock identification, structural measurement, groundwater observation	Observation, operation, data recording	Intellectual, Labor, Physical
On-site analysis	Slope stability assessment, site suitability discussion	Critical thinking, judgment	Intellectual, Moral (Prudence)
Data processing	Map drafting, photo annotation, and statistical analysis	Data visualization, organization	Intellectual, Labor, Aesthetic
Report writing	Synthesizing findings into formal reports	Logical expression, integration	Intellectual, Labor
Reflection	Group debriefs, gap analysis between theory/practice	Collaboration, metacognition	Moral (Teamwork), Intellectual

Fieldwork emphasizes an engineering-oriented approach, with routes designed based on local conditions. Internship routes and observation points are closely centered on typical engineering geological issues (such as slopes, reservoirs, springs, bridge foundations, karst caves, etc.) rather than pure geological sightseeing. The field internship route is designed as follows: Hezhou College West Campus → Shidong Reservoir in Shatian Town → Longjing Spring in Longjing Village, Shatian Town → Wugui Bridge in Mafeng Village, Shatian Town → Shiyanlong Cave in Madong Village, Shatian Town → Hezhou College West Campus, as shown in **Figure 2**. It covers the identification and recording of field geological phenomena, simple discrimination of geotechnical engineering properties, compass use, joint fracture statistics, sketching of geological profiles, simple slope stability analysis, identification of geological disaster hazards, types of groundwater, karst adverse geological phenomena, etc. In the process of the internship, modern technologies such as GPS positioning, geological APP recording, and UAV-assisted observation are integrated.

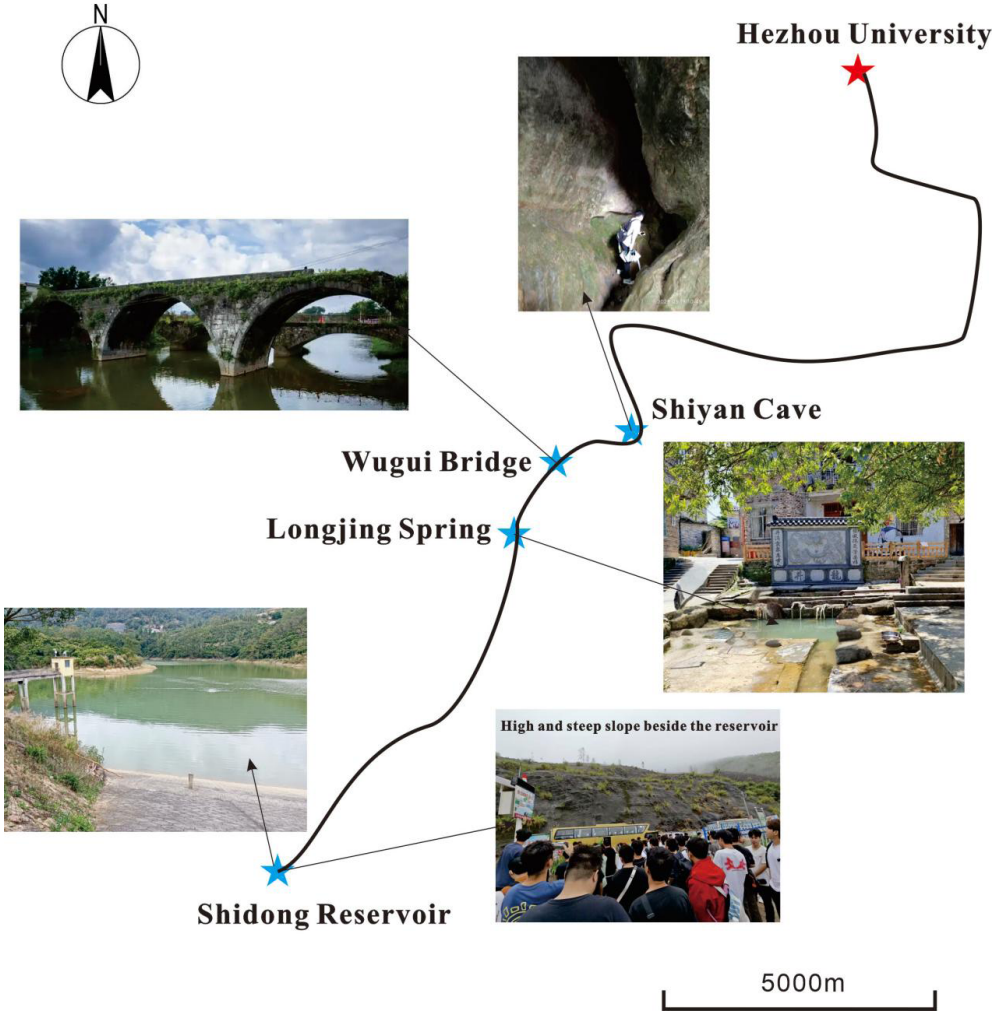

Figure 2. Field practice route of engineering geology.

5. Conclusion

Under the background of emerging engineering education reform and the "Five Educations" cultivation policy, the teaching reform of Engineering Geology becomes imperative. This paper proposes an educational model integrating the "Five-Education Integration" as its core philosophy, featuring a four-dimensional linkage of

"intensive classroom teaching-in-depth seminar discussions-industry-academia collaboration-practical field training." This model breaks through the limitations of traditional pedagogy, effectively addressing the core needs of emerging engineering disciplines for cultivating composite and innovative engineering talents.

Through the value-oriented reconstruction of classroom knowledge, the dialectical collisions in seminar sessions, the practical wisdom brought by engineers, and the comprehensive tempering of field internships, students can not only systematically master the core knowledge and skills of engineering geology, but also deeply understand the geological constraints and social responsibilities of engineering activities, temper the willpower to solve complex problems, and experience the beauty of collaboration and creation in engineering practice. This teaching model, which integrates value guidance, ability forging, knowledge imparting, physical fitness, and labor experience, not only enhances the educational effectiveness of the Engineering Geology course but also provides a universal reference paradigm for the reform of engineering basic courses in the background of emerging engineering. Future explorations will continue to focus on the refinement of the evaluation system, the in-depth development of digital resources, and the continuous optimization of the industry-education integration mechanism, to cultivate more excellent engineers in the new era who are both virtuous and talented, and integrate knowledge and practice.

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Disclosure statement

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