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Construction of Course Content Integrating Ideas of Engineering Education Accreditation for Higher Education in China: An Example of Geochemistry Course

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Abstract: Engineering education accreditation is a developing trend in undergraduate education, which requires students to be aware not only of basic knowledge and techniques, but also of patriotism, global insight, law, ecology and environmental protection. Traditional course content fails to meet these demands. Thus, it is necessary to create new course content with the guidance of engineering education accreditation. The inherent requirements for instructional objectives, course content and teaching models of engineering education accreditation have been analyzed. Additionally, the elements of engineering education accreditation are often welded onto essential knowledge. In this study, mind mapping, which establishes logic through divergent thinking, was proposed to help construct course content integrating ideas of engineering education accreditation. The detailed process and constructed course content were shown, taking a Geochemistry course as an example. The constructed course content has logic and integrity, and also motivates students' imagination and creativity and improves teaching effectiveness. Meanwhile, some effects observed during the implementation were summarized, including the limited class hours, lack of familiarity with the extracurricular knowledge points, a higher level of independent thinking in students and a higher number of requests made to teachers. Corresponding reformation strategies were proposed, such as exploring the teaching model of "student-oriented, teacher-assistance", developing case-based and heuristic teaching models and strengthening the building of dual-talented teachers and teaching groups.

Keywords: engineering education accreditation; course content; divergent thinking; geochemistry; teaching reformation

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1. Introduction

China is a manufacturing powerhouse, and engineering education shoulders the future development of industrial technology. China has also been recognized as an engineering education power, with the largest scale and the greatest number of students in engineering education in the world [1]. Improving the quality of engineering education has helped to elevate the international competitiveness of China's manufacturing industries. Engineering education is vital to the creation of a sustainable world, and also plays an important role in the pursuit of the 17 sustainable development goals (SDGs) which were approved by the United Nations in 2015 [2].

Engineering education accreditation acts as a bridge between the education field and the industrial world, supporting the international mutual recognition of engineers and engineering education [3,4]. The "Washington Accord" is a well-known international agreement on accreditation, characterized by authority, internationalization and system integrity. China formally enrolled as the 18th member state of the "Washington Accord" in June 2016 [5]. Up to the first half of 2022, 2899 majors in China were certified, including 87 majors of 23 engineering major programs such as Mechanics, Instrumentation, Materials and Electronic Information [6]. Engineering education accreditation is the current trend in the reform of undergraduate education in China and worldwide.

The "Washington Accord" advocates for "student centering (SC), outcome-based education (OBE) and continuous quality improvement (CQI)". The "Washington Accord" is based on seven major elements: Students, training objectives, graduation requirements, continuous improvement, curriculum system, teachers and supporting conditions [7]. Of these, the curriculum system is the most important in terms of increasing the quality of students' training, together with teachers and supporting conditions [8]. Courses need to evaluate the degree of achievement of curriculum objectives, explain teaching approaches and evaluate results. Course content, the core of the course, is required to respond to graduation requirements and continuous improvement. Thus, the course content should be adjusted and continuously improved, alongside the curriculum system.

However, the "Washington Accord" includes not only basic knowledge and technical ability, but also feelings of family and country, global vision, consciousness of rules and laws and of ecological and environmental protection [8–10]. According to the ideas set forth by the Accord, design thinking, engineering thinking and critical thinking should be trained, and students' innovation and entrepreneurship, disciplinary crossing and integration, lifelong learning, communication and negotiation and leadership skills should be developed [10,11]. Traditional courses, which mainly focus on basic knowledge, do not emphasize such content and cannot meet the demands of the "Washington Accord" [11,12]. Thus, it is urgent to construct new course content which integrates the ideas of engineering education accreditation.

Several approaches were developed to integrate other components into course content for engineering education. Cattano et al. [13] introduced a holistic philosophy to reinforce systematic thinking in engineering education. Module-based approaches via interdisciplinary concept connection were used in the University of Texas-Arlington, Colorado State University, University of Central Florida and Syracuse University [14,15]. Stand-alone courses were established to incorporate sustainability topics into the students' curriculum [16]. A senior design approach was viewed as partially a result of accreditation to achieve requisite outcomes [17,18]. Ashraf and Alanezi [19] took a case study in Saudi Arabia as an example and incorporated sustainability concepts into the engineering program by adopting a micro-curriculum approach. Galambosi and Ozelkan [20] summarized the overview of curriculum modifications in engineering and management study plans. Pierre et al. [21] provided short courses using an alternative approach in which modules were treated as stand-alone curricula. An et al. [22] suggested extracting examples from practice in the process of teaching a static and dynamic electromagnetic field course. Zhong et al. [7] optimized a course system for mine engineering guided by engineering education accreditation. Luo et al. [23] reformed the teaching model, course content and assessment method of an embedded system experiment course based on the "Student-centered (SC)" idea. Generally, authors worldwide argue that there is an increasing need to integrate ideas of engineering education accreditation. However, most of these studies mainly focused on the modification of a course system or course groups for a major, not of a single course. The integration was restricted to a particular idea, not the larger concept of engineering education accreditation. More importantly, the elements of engineering education accreditation and course basic knowledge are welded together, without inherent logic. Thus, the reformation of the teaching course in accordance with course characteristics and ideas of engineering education accreditation is necessary to improve the quality of talent development.

Mind mapping was proposed by British scholar Tony Buzan in the 1970s, and aroused widespread interest [24]. Through mind mapping, knowledge context and thinking processes are graphically illustrated in a network structure diagram using lines, signs, words and graphs. Mind mapping also integrates scattered knowledge points and converts fragmented information into a framework with an internal logic [24,25]. Mind mapping was attempted to be implemented in a range of teaching activities, and it was included in the special project of the 10th five-year plan for national education science in 2016 by the Ministry of Education in China [26,27]. Mind mapping centers around a keyword, to which words, thoughts and other concepts are linked through divergent thinking, forming a visual map. Therefore, mind mapping can be used to integrate consciousness of the rule and law, eco-environmental protection, social responsibility and innovativeness into course content, which can be a valid method for interlinking course basic theory and the elements required for accreditation. However, no attempt has been made to integrate the ideas for engineering education accreditation into the course content using mind mapping.

Based on the above, a Geochemistry course was taken as an example. A method of mind mapping was proposed to construct the course content, integrating the ideas of engineering education accreditation. The effects of such a change on traditional teaching activities were discussed, and corresponding reform strategies were proposed. Thus, comprehensive and harmonious course content with the guidance of engineering education accreditation was created. This research is expected to provide a theoretical and practical basis for advancing the engineering education accreditation requirements, promoting new engineering construction and the reform of other courses' teaching contents.

2. Inherent Requirements for Engineering Education Accreditation on the College Course Content

2.1. Inherent Requirements for the Reform of the Course Teaching Objectives

The course teaching objective plays a leading role in teaching activities and profoundly restricts the teaching implementation [28]. Engineering education accreditation requires not only specialized elementary knowledge, but also the implementation of basic knowledge and technology in engineering practices with a standard of engineers' occupational capabilities (engineering aspects); scientific aspects such as oral or written presentation using native or foreign languages, the ability to manipulate computers and other modern tools; and social aspects such as occupational qualities, ethics, environment, economics, law, arts and management [29]. Thus, the teaching objectives based on accreditation requirements combine engineering aspects, scientific aspects and social aspects. However, the traditional course teaching objectives mainly focus on basic knowledge and technology and highlight the knowledge-oriented tendency, which strengthens the engineering aspects and weakens the science and social aspects. The lack or dilution of the quality training of occupation, society, teamwork and leadership in course teaching objectives results in deviations from the quality-oriented ideas of engineering education accreditation.

2.2. Inherent Requirements for the Reform of the Course Content

Graduation requirements are the focus of engineering education accreditation, and the key to achieving training targets [9,30]. Graduation requirements and the course content are interdependent. Achieving the graduation requirements depends on the course content, and the formulation of course content and teaching approaches should be based on graduation requirements. Generally, graduation requirements include 12 indexes for engineering education accreditation in China: Engineering Knowledge, Analysis of Issues, Design/Development Solutions, Research, Applying Modern Tools, Engineering and Society, Environment and Sustainable Development, Professional Norms, Individuals and Teams, Communication, Project Management and Lifelong Learning [9]. Engineering Knowledge indicates the level of theoretical study. Analysis of Issues, Design/Development Solutions, Research, Applying Modern Tools and Project Management indicate the level of engineering practice. Engineering and Society, Environment and Sustainable Development, Professional Norms, Individuals and Teams, and Communication indicate the level of engineering ethic. Lifelong Learning indicates the level of engineering career. Thus, the course content of sustainable development, social views, professional ethics, teamwork, communication and continuous learning should also be involved in addition to the basic knowledge and technology.

2.3. Inherent Requirements for the Reformation of the Teaching Model

The teaching model is the media of applying teaching theory to teaching practice and should adhere to the teaching objectives and content. The traditional teaching model, mainly characterized by teacher instruction and textbook learning, is unfavorable for the cultivation of the ideas of team leadership, continuous learning and sustainable development [31]. Thus, diverse teaching models should be developed, such as "Question-inquiry learning", "Self-study assistant teaching", "Subject-heuristic teaching" and "Online and offline blended teaching". Specifically, information technology should be developed in the teaching models, and diversified "technology+" teaching models should be explored [22]. "The internet+", "Computer aided instruction", "Massive open online course + flipped classroom" and "Online learning + teachers' guidance" are examples of these methods. In this way, scientific, systematic and diverse teaching models which correspond to the ideas of engineering education accreditation are created.

3. Construction of Course Content Integrating the Ideas of Engineering Education Accreditation

3.1. Mind Mapping and Divergent Thinking

Mind mapping is a useful graphic technology and thinking aid which uses texts, graphics, lines and colors to organize systemic content associated with a central theme and to show its specific hierarchical relationship. Mind mapping has been widely applied in education and was confirmed to be effective for the development of critical thinking, innovation power, perception and exploring desire [32,33].

Mind mapping simulates the divergence of the human thinking process, with a characteristic of radioactivity. Mind mapping is centered around a center node, and gradually extends and diverges outward based on the objective connection between things, forming branch nodes [24]. Tree structures and huge knowledge networks are constructed with the ongoing divergence, and expressed using the mode of divergent thinking. Consequently, the tree-structure network of mind mapping can effectively train divergent thinking. Mind mapping is also considered a useful visual tool for expressing divergent thinking [34]. At the same time, the inherent connections and logical relationships between center nodes and branch nodes are established through divergent thinking, which avoids rigid connections between them.

On these bases, essential knowledge points are treated as the center nodes, and the ideas of engineering education accreditation are constructed as branch nodes through the divergent thinking of mind mapping. Thus, their logic and relevance can be established, integrating the essential knowledge and elements of engineering education accreditation into a whole.

3.2. Conceptual Model of the Construction of Course Content Based on Mind Mapping

Engineering education accreditation requires course teaching points not only of essential knowledge and skills but also of professional ethics, sustainable development, leadership and self-learning skills related to engineering. Compared with these points of knowledge, those related to engineering are unsystematic, scattered, rigid, remote from one another and arbitrarily connected. An attempt is made to integrate the ideas and elements of engineering education accreditation into the course content using the radioactivity and divergence of mind mapping, and a valid method of linking essential knowledge with the ideas of engineering education accreditation using mind mapping is proposed.

The conceptual model is as follows: The supported graduation requirement indexes of the course are defined according to the professional training plan. A course teaching objective is formulated considering the course characteristics and the supported graduation requirement indexes. The essential knowledge points are regarded as the center nodes, and the elements of engineering education accreditation as branch nodes. According to the course teaching objectives and essential knowledge points, the related elements of engineering education accreditation of professional ethics, social views, teamwork and leadership are introduced. These elements are linked to the essential knowledge points, and the logic and relevance between the essential knowledge points and elements of engineering education accreditation are established via the divergent thinking of mind mapping. Lines, signs, words and graphs are used to form visualization graphics and vividly express such logic and relevance. Thus, the elements of engineering education accreditation are spontaneously integrated into the course content through mind mapping (Figure 1).

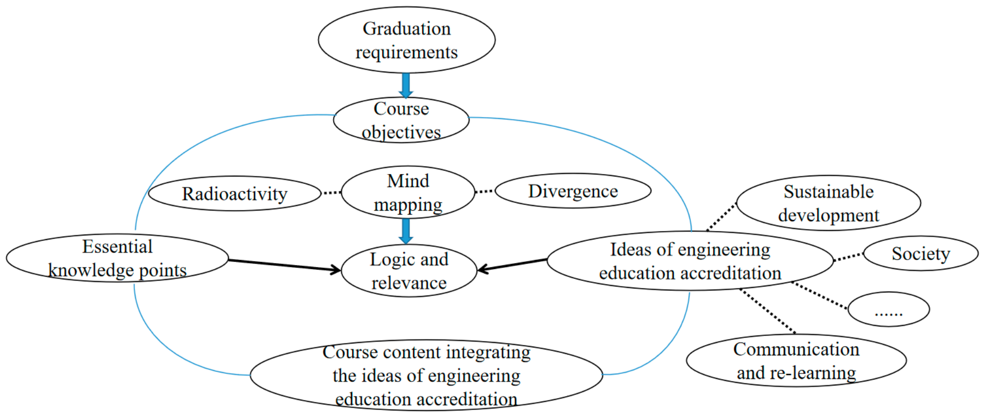

Figure 1. Conceptual model of the construction of course content based on mind mapping.

3.3. Construction of the Course Teaching Content

Engineering education accreditation follows the idea of “reverse design, forward implementation”. Training objectives are determined according to specialty characteristics and social needs. Graduation requirements are formulated based on training objectives. Then, a scientific training plan and course syllabus are developed. Specific courses and course content are needed to respond to graduation requirements and training objectives and achieve the supported graduation requirements [35,36]. Thus, graduation requirements become the criteria that course content is based on [6]. Every course supports different graduation requirement indexes since every course has different characteristics and contents. The supported graduation requirement indexes differ greatly for different majors even if sharing the same course [37]. Therefore, the construction of course content should be guided by the demands and training objectives of the majors.

Geochemistry is an important specialized fundamental course. This discipline encompasses research on chemical composition, chemical action and chemical evolution in earth systems and subsystems. It is one of the three pillar disciplines of geosciences with nearly a century of development, together with geology and geophysics. The course is widely offered to students majoring in geology, environment science, geochemistry and related subjects. The course plays a vital role in cognizing the earth, understanding the earth and appreciating the importance of a livable earth. It aims to provide mastery of the basic principles and research methods in geochemistry, cultivate geochemical thinking and explain and solve geological problems through geochemical theories.

Hydrology and Water Resources Engineering is taken as an example, and the construction process of the course content using mind mapping is shown. According to the major training objectives and the decomposed indexes of graduation requirements, this course is required to support the indexes of “Research”, “Environment and Sustainable Development” and “Lifelong Learning”. The detailed course objectives of Geochemistry are formulated and listed in Table 1. The elements of “Research”, “Environment and Sustainable Development” and “Lifelong Learning” for engineering education accreditation are integrated in the course contents as follows:

Table 1. The supported graduation requirements and course objectives of a Geochemistry course.

Graduation Requirement Index	Course Objectives
(Research) index 4.2 An ability to conduct experimental research on complex engineering issues using scientific methods, including experimental design, data collection, data processing, results analysis and interpretation.	**Course objective 1:** To be familiar with sampling and analyzing methods, be capable of data processing and analysis, and have the ability to design experiments to solve complex water environment issues.
(Environment and Sustainability) index 7.2 An ability to understand and analyze the effects of engineering practices of complex hydrology and water resources engineering issues on environmental protection and social sustainable development.	**Course objective 2:** To understand the process and influencing factors of element migration, and have the ability to assess the effects of the engineering practices of hydrology and water resources engineering issues on environments and society.
(Lifelong Learning) index 12.1 An ability to correctly cognize self-study and lifelong learning, and have awareness of ongoing learning and adaptive developments.	**Course objective 3:** To cultivate the consciousness and skills of self-study and lifelong learning.

(1) Construction of a mind map integrating the "Research" idea: The course is required to achieve the index of "Research" through the Geochemistry course as follows: Mastering the experimental theory and using experimental tools and instruments to perform experiments and design schemes; collecting and analyzing experimental data and providing reasonable conclusions; and selecting proper routes to solve problems related to hydrology, water sources and water environments. A Geochemistry course takes elements as studied objects and is devoted to chemical actions and chemical evolution. Water environmental chemistry is focused on to construct the mind mapping of the "Research" idea. The four aspects of analyzing methods, data processing methods, occupational standards and norms, and designing and optimizing of projects are linked to the essential knowledge point of water environments, and their logic and relevance are defined (Figure 2). The course content integrating the "Research" idea is detailed in Table 2. During implementation in class, the constructed course content for the "Research" index is naturally introduced when the essential knowledge point is explained. The "Research" ideas of experimental tools and methods, data analysis, problem solving and thinking model, which is related to the knowledge point of water environmental chemistry, are integrated into the course content. The ability to design projects to solve complex water environmental problems is achieved.

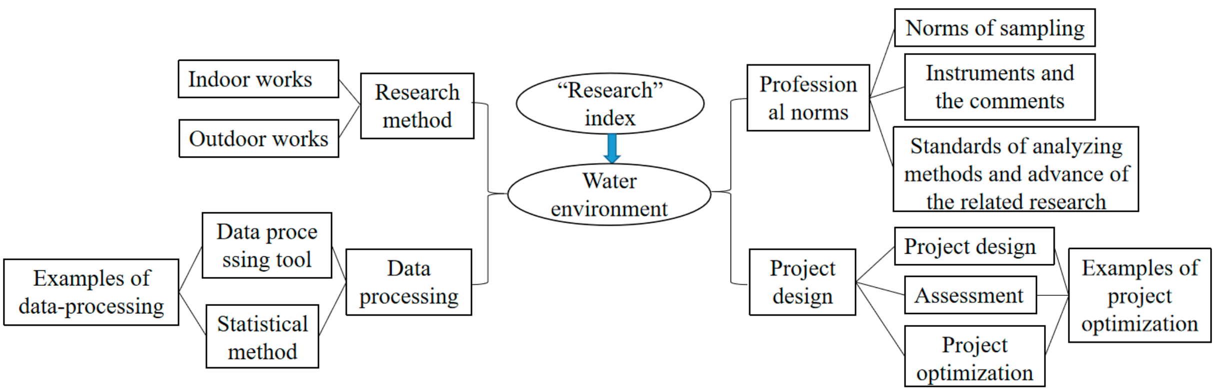

Figure 2. Sketch map of the construction of a mind map integrating the "Research" idea.

Table 2. The constructed course contents integrating the “Research” idea.

	Essential Knowledge Points	Relevance	Constructed Course Content for “Research” Index	Constructed Objectives
Research methods	Research methods of geochemistry	The instrument tools for research methods	Ordinary research methods of water environments	Master the merits, demerits and application conditions of every instrument and research method
	Research methods of crust composition	The similarities and differences between rock sampling and water sampling	The notes to water sampling	Understand representativeness, systematicness and statistics of samples
Data processing method	Micro-element tracing	Tools for analyzing micro-elements	SPSS software	Understand the application of modern tools to geochemical research
	Principles of solubility products	The interpretation of solubility products using Phreeqc	The application of Phreeqc to water environments	Establish awareness of selecting and using modern tools
Occupational standards and norms	Variation mechanism of isotopic composition	The occupational standards and norms related to isotopic composition	The occupational norms, such as GBT 14503-2008, GBT 37847-2019, etc.	Cultivate consciousness of occupational norms
Optimization of projects	Element migration in water solutions	Design and optimization of projects based on the characteristics of element migration in water solutions	Design and optimization of simulation experiments during water–rock interaction	Understand the scientific route of “problem posing—project design—data collection—conclusion” and optimize projects

(2) Construction of a mind map integrating the “Environment and Sustainable Development” idea: The index of “Environment and Sustainable Development” requires the students to understand and assess the effect of complex engineering practices on environments and society. The knowledge point of element migration was taken as the core, and two aspects were designed to construct this mind map. That is, its relationship with mineral sources and social strategies, and the relationship with water environmental pollution and protection (Figure 3). A route of “element migration process—environmental issues—social influence—project scheme optimization” is utilized in the construction of this mind map. “How do engineering practices alter element migration process? How do such processes affect environment and social sustainable development? And how can we optimize project schemes to minimize the effect?” are questions that help to shape the map and its contents. The course content integrating the “Environment and Sustainable Development” idea is shown in Table 3. While learning this content, students are required to use geochemistry theory to analyze the effects of engineering practices on society and on health and safety, and fulfill social responsibilities.

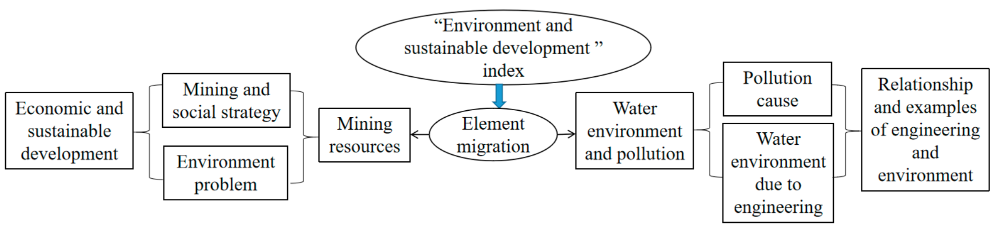

Figure 3. Sketch map of the construction of mind map integrating the “Environment and Sustainable Development” idea.

Table 3. The constructed course content integrating the "Environment and Sustainable Development" idea.

	Essential Knowledge Points	Relevance	Constructed Course Content for the "Environment and Sustainable Development" Index	Constructed Objectives
Mining resources and sustainable social development	Abundance characteristics of crust elements	Element abundance determines the types and characteristics of mining resources	The types, characteristics and situation of mining resources in China and their role in the national economy	Understand the relationship between mining resources and sustainable social development
	Influencing factors of element migration	The change of environmental factors due to mining activities and their effects	The effect of mining on groundwater quality in Huainan Coal Mine	Understand the potential effect of engineering practices on water environments
	REE geochemistry	Geochemical process of REE and the mineral deposits	Resource strategy of REE deposits in China	Understand the relationship between mines and social strategy
Engineering and water pollution	Isomorphism	The environmental effect of isomorphism	Itai-Itai Disease	Understand elements in water solutions and their environmental effects
	Isotope tracing	The theory of isotope tracing and its application to project optimization	The tracing of fractures using isotopes and its application to grouting design	Understand how to eliminate environmental effects using project optimization

(3) Construction of mind map integrating the "Lifelong Learning" idea: During this module, students are expected to efficiently communicate with their counterparts and the public regarding complex hydrology and water resource engineering problems, including writing, presentation, expressing and responding to instructions and having the consciousness and ability to engage in self-study and lifelong learning. Two aspects were selected to construct this mind map based on the essential knowledge points. Typical examples of geochemistry scholars and the long journey for some theories are introduced to cultivate the consciousness of lifelong learning. Learning skills are improved by the extracurricular practices of document reading and presentation (Figure 4). The course contents integrating the "Lifelong Learning" idea are shown in Table 4. The index of "Lifelong Learning" is achieved by integrating the related consciousness and skills of self-study and lifelong learning.

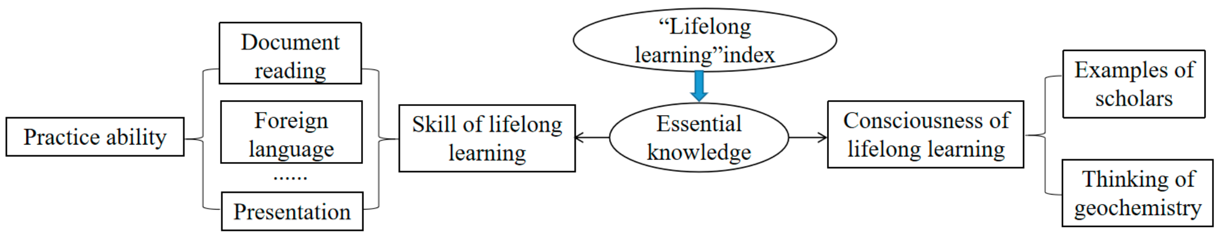

Figure 4. Sketch map of the construction of mind map integrating the "Lifelong Learning" idea.

Table 4. The constructed course contents integrating the "Lifelong Learning" idea.

	Essential Knowledge Points	Relevance	Constructed Course Content for "Lifelong Learning" Index	Constructed Objective
Consciousness of lifelong learning	Classification of element geochemistry	Goldschmidt element classification	The research journal of the scholar Goldschmidt	Cultivate the consciousness of lifelong learning taking Goldschmidt as an example
	Geochemistry and human health	Fluorine and fluorosis	The exploration journal of fluorosis in Southwest China for 50 years: from drinking-water to coal-burning fluorosis	Cultivate geochemical thinking, understand the tortuosity and chronicity of exploring scientific truth
Skills of lifelong learning			Extracurricular reading, reports and presentations	The ability to check documents, write reports and prepare presentations
			Extracurricular translation of literature	The ability to read and write in foreign languages, fostering international communication

Most of the research interest in this area focuses on integrating the ideas of engineering education accreditation into the course system of a major, such as the previous works by Zhong et al. [7], Ketchman et al. [18] and An et al. [22], and seldom into a single course. Mintz et al. [38] integrated sustainable development into a service-learning engineering course (Engineering for Developing Communities) using multidisciplinary approaches through a combination of classroom, laboratory and fieldwork exercises. Industry-based methods were developed by Johri and Olds [39], Blair et al. [40] and Cullin et al. [41]. These methods are based on engineering practices. Cruz and Frey [42] and Cummings [43] integrated ethics into accreditation through a one-day workshop and value-sensitive design approach. Panthalookaran [44] used the 4H (Head–Heart–Hands–Habit) approach to integrate scientific teaching into the engineering curriculum. A teaching approach was introduced to integrate open-ended project tasks into a complete course [45]. However, these methods did not clarify the logic and relevance of the elements of engineering education accreditation to essential knowledge points, which makes it difficult for students to master them as a whole. A networked approach to interconnect outcomes through the curriculum, proposed by Sheppard et al. [46] and Mostafavi [47], has some similarities to mind mapping, but is not used to construct course content. In this study, mind mapping is used, and the elements of engineering education accreditation are brought out by linking them to the essential knowledge points with the aid of divergent thinking. The inherent logic of and relationship between the essential knowledge points and the elements of engineering education accreditation are defined, which avoids arbitrary connections and integrates them as a whole. Moreover, the students' imagination and creativity are motivated by the divergent thinking of the mind map, which imperceptibly guides students to master the engineering application. Additionally, mind mapping, as a visualization tool, improves teaching effectiveness and students' enthusiasm.

3.4. Continuous Improvement and Further Work

"Continuous improvement" is one of the important general standards for engineering education accreditation, and provides a guaranteed improvement in the quality of talent [6,8]. The achievement degrees of the supporting graduation requirements should be periodically evaluated for the adjustment of course contents, including teaching evaluation through the internal quality monitoring system and goal attainment evaluation through the external evaluation system. Therefore, the constructed course contents should not be changeless.

The methods of analysis, occupational standards and norms, instruments and software related to the Geochemistry course are undergoing rapid development and renewal. New mining and social strategies and water pollution incidents are constantly emerging. Thus, the constructed course contents should be promptly updated. Mind mapping can be applied to construct a logical relationship between essential knowledge points and the ideas of engineering education accreditation as an effective approach.

Reasonable course scores are associated with the evaluation of teaching and learning efficiency. Traditionally, the course score is usually evaluated through a final exam, homework, tests and reports. However, such scores mainly reflect the mastery of essential theory and knowledge. Non-technical abilities such as environmental protection consciousness, lifelong learning and communication cannot be scientifically evaluated based on these scores. Thus, some creative scoring methodologies should be further explored, especially formative evaluation based on the constructed course content.

4. The Effects on Teaching Activities and the Corresponding Reform Strategies

The new course contents integrating the ideas of engineering education accreditation based on mind mapping greatly differ from the traditional contents. Some effects of the new course contents on course teaching activities were observed, and are summarized as follows: (1) course contents are redundant, but class hours are limited; (2) the students are unfamiliar with the extracurricular knowledge points, and cannot master the linked ideas through mind mapping; (3) a higher ability of self-thinking is required; (4) a higher level of requests to the teacher is needed. Therefore, some teaching models and corresponding reformation strategies were developed (Figure 5).

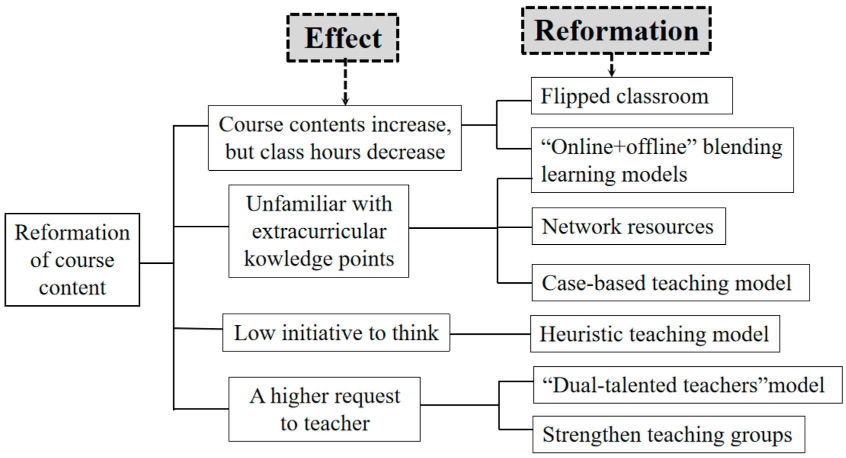

Figure 5. The effects on teaching activities and the proposed strategies.

4.1. Explore the Teaching Model of "Student-Oriented, Teacher-Assistance"

The newly constructed course contents include not only the essential knowledge points, but also the related points of eco-environment, law, safety, regulation and social economics. The course contents are redundant, but class hours are limited, causing a contradiction. To solve this problem, the teaching model was converted from teacher-oriented to teacher-assisted using these strategies: (1) converting the traditional teaching model into a flipped classroom, such as a dialogue classroom, open classroom, question classroom and capability classroom; (2) developing "online + offline" blended learning models with the aid of the Intelligent Trees Website, Tencent QQ, WeChat and other internet resources. Part of the content is deposited online for self-study before and after class.

In total, 15 course contents integrating the ideas of engineering education accreditation were established, including six for the "Research" index, five for the "Environment and Sustainable Development" index and four for the "Lifelong Learning" index (Tables 2–4). The related materials were compiled and arranged into chapters. These materials (written materials, video and audio materials) were deposited in the Tencent QQ group, and students were required to read, watch or listen to them before class. Additionally, basic knowledge needed for the course, such as the chapters on "Biology and Organic Geochemistry" and "Atmogeochemistry", was also deposited for self-study. Students could interact with their teachers through the internet. One of the constructed course contents was selected and a flipped classroom was implemented for each semester. These measures allowed teaching tasks to be completed in the planned time. Furthermore, enthusiasm was stimulated and a deeper understanding of course contents was gained as a result of the student-centered approach.

4.2. Develop Case-Based and Heuristic Teaching Models

The knowledge points of safety, social and eco-environment protections are included in the course content in addition to the essential knowledge points. These related points are unfamiliar to students and cannot easily be grasped. Additionally, mind mapping requires a high level of both independent thinking and divergent thinking. The routes to these reforms are: (1) to establish a networked database and require students to independently study these knowledge points; and (2) to develop case-based and heuristic teaching models since case-based teaching is intuitive and easily understood, and heuristic teaching is propitious to the construction of the mind map.

The networked database was also deposited in the Tencent QQ group for students to review before class. The unfamiliar constructed course contents were redefined according to students' feedback and adjusted to use case-based and heuristic teaching models to reduce the mastering difficulty. For example, the students could not master different instrument principles and their advantages and disadvantages, and thus the cases of "data analyzed by different instruments" were used, and students were required to think based on the teachers' inspiration. Most of the students had no difficulty in mastering these unfamiliar contents after multiple adjustments. Also, the cases aroused scientific interest.

4.3. Strengthen the Building of Dual-Talented Teachers and Teaching Groups

The teachers are required to know more about the extended course content, which requires improvement of the teachers' quality and strengthening of their moral fiber. Firstly, "dual-talented" teachers should be developed. The self-study model for students and research-oriented teaching model for teachers are tightly coupled. Teachers should integrate scientific achievements into the teaching content, and extend students' tasks of investigation, practice, designing, discussion and research. Secondly, the teaching groups should be strengthened. Every teacher should play to his strengths and jointly establish the mind map and teaching content.

A teaching group for the Geochemistry course, including six members majoring in different research interests, was established and was put in charge of the Geochemistry courses of all the majors. Engineering practice experience was encouraged to develop "dual-talented" teachers. The constructed course contents referred to the advice from the engineers and experts, but not the team members, in other related majors. Not all the course contents were familiar to team members, such as the social strategies, sustainable development, environment protection, instrument theory and occupation norms. Thus, collective lesson preparation was organized before class for each semester.

5. Summary and Conclusions

Engineering education accreditation is the current trend in the reform of undergraduate education both in China and worldwide. Traditional course content is oriented around the essential knowledge points and cannot meet the demands required for engineering education accreditation. Engineering education accreditation requires new and inherent requirements for course teaching objectives, teaching content and teaching models. Mind mapping was proposed to construct course content integrating ideas of engineering education accreditation considering its characteristics of visibility, radioactivity and divergence. The logic of and relevance between essential knowledge and the elements of engineering education accreditation were also established through divergent thinking, avoiding arbitrary connections. Mind mapping also enhances students' initiative, and motivates their imagination, divergent thinking and innovation ability. The detailed process and constructed course content were shown, taking a Geochemistry course as an example. The effects of such reformation on teaching activities were discussed and relevant strategies were proposed. This research provides some experience and a reference to construct course contents against the background of engineering education accreditation.

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