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A Comparative Study on the Cultivation of Undergraduate Environmental Talents in Chinese and American Universities Based on Ecosystem Management Thought*

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1. Introduction

Since the Industrial Revolution, the relationship between human beings and nature has appeared unprecedented sharp contradiction. In modern times, human beings mainly respond to the contradiction in the relationship between human and nature through environmental management.

Nature is an integral whole, therefore, environmental management requires an overall consideration objectively. However, due to the specialization of human knowledge and skills in modern times, environmental management was doomed to be carried out in subdivisions. This is a dilemma, which can be called the institutional paradox of environmental management.[1]

The initial environmental management is the emergency type of environmental management since the 1970s, with the terminal technical management as the main means and characteristics. In the 1980s, with a deepening understanding of environmental issues, environmental management shifted to pollution prevention, that is, reducing the

amount of pollution produced from the source. After that, it has been further developed into environmental management focusing on the whole process control of product life cycle, that is, to control the production of pollutants to the maximum extent in the whole process of product production, recycling economy and clean production are their widely accepted and applied models.[2] The disadvantages of these linear management methods are reflected in their orientation to the field of elements, such as water, air, soil, etc. In these linear management it is assumed that elements are separate from each other, rather than looking at them in terms of the ecosystem as a whole. They ignore the interdependence between ecosystem services and human needs and do not exert various influences on some social groups that are undermining ecosystem services.[3] Therefore, these deficiencies need to be corrected in environmental management with a more holistic view of the relationship between ecosystem services and human welfare. Focus on maintaining the functioning and adaptability of ecosystems and ensuring equitable use of ecosystem services. This is the ecosystem management.[3] It also requires all stakeholders to participate in integrated decision-making, prioritization planning and conflict resolution.[3]

As early as the 1980s, the concept of ecosystem management was proposed and promoted by American scholars and published relevant monographs.[4] It points out the need for interdisciplinary research by ecologists, economists, political scientists and sociologists to promote ecosystem management and the need for transboundary cooperation among scientific, socio-economic and governmental authorities to implement ecosystem management. Up to now, research and practice has been a hot field in the United States.[5] Since 2012, advocated by UNEP, it has gradually become a topic of interest to the scientific community worldwide.[6],[7]

UNEP has begun to promote the transition from linear environmental management in the past to systematic and networked management of ecosystem management since 2012. Change the environmental management from a block approach to an integrated approach, take into account

forest, land, freshwater and coastal ecosystems whose ecosystem services have been adversely affected, assist countries and regions in integrating ecosystem management approaches into development and planning processes to readjust its environmental programme with financing of priority ecosystem services in order to empower countries to use ecosystem management tools. Using an ecosystem management approach, natural resource managers can identify and analyze stakeholder's manipulation of the ecosystem and design appropriate methods of operation.[3]

Although Chinese scholars have begun to accept the concept of ecosystem management in tracking international progress towards sustainable development since the Rio Summit in 1992, some scholars introduced the concepts and key points of ecosystem management into China,[8] domestic scholars in the field of natural science, such as resources and environment, also refer to interdisciplinary thinking and cross-border cooperation in their theoretical discussions,[9] the focus of the understanding is on how to strike a balance between human access to ecosystem services and the maintenance of ecosystem adaptability in order to understand the concept of sustainable development from the perspective of maintaining ecosystem services.[10] This kind of research, which mainly serves the resource exploitation and economic development and occupies the natural dimension by the scientists in the field of nature, has been occupying the mainstream position in China's domestic research till now.[11],[12] From the perspectives of economics[13] and management,[14] interdisciplinary or transboundary studies are very rare in China. They occur very occasionally and are only limited to theoretical assumptions and theoretical discussions. In 2014, an example of Yellowstone National Park in the United States was presented,[15] which is a foreign empirical case of interdisciplinary cooperation in ecosystem management research that can be seen in Chinese academic journals. In general, in China, the study of ecosystem management has not exceeded the scope and circle of natural scientists, such as resources and environment. Interdisciplinary is mentioned but still out of reach, transboundary cooperation is even more difficult. The concept of ecosystem manage-

ment has been introduced into China for so many years, but so far it has not become a hot academic topic in China. Scholars live in a single discipline rather than forming teams to carry out interdisciplinary research. The lack of institutional mechanisms to support interdisciplinary cooperation and cross-border collaboration is at the root of the problem.

No matter how hesitant the academic circles in China are in related fields, this shift in ecosystem management thinking poses obvious management challenges to those responsible for natural environment management and resource management, in particular, the shift from focusing only on economic development to sustainable development that gives equal consideration to environmental protection and economic development. Corresponding to the reform of the Chinese government's administrative departments is the reform of the super ministry reform to the ministry of Environmental Protection, which has been called for since 2012. However, the implementation of the reform of the super ministry reform requires that the corresponding supply of talents in relevant departments must be continuously guaranteed. The challenge of ecosystem management in the cultivation of environmental talents in colleges and universities cannot be avoided. Therefore, it is necessary to face up to the new requirements of the thought and method of ecosystem management on the cultivation of environmental protection professionals in colleges and universities.

During this important period of change in environmental thinking, it is necessary and timely for the development of China's environmental discipline itself and the cultivation of future environmental protection talents in specialized fields by sorting out the experience and lessons of environmental discipline talents cultivation in universities in China and some representative developed countries. In today's Chinese society, where environmental protection has been promoted to the height of state strategy and ecological civilization has become the main theme, this kind of research is one of the basic information of "background" in human resource construction that is urgently needed in the capacity building of

ecological civilization of the whole society. Literature search shows that there are few studies on the cultivation of environmental protection professionals. From the perspective of comparative education research, the comparative study of Chinese and British undergraduate environmental protection talents [16] reveals the curriculum model of the three-year undergraduate education system in the UK which is also a professional training system, emphasizing on comprehensive decision - making, communication and problem - solving and other student-centered UK undergraduate environmental talent development objectives, the solid foundation of geosciences and the development of environmental sociology complementing and supporting each other with diversified interdisciplinary courses and practical internship mechanism worthy of reference by China. The study also points out the environmental protection professionals trained under the training mode of undergraduate environmental discipline in British universities, which is closer to the specification of environmental protection professionals required by ecosystem management thought than those in China.

By comparing the cultivation of undergraduate environmental talents in Chinese and American universities, this paper reveals some useful inspirations from the experience of American counterparts and some suggestions for improving the cultivation of undergraduate environmental talents in Chinese universities based on the idea of ecosystem management will also be promoted.

2. Methods and results

Because both Chinese and American universities adopt the 4-year and 8-semester system, in the evaluation, Chinese and American colleges and universities adopt the same kind of credit system, therefore, the academic system of environmental discipline undergraduate talents cultivation in Chinese and American universities is the same.[17]

This paper focuses on the comparison between China and the United States from the four aspects of training mode, discipline and major setting, major training objective and curriculum, combining with the

selected environmental departments in typical universities cases, compares the similarities and differences in the cultivation of undergraduate environmental talents in Chinese and American universities, and hopes to gain experience and enlightenment from the American experience for the reference of environmental departments in Chinese universities.

2.1 Data sources

The information source of the comparative study on the cultivation of undergraduate students in environmental disciplines in Chinese and American universities is mainly based on the text information obtained from the websites of relevant environmental departments of Chinese and American universities published on their homepages, as the basic information source of the study, combining with a few interviews with environmental departments of Chinese universities, which are mainly the results of interviews with environmental departments and relevant environmental research institutes of 23 universities in China from spring 2012 to early 2013.

Information about U. S. universities, according to U. S. authoritative ranking U. S. News[18] since 2012, online text information of top 16 U. S. environmental departments since 2012 is selected. A total of 25 universities in China are also based on the ranking of environmental departments of domestic universities and the text information of some characteristic environmental departments of some universities published on their home pages in 2012, with the information of 2012 as the main information, at the same time combining a small amount of interview information.

2.2 A Comparative Study on the Cultivation of Undergraduate Environmental Talents in Chinese and American universities

2.2.1 Comparison of the Cultivation Methods of Undergraduate Environmental Talents between China and the United States: The Specialization of Chinese Universities is Earlier than that of American Universities

From the comparison of cultivation methods, it can be found that when Chinese and American college students first enter the university, they start to enter the environment major at different times.

American college students enter college regardless of their majors. For example, Stanford University[19],[20] requires liberal arts students to take one of the three subjects of mathematics, statistics, electronic computer application technology, etc., it also stipulates that students in science and engineering must study economics, history, sociology, law, and so on. It is believed that this will help to raise students' attention to the major social issues (such as environmental problems). For example, at Columbia University's School of Engineering and Applied Sciences,[21], [22] students must take a comprehensive humanities course in the first and second years, in addition to mathematics and the natural sciences, before they enter the professional stage. Therefore, in American universities, general education is emphasized and professional division is opposed. There is no obvious major difference between freshmen and sophomores, and students of arts and sciences choose the same college courses. American universities stipulate that liberal arts students must take certain courses in four fields including humanities (literature, history, philosophy), natural science, social science (sociology, economics, management), and art.[23]

Supporting the cultivation mode of American generalist education is the setting of the curriculum of generalist education in colleges and universities. Harvard University,[24], [25] for example, has a clear requirement for a general education course. All environmental science and engineering students must complete half of the eight optional sections including: aesthetics, interpretive understanding, culture and belief,

empirical and mathematical reasoning, moral reasoning, life systems science, cosmological physical science, and world society. Another example, the general education curriculum for environmental management majors at Indiana University[26] includes: arts and humanities, quantitative methods, social and historical studies, and natural sciences. Next example, environmental engineering students at Arizona State University[27] can choose from general education curriculum like chemistry, calculus, foreign languages, humanities, arts and design, global awareness, social and behavioral sciences.

American students can have a clear understanding of themselves and the connotation of various subjects after receiving a broader generalist education. Therefore, it is only by the third year of college that students have the chance to choose the major they are interested in, and there is usually an academic advisor to guide the students. After the major is determined, students begin to study the specialized courses.

In Chinese universities, students begin their freshman year by studying directly in different majors. Grade one and two are mainly specialized basic courses and compulsory courses such as English, politics and Physical Education.

Therefore, the cultivation method of environmental discipline undergraduate education in the United States emphasizes the professional education of professional diversion on the basis of general education. Chinese universities emphasize the importance of professional education as early as possible in the cultivation of undergraduate education in environmental disciplines.

2.2.2 A comparison of the Majors in Environmental Disciplines between China and the United States: The Majors in Environmental Sociology in the United States are Relatively Abundant

As shown in Table 1 and the statistics of its results, the majors of environmental disciplines in Chinese universities are mainly focused on three majors: environmental science, environmental engineering and water supply and drainage.

As shown in Table 2, the majors of environmental disciplines in American universities can be divided into three categories: environmental science, environmental engineering, and environmental policy and management.

In terms of major, environmental science and environmental engineering in environmental departments of Chinese and American universities are the same, but the major difference lies in: environmental policy, environmental management, society and environment, which offer bachelor of Arts degrees, are more prominent and more common in American universities than in China. At present, only a few universities in China, such as Fudan University,[41] Nankai University,[34] Tongji University[32]and Renmin University of China,[23] clearly announce the research direction of environmental policy or environmental management, but they may not be able to rise to the professional level.

In addition, from the perspective of major concentration, most environmental majors in Chinese universities are concentrated in one college, while environmental majors of different nature appear in different colleges in American universities. In other words: the transdisciplinary characteristic is very obviously for the social dimension majors of Environmental disciplinary. For example, the University of California, Berkeley[52],[53] has a complete set of environmental majors, its humanities and engineering disciplines under the Faculty of Natural Resources and the Faculty of Engineering respectively. And different majors in the College of Natural Resources are also divided into different schools/departments, environmental economy and policy majors are divided into departments of Agriculture and Natural Economy, while social and environmental majors are respectively divided into departments of Environmental Science, Policy and Management. Another example, in Columbia University,[21],[22] environmental science and environmental engineering, both majors of science, belong to the College of Arts and Sciences and the College of Engineering and Applied Sciences respectively.

Table 1. The major setting of environmental discipline in Chinese universities

No.	University	College or department	Env. Sci.	Env. Engi-neering	Water supply & drainage	Built env.& equipment industry	Agricultural Resources & Env.	Water resources& environ-mental engineering	Ground-water sci.& engineering	Safety engineering	thermal energy& power engineering	equipment engineering
Total number of Majors (pieces)			16	22	6	3	1	1	1	1	1	1
1	Tsinghua University[28]	College of Environment		√	√							
2	Zhejiang University[29]	College of Environment and Resource	√	√			√					
3	Peking University[30]	College of Environ. Engineer and Science	√	√								
4	Nanjing University[31]	College of Environment	√	√								
5	Tongji University[32]	College of Environ. Engineer and Science	√	√	√							
6	Hohai University[33]	College of Environment	√	√	√							
7	Nankai University[34]	College of Environ. Science & Engineer	√	√								
8	Tianjin University[35]	College of Environ. Science & Engineer	√	√		√						
9	Ocean University of China[36]	College of Environ. Science & Engineer	√	√								
10	Beijing Normal University[37]	College of Environment	√	√								

11	Huazhong Univ. of Sci. & Tech.[38]	College of Environ. Science & Engineer		√	√	√						
12	Shanghai Jiaotong University[39]	College of Environ. Science & Engineer		√								
13	China University of Geosci-ences[40]	College of Environment		√				√	√			
14	Fudan University[41]	Environ. Science & Engineer Department	√									
15	East China Univ. of Sci. & Tech.[42]	College of Resources & Env. Engineer		√						√	√	
16	Wuhan University[43]	College of Resources & Env. Science	√	√								
17	Xi'an Univ. of Architect. and Tech.[44]	College of Env. & Municipal Engineering	√	√								√
18	South China Univ. of Sci. and Tech.[45]	College of Environ. Science & Engineer	√	√	√							
19	Southeast China[46]	College of Environment		√		√						
20	Sichuan University[47]	Environ. Science & Engineer Department	√	√								
21	Xi'an Jiaotong University[48]	Environ. Science & Engineer Department		√								
22	Beijing Forestry University[49]	College of Environ. Science & Engineer	√	√								
23	China Agricultural University[50]	College of Resources and Environ.	√	√								

Table 2. Majors of environmental disciplines in American colleges and universities

No.	University	College & Department	Major setting				
1	Duke University [51]	Nicholas Sch. of Environment	Environmental science and policy	Environmental science	Earth and Ocean Sciences		
2	University of California, Berkeley [52], [53]	College of Natural Resources Agriculture. & Resource Ecology Department. School of Engineering	Resource conservation and research Environmental economy and policy Civil and environmental engineering	Environmental science	Molecular environmental biology	Forests and natural resources	Society and environment
3	University of Michigan [54]	School of Natural Resources & Enviroment	Natural resources and the environment				
4	Syracuse University [55]	School of Public Power and Public Affairs School of Engineering and Computer Science	Environmental policy and management Environmental engineering				
5	Indiana University [26]	School of Public and Environmental Affairs	Environmental science	Public Affairs	Environmental management		
6	University of Texas [56]	Institute of Environmental Science	Environmental science				
7	Columbia University [21], [22]	College of Arts and Sciences School of Engineering and Applied Sciences	Environmental science Earth and environmental engineering	Geoscience Environmental Health Engineering			
8	Harvard university [24],[25]	Environment Centre School of Engineering and Applied Sciences	Environmental science and policy Environmental engineering and Science				
9	University of Washington [57]	College of Environmental forest Sciences	Environmental science and Resource management				

10	Stanford University [19],[20]	Department of Geology and Environmental Sciences Department of Civil and Environmental Engineering	Geology and environmental sciences Environmental engineering and Science				
11	Georgia Institute of Technology [58]	School of Civil and Environmental Engineering	Civil engineering	environmental engineering			
12	Johns Hopkins University [59]	School of Geography and Environmental Engineering	Environmental engineering				
13	Yale University [60], [61]	School of Engineering and Applied Sciences School of Forestry and Environmental Studies	Chemical engineering Environmental research	environmental engineering	Engineering science		
14	Arizona State University [27]	School of Engineering	Environmental engineering				
15	Massachusetts Institute of Technology [62]	Department of Civil and Environmental Engineering	Civil engineering	Environmental Engineering Science	Civil and environmental engineering		
16	Cornell University [63]	College of Agriculture and Life Sciences	Bioengineering	environmental engineering			

2.2.3 Comparison of Professional Training Objectives: Environmental Science and Engineering are the Same in China and the United States, but the Training Objectives of Environmental Sociology are Missing in China

The training objectives of environmental majors in Universities in China and the United States are shown in Table 3, with typical majors of several typical universities in China and the United States respectively

Table 3. A comparison of the training objectives of environmental majors in typical universities between China and U.S.

No.		University	Major	Training Objective
China	1	Peking University [30]	Env. Science	To train senior professionals with basic theories, basic knowledge and basic skills in environmental science, who can engage in scientific research, teaching, environmental protection and environmental management in scientific research institutions, institutions of higher learning, enterprises and public institutions, and administrative departments. [30]
	2	Nanjing University [31]	Env. Science	To train senior professionals and elites who are well-developed morally, intellectually and physically, possess the basic theories, knowledge and techniques of environmental science, and can be engaged in scientific research, teaching, environmental protection and environmental management in scientific research institutions, institutions of higher learning, enterprises and public institutions, and administrative departments. [31]
	3	Tongji University [32]	Water supply and Drainage	This professional learning through engineering mechanics, engineering drawing, microbiology, hydraulics, hydrology, building water supply and drainage, water quality engineering, water engineering, water supply and drainage pipeline engineering of water supply and drainage engineering discipline specialized courses such as basic theory and basic skills, cultivate a city water supply and drainage engineering, building water supply and drainage engineering, water pollution control planning, industrial water and wastewater engineering and water resources protection knowledge, to be involved in planning, design, construction, management, education and research and development work of water supply and drainage engineering senior engineering and technical personnel. [32]
U.S.	1	Columbia University [21],[22]	Env. Science	It aims to develop students' abilities in three potential career fields: earth sciences, environmental sciences or business, policy, law, medicine and administration.
	2	Johns Hopkins University [59]	Env. Engineering	With an emphasis on knowledge growth, work ethic and social service, and the development of critical thinking, clear communication and teamwork skills, graduates can be successful engineers in government or private organizations.
	3	University of California, Berkeley [52],[53]	Environmental economy and policy	The graduates have rich professional knowledge in environmental economics and policy, development economics and agricultural economics. Develop the necessary ethical concepts and skills and the motivation to serve society; It will eventually lead to a successful career.

taken as examples.

The training objectives of environmental majors in Chinese colleges and universities are mostly based on the discipline requirements from the employment, starting from knowledge and skills, and finally settling on the cultivation of high-level talents required by the society.

American colleges and universities, like those in China, focus on disciplines and expertise that serve the ultimate purpose of employment.

There is not much difference between China and the United States in terms of the expression and manner of cultivation objectives.

But the connotation of the training target itself, because the environmental major of humanities and social disciplines in China is still underdeveloped, therefore, it is obviously lacking in the training target of this field compared with the American universities.

2.2.4 Comparison of Curriculum Types and Curricula in Major of Environmental Disciplinary in Colleges and Universities between China and the United States

(1) Comparison of course types and contents in environmental discipline: The experience of American universities with broad multidisciplinary background is worthy of reference

The comparison of the types of courses taken by students majoring in environmental sciences in Chinese universities and those in United States is shown in Table 4.

In terms of course types, the courses taken by environmental majors in colleges and universities in China are mainly classified into compulsory courses and optional courses.

The courses of environmental majors in American colleges and universities are called "distributed compulsory courses", which are mainly composed of distributed compulsory courses, core courses and free elective courses.[23] Structurally, America has one more set of distributed compulsory courses than China.

This distributed compulsory course model in the United States, about 80% of universities in the United States have implemented distributed

Table 4. The type of curriculum between some universities in China and those in United States

No.		University	Major	The type of the curriculum			
China	1	Fudan University[41]	Environmental Science[41]	Major compulsory course	Major elective course	Any optional course	
	2	Hohai University[33]	Environmental Engineering[33]	Public compulsory course	Major compulsory course	Elective course for majors	Optional course out of side of the Major
	3	East China University of Science& Technology[42]	Environmental Engineering[42]	Public compulsory course	Basic Optional course	Optional course	
	4	China University of Geosciences[40]	Environmental Engineering[40]	Compulsory course (Basic course for the Major)	Compulsory course (Major course)	Major elective course	
	5	Tsinghua University[28]	Water supply and drainage[28]	Compulsory course (Core course for the Major)	Limited optional course(Major course)	Optional course	
U·S·	1	Harvard University[24],[25]	Environmental Science and Public Policy	Distributed Compulsory Course	Core course	Free optional course	Classic/ masterwork course
	2	University of Washington[57]	Environmental Science& Resources Management	Distributed Compulsory Course	Core Course	Optional course	
	3	Columbia University[21],[22]	Environmental Engineering	Major Core course	Distributed Compulsory Course	Free optional course	
	4	Stanford University[19],[20]	Geo-environmental Science	Major course	Core course	Optional course	
	5	Arizona State University[27]	Environmental Engineering	Distributed Compulsory Course	Core course	Free optional course	

compulsory courses, which are composed of three parts: distributed compulsory courses, major courses and minor courses. Distributed compulsory courses are the courses used by schools to achieve their general education goals. They are distributed in several subject areas and generally account for one fourth or one third of the total courses. Major courses are the courses that students must take in a certain discipline or interdisciplinary field, accounting for one third of the total courses. Many well-known universities in the United States, such as Harvard University,[24][25] Columbia University,[21][22] University of Chicago,[23] as

well as many prestigious doctorate-granting universities and some liberal arts colleges, have a teaching plan with the name "core curriculum" for major courses. Minor courses are the courses that students choose according to their own interests and hobbies, generally accounting for about one fifth of the total number of courses, also known as free elective courses. In addition, students must take elective courses in foreign languages and writing.

The distributed compulsory curriculum in the United States refers to "an educational curriculum plan that specifies the subject areas (generally natural sciences, social sciences, and humanities) that students are required to study, and the number of courses (or minimum scores) that students are required to study in each field." The goal of the curriculum model is to cultivate people who are both "specialists" and "generalists". That is, in addition to mastering the major professional knowledge, students can also have an understanding of the knowledge of other major disciplines. It is hoped that students' knowledge and understanding of things will be built on the basis of extensive knowledge.

From the perspective of course types, politics, English and other compulsory courses in Chinese compulsory courses are similar to the distribution of compulsory elective courses in American course modules, but there are huge differences in connotation. In the United States, distributed compulsory elective courses require students to receive certain education in the fields of natural science, social science and humanities, while in China, students are required to receive compulsory and fixed ideological education through these compulsory courses.

This kind of curriculum structure arrangement in American colleges and universities appears to have a clear and flexible structure, which is in line with the foundation of cultivating students with a wide range of disciplines, so as to meet the diversified choices and development needs of students in the global field in the future.

(2) Comparison of core courses of environmental discipline majors in Chinese and American universities: There is little difference between environmental science and environmental engineering, but significant difference between environmental sociology majors

Table 5 and Table 6, respectively, provide a list of typical representatives of environmental science and environmental engineering courses in Chinese and American universities

From the point of view of curriculum setting, since it is consistent with the training program of the Ministry of Education (Table 7), the compulsory courses of environmental majors in Chinese colleges and universities are similar. In terms of content, almost all courses of environmental science and environmental engineering in China are science and engineering courses.

The majors of environmental engineering and environmental science in American colleges and universities are also characterized by science and engineering characteristics, and there is not much difference in curriculum setting among colleges and universities. In addition to the emphasis on physics, chemistry and mathematics, professional courses also focus on environmental engineering, environmental science, engineering mechanics, environmental microbiology, and industrial waste (water, gas, slag) and its treatment.

There is no significant difference between the curricula of environmental science and environmental engineering in China and the United States universities.

As for the majors of Environmental economy, environmental policy and environmental management this kind of environment majors in China universities, except for environmental economy, which is permitted as "the list of majors outside the catalogue approved and established by the Ministry of Education" under the name of "Economics of Environmental Resources and Development",[64] environmental policy and environmental management do not exist in the catalogue of majors of undergraduates of China's Ministry of Education. However, in the catalogue of Chinese graduate majors,[65] environmental economics is placed under

Table 5. Main courses of environmental engineering and environmental science majors in Chinese universities

No.	University	Environmental Engineering Major								Environmental Science Major							
		Chemistry	Engineering mechanics	Environmental assessment and planning	engineering drawing	Environmental engineering microbiology	Solid waste disposal and resource recovery basis	Water pollution control engineering	Air pollution control engineering	Chemistry	Environment monitoring	Environmental Biology (Environmental Microbiology)	Environmental Impact Assessment (Environmental Quality Assessment)	Environmental ecology	Environmental planning	Fundamentals of Environmental Geology (Environmental Geology)	Environmental science
1	Tsinghua University[28]	√	√			√											
2	Peking University[30]				√		√			√	√						
3	Nanjing University[31]		√	√	√		√	√	√	√	√	√	√		√		
4	Tongji University[32]	√	√		√	√	√		√	√	√			√			√
5	Hohai University[33]	√	√	√		√	√		√	√	√	√			√		
6	Tianjin University[35]			√	√	√	√	√	√								
7	Ocean Univ. of China[36]	√	√		√	√	√	√		√	√		√	√	√		√
8	Beijing Normal Univ.[37]	√	√	√		√				√		√		√		√	√
9	Huazhong Univ. of Science & Technology[38]	√		√		√	√	√	√								
10	Wuhan University[43]	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√
11	South China Univ. of Science and Technology[45]									√	√	√	√	√			
12	Sichuan University[47]									√	√	√	√	√		√	

Table 6. The main course of environmental engineering and environmental science majors in United States colleges and universities

No.	University	Environmental Engineering Major								Environmental Science Major						
		Chemistry	Calculus	Hydromechanics	Environmental Engineering	Environmental Engineering design	environmental microbiology	hydrology	treatment of three wastes	Chemistry	Environmental science	Environmental geology	Environmental/ Climate Change	Water pollution	Environmental system analysis	Biology	Experiment
1	Columbia University[21],[22]	√		√	√		√		√	√			√		√	√	√
2	University of California, Berkeley[52],[53]			√	√	√	√			√	√	√				√	
3	Cornell University[63]			√	√	√											
4	Massachusetts Institute of Technology[62]	√	√			√	√	√		√	√		√	√		√	√
5	Syracuse University[55]	√	√	√	√			√	√								
6	Arizona State University[27]	√	√	√	√				√								
7	Yale University[60],[61]	√	√	√	√		√	√	√								
8	Johns Hopkins University[59]	√	√	√	√	√	√	√	√								
9	Georgia Institute of Technology[58]	√		√	√			√									
10	Duke University[51]										√	√	√	√	√		

Table 7. 《Catalogue of undergraduate major of general institution of higher learning (2012)》[64](Environmental Science) in China

Major code	Subject category, Discipline category, Major name
08	**Subject: Engineering**
0825	**Environmental Science and Engineering Discipline**
082501	Environmental Science and Engineering Major
082502	Environmental Engineering Major
082503	Environmental Science Major
082504	Environmental Ecology Engineering Major

the catalogue of economics disciplines, environmental law under the catalogue of law disciplines, environmental management is not placed under the catalogue of disciplines, and there is only one land resource management under the catalogue of management disciplines. Therefore, Chinese universities do not have such environmental majors as economics, law and management as American universities do. Although there is no such major in Chinese universities, so far, it has been found that Peking University, Fudan University, Nankai University and Renmin University of China have the research directions of environmental law, environmental economics and environmental management, etc., which is mainly set at the level of postgraduate training, not a second-level discipline. It is a research direction independently set up by relevant departments of universities under the existing second-level disciplines.

Environmental majors are developing vigorously and abundantly in American colleges and universities. As shown in Table 8, due to the different academic backgrounds or perspectives of disciplines concerned with environmental issues, different names are used and courses are provided with their own characteristics. For example, the major of environmental Science and Policy in Duke University focuses on the trend of environmental policy from the perspective of natural science, and has the characteristics of crossing the disciplines of arts and sciences. The environmental Economy and Policy major at the University of California, Berkeley, focuses on environmental issues and environmental policies from an economic perspective. The major of Environmental Policy and Management in Syracuse University focuses on the study of envi-

ronmental policy and management from the perspectives of politics, history and culture. The environmental management major at Indiana University focuses on the study of environmental management from the perspective of law and management. Although the environmental science and public policy major of Harvard University focuses on public policy from the perspective of natural science, it integrates the characteristics of economics. The environmental Science and Resource Management major of the University of Washington focuses on the sustainable development

Table 8. Typical environmental policy or environmental management majors and their curriculum in American universities

No.	University	Major	Curriculum
1	Duke University[51]	Environmental Science and Policy	Introduction of Environmental Science and Policy; Protection of life on Earth; Conservation biology: Theoretical and practical ecology; Environmental science and policy in the tropics; Energy and the environment; World trade in energy and mineral resources; American environmental policy; Fundamentals of GIS and geospatial analysis; Environmental chemistry and toxicology; Science and policy on natural disasters; Natural disasters: Rebuilding from ruins; Environmental economics; Food and energy: Applied research and theory; Environmental protection and documentary photography; Ecology; The ecosystems of a crowded planet; Introduction to atmospheric chemistry; Energy and environmental design;
2	University of California, Berkeley[52],[53]	Environmental Economics and Policy	Introduction to environmental Economics and policy; Theory and application of microeconomics of natural resources; Environmental economics; Economics of natural resources; Modeling and management of biological resources; Introductory application econometrics; Globalization and the natural environment; Agricultural and environmental policies; Economics of race, agriculture and the environment; Industrial organization and application of agriculture and natural resources; Health and environmental economic policies; Regulation of energy and the environment; Research in the field of environmental economy and policy; International trade; Population, environment and development; Poverty and technical economics; International trade; Advanced topics in environmental and Resource economics; Economics of water resources; Economics of climate change; Ecological economics under the historical background; Forest ecosystem management; The economic development.
3	Syracuse University[55]	Environmental Policy and Management	Economics of environment and resources; Population and environment; Environment and development in developing countries globally; Natural ecological environment; American Environmental History and geography; Tropical environment; River environment; Global environmental change; The geography of the mountain environment; A cold environment; Geography, climate and weather; Environmental justice; Principles of geographic information systems; Coastal environment; Global social issues; Environmental policy; Environmental politics and policy; Science and technology, politics and the environment; Environmental sociology; Biogeography; Development and sustainability; Environmental geographic information science.

No.	University	Major	Curriculum
4	Indiana University[27]	Environmental Management	Introduction to Environmental Science; Risk assessment and risk exchange presentation; Environmental management; Environmental economics and finance; International and comparative environmental policies; Environmental laws and regulations; Introduction to applied ecology; Introduction of water resources; Water supply and sewage management; Risk communication; Air pollution and control; Solid waste management; International comparative Environmental Policy; Environmental regulations; Environmental health; Finance and cost-benefit analysis; Leadership and ethics.
5	Harvard University[24],[25]	Environmental Science and Public Policy	Dynamic Earth: A geological structure that changes over time; Earth's resources and environment; Environmental health; Fluid Earth: Oceans, atmosphere, climate and environment; Introduction to meteorology and climate; Atmospheric chemistry; Microeconomic theory; Principles and policies of environmental economics; Protection and evolution; Economic environment, natural resources and climate change; Environmental science and technology; Environmental politics; Soil and environmental chemistry; Economic evaluation of environmental regulation; Ecology and land use planning; China's Energy economy: Challenges for the future from the perspective of the past; Paleontological conservation; Environmental crisis and demographic catastrophe; The technology, economics and public policy of renewable energy.
6	University of Washington[57]	Environmental Science and Resources Management	Introduction to Environmental Science; Forests and societies; Modern world wildlife conservation; Environmental sociology; Environment for social and sustainable development; Finance and accounting from the perspective of sustainable development; Introduction to environmental economics; Introduction of geographic information systems for forest resources; Soil and land use; The concept of sustainable development; Environmental and resource assessment; Natural resources issues: ancient forest management; Marketing and management from the perspective of sustainable development; Wildlife biology and conservation; Sustainability of the Pacific Northwest ecosystem.

of resources from the perspective of sociology and economics.

3. Enlightenment to China from the Cultivation of Environmental Protection Talents in American Universities

3.1 In Terms of Training Mode, the Experience of Generalist Education in the United States and the Distributed Compulsory Curriculum Setting that Supports this Concept is Worthy of Reference by Chinese Universities

American colleges and universities emphasize the cultivation of "generalists" in the lower grades, and support this educational concept through the distribution of compulsory courses. This experience is worth learning

by Chinese colleges and universities, especially for the environmental discipline, which involves the interdisciplinary field of natural science and humanities and social science, this discipline has the potential to develop into a new parent discipline. In the future, talents engaged in work, research and management in this field need to have extensive multidisciplinary and interdisciplinary knowledge and background from the beginning of undergraduate study, so that it is easier to view, study and manage the highly complex practical challenge of environmental affairs from a comprehensive perspective, from the perspective of ecosystem management.

For a long time, Chinese colleges and universities have been focusing on the cultivation of "special talents" by adopting the specialized training mode of mastering professional knowledge and laying a solid professional foundation in environmental protection personnel training. Indeed, it has created many leaders in the field of environmental protection and made great contributions to the country's social development and environmental protection.

However, when human beings have realized the high complexity of environmental problems and the challenge of sustainable development to human beings, the old technocratic, unitary model of cultivation can no longer fully adapt to the innovative and management-oriented environmental personnel training requirements for future ecosystem management ideas, nor can it adapt to the broader, more thoughtful and talented people who can promote the innovation of environmental management needed by the ministry of Environmental Protection to change to the direction of a super ministry reform.

Therefore, Chinese colleges and universities should change their ideas and properly handle the relationship between the cultivation mode of "generalists" and "specialists" according to their own development characteristics and social needs. In the field of environmental engineering and technology, there is still a need for absolutely solid professional knowledge and operational skills of engineering and technical personnel. In environmental management, social management, watershed management,

business management, economy, law and other sectors and more new areas closely related to environmental protection, in addition to the professional ability of environmental protection, also need multidisciplinary theoretical knowledge background, comprehensive decision-making ability, thinking and management innovation ability. Therefore, the talent training model combining generalists and specialists can better meet the needs of social development and the development of related industries for environmental protection talents, it can also guarantee the supply of talents for the implementation of innovative environmental management under the guidance of ecosystem management ideology and practice from the perspective of talent security.

The combination of general education and special education is not only the need of the development of environmental protection under the guidance of environmental social management and ecological system management, but also the need of the comprehensive and balanced development of college students. The single specialized education is more to push the students to become professional and technical engineering talents, while the training mode of general and specialized combination can cultivate scientific minds, extensive knowledge, innovative wisdom and professional new professional environmental protection senior talents. It is more adaptable to social and disciplinary development.

The talent training mode of general and specialized universities in the United States, which is supported by distributed compulsory courses, is worthy of reference for China in environmental protection talent training.

3.2 To Learn from the Experience of the United States to Increase the Education of Environmental Sociology Majors or Courses, It is Necessary to Promote the Improvement or Break through the Constraints of the Major Catalogue of the Ministry of Education

Environmental discipline is an open and interdisciplinary system, and has the potential to become a "mother discipline" across the characteristics of liberal arts and sciences.

American colleges and universities have more advantages in environmental sociology majors than Chinese colleges and universities. This experience is worth learning and drawing lessons from in China.

The practical environmental problems faced by the field of environmental science are not simple technical and engineering problems, but highly complex nonlinear problems, which is not only in the fields of natural science and engineering, but also in the personal and collective interests of all interested parties or stakeholders. Therefore, the economics, politics, law, management, ethics, philosophy, education, psychology and other disciplines of humanistic sociology have all begun to pay attention to environmental problems and their causes and influences.

The environmental discipline in Chinese universities, mainly in environmental science, environmental engineering and water supply and drainage, have made great contributions to the country's economic development and social construction in the past. In the future, these majors still need to make contributions to the society. However, how to increase attention to and governance of environmental issues from the perspective of humanities and sociology has become an urgent challenge threatening China's social stability and future development. This challenge requires a new type of compound environmental protection talents who have ideas, wisdom, understanding management, and can deal with the environmental crisis through management innovation, and solve the problems of long-term environmental and social stability.

Because of the limitations of the Ministry of Education's catalogue of Subjects, it is particularly difficult for new disciplines in the environmental field, especially interdisciplinary ones, to grow. The bureaucracy of the Chinese universities further strengthens the environment department to be locked in the circle.

In the future, environmental disciplines in Chinese colleges and universities need the help and efforts of many forces including the Ministry of Ecological Environmental Protection to promote the adjustment and reform of the professional catalogue of the Ministry of Educa-

tion, or break through the shackles of the university itself, to renew the old concept of talent training from the perspective of social development and the reform of government institutions, to add the necessary setting of environmental sociology majors, in order to promote the prosperity and great development of environmental disciplines in Chinese universities, to promote the establishment of new professional fields and the great development of environmental disciplines, and finally in order to make the environmental discipline take on new characteristics, and to cultivate new talents of environmental protection that the society needs to combine engineering, technology and environmental sociology.

3.3 In the Curriculum Setting, It is Necessary to Promote the Reform of the Professional Catalogue of the Ministry of Education or Break through its Shackles

American colleges and universities have one more distributed compulsory courses than Chinese ones. Its outstanding advantage is: in the study time stipulation and guarantees the student must understand the natural science, the humanities social discipline domain broad background knowledge. China should learn from this.

Most of the compulsory courses of environmental majors in Chinese universities are limited by the catalogue of disciplines and majors of the Ministry of Education, regardless of region or level. All schools should set the same course for this major, and the same course is also covered by science and engineering courses, and the talents cultivated are also technical talents. In recent years, the so-called professional course catalog has been reformed and updated only slightly. Colleges and universities do not have the full right to update courses according to social needs and professional development. They have the will and inability to integrate the characteristics of colleges and universities into some elective courses, which cannot guarantee that students will choose these courses to continue the tradition and highlight their characteristics. The comprehensive and flexible curriculum of environmental policy and management in American colleges and universities should sound the alarm that the

curriculum of environmental discipline is conservative and single in China universities. Colleges and universities in China should adjust the curriculum in time, and integrate the knowledge of various subjects into the professional courses to the greatest extent, so as to expand students' vision and cultivate environmental protection talents with comprehensive quality.

In China, only compulsory courses and elective courses have two learning time limits, so the fields and majors that need disciplinary innovation can only be placed in the elective course period. However, the optional courses are more optional, so some colleges and universities have to stipulate the requirement of "compulsory elective course". However, even if this regulation, it cannot change the composition of those credits itself stipulated in the subject catalogue of the Ministry of Education, so it cannot guarantee the influence of these compulsory or optional elective courses on students. This has become a thorny issue in the cultivation of talents including environmental protection talents in colleges and universities in China.

If China were to learn from the Experience of distributed compulsory courses in the United States, it would face a difficult problem: when should students complete the extensive study? Political and ideological courses in colleges and universities, public English courses and other courses are difficult to be changed in the catalogue of the Ministry of Education, but they are very large courses that occupy students' learning time and energy. Some core courses or important courses of environmental majors, such as the interview of some domestic colleges and universities, college teacher leadership response, can only be set in elective courses, and cannot be put into compulsory courses, because there is really no class time for students to learn.**

Therefore, the experience of distributed compulsory courses in the United States is good, but how to learn from it will challenge not only the management of colleges and universities themselves, but also the process of setting discipline catalogue and guidelines for the Ministry of Education.

3.4 The Ministry of Environmental Protection and Academic Organizations of Environmental Autonomy in Colleges and Universities are Working together to Change the Shackles of the Catalogue of Disciplines and Specialties of the Ministry of Education

Generally speaking, the experience of The United States is worth learning from by China, and most of them are places that cannot be changed by Chinese universities through their own subjectivity. Only by revising or breaking through the catalogue of subjects and specialties of the Ministry of Education can they be shaken. So change is necessary in two possible ways: (1) Take the lead of the Ministry of Environmental Protection and recommend the Ministry of Education to revise or reform the catalogue of disciplines and specialties through inter-ministerial coordination mechanism or joint meeting; (2) Environmental departments of colleges and universities have reached a consensus and jointly put forward suggestions to the Ministry of Education to break through the restriction of the Subject and specialty catalogue of the Ministry of Education on the subject and specialty development of colleges and universities, and form a new mechanism to manage the subject and specialty development of colleges and universities.

4. Examination of the Cultivation of Environmental Talents in Chinese Universities from the Ecosystem Management Way of Environmental Management Thinking Change

In terms of the paradoxical impact of environmental management system brought by ecosystem management, integration of China's environmental management system and formation of a super-ministerial system of the Ministry of Environmental Protection is a way to adopt the ecosystem management approach for environmental management system reform. If this is the case, the talents that need to be trained by universities can continuously supply the talents needed for the reform of the super ministry of Environmental Protection system, so as to support the normal operation and long-term development after the integration of the environmental management system.

However, due to the institutional problems of higher education, the new demand information of the country and society for environmental protection professionals cannot be directly reflected to the universities, or the universities turn a blind eye to it. Colleges and universities are busy following the Ministry of Education that is not willing to change more than ten years of environmental discipline professional directory and its curriculum standards blindly. This has resulted in the state and social development of environmental protection personnel demand information and the supply of environmental protection personnel training in colleges and universities between the two " not visiting each other all their lives " isolation.

It is helpful to evaluate the ability of supporting the integration of environmental management system from the point of university talent supply to clarify the current situation and ability of social talent demand side and university talent supply side, clarify the trend of environmental discipline development in Chinese universities in the future, and see clearly the limitation of discipline development, so that in the future there will be opportunities to achieve effective institutional breakthroughs to improve the current situation of environmental disciplines.

4.1 There is a Long Distance between the Cultivation of Environmental Professionals in Chinese Universities and the Cultivation of Professionals Required by Ecosystem Management

The institutional paradox of the management of nature as a whole, based on the knowledge of disciplinary division, is a natural gap between the current environmental management and ecosystem management methods implemented by all countries in the current human society.

Ecosystem management puts forward the requirements of cultivating interdisciplinary talents, comprehensive decision-making ability, critical spirit, critical thinking ability and innovation ability, and seeking benefits from organizational management innovation. At present, there is still a big gap between the cultivation of environmental protection talents in higher research institutes and the talents required by ecosystem manage-

ment. However, the gap between the cultivation of environmental protection talents in the UK[16] in the US and the talents required by ecosystem management is much smaller than that in the cultivation of talents in Chinese universities.

4.2 The Development of Environmental Discipline in Chinese Colleges and Universities is Compared with That in Foreign Countries Like UK and US: Wrong Birth and Wrong Prescription

4.2.1 The Development of Environmental Science can not Find its Direction because of the "Wrong Birth"

The environmental disciplines in Chinese universities, which are from various and complicated backgrounds, have been developing towards engineering technology. However, due to the lack of the source of discipline development, almost none of the predecessors of these environmental disciplines, which are from various sources, can assume the responsibility of thinking about the future development direction of environmental disciplines. The root cause is the lack of a "root" discipline source or mother discipline that can generate and reflect on the future direction of discipline development. The experience of geography as the source of the environmental discipline in British universities[16] tells us that China's environmental discipline has been wrong birth, and it is in urgent need of an original process to examine the pulse for the future development of this discipline. In the catalogue of disciplines and specialties of the Ministry of Education in China, the development trend of the secondary disciplines under the category of "big environmental protection", such as agriculture, forestry, Animal husbandry and fishery, ecology, geology and civil engineering, is better than that of the special environmental disciplines. This also shows that if the source of environmental discipline is placed on the "big environmental protection", which emphasizes the comprehensive thinking of geography, the development of environmental discipline can be on the broad direction of disciplinary development in accordance with the law of disciplinary development.

4.2.2 The "Wrong Prescription" Leads to the Professional Development of Environmental Discipline Lost and can not Find the Right Path of Development

(1) The professional setting is not rich enough, the professional setting short leg problem is prominent

Compared with American universities and British universities,[16] China is relatively unitary in terms of the abundance and diversity of specialties for undergraduate and graduate talent cultivation.

The phenomenon of professional short legs is obvious and outstanding in comparison with the universities and environmental departments of developed countries in the UK[16] and the US, for example, the lack of environmental sociology and their problems of difficult growth and development are very common in Chinese universities.

In the specialty setting of environmental departments of British universities[16] and American universities, there is a common point that is worthy of reference of Chinese universities' environmental departments, that is, the development of environmental sociology.

In the United States, the broad-caliber training mode of this major, and in the United Kingdom,[16] the interdisciplinary training mode of this major can be used for reference in the development of environmental sociology in China.

(2) The rigidity of Major Settings is obvious

This problem of rigid specialty setting is highlighted in comparison with environmental departments of universities in developed countries in the UK[16] and the US. Outstanding performance for the Ministry of Education professional directory nationwide one-size-fits-all restrictions brought by the immovable and indomitable.

The talents urgently needed in the future development of environmental protection in China are interdisciplinary talents in the field of environmental sociology. Although a small number of universities in China have gradually developed this major or field, its scale and influence still need to be improved. The biggest limitation and challenge to the development of this profession and field comes from the discipline

catalogue and standard of environmental specialty of the Ministry of Education. As a result, only those colleges and universities that have the right to set up second-level disciplines have the privilege to do such a major. And even those institutions in higher education which have the privilege of offering this major have not necessarily so far offered it. As a weak field of environmental departments in universities, it is difficult for environmental sociology to develop into a major level.

(3) Short board of curriculum design and setting

The comparative study also found shortcomings in the curriculum design and setting of environmental departments in Chinese universities. That is, in addition to a few colleges and universities, there is generally lack of practice, practice quality problems of environmental personnel training deficiencies.

In the UK,[16] the combination of production, study and research of environmental institutes and departments of universities and colleges emphasizes the talent cultivation mode of practice and internship guarantee, which is worthy of reference of environmental institutes and departments of universities and colleges in China.

Environmental departments of Chinese universities have unanimously approved the cultivation mode of the combination of production, study and research. However, how to establish this training mode from the perspective of organizational management mechanism, which belongs to the internal affairs of environmental departments in universities at present. Some universities have developed such a platform for the combination of industry, education and research, while more universities have not yet established such a mechanism. Need to be strengthen.

(4) The rigidity of the curriculum arrangement is serious, and the talent training mode based on the research project cannot cover the talent training at the undergraduate level

The comparative study also found that there is a rigid problem in the curriculum arrangement of environmental protection personnel training in Chinese universities, because all the courses are restricted by the professional curriculum standards of the Ministry of Education. And

there is also a mismatch between the amount of time required and the amount of time available for elective subjects, and the percentage of elective subjects that universities have the autonomy to arrange is too small.

The training of master's degree and above in environmental departments of Chinese universities is mostly based on tutor's project. However, this method cannot cover undergraduate training extensively and comprehensively.

In this form of training, there is little difference between the training of graduate students and above in Environmental departments of Chinese universities and the training of graduate students and above in Environmental departments of British [16] and American universities.

Globally, environmental science in the modern sense emerged from the industrialized world after World War II. It is mainly based on the severity and pervasiveness of environmental pollution to develop. The guiding ideology of the development of environmental discipline has gone through the process from technicalism to ecologism successively. Before and after the 1970s, the guiding ideology of the development of environment expand to the social dimension, the social dimensions in the field of environmental economics, environmental management, environmental politics and environmental behavioral science, environmental health, environmental literature, environmental education, and other fields, and even art has set up a formal association. This development process indicates that the environmental discipline has stepped out of the narrow technical vision, expanded to a broader level and field such as ecological field and Human society, and is on the way to becoming a "mother discipline" with great development potential. The guiding ideology in the field of environmental management is also undergoing a transformation from the departmental management ideology dominated by factor management to the ecosystem management ideology recognizing the integrity of the ecosystem.

In the late 1970s, China's universities mainly trained environmental technicians. In the 1980s, during the pollution prevention and control stage, environmental disciplines in Chinese universities mainly trained

environmental engineering and technical personnel. Meanwhile, environmental impact assessment and environmental economics were also started to train environmental personnel who were oriented towards element type environmental management. As the Chinese government has incorporated environmental protection into its overall social layout in the name of ecological civilization, has elevated environmental protection to the level of statecraft, environment and nature conservation are beginning to shift towards ecosystem management. How to train the talents of ecological civilization construction in all walks of life needed by the future social ecological civilization construction and development in China's higher education, especially the professional environmental protection talents trained by the environmental discipline, has become an urgent and key issue to support the construction of China's social ecological civilization capacity, which deserves further in-depth discussion.

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