The Diversified Implementation Path of China's "New Engineering" Construction and the University's Choice of Paths

Dr. Lina Wei, Zhejiang University

Wei Lina, Ph.D candidate in Institute of China's Science Technology and Education Policy in Zhejiang University. Research direction:Engineering education reform and interdisciplinary research.

Prof. Wei Zhang, Zhejiang University

2015-Present Professor, Institute of China's Science,Technology and Education Strategy, Zhejiang University Associate director of Research Center on Science and Education Development Strategy, Zhejiang University 2012-2014 Professor, School of management, Hangzhou Dianzi University Dean of Organization Management, School of management, Hangzhou Dianzi University 2008-2012 Director of Teaching & Research Division, School of management, Hangzhou Dianzi University 2007-2012 Associate Professor, School of management, Hangzhou Dianzi University 2005-2007 Assistant Professor, School of management, Hangzhou Dianzi University

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Abstract

Background Emerging Engineering Education (3E) is a reform direction of engineering education based on the new needs of China's strategic development and the new situation of international competition. Compared with traditional engineering, new engineering generally refers to an emerging field of engineering, which is newly born and has not yet formed a complex of relatively mature engineering education concept, disciplinary structure, talent cultivation model, teaching quality standard, organizational operation mechanism and supportive service system. At present, Chinese colleges and universities actively promote the pilot reform of new engineering majors. 612 projects from universities across the country have been recognized as the first batch of "New Engineering" research and practice projects by the Ministry of Education, indicating that the construction of new engineering in universities has entered the implementation stage.

Purpose/Hypothesis This study in-depth interviews with 15 typical "New Engineering" universities, aiming to extract the implementation path of "new engineering" in China, and provide a useful reference for the development of "new engineering ." Specifically, the research questions in this study are: (1) What are the core paths of China's new engineering construction? (2) What is the selection model of the "new engineering" construction path for different types of colleges and universities?

Design/Method Firstly, based on the previous literature, the theoretical model of "new engineering" construction was constructed. Then, through semi-structured interview method, the first-hand data of new engineering path selection in colleges and universities was obtained, and content analysis technology was applied to analyze the data in a bid to verify the theoretical model extract key factors in the construction of new engineering in colleges and universities eventually.

Results Research shows that the path of discipline integration, the path of discipline derivative, the path of Exogenously industry-led, and the path of Endogenously discipline-driven have become the main paths for the construction of "new engineering" in colleges and universities. Moreover, the path of engineering innovation has also been fully affirmed by some universities. The nature of disciplines along with the types and characteristics of colleges and universities exerts an influence over the choice of new engineering pathways in universities, universities and colleges at local level have relatively restricted options in the path of new engineering construction.

Conclusions Based on the data results, the research further explores the connection and combination model between the university's main body and the new engineering construction path.(1) engineering advantaged college and universities can take advantage of technology and engineering, and give priority to the "the exogenously industry-led" transformation path and the "disciplinary integration" new path.(2) Comprehensive universities should give full play to the supporting role of basic disciplines and the

advantages of cross-disciplinary integration. New engineering will be built through the path of "discipline-derived" and "disciplinary integration" .(3) Local universities and colleges should give priority to adopting the "the exogenously industry-led" path, construct a collaborative education system for deep cooperation between schools and enterprises, and enhance the service capabilities of region-oriented advantaged industries.

Introduction

The new round of scientific and technological revolution and industrial transforms, sweeping across the globe, has spawned a new economy characterized by new technologies, new industries, new formats and new models[1]. The new economy trend has exerted a huge impact on traditional engineering, leading to the formation of China's "New Engineering."Emerging Engineering Education (3E) is a reform direction of engineering education based on the new needs of China's strategic development and the new situation of international competition [3]. Compared with traditional engineering, new engineering generally refers to the emerging engineering specialty field that was newly born and has not yet formed a relatively mature engineering education concept, discipline professional structure, talent cultivation model, teaching quality standard, organizational operation mechanism and supportive service system [2].

Since February 2017, the Ministry of Education of China has actively promoted the construction of "new engineering" , and has formed the "Fudan Consensus", "Tianda Action" and "Beijing Guide" , and fully explored the formation of a Chinese model and Chinese experience that led the global engineering education, bolstering the construction of a strong country in higher education. At present, Chinese colleges and universities actively promote the pilot reform of new engineering majors. 612 projects from universities across the country have been recognized as the first batch of "new engineering" research and practice projects by the Ministry of Education, and the construction of new engineering in universities has entered the implementation stage. In the process of implementation, China’s universities have formed a diversified implementation path based on their own characteristics and resource bases, and hammered out a path combination model that adapts to disciplines and professions.

In this context, we used in-depth interviews of 15 typical "new engineering" colleges and universities to obtain first-hand interview data and conducted a content analysis, extracted the main implementation path of China's "new engineering," and provided useful reference for the development of "new engineering."

1. Research question

The purpose of the new engineering construction is to deepen the reform of the engineering education system, improve the quality of education and teaching, and cultivate engineers with practical and innovative capabilities, so as to deliver a steady stream of emerging power to the country's engineering and industry. This study aims to refine the main path of the

implementation of new engineering in colleges and universities, and to summarize the combination model of university path selection. Specifically, the research questions in this study are as follows:

(1) What are the core paths of China's new engineering construction?

(2) What is the selection model of the "new engineering" construction path for different types of colleges and universities?

2. Literature review

2.1 The concept of new engineering concept

The "new" of new engineering construction is reflected in five aspects [4]: (1) The new concept of engineering education. With the new economy and new industries as the background, the new engineering construction needs to establish a new concept of innovative, integrated and full-cycle engineering education. (2) The new structure of the discipline profession. Carry out research and exploration of new engineering majors, update and upgrade traditional engineering majors, and build a new discipline structure combining both new engineering and traditional engineering. (3) A new model of talent cultivation. Deepen and perfect the system and mechanism underlying the Exogenously industry-led path, the cooperation of school and enterprise, and explore a new model for implementing engineering education talent cultivation. (4) The new quality of education and teaching. Study and formulate the teaching quality standards for emerging engineering majors, carry out multi-dimensional evaluations of education and teaching quality, and create new quality of engineering education with competitiveness in an international context. (5) A new system for development by classification. Construct a new system structure for the development of colleges and universities by classification and the training of engineering talents by classification.

2.2 The main body of new engineering construction

The existing main subjects of new engineering construction are mainly divided into three categories:engineering advantaged college , comprehensive universities, and local universities. Engineering superiority colleges, recognized as a feature of traditional engineering as well as characteristic universities within the industry, have the characteristics of strong overall engineering strength [5], obvious advantage of research and development in leading technology, and close connection with industry. Comprehensive universities have many advantages such as multidiscipline [6], solid foundational science, scientific research and resource allocation diversity [7], and have made a great contribution to meeting national science and technology needs and technology research and development [8].The development of local colleges and universities mainly relies on the support of local government finance and regional industrial resources, and local colleges focus on coordinated development with local society, economy and industry, bolstering local industrial transformation and upgrading, and serving regional innovation and development in turn[9].

2.3 New engineering construction logic

Scholars have analyzed the driving forces of new engineering from policy-led logic, industry demand logic, disciplinary evolution logic and knowledge-derived logic [10].The Chinese government has actively promulgated and implemented various industrial policies and talent policies with a view to maintain competitiveness in the global scientific and technological revolution and industrial revolution, and this has become the policy logic for promoting new engineering construction. The logic of industrial demand emphasizes that the construction of new engineering should further explore the characteristics of industrial demand and engineering education with Chinese characteristics, and continuously optimize the knowledge system, level type and capacity structure of engineering talents to conform to the evolution of global technological change [11]. Disciplinary evolution logic believes that new engineering is a more dynamic concept than traditional engineering [12], and the construction of new engineering cannot be completely separated from traditional engineering. Instead, it should be transformed and upgraded on the basis of traditional engineering. The logic of knowledge production emphasizes that the production model of knowledge will change under the new industrial development needs, and the traditional knowledge system will not be able to meet the needs for current development, thereby making the innovation reform urgently needed [13].

2.4 New engineering construction situation

At present, the research on construction situation is more comprehensive, mainly analyzing the construction situation of "new engineering" from several aspects: curriculum content system [14], multiple teaching mode [15], engineering education evaluation [16], engineering innovation platform [17], etc. Some scholars started from the professional logic, explored the new curriculum system of design experiment/practice teaching, and comprehensively reconstructed the course content system. Some scholars have carried out research on the ability cultivation system, teaching model innovation, mechanism and guarantee, and formed a multi-level, modular and research-oriented engineering innovation talent training model [18]. Some scholars have analyzed the engineering education evaluation system [19], analyzed the engineering education faculty, and put forward policy recommendations for reforming job title evaluations and course evaluations.

2.5 New engineering construction path

"Reconstruction and upgrading of traditional engineering majors" and "innovation and fusion of new engineering" are the two major directions for the construction of new engineering. Through case studies, scholars summed up four paths of new engineering construction: (1) The university represented by U1 adopts the path of "disciplinary integration" , which is, through the cross-compositing of engineering and engineering, or the intersection of engineering and other disciplines, to bulid unprecedented new engineering majors. (2) The university represented by U3 derives a new and unprecedented new engineering specialty from the applied science through the "discipline-derived" path.

(3) Universities represented by U6 promote the reform and innovation of existing engineering majors through the "exogenously industry-led path," which is to drive reforms and innovations of existing engineering disciplines through transformation, restruction and upgrade activated by exogenous demand,in both traditional and present engineering disciplines(4). The university represented by U13 adopts the "endogenously discipline-driven" path, which is the transformation, restruction and upgrade of traditional and existing engineering disciplines driven by the endogenous demand of the discipline. As for the research content, the existing literature lacks verification of the new engineering construction path. There is almost no mature verification construct, and seldom exist quantitative indicators of path selection.

2.6 Research Model Construction

The existing literature has focused on the exploration of the motivations, subjects, logics, goals and situations of new engineering construction, and has achieved certain results. However, the existing research lacks overall consideration of various factors, along with verification of the validity of the new engineering construction path, and has not yet formed an effective analytical framework. Given this context, this study constructs a "new engineering" analysis framework, refines the new engineering construction path and explores the choice of "new engineering" construction paths for different types of colleges and universities.

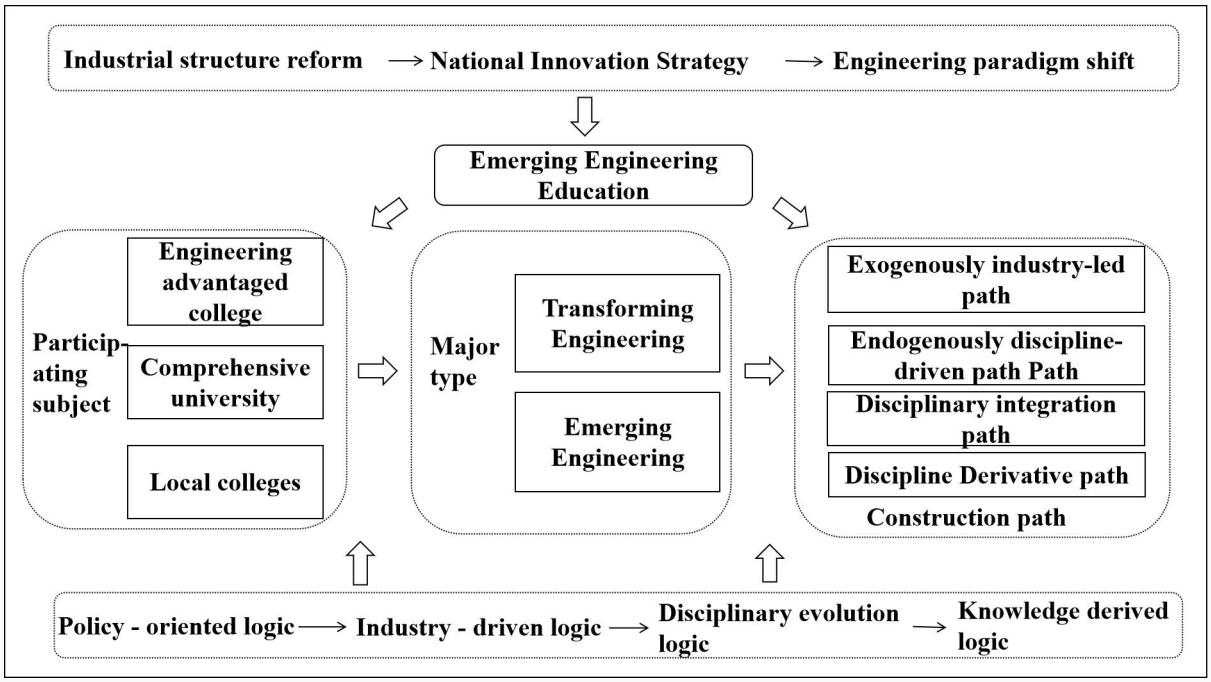

Figure 1 "New Engineering" construction path model diagram

3. Methodology

Through semi-structured interviews, the research obtains the first-hand information of new engineering construction in colleges and universities, and uses content analysis technology

to qualitatively and quantitatively analyze the data, so as to verify the path model and explore the preference of new engineering path selection in colleges and universities. In terms of case selection, the study selects multiple case studies, which can make the analysis more universal and more suitable for constructing theory [20].

3.1 Participants and data collection

This study selects research samples based on the list of 612 "New Engineering Research and Practice Projects" issued by the Ministry of Education [21]. The selection principles of the research samples are as follows: (1) The selected samples need to reflect the diversity of new engineering construction paths and cover all four paths of the theoretical model. (2) The selected samples need to reflect the diversity of the new engineering practice subjects, covering typical engineering advantaged college , comprehensive universities, and local colleges. (3) The selected professions are diverse ,covering both traditional and emerging engineering. Based on this, this study selected 27 new engineering projects from 15 typical universities as case samples. The sample data is shown in Table 1 (see Annexes 1 and 2 for details). After determining the school and project samples, the research team is actively engaged in contacting the dean of each undergraduate college who will introduce and recommend the interviewees. The interviewer data obtained are as follows (see Table 2).

Table 1:basic information of cases

University type	**Characteristics**	**Percentage**	**Interviewee**	**Major**
Engineering advantage college	The overall strength of engineering is strong, and the advantage of the research and development of leading technology is obvious. .	6(40%)	11（40.7%）	EE(6)+ TE(5)
Comprehensive university	Multidisciplinary, solid foundation, scientific research and resource allocation diversity.	5(33.3%)	9（33.3%）	EE(5)+ TE(4)
Local colleges	Professional disciplines have strong regional characteristics and rely mainly on the support of local government finance and regional industrial resources.	4(26.7%)	7（25.9%）	EE(3)+ TE(4)

Note: TE stands for Transforming Engineering . EE stands for Emerging Engineering .

Table 2: Basic information of interviewees

Interviewee ID	**Name**	**University**	**Emerging Engineering Education project**
IP1	Zengx	U1 University	The "Emerging Engineering Education " practice of automation professional development
IP2	Sunxx	U1	Software Engineering Training System and

		University	Platform Construction for Emerging Engineering Education
IP3	Shuxx	U2 University	Exploration and practice of Emerging Engineering Education specialty construction based on multidisciplinary intersection and Exogenously industry-led
.....			

3.2 Interview design

The study collects qualitative data through semi-structured interviews and conducts purposeful conversations with the research subjects directly or indirectly to better describe and explain things, events, phenomena, people, and to better understand the research questions [22]. Centering on the theme of "New Engineering Construction Path Recognition and University Path Selection," the research has designed related interview questions. Example questions are:

"What are the characteristics and advantages of your new school/professional/project new engineering construction?"

"What kind of path or path combination does your school/professional/project take to implement new engineering construction?"

"Why is this path used, and what are the characteristics and effects of the path?"

"What difficulties and challenges have you encountered in implementing this path?"

"Based on the existing implementation results, what experience can be shared when selecting a new engineering implementation path?"

In the interview, the interviewee is introduced to the background of the new engineering construction, and then the interviewers pivot the questions above, asking and discussing with the interviewees in light of the specific circumstances. The time of each interview is controlled at 2-3 hours. After the interview, the interview content will be sorted into word text in time, paving the way for subsequent analysis.

3.3 Coding procedure

The essence of content analysis technology is to convert the documents expressed in linguistic representation rather than in figures into data in quantitative representation by identifying key features in the target text, and to use statistical descriptions of the analysis results. And based on further analysis of the "quantity" of text content, the study identifies easy-to-count features which reflect a certain essential aspect of the content of the document, and clarify the text content’s laws and test and interpret it [23].After obtaining the interview data, this study used the content analysis model of chou and chang's (2010) to analyze the data step by step:

1.Sampling: The 27 interview materials of 15 colleges and universities are collated, and a complete paragraph is expressed as a minimum analysis unit. A total of 126 analysis units are extracted and detailedly coded.
2.Conceptualization: Corresponding to the problems raised above, this study focuses on the following two aspects: (a) What are the main implementation paths for new engineering construction in China, and (b) the path selection model for different types of universities in the "new engineering" construction.
3. Coding book: Based on the research problem, the code book and code table of the inductive coding strategy are created. In this paper, the deductive coding method is used to determine the four paths of coding according to the literature analysis. The remaining paths are supplemented according to the interview content. In the coding, the path is selected in AD, the school is at 1-15, the interview object is at 1-27, and the number of paths is changed at the range of 1-126. The coding strategy is shown in Table 3, coding table 4, and the detailed coding process is shown in Annex 2.
4. Confidence Check: According to the content analysis rule, it is necessary to select different judges to compare the coding results of the same analysis sample, and the consistency α coefficient >0.8 is reliable [24].The study was coded by two professionals, including one professor in engineering education and one PhD candidate in engineering education. The research data and coding process were in accordance with the triangulation method of Miles and Huberman (1984) [25].The coder consistency coefficient of the new engineering construction path is 0.9, which satisfies the reliability and validity of the code.

Table 3: New Engineering Construction Path Coding Strategy

coding	Path identification	description
A	Exogenously industry-led path	The transformation, transformation and upgrading of traditional and existing engineering disciplines driven by industrial exogenous demand will promote the reform and innovation of existing engineering disciplines.
B	Endogenously discipline-driven path	The transformation, transformation and upgrading of traditional and existing engineering disciplines driven by the endogenous demand of the discipline can be defined as the transformation path of "endogenously discipline-driven" .
C	Disciplinary integration path	Through the cross-combination of engineering and engineering, or the integration of engineering and other disciplines, the construction of new and unprecedented new engineering majors.
D	Discipline derived path	New and emerging new engineering majors are derived from applied science.

Table 4: "New Engineering" Construction Path Identification Code Table

"New Engineering " construction implementation path

Path Selection		Exogenously industry-led	Endogenously discipline-driven	Disciplinary integration	Discipline derivative	other
University type	Engineering advantaged college					
	Comprehensive university					
	Local colleges					
Professional type	Emerging Engineering Education					
	Transformation Engineering					

3.4 Data analysis

The study analyzes the data from three angles: First, the statistical analysis is carried out from the overall perspective, which is to capture the characteristics of the new engineering construction path without considering the type of the university and the nature of the profession; Secondly, the university type variables are included in analysis; Third, the profession nature is included in the analysis of the new engineering construction path.**This paper analyzes the statistical significance of related data by means of SPSS software.**

（1）Coding result of the implementation path of "new engineering" based on the overall perspective

In the construction of new engineering, the frequency of selecting the path of exogenously industry-led was the highest, at 46, accounting for 36.51% of the total frequency,followed by the selection of the path of discipline integration which constitutes 25.40% of the total frequency. Disciplinary pathways and endogenously discipline-driven path Pathways accounted for 19.84% and 13.49% of the total frequency, respectively. **In addition, the interview data also reflects the engineering innovation path, which is to implement the construction of “New Engineering” by establishing innovation practice platforms and constructuring an engineering innovation and entrepreneurship center.** Although the proportion of its frequency is only 4.80%, some universities have still fully affirmed this path during the interview.

Table 5: Coding results of the implementation path of the "new engineering" construction based on the overall perspective

Emerging Engineering Education construction path	**Frequency**	**The ratio of frequencies**
Exogenously industry-led path	46	36.51%
Endogenously discipline-driven path	17	13.49%

Disciplinary integration path	32	25.40%
Discipline Derivative path	25	19.84%
Engineering innovation path	6	4.80%

Note: The engineering innovation path is supplemented by the interview text.%=Percentage represents the proportion of single-item frequencies in 126 interview coding units.

（2）Path coding result of "new engineering" implementation based on the nature of discipline

The level of significance of Table 6 shows that the profession nature does not affect the implementation of the pathway of integration of education and education and the path of discipline integration. The chi-square values of the two are not significant.The endogenously discipline-driven path Path is influenced by the profession nature of the discipline. The transformation engineering has an absolute advantage in implementing the endogenously discipline-driven path Path, accounting for 88.24%, whereas the new engineering only accounts for 17.65%. The chi-square analysis also shows that the discipline-derived path is also influenced by the profession nature. The emerging engineering has obvious advantages over the transitional engineering in the implementation of the discipline-derived path, accounting for 76% , In contrast, the transformation engineering only takes up 24%.

Table 6: coding results of the implementation path of "Emerging Engineering Education " construction from an overall perspective

	Exogenously industry-led	**Endogenously discipline-driven**	**Disciplinary integration**	**Discipline Derivative**	**Engineering innovation**
	F / %	F / %	F / %	F / %	F / %
Emerging Engineering	20（43.48%）	3（17.65%）	24（75.00%）	19（76.00%）	3（50.00%）
Transformation Engineering	26（56.52%）	15（88.24%）	8（25.00%）	6（24.00%）	3（50.00%）
Chi-Square	0.096	8.824**	0.309	8.241**	-
Significant degree	0.075	0.003	0.578	0.004	-

Note: The engineering innovation path is supplemented by the interview text. %=Percentage represents the proportion of single-item frequency in the single-item path interview coding unit, and F=Frequency represents the frequency of occurrence of the single-item indicator.* indicates that its chi-square value is significant at the level of 0.1, ** indicates that its chi-square value is significant at the level of 0.05, and *** indicates that its chi-square value is significant at the level of 0.01.- Indicates no measurement results.

（3）Path coding result of "new engineering" based on the characteristics of colleges and universities

The saliency level of Table 7 shows that the type of college does not affect the implementation of the exogenously industry-led path, which has a high frequency and proportion in the selection of various colleges and universities. By comparison, the endogenously discipline-driven path path and the subject derivative path are greatly

influenced by the type of colleges and universities. The frequency and proportion of engineering advantaged college and comprehensive universities on the two paths are significantly higher than those of local universities, and the chi-square value is overall maintained at 0.05 of significance level. In addition, there is no significant difference in the choice of various paths between engineering advantaged college and comprehensive universities.

Table7: coding results of the construction path of "Emerging Engineering Education " based on the nature of disciplines

	Exogenously industry-led	**Endogenously discipline-driven**	**Disciplinary integration**	**Discipline derivative**	**Engineering innovation**
	F / %	F / %	F / %	F / %	F / %
Engineering advantaged college（EAU）	17（37.00%）	5（29.41%）	11（34.37%）	7（28%）	3（50%）
Comprehensive university (CU)	10（21.74%）	10（58.82%）	16（50.00%）	13(52.00%)	1（16.7%）
Local colleges(LU)	19（41.30%）	2（11.76%）	6（18.75%）	5(20.00%)	2（33.3%）
EAU/CU **Chi-Square** **Significant degree**	 3.238 0.072	 0.021 0.884	 0.008 0.93	 0.225 0.635	- -
EAU/LU **Chi-Square** **Significant degree**	 0.358 0.459	 7.828** 0.005	 1.805 0.179	 8.544** 0.004	- -
CU/LU **Chi-Square** **Significant degree**	 0.037 0.847	 7.112** 0.008	 1.278 0.224	 14.715*** 0.001	- -

Note: The engineering innovation path is supplemented by the interview text.%=Percentage represents the proportion of single-item frequency in the single-item path interview coding unit, and F=Frequency represents the frequency of occurrence of the single-item indicator.* indicates that its chi-square value is significant at the level of 0.1, ** indicates that its chi-square value is significant at the level of 0.05, and *** indicates that its chi-square value is significant at the level of 0.01.- Indicates no measurement results.

4. Finding

Research shows that the discipline integration path, the discipline derivative path, the industry and education integration path, and the endogenously discipline-driven path have become the main paths for the construction of “new engineering” in colleges and universities. The engineering innovation path has also been fully affirmed by some universities. The nature of disciplines affects the choice of new engineering pathways in colleges and universities. The differences in the types and characteristics of colleges and universities have resulted in significant differences in the path choices. Local colleges have less room for choices in the new engineering construction path.

Because the "engineering innovation path" has a lower frequency, the data analysis result thereby cannot be obtained. Based on this, we exclude this path from analysis in the following text. Subsequent analysis still centers on the first four paths.

4.1 Profession nature affects the choice of new engineering construction path

1. Traditional engineering: driven by engineering theory and implementation capability, preferring the path of "Endogenously discipline-driven" and "Exogenously industry-led"

In the construction of "new engineering" , traditional engineering favors the path of "endogenously discipline-driven" path and the "exogenously industry-led" path, and it has significant advantages in the endogenously discipline-driven path in particular. In general, the transformation of traditional engineering shows the following characteristics: (1) The exogenous demand of industries drives the transformation and upgrade of traditional engineering. In order to meet the demand for industrial application which is derived from knowledge, traditional engineering is focusing on the active construction of new professions in a way that highlights the importance of docking industries..(2) The traditional engineering department make use of its theoretical and engineering capabilities. It bases the transformation, restruction and upgrade of traditional and existing engineering disciplines on the exploration of edge of theory, knowledge and technology, aiming to build a new engineering profession that leads the.way and sets an eye on the future.

2. Emerging Engineering: For new industries and new technologies, the "Disciplinary integration" and "Discipline derivative" paths are the mainstream

In the construction of "new engineering" , the new engineering department has more choices of "discipline-derived" path and "disciplinary integration" path. The main reasons and characteristics of the study are as follows: (1) The emergence of new engineering has been nurtured, extended and expanded from the application of basic disciplines such as science, thereby emphasizing the interdisciplinary and interdisciplinary expertise. (2) The new engineering department is set up for the development of new technologies and new industries in the future. It aims to solve the complex problems of the education and industry, and it pays more attention to the development of interdisciplinary innovative thinking.

4.2 University Characteristics Affecting the Choice of New Engineering Construction Path

There are significant differences in the path selection of "new engineering" construction in three different characteristics and types of colleges and universities. (1) engineering advantaged universities have the advantages of strong engineering strength and leading technology research and development, allowing it more choices for the transformation path of "exogenously industry-led" and the new path of "disciplinary integration." (2) Comprehensive universities should give full play to the supporting role of basic disciplines

and multi-disciplinary cross-integration advantages, and they prefer to choose "discipline-derived" and "disciplinary integration" in the construction of new disciplines. Besides, "engeering science" manifests itself in engineering advantaged college and comprehensive universities, but to a limited extent. (3) Local universities adopt more "exogenously industry-led" paths to enhance the service capabilities of region-oriented industries.

4.3 Path selection model for the implementation of new engineering construction in colleges and universities

According to the analysis results, the combination model between the main body and the path of new engineering construction in China can be further explored (Table 8).

Table 8: The main body and path selection of new engineering construction

<table>
<tr><th>Major type</th><th colspan="2">Transformation Engineering</th><th colspan="3">Emerging Engineering</th></tr>
<tr><td>Overall path</td><td colspan="2">（Transforming Path）：
Transform, transform and upgrade traditional and existing engineering disciplines, expand connotation, reform and training models, and promote reform and innovation of existing engineering disciplines.</td><td colspan="3">（Emerging Path）：
That is, according to the needs of the development of modern industry, we will actively set up and develop a number of new and unprecedented Emerging Engineering Education majors.</td></tr>
<tr><td>Subpath</td><td>"Endogenously discipline-driven path" Path：The transformation, transformation and upgrading of traditional and existing engineering disciplines driven by the internal demand of disciplines.</td><td>"Exogenously industry-led " path：
Transformation, transformation and upgrading of traditional, existing engineering disciplines driven by industry exogenous needs.</td><td colspan="2">"Disciplinary integration" path：Through the cross-compositing of engineering and engineering, or the integration of engineering and other disciplines, we will build new and unprecedented Emerging Engineering Education majors.
Engineering+ Engineering method | Engineering + Science method</td><td>"Discipline-derived"path：From the application of science, a new and unprecedented engineering major has been derived.</td></tr>
<tr><td>Engineering advantaged college</td><td>√</td><td>√</td><td>√</td><td>√</td><td>*</td></tr>
<tr><td>Comprehen-sive university</td><td>√</td><td>*</td><td>*</td><td>√</td><td>√</td></tr>
<tr><td>Local college</td><td>*</td><td>√</td><td>*</td><td>*</td><td>*</td></tr>
</table>

Note: "√" is the main path and "*" is the auxiliary path.

From the perspective of China's "new engineering" construction path and trend, in the future, breakthroughs are likely to made across the world in four aspects: (1) Explore the new engineering talent cultivation model for industrial needs. Improve the quality of engineering talents based on industry standards. Cultivated engineering talents should be judged as "products" based on industry standards. Promote the deep integration of science and education between universities and enterprises. (2) Emphasize on the main functions of college educators, and build an innovative engineering talent support system. Deepen the curriculum and teaching reform in colleges and universities, attach importance to the development of students' abilities, qualities, engineering ethics, and stratify and classify talents. (3)Increase the supply of engineering education talents and the funding of training funds. Strengthen research support in the field of engineering education. Pay attention to the research of Endogenously discipline-driven issues and provide consultation and decision-making for the development of new engineering.

5. Conclusions

This study focuses on the construction of new engineering in China, analyzes and refines its diversification path, explores the path selection model for new engineering construction in universities, and proposes differentiated policy recommendations for further development of new engineering strategies in China. Nevertheless, this study failed to judge the effectiveness of the existing implementation of the existing path. Our next step is to combine the case study and empirical investigation methods to analyze the specific effects of new engineering construction and build an effective model for the training of emerging engineering talents from the perspective of quality assurance.

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APPENDIX 1

Table A1: University characteristics

University ID	Student Population	Research/Teaching Focus	Source of Funding	Campus type
U1 University	Large	Master's Colleges & Universities:Larger Programs	Ministry of Education	Engineering advantage college
U2 University	Large	Doctoral Universities: Moderate Research Activity	Ministry of Education	Engineering advantage college
U3 University	Medium	Doctoral Universities: Highest Research Activity	Ministry of Education	Comprehensive university
U4 University	Large	Doctoral Universities: Highest Research Activity	Ministry of Education	Comprehensive university
U5 University	Medium	Master's Colleges & Universities:Larger Programs	Local government	Local colleges
U6 University	Medium	Master's Colleges & Universities:Larger Programs	Local government	Local colleges
U7 University	Medium	Master's Colleges & Universities:Larger Programs	Local government	Local colleges
U8 University	Medium	Master's Colleges & Universities:Larger Programs	Local government	Local colleges
U9 University	Large	Doctoral Universities: Highest Research Activity	Ministry of Education	Engineering advantage college
U10 University	Large	Master's Colleges & Universities:Larger Programs	Ministry of Education	Engineering advantage college
U11 University	Medium	Doctoral Universities: Highest Research Activity	Ministry of Education	Comprehensive university
U12 University	Large	Master's Colleges & Universities:Larger Programs	Ministry of Education	Engineering advantage college
U13 University	Large	Master's Colleges & Universities:Larger Programs	Ministry of Education	Comprehensive university
U14 University	Large	Doctoral Universities: Moderate Research Activity	Ministry of Education	Comprehensive university
U15 University	Large	Master's Colleges & Universities:Larger Programs	Ministry of Education	Comprehensive university

APPENDIX 2

Table A2:The interviewer's university and project

Interviewee ID	Name	University	project name	Major
IP1	Zengx	U1 University	The "Emerging Engineering Education " practice of automation professional development	TE
IP2	Sunxx	U1 University	Software Engineering Training System and Platform Construction for Emerging Engineering Education	EE
IP3	Shuxx	U2 University	Exploration and practice of Emerging Engineering Education specialty construction based on multidisciplinary intersection and Exogenously industry-led	EE
IP4	Wangxx	U2 University	Exploration and Practice of the Transformation of Traditional Engineering Majors and the Cultivation System of Multiple Innovative Talents	TE
IP5	Duxx	U3 University	Constructing Engineering Talent Training Course System Based on Multidisciplinary and Interdisciplinary Integration	EE
IP6	Chenx	U3 University	Exploration and Practice of the Extension of the Talents Training System of Shanghai Jiaotong University	EE
IP7	Zhangxx	U4 University	Using the Institute of Engineers as an engine to promote the development of high-level engineering talents in this research-oriented industry chain	TE
IP8	Gex	U4 University	Exploration and practice of multi-disciplinary and cross-combination intelligent robots	EE
IP9	Zhengxx	U5 University	Exploration and Practice of the Construction of Science Application in Emerging Applications of "Information Computing and Security"	EE
IP10	Wangxx	U5 University	Exploration and Practice of Emerging Professional Construction in the Integration of Air, Heaven, Letter and Medicine	EE
IP11	Xiongx	U6 University	Research and Practice on the Construction of Emerging Engineering Education in Light Industry Specialty in China	TE
IP12	Caixx	U7 University	Construction and Application of Emerging Engineering Education General Education Curriculum System Based on Exogenously industry-led	TE
IP13	Baoxx	U7 University	Exploration and Practice of Multi-disciplinary Cross-integration Transformation and Upgrade Path for Mechanical Majors in Intelligent Manufacturing Industry	EE
IP14	Hexx	U8 University	Research and Practice on the Integration of Emerging Engineering Education Practice Teaching System and Innovation and Entrepreneurship Education Based on CDIO Engineering Education Concept	TE
IP15	Luxx	U9 University	Exploration and Practice on the Training of Multi-dimensional Engineering Applied Talents in Local Universities under the	TE

			Background of Emerging Engineering Education	
IP16	Shixx	U9 University	Exploration and practice of multidisciplinary and cross-compositing big data and business intelligence emerging engineering specialty construction	EE
IP17	Lix	U10 University	Exploration and Practice of Promoting Emerging Engineering Education Construction by Characteristic Industrial College	TE
IP18	Sunxx	U10 University	Research on Construction and Practice Platform Construction of Mechanical Engineering Professional Practice Education System Based on Collaborative and Co-construction Mode of "School Management Enterprise Association"	TE
IP19	Chenxx	U11 University	Research on the Cultivation Demand and Countermeasure of Intelligent Engineering for Emerging Engineering Education Science and Technology Talents	EE
IP20	Zhangxx	U11 University	Research on Emerging Engineering Education Talents Training System for Smart City Infrastructure Construction and Management	EE
IP21	Zangxx	U12 University	Exploration and Practice of the Construction of Technical Medicine Specialty	TE
IP22	Panxx	U12 University	Quantum Information Emerging Engineering Education Construction	TE
IP23	Linxx	U13 University	Interview Record of Fudan University Microelectronics College	TE
IP24	Luo x	U13 University	Research and Practice of the Basic Course System of Emerging Engineering Education Software Engineering Majors Trained to Individualized Talents under the Big Application Environment	EE
IP25	Sunxx	U14 University	Exploring the Training Mode of Emerging Engineering Education Talents' Innovation and Entrepreneurship Ability——Taking Environmental Engineering as an Example	TE
IP26	Linxx	U15 University	Exploring the Cultivation of Innovation and Entrepreneurship Ability of "Software +" Emerging Engineering Education Talents	EE
IP27	Wuxx	U15 University	Demonstration Software College Education Reform Experience Analysis and Leading the Future of Emerging Engineering Education Exploration	EE

Note: TE stands for Transforming Engineering . EE stands for Emerging Engineering .

APPENDIX 3

TableA3: Codebook and example quotes used in analysis

Category	Dimension	Key elements	Example Quote
Transformed Engineering	**Exogenously industry-led**	School-enterprise joint construction of majors and courses	We have established good relations with local enterprises and governments, and the construction of Emerging Engineering Education majors is in line with the needs of local industries and enterprises. [U6IP2]
		Teaching model innovation	The school provides sufficient funds for student development. Our students go to the company for internships every semester, and the internship scores account for 30% of the course score. [U5IP3]
		Talent training model innovation	Together with the company, we have established a mechanism to train order-based talents in cooperation with enterprises. [U4IP7]
	Endogenously discipline-driven	Reform evaluation method	We have a looser assessment of the newly established frontiers of engineering, and we hope that this Emerging Engineering Education profession will develop further. [U4IP2]
		General education	We want to train a wide-ranging talent, so in the first two years of engineering undergraduate students, we don't have a major, only a general education course, and a core course in the next two years.
		Construction Engineering Innovation Center	To explore the needs of cutting-edge knowledge, it is necessary to establish a professional research center to provide a pilot site for the future development of the professional. [U4IP2]
Emerging Engineering	**Disciplinary integration**	Interdisciplinary concept	Interdisciplinary is the core feature of the Emerging Engineering Education construction. To this end, our school has set up an interdisciplinary committee to promote cross-disciplinary professional construction. [U1IP2]
		Mixed teaching	Teaching with questions and projects as a guide to promote students' application of multidisciplinary knowledge. [U1IP2]
		Teaching evaluation reform	Involving interdisciplinary, it is difficult for teachers to evaluate classes. We have set up an interdisciplinary evaluation system. [U2IP2]。
	Discipline-derived	Science professional reform	We expand the extension of mathematics statistics and combine the information profession to create an emerging big data major. [U2IP2]

		Textbook preparation	The profession is too new, we will send teachers to study abroad, introduce foreign textbooks, and re-set the course. [U1IP2]
		Mixed teaching	Teaching with questions and projects as a guide to promote students' application of multidisciplinary knowledge. [U1IP2]
		Teaching evaluation reform	Involving interdisciplinary, it is difficult for teachers to evaluate classes. We have set up an interdisciplinary evaluation system. [U2IP2]。
	Discipline-derived	Science professional reform	We expand the extension of mathematics statistics and combine the information profession to create an emerging big data major. [U2IP2]
		Textbook preparation	The profession is too new, we will send teachers to study abroad, introduce foreign textbooks, and re-set the course. [U1IP2]
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Note: U6IP2 stands for the university number u6, the interviewer and the project number is IP2 interviewer, and the rest are analogous.