Research on the Structural Characteristics of Interdisciplines in Chinese Universities

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Abstract. Interdisciplinary construction is the main direction of developing the higher education discipline system. Based on the discipline classification of liberal arts, science, engineering, agriculture, and medicine, the article analyzes the interdisciplinary structural characteristics including the diversity and association of supporting disciplines from 2019 to 2023, through Shannon entropy and social network analysis respectively. The article found that the disciplines of other fields have a high degree of interdisciplinary integration, but the diversity of engineering-oriented interdisciplines is still low, and the association between engineering is weak. As a whole, the association of disciplines shows the characteristics of core-periphery structure. Universities should give full play to the effect of core disciplines, and expand the path of interdisciplinary construction, and establish a pluralistic talent training system of interdisciplines.

Keywords: Interdisciplines; Structural characteristic; Discipline integration

1 Introduction

In the new era, the original single discipline system has made it difficult to meet the needs of knowledge production and talent training. The construction of interdisciplines is the way to achieve original innovation (Li, 2023) [1], breaking down the disciplinary barriers, and giving full play to the advantages of interdisciplines are the key points in the construction of discipline systems in universities. As an important part of talent training, graduate education should promote the combination of technology and production practice through interdisciplinary integration, and construct disciplinary clusters of hard and soft disciplines (Chen, 2022) [2], tamping the foundation of discipline knowledge for talent training. Therefore, the current situation of interdisciplinary construction and how to develop in the future are urgent problems to be explored.

The disciplinary structure can reflect the internal logic of the discipline (Chen,1990) [3]. Exploring the interdisciplinary structural characteristics is helpful to clarify the current situation of interdisciplinary construction. The core of interdisciplines is the integration of discipline knowledge (Porter et al. 2007) [4], it is formed by the deep intersection of various supporting disciplines (Zhu & Zhang, 2024) [5], and they constitute

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the internal structure of interdisciplinarity in the form of innovative knowledge (Wang & Li, 2023) [6]. Thus, it can be seen that the diversity and association of supporting disciplines are the key dimensions to examining the interdisciplinary structural characteristics. In existing research, De (2020) [7] analyzed the disciplinary association characteristics based on 13 discipline fields, as well as natural science and humanities and social sciences. Ma & Zheng (2022) [8] separately analyzed the supporting disciplines' association characteristics of closely related interdisciplines and distant interdisciplines. Wang & Li (2023) [6] constructed the Interdisciplinary True-diversity index to measure interdisciplinary diversity and analyzed interdisciplinary cohesion from the perspective of discipline and discipline field. Tao & Qie (2022) [9] analyzed the structure of the interdisciplinary layout through the interdisciplinary degree, concentration degree, and grouping strength. Ma. et al. (2023) [10] explored the network structure of interdisciplinary association through the method of complex network analysis.

To sum up, the existing research on the characteristics of interdisciplinary diversity, and association has mostly started with 13 discipline fields. However, fewer studies classify disciplines based on disciplinary research fields and knowledge systems. Scholars also rarely analyze interdisciplinary development trends. Thus, from the perspective of discipline classification of liberal arts, science, engineering, agriculture, and medicine, this article based on the interdisciplinary data from 2019 to 2023, analyzes the interdisciplinary structural characteristics, including the diversity and association of supporting disciplines. To explain the current situation of interdisciplinary construction, and the degree of knowledge integration among the disciplines of various fields.

2 Methodology

2.1 Research Design

The data of "List of interdisciplines set up autonomously by degree conferring institutions (excluding military units)" released from 2019 to 2023 are taken as the main research object in this article, and analyzes the diversity and association of supporting disciplines through Shannon entropy and social network analysis respectively. The aim is to analyze interdisciplinary development trends longitudinally while researching interdisciplinary structural characteristics horizontally.

This article classifies the data based on discipline fields. The disciplines of engineering, science, agriculture, and medicine are classified according to the corresponding discipline fields in the bibliography of discipline and major, and according to the content of humanities and social sciences, the disciplines in the rest of the nine discipline fields, such as philosophy and economics are classified as liberal arts for analysis.

This article further processes the classified data of interdisciplines. First, based on the proportion of disciplines in each field in the supporting disciplines, interdisciplines are mainly classified into liberal arts-oriented, science-oriented, engineering-oriented, agriculture-oriented, and medicine-oriented types. Second, to analyze the association of supporting disciplines, Python is used to count the frequency of two disciplines as supporting disciplines for the same interdiscipline. If there is a co-occurrence relationship between the two disciplines, the count is 1, otherwise, the count is 0. Finally, the

co-occurrence matrix of disciplines in each field, and the co-occurrence matrix containing all supporting disciplines are formed from 2019 to 2023.

2.2 Design of Correlation Measure Index

Index for Measuring the Diversity of Supporting Disciplines.

The concept of diversity is derived from the biological sciences (McCann, 2000) [11]. In this article, Shannon entropy is selected as the diversity measure index, and the interdisciplinary diversity is measured with 2 as the bottom number. Shannon entropy is usually used to characterize the uncertainty of uncertain events in the system or to measure the complexity of the system. The formula is defined as follows. Among them, $p(x_i)$ denotes the proportion of disciplines in x_i field to the total number of supporting disciplines of the interdiscipline. Larger discipline Shannon entropy indicates a more balanced distribution of disciplines in each field, and smaller discipline Shannon entropy means the distribution of disciplines in each field is more concentrated. In this article, the diversity of interdisciplines is measured according to the classification of disciplines in 13 fields.

$$H(x) = -\sum_{i=1}^{n} p(x_i) \log p(x_i) \tag{1}$$

Index for Measuring the Association of Supporting Disciplines.

This article used UCINet 6 as the main research tool for social network analysis. The closeness of the discipline co-occurrence network is presented through network density calculation, and the core disciplines are found through centrality calculation. At the same time, this article further analyzes the supporting disciplines' co-occurrence network through Lambda Sets analysis, to explore the activity of disciplines in each field in interdisciplinary integration.

3 Result

3.1 Analysis of Interdisciplinary Diversity

Table 1. Number of discipline fields involved in each interdisciplinary Shannon entropy range.

Shannon entropy range	Number	Shannon entropy range	Number
0	1	1.9< ≤2	4
0.6< ≤1	2	>2	5
1< ≤1.6	3	-	-

Figure 1 shows the proportion of interdisciplines dominated by different fields in each range of Shannon entropy from 2019 to 2023. Combined with Table 1, the supporting disciplines of liberal arts-oriented interdisciplines mainly involve 2 to 3 discipline fields, and a few are supported by five or more discipline fields. The proportion of interdisciplines that involve multiple discipline fields is increasing. Among the engineering-oriented interdisciplines, the interdisciplines supported only by engineering

account for the largest proportion. However, the proportion of interdisciplines involving 2 to 3 discipline fields is increasing. In the recent two years, some universities have set up interdisciplines involving 4 discipline fields again. Science-oriented interdisciplines, agriculture-oriented interdisciplines, and medicine-oriented interdisciplines are mainly supported by two discipline fields. The medicine-oriented interdisciplines are gradually becoming more specialized, and the proportion of science-oriented and agriculture-oriented interdisciplines in each range shows a floating state. However, the number of disciplines involving three discipline fields is relatively large in the agriculture-oriented interdisciplines, and universities have also set up science-oriented interdisciplines and medicine-oriented interdisciplines involving four discipline fields in recent years.

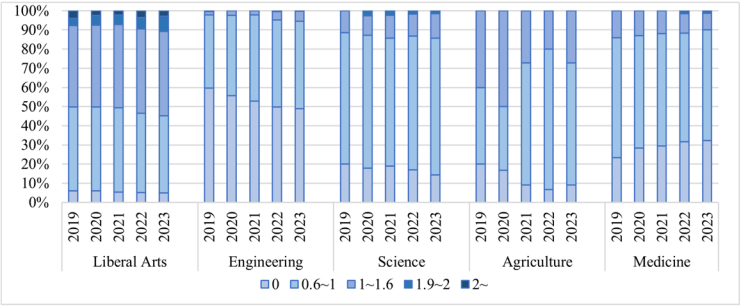

Fig. 1. The proportion of interdisciplines in each range of Shannon entropy.

3.2 Association Analysis of Supporting Disciplines

Analysis of Association within Disciplines in the Same Field.

From 2019 to 2023, the co-occurrence network density of disciplines in each field showed an increasing trend and reached the maximum network density in 2023. Among them, the network density of the liberal arts co-occurrence network is 0.6087. The number of disciplines with high centrality in the network has increased significantly, and the supporting and connecting role of literature and management science in interdisciplinary construction has gradually prominent. The network density of the engineering co-occurrence network is 0.41. According to the high centrality disciplines in the network from 2019 to 2023, Mechanical Engineering, and Computer Science and Technology have promoted communication and integration between disciplines. The science co-occurrence network has 47.4 % of the network connections, Biology gradually withdrew from the ranks of the highest centrality disciplines, but Mathematics, Chemistry, Statistics, and Geography give full play to their disciplinary advantage and core role. The density of agriculture co-occurrence networks reached 0.639, the density of medicine co-occurrence network reached 0.667, and the disciplines within the two fields are more closely associated. Among them, Crop Science and Horticulture in agriculture are most closely associated with other disciplines, and the most active disciplines in medicine are Clinical Medicine and Public Health and Preventive Medicine.

Analysis of Association within disciplines in Various Fields.

From 2019 to 2023, the density of the supporting disciplines' co-occurrence network showed an increasing trend, but the network density was only 0.2401 in 2023. Among them, Computer Science and Technology and Management Science and Engineering are the top two disciplines of degree centrality and betweenness centrality for five consecutive years, which are important components of many interdisciplinary knowledge systems. At the same time, the Lambda Sets analysis shows that the maximum Lambda of the network has increased from 2019 to 2023, and the corresponding subgroups are all {Computer Science and Technology, Management Science and Engineering} sets. When other disciplines are added to the set, the Lambda is significantly reduced.

To further explore the subgroup distribution of disciplines in each field, the Lambda Sets analysis results are simplified by the form of hierarchical classification (Figure 2). When the set is located in the first level, it indicates that the discipline relationship within the set is the most robust. Currently, the disciplines are mainly concentrated in the set of the fourth, fifth, and sixth level, and the level distribution of disciplines in the same field is relatively scattered. Among them, the second and third level only include liberal arts, science, and engineering. In the field of medicine and agriculture, only Basic Medicine, Clinical Medicine, Public Health and Preventive Medicine, and Crop Science are in the fourth level, other disciplines are scattered in the fifth and sixth level.

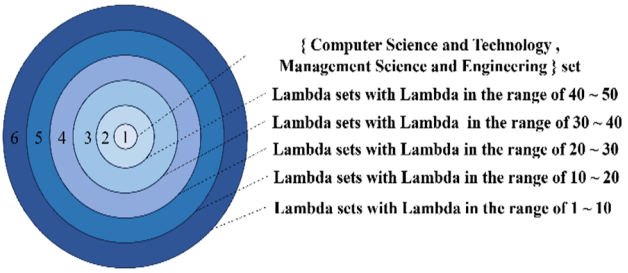

Fig. 2. Simplified graph of Lambda Sets analysis.

4 Discussion

The disciplines of liberal arts, science, agriculture, and medicine have a high degree of interdisciplinary integration, but the integration degree of engineering is still low. In terms of the dominant discipline field of interdisciplines, the diversity of liberal arts-oriented interdisciplines, science-oriented interdisciplines, agriculture-oriented interdisciplines, and medicine-oriented interdisciplines is relatively high. Most of the engineering-oriented interdisciplines only involve the engineering field, and engineering is weakly integrated with disciplines in other fields. However, from the trend of engineering-oriented interdisciplinary construction, the discipline fields involved in supporting disciplines gradually diversified.

In the fields of liberal arts, agriculture, and medicine, disciplines are more closely associated, and the association between engineering is weak. According to the analysis of the internal association of disciplines in each field, it can be seen that the activity of

disciplines in the liberal arts co-occurrence network has increased significantly. Because of their professional characteristics, agriculture, and medicine are closely related to other disciplines in the same field. The degree of discipline association in the science co-occurrence network is general, while the internal association of engineering is relatively weak. Combined with the diversity analysis results of engineering-oriented interdisciplines, it can be seen that some disciplines have already established a relatively stable association, and as the core disciplines in the interdisciplinary construction promote the participation of another engineering. So, the engineering co-occurrence network does not show a clear centralized trend, but the network density is low.

The association of disciplines shows the characteristics of the core-periphery structure. According to the analysis of the association of each discipline, it can be seen that the core disciplines of interdisciplinary construction are developing steadily and the relationship is robust. Both of them have a positive role in promoting interdisciplinary construction. From the perspective of discipline association, some disciplines within the liberal arts, science, and engineering are more robustly associated with other disciplines, whereas disciplines within agriculture and medicine have relatively less robust relationships with other disciplines. As a whole, the disciplines in most sets are relatively weakly correlated. Although some disciplines have the potential to integrate with other disciplines, their participation in interdisciplinary construction is low, and the application of the disciplines still needs to be strengthened.

5 Conclusions

5.1 Main Conclusions

The article is based on the relevant data from 2019 to 2023, and mainly analyzes the structural characteristics of the diversity and association of supporting disciplines in the interdisciplines, through Shannon entropy and social network analysis respectively. The article found that the disciplines of liberal arts, science, agriculture, and medicine have a high degree of interdisciplinary integration, but the diversity of engineering-oriented interdisciplines is still low. In the fields of liberal arts, agriculture, and medicine, disciplines are more closely associated, but the association between engineering is weak. As a whole, the association of disciplines shows the characteristics of core-periphery structure.

5.2 Contribution

Firstly, according to the nature and research field of the discipline, this article puts forward a new form of discipline research, based on liberal arts, science, engineering, agriculture, and medicine. Secondly, based on the relevant data from 2019 to 2023, this article explores the development law of interdisciplinary structural characteristics longitudinally and has a certain reference value for universities to explore the development direction of interdisciplinary construction. Finally, this article puts forward the following suggestions for interdisciplinary construction.

Give Full Play to the Effect of Core Disciplines.

Universities should give full play to the leading and intermediary role of the disciplines with high centrality in each field, and promote the participation of edge disciplines within the same field in disciplinary integration, to provide innovative perspectives and approaches to solving problems in relevant fields. Universities should also focus on promoting the deep integration of disciplines in various fields, explore the "bridge" between agriculture, medicine, and other disciplines respectively, and strengthen the construction of agriculture-oriented interdisciplines and medicine-oriented interdisciplines. Assisting our country to make breakthroughs in technological innovations in agriculture and medicine. At the same time, universities should construct a comprehensive and diversified interdisciplinary group with the high centrality disciplines as the center, and educational philosophy and major characteristics as the guide. Optimize and adjust the layout of disciplines, and promote the coordinated development of advantageous disciplines, characteristic disciplines, and emerging interdisciplinary disciplines.

Expand the Path of Interdisciplinary Construction.

At present, interdisciplinary integration is still dominated by the 'narrow cross', and the integration between some disciplines is relatively less. Therefore, universities should strengthen the design of interdisciplinary construction schemes, and according to the internal logic of discipline integration, scientifically select supporting disciplines, to improve the random stacking problem between interdisciplinary knowledge. Rationally plan and expand the discipline integration path of wide cross, and explore potential interdisciplinary fields. Promote the integration and innovation of natural sciences and humanities and social sciences, to enhance the theoretical basis and humanistic connotation of interdisciplines.

Establish a Pluralistic Talent Training System of Interdisciplines.

The construction of interdiscipline is not only the integration of knowledge across discipline fields but also the crossing of science and society, which requires the participation of universities, professional researchers, and other relevant organizations. Also, the process of promoting interaction between participants is necessary to promote interdisciplinary research (König et al. 2013) [12]. Therefore, universities should pay attention to the application research of disciplines, and strengthen the training of talent innovation and practical ability. At the same time, universities should formulate interdisciplinary evaluation mechanisms with diversified evaluation sources and evaluation objects. Relevant organizations should also integrate resources build an interdisciplinary information service platform with universities, and actively organize seminars, training sessions, and other activities. To provide a communication platform for researchers, and promote the cooperation of various organizations to solve practical problems.

References

1. Li, L.G. (2023) The New Mission of National Development and Interdiscipline Construction. Social Sciences of Beijing, (01): 87-90.
2. Chen, L. (2022) Conflict Patterns and Cooperation Directions in the Development of University Discipline Clusters. Nanjing Journal of Social Sciences, (08): 134-142. DOI: 10.15937/j.cnki.issn1001-8263.2022.08.015.
3. Chen, X.J. (1990) Outline of the History of Subject Structure Theory. Quarterly Journal of Shanghai Academy of Social Sciences, (01): 5-15.
4. Porter, A.L., Cohen, A.S., Roessner, J.D. et al. (2007) Measuring researcher interdisciplinarity. Scientometrics, 72: 117–147. https://doi.org/10.1007/s11192-007-1700-5.
5. Zhu, X.P., Zhang, J.J. (2024) On the Paradigm Construction and Action Path of Interdisciplinary Disciplines. Academic Degrees & Graduate Education, (01): 63-69. DOI: 10.16750/j.adge.2024.01.009.
6. Wang, C.Y., Li, Y. (2023) Diversity and Cohesion: Structural Characteristics of the Independent Establishment of the Interdisciplinary Subjects in Universities in China. University Education Science, (01): 35-47. DOI: 10.3969/j.issn.1672-0717.2023.01.03.
7. DE, J.F. (2020) Research on the Associated Characteristics of Interdisciplines Set Up Autonomously by Universities. China Higher Education Research, (03): 70-79. DOI: 10.16298/j.cnki.1004-3667.2020.06.16.
8. Ma, T.Q., Zheng, Z.J. (2022) On the Correlation Between the Distribution of Independently Designed Interdisciplines and the Supportive Disciplines: Based on the Data Analysis of the Independently Designed Interdisciplines in Universities. Journal of Graduate Education, (06): 81－90. DOI: 10.19834/j.cnki.yjsjy2011.2022.06.11.
9. Tao, J.H., Qie, H.X. (2022) The Layout Structure, Organization Pattern, and Construction Mode of Interdisciplines Autonomously Set up by Universities. Jiangsu Higher Education, (08): 36-44. DOI: 10.13236/j.cnki.jshe.2022.08.005.
10. MA, N., WANG, H.B., LIU, Y.J. (2023) Research on the Trend Characteristics and Multidimensional Measures of Interdiscipline Development in China. Journal of Graduate Education, (03): 1-9. DOI: 10.19834/j.cnki.yjsjy2011.2023.03.01.
11. McCann, K.S. (2000) The diversity–stability debate. Nature, 405: 228–233. https://doi.org/10.1038/35012234.
12. König, B., Diehl, K., Tscherning, K. et al. (2013) A framework for structuring interdisciplinary research management. Research Policy, 42: 261-272. https://doi.org/10.1016/j.respol.2012.05.006.