• Research on the Renovation and Expansion Design of Existing Higher Vocational Colleges Based on SNA

- Taking the Conghua Campus of Guangzhou Health Science College as an Example

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Abstract. Against the backdrop of urban stock renewal and the continuous expansion of vocational education demands, the renovation and expansion of existing vocational colleges have become a new research direction. There are two key issues in the process of vocational college renovation and expansion that need to be addressed: spatial order and functional configuration. Taking Conghua Campus of Guangzhou Health Science College (hereinafter referred to as "Conghua Campus"), this study uses Social Network Analysis (SNA) to analyze the campus space-related indicators and identifies issues such as uneven node distribution and chaotic functional organization, proposing corresponding solutions. A spatial network model is then constructed for the renovated campus to analyze and verify whether the campus space structure has been optimized. SNA provides strategies at the overall campus space level for the evaluation and renovation and expansion design of existing vocational college campuses, offering a reference for similar renewal and expansion projects.

Keywords: Vocational Colleges, Campus Space, Social Network Analysis (SNA), Quantitative Evaluation, Renovation and Expansion Strategies

1 Introduction

As China enters a new stage of development, the continuous adjustment of industrial upgrading and economic structure has led to an increasing demand for technical and skilled talents, highlighting the increasingly important position and role of higher vocational education. This requires more detailed research on the construction of higher vocational schools to establish a comprehensive vocational education system that is

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compatible with the overall economic functions. Currently, China's infrastructure construction has shifted from incremental expansion to stock renewal, and the large-scale construction of vocational colleges has become more moderate. However, there is a large number of campus building environments that are in urgent need of renovation: on one hand, due to the short development history, small scale, and poor hardware conditions (practical training) of many vocational colleges, which cannot meet the requirements of modern teaching; on the other hand, influenced by factors such as the school's management model, government policy behavior, and the transformation needs of the industrial economy, the planning of vocational colleges has become a dynamic and continuously changing process.

Current systematic research on the construction of vocational colleges mainly focuses on practical training spaces, while research on the overall planning and renovation and expansion of vocational colleges is mostly at the engineering practice level, lacking in-depth theoretical and methodological research, especially the lack of quantitative analysis of existing campus spaces, and has not formed a campus space structure renovation strategy that meets the needs of modern vocational education.

SNA is a digital research tool formed through scientific argumentation, originally applied in the field of sociology, and has begun to emerge in research related to architecture and urban and rural planning in recent years. Applying it to the diagnosis of spatial problems in the renovation and expansion of vocational colleges and the evaluation of the effects of renovation and expansion can reveal the underlying patterns of campus space structure relationships, deepening designers' and users' understanding and organizational reconstruction capabilities of vocational college campus spaces.

2 Current Status and Issues of Spatial Transformation Research in Higher Vocational Colleges in China

2.1 Spatial Order

Due to reasons such as early construction period, insufficient emphasis, and lack of funds, most vocational colleges in China did not form a sustainable overall plan during the initial construction phase. Instead, they have been built and renovated in a bottom-up, small-scale, and incremental manner. In this process, the focus was on solving functional needs, while lacking consideration for overall, humanistic, and regional aspects, leading to a disorderly campus space. Over time, as the campus expands and teaching requirements increase, the limitations of this non-sustainable planning model gradually become apparent: facing continuous growth in demands, the disorderliness of campus planning makes it difficult for schools to adapt in terms of spatial layout, functional integration, and environmental optimization.

2.2 Functional Configuration

In the planning of existing vocational college campuses, the old thinking of university campus planning is still followed, with the library, teaching main building, etc., as the core of the campus layout. Alternatively, it is believed that training workshops are not aesthetically pleasing and are therefore placed in secondary areas of the campus, fundamentally neglecting the functional composition of vocational college campuses and lacking correct cognition and layout consideration for training spaces. This functional layout model failed to anticipate the new trends in the development of vocational education, especially in terms of the changes in requirements for increased research demands in vocational colleges, improved per-student land standards, and the deepening integration of industry and education. The basic conditions and facilities are no longer able to meet the application needs of new technologies and equipment.

3 Social Network Analysis and Related Parameter Calculation

3.1 Social Network Analysis (SNA)

Social Network Analysis (SNA) is a quantitative method for studying social structures and relationships between individuals. It originated in the field of sociology and has recently begun to appear in research related to architecture and urban and rural planning[1]. By treating individuals as nodes in a network and the relationships between individuals as edges connecting these nodes, it reveals the structural characteristics and dynamic changes of the network. In the study of higher vocational college campus space, it can transform indoor and outdoor space nodes into data, and its output parameters can accurately present the quantification of power for each node and the completeness of the overall network, as well as visualize them. Compared to spatial syntax and GIS network analysis, SNA is more suitable for analyzing closed, clearly defined areas and can establish three-dimensional dynamic association methods, making it suitable for the study of the overall spatial structure of campuses.

SNA is a quantitative method for studying the social structure and relationships between individuals. It reveals the structural characteristics and dynamic changes of networks by treating individuals as nodes in the network and the relationships between individuals as edges connecting these nodes. Compared to traditional research methods such as Space Syntax and GIS network analysis, SNA is more suitable for the study of the overall spatial structure of vocational colleges. The specific reasons are as follows:

(1) Unlike methods such as spatial syntax and GIS network analysis that focus on analyzing the planar linear relationships between spaces, SNA can establish dynamic association methods in three dimensions, providing a more comprehensive consideration of real space;

(2) Spatial syntax pays attention to the characteristics of streets and alleys themselves, with less consideration of their relationships with surrounding elements. In contrast, SNA focuses on the topological relationships between elements, emphasizing the overall network relationships rather than the characteristics of individual elements, making it more suitable for research at the regional planning level;

(3) In terms of research approach, SNA is more suitable for closed, clearly defined areas compared to the other two methods, making it applicable to the relatively independent spatial system of schools;

(4) Unlike Space Syntax and GIS network analysis methods, which can only analyze the physical spatial structure, SNA can also be used for individual behavioral demand analysis. Subsequent comparative studies between physical space networks and social relationship networks can better meet the needs of users.

In the study of campus space in vocational colleges, it can transform indoor and outdoor spatial nodes into data. Its output parameters can precisely present the quantification of power for each node and the completeness of the overall network, and visualize the presentation[2].

3.2 Related Parameters

Using UCINET software to build a spatial network relationship model, abstracting the spatial units in the campus into nodes, and the behavioral associations between nodes into lines, thus constructing a spatial structure network and quantifying the relationships between nodes[3]. The analysis yields indicators such as centrality, central tendency, cohesive subgroups, and density, which are translated into characteristics of the spatial network's balance, tightness, and zoning. Utilizing NETDRAW as a visualization tool to draw spatial relationship diagrams can more accurately and intuitively reflect the characteristics of campus space, thereby assisting in the optimization of spatial order and functional configuration (Table 1).

Table 1. SNA Metrics

Problem	**Metric**	**Meaning**	**representation interpretation**
Spatial Order	centrality	The degree of control between nodes	The main indicators selected for analysis are degree centrality and betweenness centrality. The higher the node centrality means the more nodes it is directly connected to or the more shortest paths it lies on, reflecting greater power (stronger public nature) within the campus, but an overly high centrality can lead to imbalance and congestion.
	Centralization	The concentration effect of the entire network	The main indicators selected for analysis are degree centralization and betweenness centralization. A higher degree centralization reflects a more concentrated overall campus, where one node has a very high centrality while other nodes have low centrality. A higher betweenness centralization indicates that nodes within the campus may be divided into multiple cliques and are overly dependent on a single node for relaying connections. Within a reasonable range, the

			lower the centralization, the more balanced the distribution of campus space; however, too low a level suggests homogenization of campus space and a lack of vibrant spaces.
Functional Configuration	Cohesion	potential secondary clusters within the network	By analyzing cohesion, it is possible to identify which areas within the campus have formed tight-knit communities, guiding the functional zoning accordingly
	Density	the degree of internal/inter-cluster connectedness	Guiding which areas need to improve connections. The greater the density, the closer the internal/inter-subgroup connections are, and the more convenient the internal and external connections of the functional zones determined by this will be

Centrality and Centralization.

Centrality reflects the degree of importance of a node within the network structure, while centralization reflects the concentration effect of the entire network[4]. Centrality can be measured using degree centrality and betweenness centrality as indicators: Degree centrality refers to the number of direct neighbors a node has, indicating the node's importance in the network; Betweenness centrality refers to how many shortest paths a node lies on, reflecting the node's control over other nodes[5]. Centralization can be measured using degree centralization and betweenness centralization as indicators: Degree centralization reflects the overall centrality of the network, with a higher value indicating a stronger concentration effect, meaning one node has a very high centrality while others have low centrality; A higher betweenness centralization suggests that nodes in the network may be divided into multiple cliques that are overly reliant on a single node for relaying connections, with that node holding an extremely important position in the network[6][7]. In campus settings, it is often necessary to increase node centrality and balance while reducing network centralization to prevent the emergence of a single node with excessively high centrality, thereby enhancing the overall balance, connectivity, and completeness of the campus spatial network. In UCINET, "Network-centrality" can be used to calculate the centrality of nodes and the overall network centralization.

Cohesion and Density.

Cohesion research involves studying the potential secondary groupings within a network, and based on the calculated subgroups, it is possible to identify spaces with closely linked functions to form functional zones. The Concor block model can be used to analyze the cohesion of the existing campus spatial structure. Concor is an iterative correlation convergence method that can be used to analyze the distribution of spatial subgroups, the main types of subgroup composition, and the cohesion within and between subgroups. In UCINET, "Network -Role & Position -Structure -Concor" is used for cohesion calculations.

Concor block model analysis in UCINET also allows for the calculation of density within and between subgroups. Density is the ratio of the actual number of connections between node pairs to the maximum possible number of connections, with a value range of 0-1. Analysis of density can guide the adjustment of connections within and between subgroups. Internal density reflects the tightness of connections among nodes within a subgroup, while inter-subgroup density reflects the overall tightness of connections between each pair of subgroups.

4 Case Study

4.1 Project Background

The renovation and expansion project is located in Conghua District, Guangzhou City, Guangdong Province, covering an area of 77,279 m^2, with an existing construction area of 20,609 m^2 and a proposed total construction area of 109,450 m^2 after expansion. The current situation lacks clear planning and construction, with existing buildings concentrated on the south side of the site, and the rest are large areas of vacant land awaiting development; the entrance is located on the east side of the site, with a short axis, and no architectural sequence has been formed on either side (Fig. 1). The existing buildings have a mixed function without a clear zoning, and the scale of the buildings is small, which does not meet the usage requirements. It is planned to carry out renovation and expansion to improve the functionality and enhance the campus environment. SNA will be utilized to analyze the existing problems in the spatial structure of the vocational college campus and propose targeted renovation and expansion strategies.

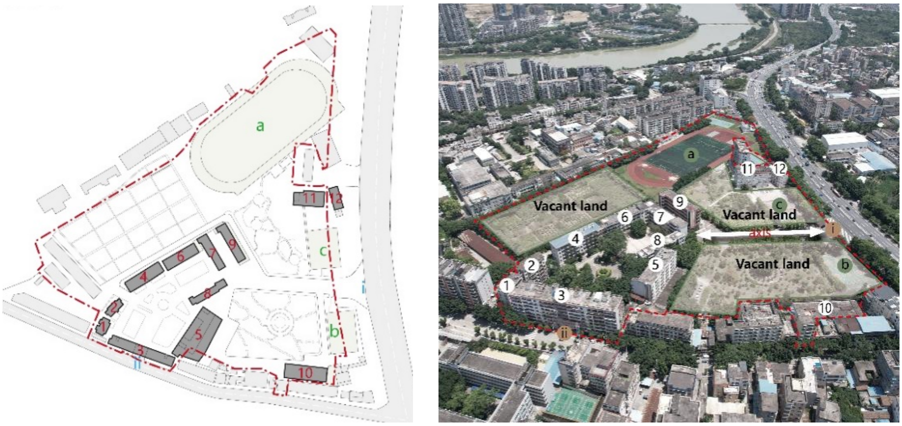

Fig. 1. Current Planning and Spatial Nodes of Conghua Campus

Table 2. Correspondence between Node Numbers and Building Functions

1	Family Housing Building	7	Teaching & Training Building	a	Playground
2	Family Housing Building	8	Training Building	b	Athletic Field 1
3	Family Housing & Office Building	9	Teaching Building	c	Athletic Field 2
4	Training Building & Student Dormitory	10	Student Dormitory	i	School Gate 1
5	Canteen& Library & Student Dormitory	11	Training Building	ii	School Gate 2
6	Teaching & Training Building	12	Training Building		

4.2 Current Spatial Network Model Construction

The model construction is divided into indoor building spaces, outdoor activity spaces, and key campus nodes, with Arabic numerals, letters, and Roman numerals used as corresponding node numbers (Fig. 1, Table 2). The campus spatial structure is abstracted into a network model, and based on existing research in related fields, a service radius of 200 meters walkable is adopted as the criterion for spatial node accessibility, that is, the standard for measuring whether a spatial node is reachable[8]. If the existing roads within the range of a spatial node meet the accessibility requirements, then a "relationship" between "points" is recorded as "1", and if there is no "relationship", it is recorded as "0", establishing a data matrix (Fig. 2). The current spatial network model of Conghua Campus is constructed using social network analysis software UCINET and visualization software NETDRAW.

	1	2	3	4	5	6	7	8	9	10	11	12	a	b	c	i	ii
1		1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1
2	1		1	1	1	1	1	1	1	0	0	0	0	0	0	0	1
3	1	1		1	1	1	1	1	1	0	0	0	0	0	0	0	1
4	1	1	1		1	1	1	1	1	1	0	0	0	0	0	0	1
5	1	1	1	1		1	1	1	1	1	0	0	0	1	1	1	1
6	1	1	1	1	1		1	1	1	1	0	0	0	0	0	0	1
7	1	1	1	1	1	1		1	1	0	0	0	0	0	0	0	1
8	1	1	1	1	1	1	1		1	1	0	0	0	0	0	0	1
9	1	1	1	1	1	1	1	1		0	1	1	1	1	1	1	1
10	0	0	0	1	1	1	0	1	0		0	1	0	1	1	1	0
11	0	0	0	0	0	0	0	0	1	0		1	1	1	1	1	0
12	0	0	0	0	0	0	0	0	1	1	1		1	1	1	1	0
a	0	0	0	0	0	0	0	0	1	0	1	1		1	1	1	0
b	0	0	0	0	1	0	0	0	1	1	1	1	1		1	1	0
c	0	0	0	0	1	0	0	0	1	1	1	1	1	1		1	0
i	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1		0
ii	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	

Fig. 2. Current Spatial Relationship Data Matrix of Conghua Campus

4.3 Analysis and Solutions of Existing Campus Spatial Network Models

In response to the two key issues arising from the renovation of vocational colleges, this approach involves using SNA to analyze four corresponding indicators, and then proposes targeted spatial optimization strategies based on the issues revealed by these indicators.

Spatial Order Reconstruction Methods Based on Centrality Analysis.

Table 3. Existing Node Centrality Analysis

Node	Degree	Betweenness	Node	Degree	Betweenness
1	56.250	0.000	10	50.000	3.917
2	56.250	0.000	11	37.500	0.000
3	56.250	0.000	12	43.750	0.521
4	62.500	1.146	a	37.500	0.000
5	81.250	9.896	b	50.000	1.104
6	62.500	1.146	c	50.000	1.104
7	56.250	0.000	i	50.000	1.104
8	62.500	1.146	ii	56.250	0.000
9	93.750	28.083			

The analysis of the degree centralization and betweenness centralization of the campus network at Conghua Campus shows values of 42.08% and 26.77%, respectively. An analysis of the degree centrality and betweenness centrality of each node in the network (Table 3) reveals a positive correlation between the two measures. The teaching building (Node 9) has the highest degree and betweenness centrality, making it the most prominent in the network. This is due to its central location on campus and its role as the sole connection point between two existing planned areas. On the other hand, the practical training building 1 (Node 11) and the sports field (Node a) have the lowest degree and betweenness centrality, likely because they are located on the northern edge of the site, far from other buildings and with limited pathways.

Reconstruction Strategy: Leveraging the high centrality of Node 9, it can be transformed into a key public building that connects the teaching and training area with the sports area. Additionally, the vacant southeast corner and the western side of the site can be fully utilized to construct public nodes that will share the centrality of Node 9, enhancing the balance of the network. Node 10, with its low centrality and accessibility, is not suitable to continue its original function as a dormitory and can be demolished and rebuilt.

Functional Matching Methods Based on Cohesion Analysis.

The analysis of the Conghua Campus network using the Concor block model shows that when the maximum division depth is set to 2, the resulting fit is 0.8, which is the best for subgroup division. At this point, the entire network can be divided into two subgroups: [1, 2, 3, 4, 5, 6, 7, 8, ii] (referred to as Subgroup 1) and [11, 12, a, b, c, i] (referred to as Subgroup 2), along with two isolated nodes, 9 and 10 (Fig. 3, Fig. 4, and Fig. 5). The South Side Subgroup mainly consists of buildings with high daily participation from teachers and students, such as teaching, training, and canteen facilities, concentrated in the middle of the campus's southern side and closely connected to the southern entrance ii; the East Side Subgroup mainly consists of sports fields and training buildings, spread across the eastern side of the campus and closely connected to the eastern entrance i. The internal density of both subgroups is 1, indicating very tight connections; however, the density between the two subgroups is only 0.056, showing that they are quite isolated from each other (Table 4). The teaching building (9) and the dormitory building (10), both closely related to students, are in an isolated position within the campus network structure. This is due to the teaching building being in the center of the campus but blocked by buildings 6, 7, and 8, making the paths to other buildings not smooth, while the dormitory building is located in a remote corner of the campus.

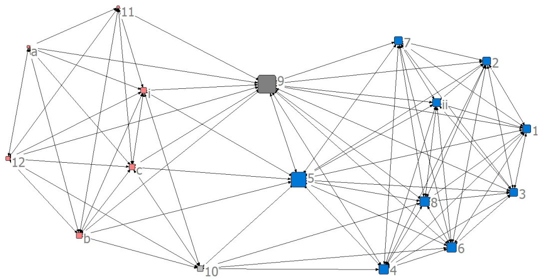

Fig. 3. Existing Spatial Network Centrality Analysis

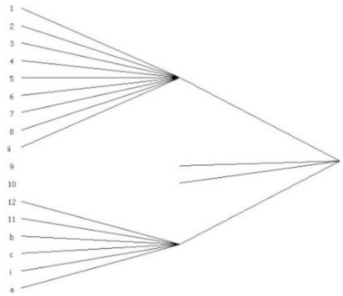

Fig. 4. Analysis of Cohesive Subgroups in Existing Spatial Networks

Table 4. Analysis of Subgroup Density in Existing Spatial Networks

	Subgroup 1	Node 9	Node 10	Subgroup 2
Subgroup 1	1.000	1.000	0.444	0.056
Node 9	1.000		0.000	1.000
Node 10	0.444	0.000		0.667
Subgroup 2	0.056	1.000	0.667	1.000

Renovation and Expansion Strategy: The average node centrality of the South Side Subgroup is higher than that of the East Side Subgroup, making it more suitable to continue existing functions and maximize the retention of existing buildings as frequently used teaching and training spaces. It can be combined with the previously mentioned node 10, located in the southeast corner of the campus, to create a teaching and training area. Sports activities, which are relatively more purposeful, can be placed in the East Side Subgroup with relatively lower centrality, integrating with the existing sports field on the north side of the venue; the living area can be arranged on the quieter west side of the venue, while also being closely connected to the teaching and training area and the sports area (Fig. 6).

Fig. 5. Campus Spatial Cohesive Subgroup Division

Fig. 6. Functional Zoning

Summarize and organize the implementation results of the above renovation and expansion strategies as shown in Table 5.

Table 5. Conghua Health School Renovation and Expansion Strategy Review and Outcomes

Problem	Strategy	Before	After
Spatial Order	Create a complex of comprehensive buildings around Node 9, demolish Node 10		
Functional Configuration	The southeast, southwest, and northeast sections of the campus are designated as the teaching and training area, living area, and sports area, respectively.		

5 Discussion on the Results of the Renovation

The spatial network model after the renovation is reconstructed following the same principles as before the renovation, where a direct connection is considered to exist between two nodes if they are within a 200m walking distance from each other. Conduct a comparative analysis of the spatial network models before and after the expansion.

Table 6. Comparative Analysis of Various Parameters of the Campus Spatial Network of Conghua Campus Before and After Renovation and Expansion.

	Number of Nodes	Degree centrality	Betweenness centrality	Weighted Clustering Coefficient	Density
Before	17	42.08%	26.77%	0.799	0.566
After	20	35.67%	9.03%	0.824	0.679

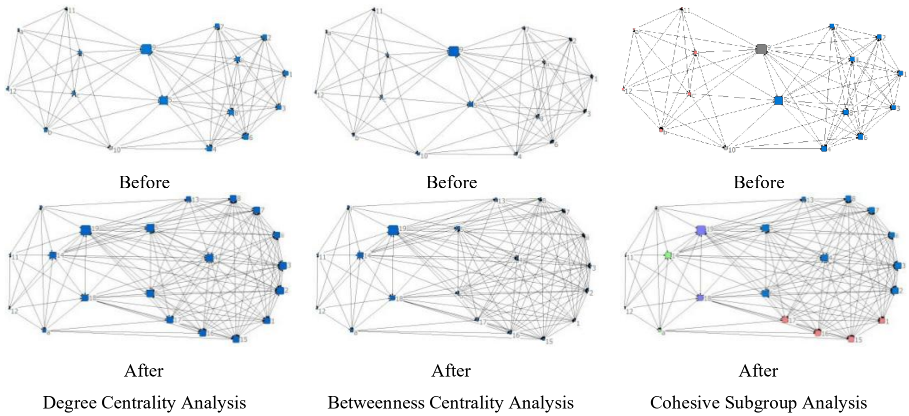

Fig. 7. Comparative Analysis of Spatial Networks at Conghua Campus Before and After Renovation and Expansion

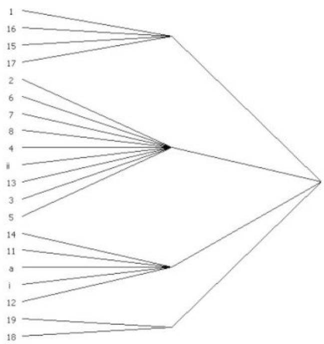

Fig. 8. Cohesive Subgroup Analysis (After)

Table 7. Density Analysis (After)

	Subgroup 1	Subgroup 2	Subgroup 3	Subgroup 4
Subgroup 1	1	0.889	0.15	1
Subgroup 2	0.889	1	0.222	0.778
Subgroup 3	0.15	0.222	1	0.9
Subgroup 4	1	0.778	0.9	1

5.1 Enhanced Spatial Accessibility and Increased Diversity in Spatial Sequence

The betweenness centralization of the network before and after the renovation and expansion are 26.77% and 9.03%, respectively (Table 6). After the renovation, the transmission capacity of individual nodes in the campus spatial network has become more evenly distributed, eliminating the phenomenon of over-reliance on a single node for transmission (Fig. 7). The dependency on the teaching building (Node 9) before the renovation has been transformed into indirect connections through multiple nodes such as the comprehensive building (Node 14), auditorium (Node 18), and the library complex (Node 19) (Fig. 7), enhancing the spatial network structure's resilience to paralysis caused by congestion at key nodes.

Following the reorganization of spatial functions, the centralization within the campus has decreased from 42.08% to 35.67%, and multiple nodes with comparable high centrality have emerged (Table 6), which is conducive to enhancing and balancing the overall vitality of the campus.

5.2 Rational Functional Zoning and Enhanced Balance of Cluster Vitality

The weighted clustering coefficient values of the network before and after the renovation and expansion are 0.799 and 0.824, respectively (Table 6), indicating a stronger cohesion in the campus spatial network after the renovation. There are no longer any isolated points in the spatial network, but instead, four subgroups have formed: [1, 15, 16, 17] (mostly in the living area), [2, 3, 4, 5, 6, 7, 8, 13, ii] (mostly in the teaching and training area), [11, 12, 14, a, i] (mostly in the sports area), and [18, 19] (Fig. 8). The formed cohesive subgroups basically align with the functional divisions, with the auditorium (Node 18) and the library complex (Node 19), which have strong public functions and are located at the center of the campus, forming a separate subgroup. After the renovation and expansion, the distribution of subgroups in the campus spatial network more closely aligns with functional divisions, and the density between each subgroup has increased (Table 7), with the overall spatial network density rising from 0.566 to 0.679 (Table 6). This means that the post-renovation network is denser overall, with increased direct and indirect connections between spaces, better adapting to the complex demands of modern vocational college multifunctional teaching.

6 Conclusions

The renovation and expansion of existing vocational colleges is not just about superficially filling in functional gaps and repairing the exterior of buildings, but rather a deep integration of the overall campus spatial experience with the modern teaching, learning, and communication needs of teachers and students. This means that renovation and expansion projects need to go beyond simple facility upgrades and deeply consider how spatial design can promote the improvement of educational quality, the optimization of the learning environment, and the cultivation of campus culture, in order to meet the new trends and challenges of modern education. The use of social network analysis methods, with data association and integrated analysis, greatly enriches the traditional linear approach to spatial planning, establishing a three-dimensional, dynamic way of spatial association, which allows for the observation of many issues that are difficult to see under linear and subjective thinking.

This study uses SNA to examine the campus space model of the Conghua Campus of Guangzhou Health Science College, identifying existing problems and proposing expansion and optimization strategies. The main findings are:

(1) Based on SNA, the semantic model's "points" and "lines" are determined. The existing vocational college spatial network model is constructed on the UVINET platform, and a visual structure diagram is obtained to preliminarily judge the campus structure characteristics

(2) By analyzing the centrality of the vocational college campus space, the balance and integration of the campus spatial structure are judged, abnormal nodes are identified for renovation; through clique analysis, spatial groups more suitable for the same functional area are sought. For the two objective problems of spatial order and functional configuration in vocational college expansion and renovation projects, three corresponding solutions are proposed: i. Strong public nodes are identified through centrality analysis, and their public nature is utilized to build additional buildings and paths around them to disperse regional flows, making the campus spatial network more balanced, and enhancing spatial accessibility and sequence diversity; ii. Nodes with weak accessibility are identified through centrality analysis, guiding the judgment on the retention, renovation, and demolition of existing buildings; iii. Buildings and outdoor spaces belonging to the same faction are judged through the calculation of cohesive subgroups, and functional zones are re-integrated in combination with the original functions of the group and the conditions of the block to improve the balance of vitality between groups.

Post-renovation, the campus saw a more balanced distribution of power among buildings, improved spatial order, increased network cohesion, and more rational functional layout. Unlike traditional approaches focusing on functional complement and superficial repairs, this study emphasizes the macro environment of campus space for comfortable living circles and provides quantitative evidence to avoid design biases. It offers a new quantitative research method for the evaluation and in-situ expansion of vocational colleges, with broad reference value for similar projects. There are more forms of mutual relationships between campus space nodes in vocational college campuses. In the future, various "line" element judgment methods that match the research purpose can be adopted[9][10].

Origin of Charts and Graphs.
All drawn by the author.

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