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Research on the Spatial Optimization Strategy of a Medical and Health Vocational College in Guangzhou

Lin Jingmi, Guo Haoxu

School of Architecture, South China University of Technology, Guangzhou, Guangdong, 510641, China

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Abstract: In recent years, with the country attaches great importance to vocational education, vocational colleges have ushered in the opportunity period of rapid development. Under the background of the increasing policy support and the growing demand for skilled personnel, the scale and influence of vocational education have been significantly increased. Among them, medical and health higher vocational colleges, as an important force in the strategy of serving health in China, have developed particularly rapidly because of their distinctive professional characteristics and strong social demand. With the expansion of enrollment scale and the increase of enrollment, many old campuses of such colleges have gradually exposed problems such as unreasonable spatial layout and low use efficiency, which are difficult to adapt to the needs of modern education, practical training and life. These problems not only affect the smooth development of teaching and practical activities, but also cause certain restrictions on students' daily learning and life experience. Using the theory of spatial syntax, with the help of DepthmapX, the paper analyzes the spatial characteristics of the new and old campuses of typical medical and health vocational colleges, focusing on the core indicators such as the integration, understanding and visual integration of the public space, and compares and analyzes the differences of different campuses in specific indicators. On this basis, the key factors affecting the optimization of campus space are summarized, and the targeted reconstruction and expansion design strategies are put forward, in order to provide scientific reference and practical reference for the renewal of the old campus of such colleges and the planning and construction of the new campus.

1. Research background

In recent years, China has attached great importance to vocational education, introduced a number of policies to promote its development, clearly requiring the improvement of the vocational education system, enhancing the equal status of vocational education and ordinary undergraduate education, and cultivating high-quality skilled talents. At the 2024 National Education Conference, General Secretary stressed the establishment of a vocational education system that integrates employment and industry and education, and trains craftsmen and highly skilled personnel from major countries. In this context, the scale of vocational education has expanded rapidly, the enrollment of vocational colleges and the scale of students have increased significantly, and vocational undergraduate education has also developed rapidly.

As an important part of vocational education, medical and health higher vocational colleges undertake the task of cultivating medical and health talents for the strategy of "healthy China". However, the old campuses of many colleges and universities are developed from secondary vocational schools, and the construction standards and spatial planning lag behind the needs of higher vocational education. There are problems such as insufficient space for teaching and practical training, and unreasonable functional zoning, which affect the teaching quality and students' life experience. Therefore, to scientifically optimize the spatial layout of the old campus to make it adapt to meet the needs of modern vocational education.

2. Research status

At present, the spatial organization of higher vocational colleges needs to emphasize the practical training function, the space adaptability of public space and the integration of teaching and living space (Liang Ying, 2013).[1] However, there are few systematic studies on the renovation and expansion of old campuses, and the transformation strategy relies on experience and lacks quantitative analysis. According to some studies, the optimization of public space can improve accessibility and interactivity (Lai Yanhong, 2020) [2], the layout of the training area should be developed around functional combination and space organization (Chen Zhen, 2017) [3], and the renovation and expansion should be adjusted around the teaching core area to strengthen the interaction with the surrounding environment (Liang Haixiu, 2009).[4]

The training space of medical and health vocational colleges mainly revolves around the simulated medical environment, spatial planning should combine the teaching mode and behavior needs (Zhang Guoqiang, 2023) [5], simulation teaching space can improve the training effect (CAI Yu, 2020) [6], nursing training should be both simulation and operability (Wang Yan et al., 2016).[7] However, the existing research is mainly based on empirical analysis and lacks of scientific and quantitative spatial optimization methods.

Taking Conghua Campus of Guangzhou Health Vocational and Technical College as an example, this paper tries to change from the traditional experience mode to the quantitative research. Combined with the spatial syntax theory, this paper analyzes the influence of campus spatial layout on teaching, practical training and students' life, so as to provide data support and theoretical basis for the spatial planning and design of medical and health vocational colleges. The research method and framework can also be applied to other higher vocational colleges to provide reference for academia and practical fields.

The innovation point of this paper is to focus on medical and health vocational colleges, combined with spatial syntax methods, and quantitatively analyze the impact of campus spatial layout on teaching, practical training and students' life. In addition, the study not only discusses the differences in the planning and public space design of the new and old campuses, but also puts forward the optimization strategy for the reconstruction and expansion of the old campuses, which provides reference for the planning and construction of medical and health higher vocational colleges, and also has certain reference significance for the campus design of other higher vocational colleges.

3. Research framework and methods

3.1 Research framework

In this study, taking a medical and health vocational college in Guangzhou as an example, construct a typical spatial layout model of its old campus, use DepthmapX software to conduct spatial syntactic analysis, calculate core indicators such as integration, comprehension, visual integration and Angle depth, and quantitatively evaluate the spatial structure characteristics of campus. By comparing the differences between different schemes in different indicators, it identifies the key factors affecting the optimization of campus space, such as the connection degree between teaching and training space and the accessibility of public space, and proposes the optimization strategy based on the analysis results, so as to improve the overall efficiency and rationality of campus space[8].

3.2 Study Methods

Space Syntax proposed by Bill Hillier in 1974, aims to mathematically analyze the topological relationships of spatial systems, such as spatial cognition, behavioral patterns and social structure. The core idea is to use topology to analyze the spatial structure, focusing on connectivity and accessibility, rather than geometric properties (such as length and Angle)[9]. Common analysis methods include convex space analysis, axis analysis, and horizon analysis. In this paper, spatial Axial Integration, comprehension Intelligibility and Visual Integration are calculated to evaluate the accessibility, structural clarity and spatial recognition of the campus space, and to discuss the influence of the reconstruction and expansion of higher vocational colleges on the site image.

4. Sample selection: Sample selection and campus status of a medical and health vocational college in Guangzhou

4.1 Sample status

In this study, a higher vocational college of medicine and health in Guangzhou was selected as the research object. The school is organized by Guangzhou Municipal People's Government, and its history can be traced back to 1902. It was formerly known as The Duan Na Nurse School of Roji Women's Hospital. Later, it underwent many adjustments and mergers, and officially changed its name to the existing name in 2016. At present, the university has four campuses: Baiyun, Conghua, Tianhe and Yongfu, including 73 mu of Baiyun campus, 115.9 mu of Conghua campus and 469 mu of Tianhe Campus (including 401 mu of reservoirs).

Among them, Conghua Campus, formerly Conghua County Health School founded in 1959, is one of the oldest campuses of the school. The campus covers an area of 115.9 mu, with the current construction area of about 20,370 square meters, with the existing floor area ratio of 0.377 and 537 residential students. The current buildings on the campus are training building, teaching building, office and management rooms, student dormitories and family buildings. After decades of development, the campus has experienced different historical period of construction and expansion, campus land scope constantly adjust, the existing building construction time from 1982 to 2005, within the scope of extensive expansion, architectural style, school conditions, space organization mode is complex, formed the typical medicine and health higher vocational colleges old campus characteristics, compared with the current enrollment scale and teaching task serious imbalance, cannot meet the requirements of modern higher medical education. As show in Fig 1.

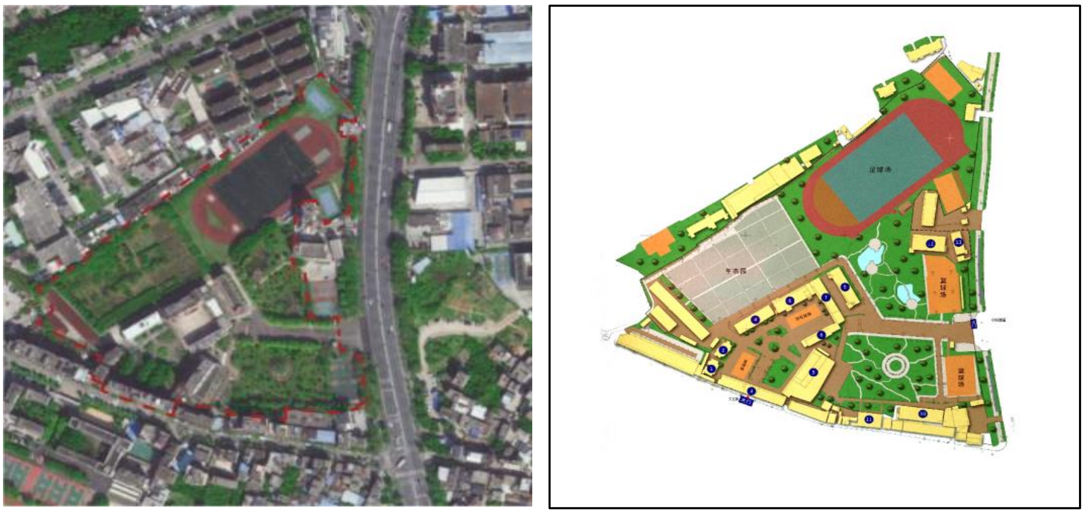
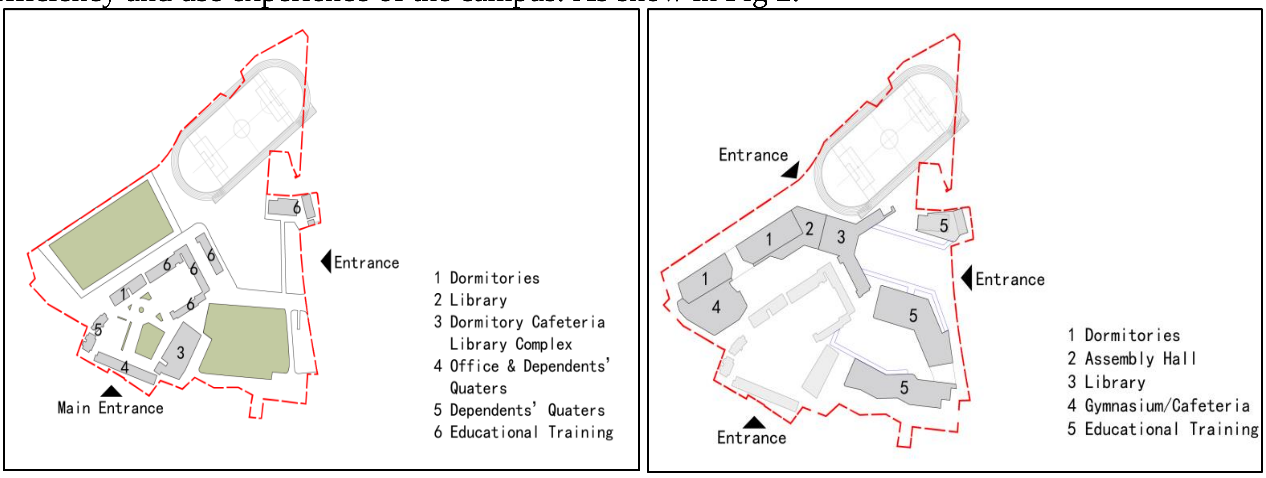


Fig. 1 Satellite picture and floor plan of Conghua Campus of Guangzhou Institute of Health Professions and Technology (Source: Baidu map and author's own photo)

4.2 Project overview and renovation and expansion objectives

In order to improve the deficiencies of the campus in terms of architectural function, spatial organization and campus streamline, the total construction area of 91,445.32 square meters, including the ground floor area of 83,645.32 square meters and the underground construction area of 7,800 square meters. The newly-built buildings include the teaching and training complex building, the dormitory building (including the gymnasium and canteen), the book complex building (including the lecture hall), the basement and the main school gate, aiming to optimize the overall layout of teaching, practical training, living and public space, so as to improve the space efficiency and use experience of the campus. As show in Fig 2.



a) Current

b) Long-term

Fig. 2 Changes in the layout of Conghua Campus of Guangzhou Institute of Health Professions and Technology(Source: Drawn by the author)

4.3 Analysis and comparison

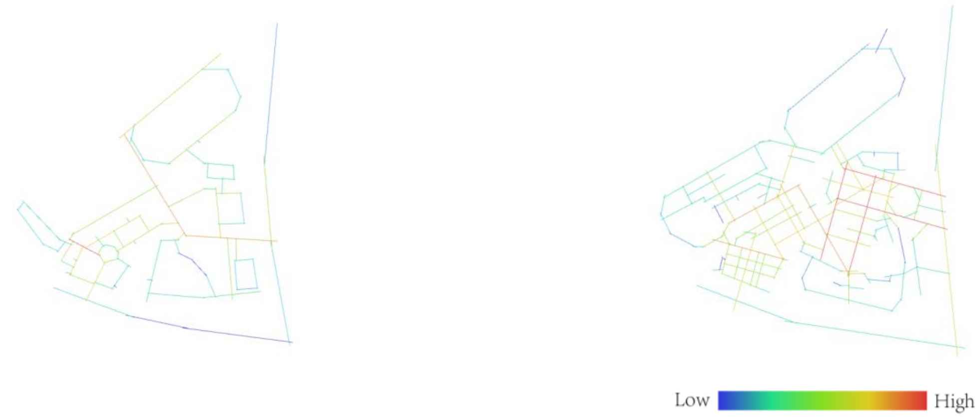
In this study, the Space Syntax method was used to calculate the integration, comprehension, visual integration and Angular mean depth based on DepthmapX, comparing the spatial optimization before and after the expansion of the campus, so as to verify the effectiveness of the campus planning strategy in a quantitative way[10].

4.3.1 Axis analysis

Axial Analysis is a quantitative research method based on Space Syntax, which establishes the spatial structure model through the interconnection of axes, and calculates and analyzes it. The core principle is to represent the spatial organization through a set of interrelated longest visual axes, and then to evaluate the accessibility and integration of the space. To determine the longest visual axis as the starting axis of the entire space system, one should first identify the primary axis that spans the greatest distance within the study area. Once the longest axis is established, the next step is to draw the secondary axis that intersects the longest axis at a strategic point. This process should be repeated until the entire study space is adequately covered. The goal is to form a collection of the least number of interrelated axes, which will serve as the foundation for building a comprehensive spatial analysis model. This approach ensures that the spatial analysis model is both efficient and effective, as it minimizes redundancy while maintaining the necessary connections between axes to accurately represent the study space. As show in Fig 3.

a) Integration[HH] R=n before modification

b) Integration[HH] R=n after modification



c) Integration[HH] R=3 before modification

d) Integration[HH] R=3 after modification

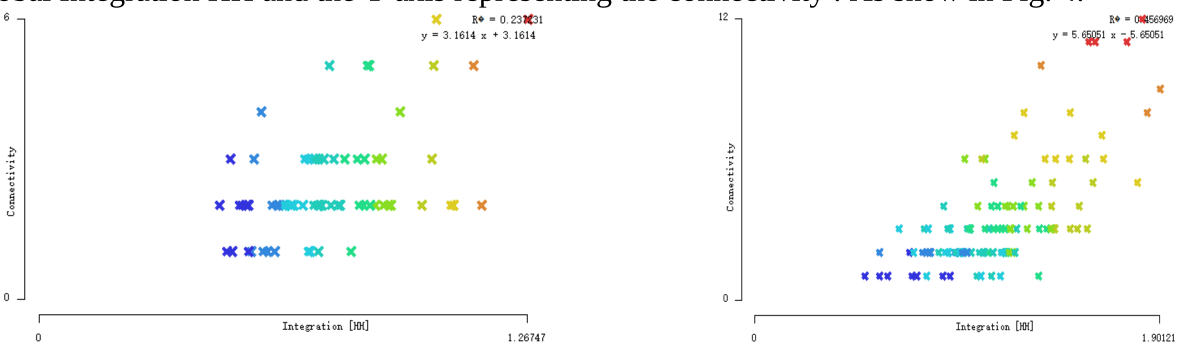
Fig. 1 Comparison of campus axis integration before and after renovation(Source: Drawn by the author)

In this study, the axis map was drawn based on the current campus traffic space, and the quantitative analysis was conducted based on it to directly present the accessibility characteristics of the campus space. The analysis results are visualized by the color gradient, in which: the red area represents the space with a high integration degree, usually corresponding to the core traffic flow line or the main intersection point of the campus. Blue areas represent spaces with low integration, often corresponding to campus edges, closed, or impassable areas. Through the axis analysis, it can clearly identify the rationality of the campus streamline organization, the distribution of the main human flow lines, and the possible spatial fracture problems in the area with low integration degree, so as to provide data support for optimizing the spatial layout of the campus traffic.

Through the analysis of the integration degree of the campus axis before the transformation, it can be seen that the main entrance on the east side of the campus and the road axis connected to the sports field have a high integration degree, while the overall integration degree of the southern training area is low. Among them, the small square in the south is enclosed by surrounding buildings, and is affected by the separation of roads and sports fields, so the accessibility is poor, and it is difficult to form an effective public space. However, in the actual use process, although the main entrance on the east side has a high degree of integration, the students' daily traffic willingness is low due to the proximity to the national road and the dense traffic flow. In addition, the entrance road is separated from the core area of the campus, with few surrounding landscape and functional facilities, and fails to form an effective campus main axis, which makes the overall streamline organization of the campus lacks a clear level, the space accessibility is low, and the overall accessibility is insufficient.

In the new plan, the integration of the campus axis has been significantly improved by reorganizing the main lines of the campus, optimizing the layout of the axis, and increasing the number of corridors and walking space. The optimized space organization is more reasonable, the area with high integration degree increases significantly, and the main teaching and training space is more closely connected with the dormitory area, forming the campus core area with clear structure, and the integration degree decreases from the central government to the periphery.

Using DepthmapX, the understandable scatter map is calculated, with the X axis representing the global Integration HH and the Y axis representing the connectivity . As show in Fig. 4.



a) Intelligibility before modification b) Intelligibility after modification

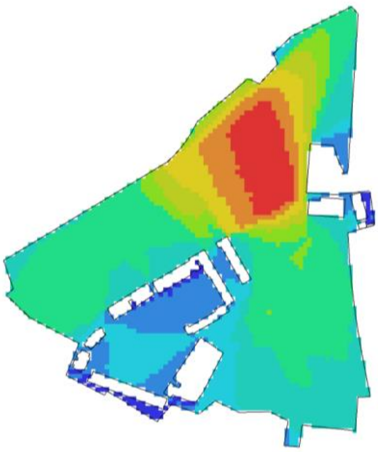
Fig. 4 Comparative intelligibility analysis(Source: Drawn by the author)

The current situation of the old campus is low (R^2=0.237), the spatial structure is scattered, the mainstream line is not clear, and the connection between local space and the overall system is weak, leading to low recognition of campus streamline and difficulty in spatial cognition. In the renovation scheme, the overall understanding of the campus is significantly improved (R^2=0.457), the connection between functional areas is closer, the spatial organization is more orderly, the clarity of mainstream lines is improved, and the areas with low connectivity are reduced. The research shows that optimizing the main axis streamline, enhancing the integration of various functional areas, and reducing the isolated areas can effectively improve the readability of the campus space.

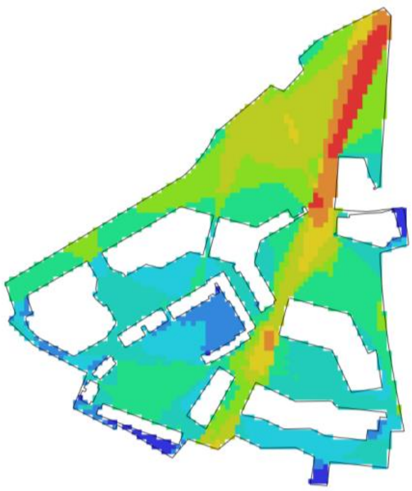
4.3.2 Vision model analysis

The study uses DepthmapX to calculate the visual integration degree and Angle depth, to analyze and compare the visual optimization effect before and after the campus transformation: to calculate the visual integration degree of the whole campus scope, and to evaluate the visibility change of the core area before and after the transformation. To calculate the angular mean depth to evaluate the optimization of the walking streamlines, one must first determine the angular deviation of each streamline from a reference axis or path. This involves measuring the angles formed between the streamlines and the reference axis, then computing the mean of these angular values. The angular mean depth serves as a metric to assess how well the walking streamlines are aligned or optimized within the given space. By analyzing this metric, planners or designers can identify areas where the streamlines may need adjustment to improve efficiency, reduce congestion, or enhance user experience. This process ensures that the walking paths are optimized for both functionality and spatial coherence.

The visual integration of the campus presents a highly concentrated but limited scope feature, mainly concentrated in the sports field in the north of the campus. On the contrary, the training areas, dormitory areas and some public Spaces that are used more frequently in the south have less integration. This feature leads to poor visual connectivity and overall spatial recognition of the campus. Under such a spatial structure, the main axis of the campus is not fully extended to the core teaching and living areas, resulting in the formation of low visibility space in some areas, which limits the activity range of teachers and students and has weak spatial interaction. At the same time, as the expansion of the campus has experienced the gradual expansion in different stages, the overall planning has failed to form a unified visual guidance system, leading to the connection between some teaching, practical training and living areas is not close enough, which affects the rationality of the campus streamline. Similarly, low Angular Mean Depth areas are mainly concentrated in green space and sports fields, which have low accessibility and reasonable pedestrian flow lines, resulting in insufficient space utilization. As show in Fig 5-6.

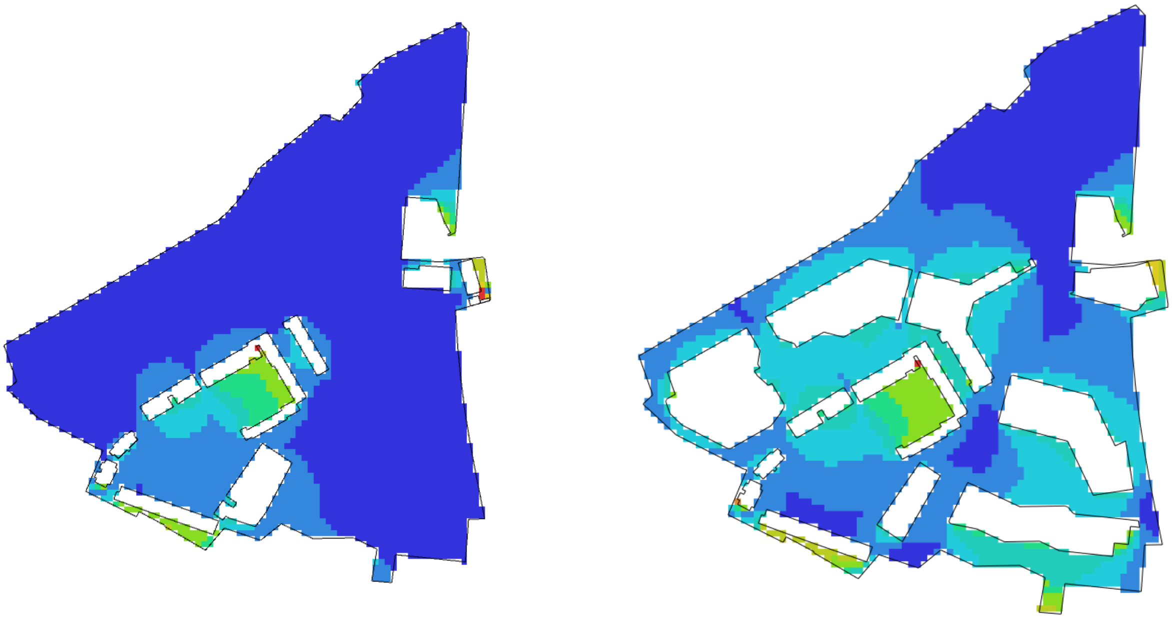


a) Visual Integration[HH] before modification



b) Visual Integration[HH] after modification

Fig. 5 Comparative Visual Integration(Source: Drawn by the author)



a) Angular Mean Depth before modification　　b) Angular Mean Depth after modification

Fig. 6 Comparative Angular Mean Depth(Source: Drawn by the author)

The spatial distribution of visual integration degree changed significantly in the reconstruction and expansion scheme. The area of high integration has expanded from the originally limited north to the core area of the whole campus, forming a continuous corridor of high integration, which runs through the main functional areas of teaching area, training area and public activity area. This strategy significantly improves the openness and accessibility of the overall campus space, which not only enhances the clarity of the main and secondary streamlines. In addition, the distribution of the visual integration degree after the transformation is more balanced, which improves the interactivity of the campus public space and makes the connection between different functional areas more close. At the same time, the area of the low integration area is reduced, and the originally closed or separated space is integrated, which improves the spatial recognition and sense of orientation of the campus. The reconstruction and expansion plan builds new dormitory buildings in the original idle green land plots, and the transportation system is optimized and integrated, so that the original large area with low angles and depth is replanned. In addition, the Angle depth value increases on the whole, and the walking streamline presents a more multi-level distribution pattern. The spatial accessibility is no longer limited to a single access path, but forms a gradual transition structure of the space from the core of high accessibility area to the surrounding area. This change shows that the campus streamline is more organized and hierarchical, and the connection between different regions is smoother, while avoiding excessive concentration or low accessibility in the original space.

4.4 Analysis and summary

Through the analysis of the spatial layout before and after the transformation of the campus, and the verification of the optimization scheme by the spatial syntactic method (understanding, integration, Angle depth, etc.), the results show that the scientific and reasonable spatial optimization strategy can effectively improve the spatial adaptability of the campus, the rationality of streamline organization and the use efficiency of public space use.

After the renovation and expansion, the overall readability and comprehension of the campus are significantly improved, and the improvement of comprehension R^2 shows that the optimized spatial structure is clearer, and the problem of original streamline chaos is improved. The newly added north-south main axis is combined with the original east-west axis to build a higher-level space grid system, which effectively enhances the spatial organization of the campus. The optimized streamline system strengthens the connection between the teaching and training area, living area and sports area, reduces the low integration area, and improves the accessibility and interactivity of different functional areas.

In addition, the enhancement of visual connectivity makes the public space more open, and the visual connection between the Spaces is more smooth, which effectively eliminates the sense of separation in the original environment, and further improves the overall spatial experience and use efficiency.

5. Optimization design strategy of public space in medical and health vocational colleges

5.1 Spatial optimization features

The campus planning of medical and health higher vocational colleges not only has the functional zoning characteristics of vocational colleges, but also presents the spatial organization characteristics of ordinary colleges and universities. Similar to vocational colleges, its spatial layout usually includes multiple functional sections such as practical training teaching area, living area and sports area to meet the practical training needs of vocational education. However, different from some mechanical or art vocational colleges, the practical training area of medical and health colleges and universities has no special restrictions in terms of size and noise control, and its space requirements are closer to the experimental teaching environment of ordinary colleges and universities. Therefore, in the process of reconstruction and expansion of the old campus, it is necessary to seek a balance between the functionality of vocational education and the spatial integrity of ordinary universities, so as not to only ensure the efficient operation of practical training and teaching, but also optimize the spatial integration to make the campus environment more open and coherent.

In the actual process of reconstruction and expansion, it is necessary to form a hierarchical and progressive spatial transformation strategy from the overall spatial structure to the specific detail optimization. This study mainly focuses on macro spatial optimization, that is, how to adjust the layout on a large spatial framework, improve the overall accessibility and use efficiency of the campus, and by optimizing the campus streamline and enhance the interaction of public space, so that the old campus can better adapt to the development needs of modern vocational education.

5.2 Spatial optimization strategy

In the process of reconstruction and expansion, the optimization strategy of the old campus should follow the four core principles of "spatial integration, streamline optimization, functional adaptation and environmental improvement", and combine the practical requirements of vocational education and the spatial organization characteristics of ordinary colleges and universities to form a more reasonable campus system. This study summarizes the following reconstruction and expansion strategies suitable for medical and health vocational colleges:

(1) Optimize the campus streamline and improve the overall accessibility

Due to the large span of construction and the complex land expansion, it often leads to the chaos of campus moving lines and the inconvenience of cross-district traffic. After the transformation, by adjusting the main axis, enhancing the walking network and optimizing the streamline intersection, the accessibility between the core functional areas is improved, so as to make the streamline between teaching, practical training and dormitory more efficient and smooth.

(2) Enhance the spatial integration degree, and build an efficient campus structure

The layout of the original campus buildings is scattered, and the buildings built in different ages fail to form a unified space system, resulting in the weak connection between the functional areas and the low space utilization rate in some areas. The optimized campus structure should take the mainstream line as the framework, combined with the building renewal, strengthen the spatial integration of the core area, so that the teaching, practical training and living space form a close interactive relationship.

(3) Reasonably adjust the building layout to realize the symbiosis between the old and the new

In the process of reconstruction and expansion of the old campus, large-scale demolition should be reduced as far as possible, the adaptive renovation of the original building should be given priority, and its internal layout should be optimized to meet the increasingly updated use needs. In addition, the newly built part should be formed in an overall coordination with the original buildings, and by adjusting the architectural form and corridor, so that the old and new buildings in the visual and functional integration.

(4) Activate the public space and improve the quality of the campus environment

The old campus planning of vocational colleges often ignores the utilization rate of greening and open space, resulting produces unused space. The optimized campus should incorporate the green space into the streamline system, and set up multi-functional places such as rest, social interaction and learning along the main traffic path, so that the green space not only has ecological value, but also becomes the core place to promote the interaction between teachers and students.

6. Conclusion

Based on the case of a vocational college of medicine and health in Guangzhou (Conghua Campus), this study discusses the spatial optimization strategy of the old campus of medical and health vocational colleges, and verifies the effectiveness of the transformation with spatial syntactic analysis. The research results show that reasonable spatial optimization can not only improve the accessibility and functional integration of the campus, but also promote the modernization and upgrading of the vocational education environment, and provide support for the sustainable development of vocational colleges.

The optimization strategy proposed by the research focuses on the four core directions of streamline reorganization, spatial integration, functional adaptation and environmental improvement. By optimizing the mainstream line, improving the spatial integration degree, coordinating the symbiosis of old and new buildings, and enhancing the interaction of public space, a more efficient, coherent and livable campus environment is formed. These strategies are not only applicable to this case, but also provide scientific reference for the renovation and expansion of a wider range of old vocational schools.

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