

Research on the Strategy of Whole-Life-Cycle Campus Design from the Perspective of Sustainable Concept: A Case Study on Hangzhou Senior High School in Zhejiang

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Abstract—With the development of social economy and the popularization of quality education, the Chinese government invests more and more funding in education. Campus constructions are experiencing a great development phase. Under the trend of sustainable development, modern green campus design needs to meet new requirements of contemporary, informational and diversified education means and adapt to future education development. Educators, designers and other participants of campus design are facing new challenges. By studying and analyzing the universal unsatisfied current situations and sustainable development requirements of Chinese campuses, this paper summarizes the strategies and intentions of the whole-life-cycle campus design. In addition, a Chinese high school in Zhejiang province is added to illustrate the design cycle in an actual case. It is aimed to make all participants of campus design, especially the designers, to realize the importance of whole-life-cycle campus design and cooperate better. Sustainable campus design is expected to come true in deed instead of becoming a slogan in this way.

Keywords—Campus design, green school, sustainable development, whole-life-cycle design.

I. BACKGROUND

A. The Development of Chinese Green Campus

IN 1996, the national program of action on environmental publicity and education was promulgated, which made green schools the goal of education infrastructure construction. In 1998, Tsinghua University proposed to establish a green university, and with it, sustainable environmental education started spreading in the universities. In 2007, the green campus became dominated by conservation-oriented campus, and much attention has been paid to energy-saving and emission-reduction. In 2013, the state published the first “green campus evaluation criteria” which refined the green campus concept and put forward some regulations to guide and evaluate the campus construction work in order to promote Chinese green campus sustainable development [1].

B. Green Talents Cultivation and Campus Construction

School construction plays an important role in personnel training, education development and national prosperity. The purpose of the green campus is to cultivate high-quality green

talents.

In kindergartens, schools foster children's good habits and stimulate their curiosity. Designers provide children with a learning and playing paradise. In primary schools, schools train children's discriminant ability, morality and attitude. Designers increase children's interest by creating diverse enjoyable learning spaces. In junior high schools, schools cultivate children's autonomous ability and provide the possibilities of making friends for them. Designers offer suitable learning environments. In senior high schools, institutions train children's thinking ability and social ability. Designers supply rich and diverse communication spaces. In universities, students need to establish a sense of belonging to the community and explore personal values. Designers provide multi-direction and multi-disciplinary places for students to cooperate and exchange. It proves that school's educational philosophy and teaching mode are not the only effect factors on children's learning ability. Educational environments created by designers influence students all the time, as well from the students coming into schools.

C. Non-Ideal Status of Chinese Campus Construction

Due to various constraints, the implementation of the green campus in China is not ideal. For example:

- 1) As in Fig. 1, limited land, due to the undesirable school location, forced the school to set a small sports field on the roof, which leads to weak campus culture, lack of green space and not safe enough roof activities.
- 2) Design decisions ignore the future development of schools, leading to the stereotyped school layouts and forms, as well as the relatively backward teaching functions which are unable to meet the needs of the educational development after the school usage.
- 3) As in Fig. 2, the lack of communication between designers and users results in many unreasonable functions, nondurable materials and destroyed original designs caused by later transformation.
- 4) Ignoring the applicability of architectural art and technology, some campuses mix too many green building technologies together blindly and apply skills mechanically according to the evaluation standard of green building because of the star level of green building [2]. Ultimately, these campuses become green building technology device exhibits with low practical energy

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saving effect.



Fig. 1 Roof playground in a primary school



Fig. 2 Reconstruction due to original unreasonable design

It can be seen that how to implement green campus indeed is an important topic of campus design to achieve sustainable school development. An old Chinese saying goes, “it takes ten

years to grow trees but a hundred years to rear people”. Campus design and construction should be based on the present and look to the future. Only the campus with heat and vitality can cultivate green talents with sound personalities better. It promotes sustainable social development through green education. Accordingly, this paper puts forward a model of design process called whole-life-cycle campus design, an important strategy for sustainable campus and society development.

II. CONCEPT

Throughout the Chinese status of campus development, the non-ideal essence lies in the failure to look at the development with sustainable concept. Generally speaking, in the process of campus development, creating a sustainable campus means carrying out a sustainable development concept and ensuring its ability to develop sustainably [3]. Whole-life-cycle campus design divides the design process into seven steps, including location selection, functional planning, conceptual planning, overall planning, architecture design, architectural construction, utilization tracking.

III. RELEVANT ROLES

Whole-life-cycle campus design emphasizes the whole process involve all relevant roles such as schools, designers, governments, educators, students, functional departments and so on, which differs from the traditional campus design dominated by schools and designers only (see Table I).

TABLE I
RELEVANT ROLE INTERVENTION COMPARISON IN TRADITIONAL AND WHOLE-LIFE-CYCLE CAMPUS DESIGN

	Location selection	Functional planning	Conceptual planning	Overall planning	Architecture design	Architectural construction	Utilization tracking
Governments							
Schools							
Educators							
Planners							
Designers							
Constructors							
Managers							

Present situation of traditional campus design
 Ideal situation of whole-life-cycle campus design

A. Advanced School Intervention

One the one hand, there are few Chinese design units specializing in educational architecture, which means only a few designers understand what educational architecture actually needs. On the other hand, Chinese school construction programs are mainly implemented by the government

launching a bid or the school entrusting one design unit directly. Schools have little or sometimes nearly no priority to the site selection. However, if there is any chance to choose sites, it is necessary that schools and designers take part in location selection and determine the rational location from both educational and architectural aspects. In addition, the

expression, modes of thought and knowledge do not completely match between schools and designers. It is highly possible that school requirements cannot be completely conveyed to designers. Some schools are even not involved in the campus design until use, resulting in that architecture which cannot meet the educational needs is created. Both originally needless abandoning and rebuilding space are detrimental to the sustainable school development. Therefore, the ideal situation of whole-life-cycle campus design suggests that schools intervene from the location selection which is the beginning of the design and fully express needs to all the other roles in order that campus architecture is designed for real education services.

B. Advanced Educator Intervention

In China, it is architecture experts mainly involved in the campus design functional planning and conceptual scheme evaluation. Education experts in China mostly refer to the professionals in education sector. With the development of modern campus, however, it is increasingly obvious that campus design is related to both education and architecture sectors. Due to the lack of forward-looking and scientific technical analysis, present campus design ignores the dynamic changes of campus architecture [4]. Without educators' suggestions, in a manner of speaking, designers' educational architecture outlook is subjective and one-sided, or, in a word, unscientific. Clarifying relationship between campus and design is the only efficient way to create a high-qualified school rather than a nice building. Consequently, whole-life-cycle campus design needs education experts in the overall planning, architectural design and other follow-up steps to track, guide and research the campus design.

C. Advanced Designer Intervention

In general, designers take part in the conceptual design, overall planning, architecture design and architectural construction. Whole-life-cycle campus design encourages designers to offer professional advices earlier in the stage of site selection, functional planning from the architecture perspective. For instance, designers' advices on potential lighting effect by surrounding buildings, potential student security threat affected by traffic entrances, noise reduction measures by architecture and so on need to be taken into account with schools' requirements like spaces for shuttle vehicles and waiting areas. After carrying on all-round, multi-perspective studies and balancing designers' and schools' requirements that the selected location must be the most scientific, rational and sustainable. Besides, what Chinese designers tend to overlook and needs to be thought highly of, is utilization tracking. The lack of utilization tracking results in the problems which cannot be easily solved by schools such as mismatched function, classroom shortage, etc. In some cases, however, the problems can be easily solved by designers and unnecessary destruction and waste can be avoided if designers track and improve the design.

As a consequence, improving the role participation mode of traditional campus design, paying attention to the effects of each role in each of the steps and finding more scientific,

reasonable and effective ways to cooperate become the new requirements of whole-life-cycle campus design for campus design process.

IV. CONTENT

A. Location Selection

Firstly, location should follow equilibrium principle. Taking overall urban planning and the school layout adjustment programs into consideration, reserved space should be set in appropriate scale in order to reduce the campus reconstruction constraint or waste caused by the future city development and education reform.

Secondly, the plan should follow the sharing principle. Campus gymnasium, restaurants and some campus facilities can be open to the community, which requires the planning to solve sharing and management problems. In addition, a campus can share the entrance plaza, border aisle space, open space, landscape and holidays with the community. Maximized utilization of campus resources promotes community and campus harmonious communion and mutual sustainable development.

B. Function Planning

At present, Chinese education development is in the stage of exploration and innovation. Numerous schools are starting to try many new teaching patterns such as mobile learning system and small classes, which makes schools' function orientation and function space area demand change. The transition of teaching mode and educational philosophy promote open campus and become a new developing trend of the future campus. Differing from a traditional campus, an open campus contains gym, museum, library, art center and so on, which can be open to the community rather than servicing surrounding areas as an education building only. Accordingly, school characteristics, possible future teaching mode, service objects and campus cultural characteristics should be all oriented in campus function planning.

C. Conceptual Planning

Conceptual scheme comparison is a commonly used form of preliminary campus design, but the impact in whole-life-cycle campus design is far more than that. Strict building codes compel Chinese campus buildings to be limited in the rules of various indicators, which forms schools' one-size-fits-all paradigm. As a result, whole-life-cycle campus design suggests indicators in descriptions given by party A as a reference only. Conceptual planning provides reasonable feedback to adjust indicators within a certain range after comparing the preliminary designs. It is aimed to avoid missing the major goal to supply students with enjoyable free learning spaces because of the secondary contradictions like overly rigid specification indicators.

D. Overall Planning

Overall planning should take several aspects into consideration, including reasonable functional partition, community sharing, flexible reserved space, campus

environment, landscape design, rational traffic flow and terrain control. The comprehensive arrangement looks much like the traditional campus design, with the exception of the new concept about community sharing and other aspects affected by whole-life-cycle campus design.

E. Architectural Design

Whole-life-cycle campus design contains people-oriented design and people-oriented education. It is aimed to cultivate

green talents through whole-life-cycle campus design according to multi-function, multi-level communication space and learning space by color design, material selection, and layout and so on. For example, as in Fig. 3, flexible space transformation by movable partition and movable furniture can realize diversified composite space, create different learning environments, stimulate students' active learning and avoid the waste of campus space and facilities.

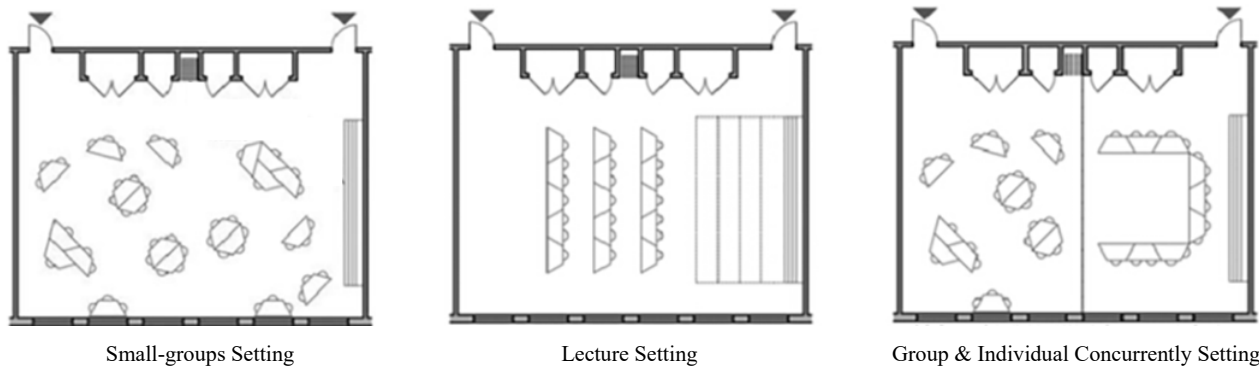


Fig. 3 Flexible space pattern: The art and music precinct must be conceived as a flexible, multifunctional place that assists the learners when they practice, produce and perform [5]

F. Architectural Construction

Current construction details including material sampling, equipment selection, furniture selection, detail control and tree species selection have been seldom paid attention to or have been distributed to other professional departments to design. Whole-life-cycle campus design suggests designers participate in construction and consider details in the design phase in order to avoid construction misleading the school actual demand after multi sector passing information.

G. Utilization Tracking

Utilization tracking is the most difference between whole-life-cycle campus design and traditional campus design. As designers, guiding school to use space better, guiding schools to use furniture correctly and designing versatile-use furniture to meet the new activities can all be realized in this step. As users, schools can test whether design space meets the original intention. The late demand needed to build or modify can also find designers putting forward reasonable modification opinions, such as rearranging the layout. On the one hand, accordingly, designers can reduce the work discordance caused by later uncontrolled and unprofessional transforms and get richer experience in education architecture design. Meanwhile, it is more valuable and honorable that designers earn a schools' deeper trust and acceptance, which stimulates their passion for conducting school research and design. On the other hand, school users can gain a better environment to teach and study, as well as longer operational support and professional rebuilding guidance. It can be said that utilization tracking is a mutual intimate security for both schools and designers.

V. CASE ILLUSTRATION

Hangzhou Senior High School Campus in Qianjiang District was planned as a boarding high school with 48 classes, 2,400 students and covering a construction area of 1,023,930 square meters.

As in Fig. 4, the campus is adjacent to Riverside Avenue and Qiantang River, the largest river in Zhejiang was the main feature. It also resulted in the main design difficulties including noise protection along the river and the entrance image-building.



Fig. 4 Site situation of Hangzhou Senior High School Campus

A. Site Demonstration and Adjustment and Planning Index Adjustment

According to a conceptual scheme comparison, school discussion and determination, as well as government examination and approval, final design adjusted and optimized the land scope, boundary, economic and technical indicators

and environment landscape type, such as adding a landscape platform across the road, adjusting the height-ascending field, and moving the public transit port to the west (see Table II). On the basis of meeting the requirements of original planning, final design ensures the peace for the students, and opens a sight to the landscape along the river for the campus, and also adds a new viewing platform for the city.

TABLE II
INDEX ADJUSTMENT AFTER SITE DEMONSTRATION

	Before demonstration	After demonstration
Land area	8.0ha	8.87ha
Volume rate	≤ 0.6	≤ 1.2
Building density	$\leq 25\%$	$\leq 35\%$
Green rate	$\geq 35\%$	$\geq 30\%$
Building height	$\leq 24\text{m}$	$\leq 80\text{m}$

B. Multi Role Participation

School officials, educators, designers and other roles are involved in exploring campus function, such as an open school history museum, gymnasium and music hall, as well as a planetarium combined with old campus cultural characteristics (see Fig. 5). Moreover, through technical support and assistance, the campus sound environment, shading system, natural ventilation, lighting system and water recycling were designed sustainably.

C. School Resource Sharing

The campus shares information, indoor space and the outdoor playground with their local community. As in Fig. 6, reasonable distribution separates shared areas and school-in-school managements. With the location adjacent to the river, it also shares a landscape platform with the city, which moulds the unique etiquette entrance and greatly deepens the campus' cultural image.

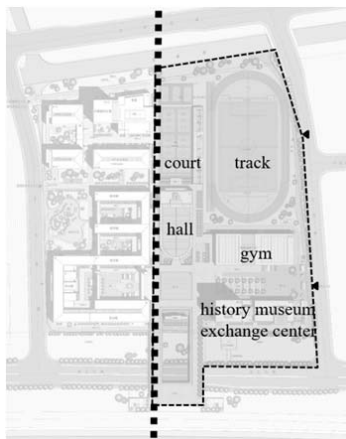


Fig. 5 Campus open function shared with communities

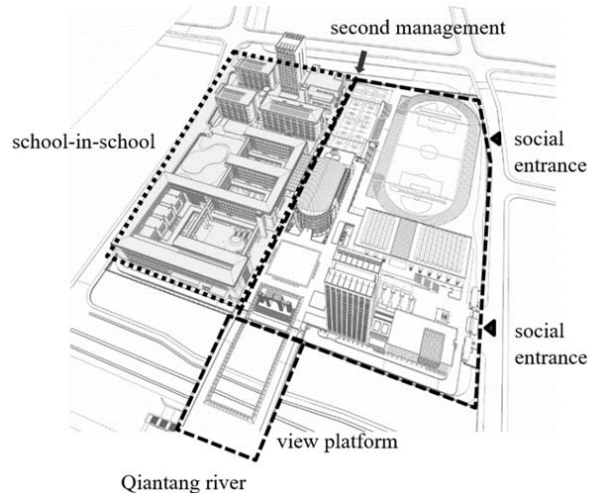


Fig. 6 Layout considering teaching and sharing area management

D. Technical Guidance and Service Tracking

After the school opens, designers guide the school on site instructions, the hardware usage, landscape promotion, site extension, later consultation, etc. For example, the square can be prepared for an outdoor concert and the roof platform can service a stadium audience. The purpose of technical guidance and service tracking is not only to help the school, but also to protect the design intent and concept.

VI. CONCLUSION

What school education transmits now is no longer confined to the impartment of cultural knowledge, which is to cultivate students' ideological quality and other comprehensive qualities further. In addition to an innovative teaching mode, a well-designed campus environment also plays a key role in promoting students' qualities and all-round development [6].

Whole-life-cycle campus design is aimed to practice the green ecological consciousness in every corner of a school by carrying on the whole design process in the most energy-saving and resource-efficient way which includes location selection, functional planning, conceptual planning, overall planning, architecture design, architectural construction and utilization tracking.

It is believed that whole-life-cycle campus design makes all relevant roles aware that green design is not limited to ecological design. Meanwhile, it reminds us of campus design essence beyond the building category. Each link in the chain of campus design is associated with children's green education. The green campus embodies education in every detail outside the classroom. Students are exposed to every tree and bush, and every wall and tile in a sustainable education environment. Students, architecture and environment will hopefully achieve common sustainable development. Such cultivated students are more likely to adapt to future society better and to create a better future and sustainable world, which are the optimal goals of sustainable development and the final purposes of whole-life-cycle campus design.

REFERENCES

- [1] Zhen Guo, Shanghai Jiaotong University, "Design strategy of green campus," 2014, pp. 2-3.
- [2] Jihong Han, Hongwu Fan, Xinbo Ma, "Opportunities and challenges of green architecture industry under the new normal development," *Construction Technology*, 2016, pp. 29-31.
- [3] Jia Hai, South China University of Technology "sustainable campus planning strategy based on the symbiosis concept," 2011, pp. 55.
- [4] Decai Zhu. "Research on planning and design of Middle School Campus: A case study on overall planning and design of Sixin middle school in Wuhan," *Architectural Knowledge*, 2016, pp. 57.
- [5] P. Lippman, "Promoting a framework for the design of learning communities," *Evidence-based Design of Elementary and Secondary Schools: A Responsive Approach to Creating Learning Environments*, 2010, pp. 169-209.
- [6] Haiying Cao, "Primary and secondary school campus design strategy," *Doors and Windows*, 2016, pp. 82-83.