Integrated renovation practices on water resilient infrastructure in Tainan Taikang elementary school in Taiwan

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Abstract. From 2009 to 2017, there were more and more climate disasters which has caused serious damages in campuses, especially the heavy rain, flooding, debris flow in summer and long-term drought in winter. Therefore, based on the successes of small scaled experiments and solutions, MOE start the demonstration campus project in the year of 2018 to make a holistic solution demo site in typical aspect which can be the liveable learning centre for all. The Taikang elementary school in the countryside of Tainan was selected. Goals were set to fully demonstrate both rainwater and grey water resilience and its enhanced usage in the campus. There are four goals: 1. reduce of use and disaster impact, 2. full water absorption ability of all infrastructures from building to site, 3. bioclimate control by introducing green land and water areas to cool down the campus, and 4. maximized reusability. The campus has been reorganized by introducing a holistic water system with large underground water storage rooms underneath both buildings and playground runways paved with demolished concrete gravels, and a reconnected water circulation system for stormwater management and natural infiltration irrigation. Supported by the participation of community, the total cost of the system was a staggering 200,000 USD. The changes were obvious from the taps to the entire system integrated with environmental education. In comparison to previous situations, the campus can withstand heavy rainfall over 80 mm/hr for three hours without flooding, meanwhile providing more than 90% of all the irrigation water needed to water the green lands the entire year. Moreover, the natural cooling system of green lands and water areas provides a cool breeze for natural ventilated classrooms.

1. Introduction
Since the year of 2003, the Ministry of Education has been promoting the “Renovation Program for Sustainable Campus” (TSCP), and leading the trend for campus renovation in different aspects including Energy and Resource Management, Ecological Cycle, Indoor Environmental Quality and Disasters’ Impact Adaptation.[1] Figure 1 is the concept of the sustainable campus, which was defined in 2003 to direct the promotion.[2] There has been 825 places, including elementary schools and universities, which have participated in this program till now. However, extreme weather conditions has impacted campuses which were not designed to withstand them, and more and more campuses do not really understand how to adapt with the changing climate. Although there were also successful examples of campuses which has made holistic and autonomous solutions, systematic regional based actions were not yet to be found.
Therefore, in the year of 2018, the Ministry of Education of Taiwan and the Tainan City Government shuttled a strategic action plan, “New Circular Campus toward Sustainability”, to face the challenges under climate change.[3] The first strategy is to identify regional characteristics based on local climate, geography, local industry, and climate disasters for sustainable and resilient renovation. In the year of 2018, there were only two campuses selected among 12 candidate-campuses for “Featured Correspondence Demonstration”. Taikang Elementary School in a suburban village in Tainan is the first demonstrate school for water-resilient campus.

2. Strategic Workshop and Program of sustainable campus by MOE
In order to promote the sustainable campus renovation, a technical committee was organized under the EPG in Ministry of Education to collect holistic solutions from different professional fields. A counselling and promoting team was key to the progress and the mechanisms of the TSCP, which is based on the environmental conditions of Taiwan. There were three major parts of the mechanism to promote and adopt the renovation of the TSCP.

2.1. Strategic Processes
- A top-down advocating curriculum of concept establishment has been set for schools around the island. The program collects ideas from different professions, including Architecture, environmental science, eco-system, environmental engineering and so on. These will be integrated with environmental education in school campuses.
- A bottom-up applied system with on-line process has been adopted to encourage schools, from elementary school to university, to participate in the preliminary test of 16 items. The review process has also became the standard of bottom-up applied projects in MOE.

2.2. Integrated Progresses
- An accompany Process of mentors with regional schools was the core value of the program. A dynamic approach was taken toward the goal.
- Establishment of comprehensive practice items for thinking and following. See as Figure 2.
- A comprehensive renovation demonstration of the pilot schools has also been finished and evaluated, aiming to become the learning cases for other schools in the beginning of the project.

Figure 1. Environmental Education Software integrated with campus hardware renovation concepts.
2.3. Education for Sustainable Development (ESD) Progresses

- Encouraging the innovative ideas from schools under the concept of sustainability to find out local solutions with oriental characteristics.
- All participating schools should develop unique curriculums depending on respective sustainable campus renovations, and complete core program revisions of environmental education.

3. Technical Planning and Design Processes

In end of 2018, the Taikang elementary school was selected by the technical committee for TSCP of Ministry as the “Water Resilience Technical Learning Center”. Six members joined in the technical group to review and instruct the integrated planning of water system. The mechanism of the renovation processes followed five steps: 1. Reviewing the campus and its surrounding areas thoroughly, 2. Identifying systematic problems and places to enlist win-win strategies for key renovation solutions by the method of SWOT and campus map drawing processes, 3. Communication Workshops: several workshops were being held to encourage social participation with students and different groups of people, 4. The co-working processes with architects for technical planning and design, 5. The ESD joint-venture adopted into the renovation construction which may connect to the target of the SDGs.

3.1. Inventory and Review of the Campus

The first step is to invite key stakeholders including the principle, department directors, teachers and professional committee members in different fields to examine through the campus and its surrounding areas. Previous problems were collected and analysed in order to establish a database that put its aim on understanding its reasons in a holistic approach. The examination was held twice for second inventory process to recheck, at the same time to explore more people’s interests, especially the teachers participating the ESD programs. Figure 3, 4, 5 show the water problems campuses owing to the substantial rainfalls flooding through the school gates into the low-lying campuses.
3.2. The concentrated systematic solutions identification

After the examination process, the key stakeholders gathered together to discuss about the renovation targets, which should integrate all the problems and have concluded the priority steps. The professional consulting group by MOE help concentrate the renovation stages by means of budget control and come up with reasonable systematic solutions. Therefore, both the stage plan and solution were completed step by step to achieve the stakeholders’ ideas. Figure 6 is the revised applied plan by the school, which was agreed by the school and have made first application to the TSCP demo-renovation.

3.3. Workshops for stakeholders to collect consensus

Through the permission to make the demo-renovation site for “Sustainable Campus”, there were six processes which the schools should go through, including the workshops which aimed to make more practical and technical solutions.

- Evaluating the sustainability of Campuses based on campus environmental inventories is the first step.
- Passive priority, and can provide resource convergence from the campus resource cycle to respect the efficiency of ecological micro climate control in campus.
- Reduction of maintenance and increase of efficiency on equipments and technologies were required.
- The overall application must base on a complete campus system; rainwater, reclaimed water, and ecological water should be considered at the same time.
- The items must be able to integrate closely with environmental education.
- Encouraging experimentation and perception of measurement, which can be operated by students.

Architects has been chosen to join the processes, which is also a learning program for their teams. Several workshops were held: 1. collecting stakeholders’ awareness on sustainable goals; 2. education integrated concepts for sustainable system which also was a decision-making process; 3. The open mind drawing for future campuses; 4. Professional team to help the concentration of the conclusions, meanwhile allowing the stakeholders to explain by themselves; 5. The architect’s team help draw the sketch for future planning and design details.
3.4. Co-working Process for planning and technical design

A young architect team joined the renovation group, which is a key learning progress for sustainable systems be adapted to the design process. Therefore, the co-working mechanism was established through weekly online conferences to discuss with professional groups by TSCP/MOE. There were five professional fields, professors and experts in water, energy, bio-climate, bio-landscape and building technology were considered at the same time for holistic solutions. Moreover, the water issue is the first priority. Through three months of planning, learning, discussing and conduction of design process, an “Integrated Strategies, Terrain elevation and Drainage direction Plan” was produced collaboratively as Figure 7 shows. Improved drainage and renovation strategy is set as right side of Figure 7, which look deeply for the solutions to whole campus and surrounding area. At the same time, the “Energy”, “Bio-climate control” and “Indoor Environment Quality” designs were showed as Figure 8, which integrated with the water solutions to improve the cooling and ventilation effect through the revise of opening by pivot window to introduce the wind pass by into indoor efficiently.

![Figure 7. Integrated Strategies, Terrain elevation and Drainage direction Plan.](image)

![Figure 8. Integrated Strategies, ventilation, sunlight, water system and opening renovation design.](image)
Furthermore, areas that are relatively lower than their surrounding areas made the traditional way of natural drainage system difficult to work during heavy rain season. Especially when continuous heavy rainfall reaching over 400mm in 3 days after the year 2016, which now happens annually, the traditional idea can't match its original design. Therefore, a new idea for integrating rain water harvesting, grey water purification (controlled used tap water), open cover waterway with infiltration, underground stormwater reservoir by reusing cement rock as gravel system, wetland, and the level controlled natural overflow and emergency mechanical drainage system. All the concept and design are shown as Figure 9. The new idea is calculated with the 400mm rainfall volume for whole campus collection and evacuation. Some basic information: total campus area is 18,000 m$^2$, the greenery cover area is 12,000 m$^2$, and the building basement for rainwater management is 1,500 m$^3$. There were three different purposes reservoirs, which covered buffering control (nearby the building, several small spot and well connected), major storage (underground of playground), and level up mixed surface and subsurface pond with good penetration rate into soil (at the southern green area). The group calculated for the underground reservoirs should achieve 680 m$^3$ capacity. Moreover, during the dry season, the system can easily integrate with the grey water system to refill for irrigations.

Figure 9. Systematic design for water system by integrated nature system for retention and reuse.

Figure 10. The sustainable water curriculum for ESD toward SDGs.
3.5. Education for Sustainable Development (ESD) Progresses
The most important thing for this project is deeply linked with the curriculum development. “There will not happen without the people to learn and use for sustainable system” the Principle Mr. Wei said. Therefore, the Taikang school utilized this opportunity to develop the ESD core courses for water and sustainability. Figure 10 shows the structure of the new course, which make teachers of Nature, Science and Society courses to develop a series learning program from first grade to six grades, and some issue connected with SDGs (4, 11, 13, 15, 17). Furthermore, the social participation with the community started up the Volunteer Partnership Cooperation for step forward to influence the neighborhood behavior and awareness toward sustainability, which mean the understanding to each other and living in a symbiotic balance.

4. Practices and Feedbacks
In the year 2018 and 2019, the renovation of the system step by step finished, and the water system from the interception, collecting, buffering, saving, purification and evacuate control, and systematic integrated with grey water, irrigation and infiltration are showed from Figure 11 to Figure 16. The system is not expensive and without lots artificial constructions, and it tightly integrated with the ecosystem of campus. The clean and cooling effects were also can improve both the outdoor and indoor environment. In the year of 2019, the landscape maintenance of whole campus was support fully with rain water and grey water system, and it means the only tap water use is for human. There is a circular system was established by the water system to green system, and influence bio-climate control with nature for comfort perception.

It is really great that the member of school realized the benefits of sustainable and passive system can help for safety, comfortable, amenity and developing new ESD course, which upgrade the awareness and achievement for their career. After that, the renewable energy issues, competition for energy saving with lighting control pattern, and even the plating shading were become the next step for whole campus. Even the community people, who belonged to parent committee, felt the change and voluntary to join the teaching program. More and more ideas were created to go further more.

In the year of 2020, the school has the earthquake damaged old building demolished and new for under construction, and the vision from Principle to children hope to build a really sustainable circular campus. The new building will follow the idea and make more comprehensive solutions. Figure 17 is the progresses that from end-users to architect for new campus corners. It is a really great feedback to the project.
5. Conclusions and Discussions
From 2018 to 2019, there are two campuses going through the renovation progresses. The Taikang experience now is the benchmark with milestone to encourage the TSCP of MOE going further more. It is exciting that whole system just only cost 300,000 USD, and supported by participation of community. The changes were from the taps to whole system and integrated with environmental education. In comparison of before, the campus can afford over 80mm/hr heavy rain for three hours without flooding, and provide more than 90% of all the irrigation need of green for whole year. Moreover, the natural cooling system by green and water makes the cool breeze for natural ventilation classroom, and the school become campus without air conditioning campus in southern part of Taiwan.

For the next step of program is the long-term monitoring and evaluation for Taikang School, and the maintenance mechanism is also the issue for sustainable operation. Furthermore, the “Watch Program” for education to verify the learning outcome for students after school is also another topic to understand the influence, who will be the leadership in the future.

6. References
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