

Article

Using the Fuzzy Delphi Method to Study the Construction Needs of an Elementary Campus and Achieve Sustainability

Jen Chun Wang ¹, Kuo-Tsang Huang ^{2,*}  and Meng Yun Ko ¹

¹ Department of Industry Technology Education, National Kaohsiung Normal University, No.62 Shenjhong Rd., Yanchao District, Kaohsiung 82446, Taiwan; jcwang@nknu.edu.tw (J.C.W.); mvp2260@dove.kh.edu.tw (M.Y.K.)

² Department of Bioenvironmental Systems Engineering, National Taiwan University, 1, Sec.4, Roosevelt Rd., Taipei 10617, Taiwan

* Correspondence: huangkt@ntu.edu.tw

Received: 3 October 2019; Accepted: 26 November 2019; Published: 2 December 2019



Abstract: One of the crucial concerns for achieving a campus's sustainable development is that the school buildings should meet the needs of students and teachers. The design of school buildings should not only facilitate teaching activities but also provide a teaching environment that stimulates or encourages autonomous learning in students. School buildings are the site of classroom instruction and also serve as a teaching tool that helps in achieving educational objectives and providing compulsory education. They must consider modern ideas before construction, since education is constantly reformed and updated using new policies. Elementary school teachers and students are the most frequent users of school buildings, and their needs must be prioritized vis-à-vis elementary school building construction. We invited a total of 29 scholars, experts, and school managers to help create questionnaires to assess user level of need for each item of school building design, employing the fuzzy Delphi method. Questionnaires were divided into four major dimensions, namely campus buildings, campus environment, athletic fields, and auxiliary facilities, and the dimensions were composed of 33 items. The targets of the survey were teachers and students at a school located in Kaohsiung City, Taiwan. The results suggest that teachers and students both most highly value improved athletic fields; in particular, an indoor stadium was the most highly desired construction project. For safety reasons, replacing school walls with dwarf hedges was the least desirable item among teachers and students. Our objective was to provide a school building design reference for school administrative authorities and architects.

Keywords: school buildings; campus planning; questionnaire survey; satisfaction; level of needs

1. Introduction

According to Winston Churchill, 'we shape our buildings; thereafter they shape us'. School buildings and the campus do not merely comprise facilities that assist teaching. They also facilitate environmental education. Well-designed buildings can cultivate students' bodies and minds, inspiring their interest in learning and breeding an open-minded life philosophy [1,2]. Therefore, the quality of school buildings naturally has a profound influence on educational functions, the attainment of educational objectives, encouragement of teacher–student interactions, and alteration of student behavior [3,4]. School building planning yields various perceptions of the school environment. Students' satisfaction with the school environment also influences their learning interest and behavior [5,6]. This demonstrates that school buildings play a pivotal role in students' learning behavior. In addition to school buildings, the school campus also plays a crucial role in constituting a school's learning

atmosphere [7,8]. A learning environment that integrates concern for ecology, health, environmental protection, energy conservation, and resource conservation not only incorporates the thought of sustainability into education but also increases learning satisfaction [9,10]. Accordingly, a school campus environment should have an outdoor space for physical activities, such as a track and field stadium, sports field, playground, gym, and a student union building, in addition to educational and administrative buildings.

The government of Taiwan, after experiencing the 921 earthquake in 1999, devoted a considerable amount of its budget to school campus reconstruction, which initiated a new trend of sustainable campus design in the last two decades. However, Taiwanese schools have placed stronger emphasis on building design that incorporates molding, safety, environmental-friendliness, public arts, and barrier-free facilities during new construction and reconstruction processes. The construction process is usually decided through collaborative negotiation between the administrative team led by the school principal and architects. From planning, designing, and constructing, numerous buildings are finished within a short period of time. The resultant school campus and buildings are beautiful and magnificent but may not necessarily fit curricular and teaching development needs. One main reason for this is that, although the large faculty and student body are future users of the buildings, they have not had the opportunity to express their opinions during the construction process. Buildings are constructed for their users, and therefore the opinions and needs of users should be considered as much as possible. Such consideration should be regarded as a crucial reference for school construction design. This research attempts to include the insights from the experts and the campus users for campus design/planning references. We hope that the expectations from the teachers and the students could be fulfilled during the phase of preliminary design by taking their perspectives into consideration.

2. Literature Review

Numerous methodologies for assisting designers or users to evaluate what they need in a building are available in the early design stage. Some studies have adopted building information modeling to evaluate buildings and their surrounding environment to provide an evaluative model that facilitates communication between users and designers [11,12]. Accompanied with the space design and management, there are various discussions on the multiple uses of a learning space in recent literature [13–15]. To achieve the objective of sustainable learning, this issue is crucial for teachers while practicing teaching and is also crucial for school operators to ponder. Regarding the relationship between school buildings and users, several studies have used questionnaire surveys to investigate satisfaction, but relatively few studies have discussed the level of user needs. Studies that have investigated campus or school building satisfaction are highly diverse. Some studies have assessed user satisfaction with indoor air quality of architectural spaces and discovered that air quality simultaneously affected physiological and psychological status [16,17]. Other studies have examined satisfaction of a budget, economic benefits, and effective use of a budget to maximize the benefits of sustainability [1]. Satisfaction with campus safety has also been investigated, and this topic was relevant to user trust vis-à-vis the school environment [18]. Moreover, several studies regarding campus planning satisfaction have focused on sustainable campus development. Such studies have proposed that the level of environmental protection and sustainability can influence user perception and differences between satisfaction levels can exist [19,20]. Some studies have adopted overall environmental evaluation as the crucial reference for a sustainable campus, and the environment was evaluated through overall perception using a qualitative description [21]. Quantitative assessment has also been conducted on the relationship between carbon dioxide emissions and student behavior with the aim of investigating the sustainable campus topic [22]. The analytic hierarchy process (AHP), expert questionnaire, and fuzzy Delphi method have been used to integrate the opinions of scholars and experts with an aim to discuss the construction of various indicators of a sustainable campus [23,24]. Similarly, the AHP method has been used to implement an inquiry of sustainable campus strategies. Expert consensus was obtained gradually through hierarchy analysis to formulate feasible strategies

and improve user satisfaction [25,26]. The quality of the surrounding environment of buildings is as crucial as the buildings themselves, particularly during campus design. If the outdoor environment can appropriately serve as a leisure space, it can play a pivotal role in prompting a relaxed mood and harmonizing teacher and student lives [27–29]. When evaluating the environmental needs of a campus, the outdoor environment must also be incorporated and considered. The aforementioned literature review indicates that numerous studies have used the questionnaire survey to undertake strategic considerations of how to fulfil the level of user need for aspects of school buildings. Through appropriate questionnaire design, designs that obtain agreement from the majority can be identified to develop specific and feasible strategies.

3. Methods

This study conducted analysis on previous literature and consulted existing campus sustainability indicators in Taiwan [30], identified the factors affecting service quality of school buildings and facilities, and assessing physical levels of campus design (e.g., climate, orientation, color, vision, lighting, illumination, ventilation, temperature, humidity, and soundproofing quality). Additionally, the completeness of physical facility designs such as the location, quantity, and quality of school buildings, athletic fields, the campus, and auxiliary facilities were also examined. We first drafted the questionnaire, and the content conformed to the content validity of the aforementioned school buildings and facilities. Four dimensions of campus planning were identified as follows: campus buildings, campus environment, athletic fields, and auxiliary facilities, and these items were assessed by questions 11, 9, 8, and 12, respectively. This study analyzed various demands and expectations of a school building from the perspectives of students and teachers of various backgrounds by using questionnaires. The research results include perspectives from the users can provide as a reference for the planning/design of an elementary school for education authorities and architectural designers.

3.1. Questionnaire Participants

Subsubsection

Determination of needs affects campus planning decisions and is of great importance. Therefore, inductive analysis of the opinions of the experts and scholar groups was necessary, and the targets of the questionnaire were people related to campus construction, reconstruction, and maintenance, or academic researchers in the domain. For elementary and middle schools, the director of the general affairs division is responsible for school building planning, construction supervision, campus building maintenance, and safety supervision. The chief of the general affairs division has responsibilities such as school facility purchases, repairs, and maintenance. The chief of the environmental education division has responsibilities such as campus environmental maintenance, greening and beautification planning, energy conservation planning and advocating, and recycling. The aforementioned director and chiefs also have part-time responsibilities as teachers. They are responsible for the promotion of relevant affairs such as campus planning and maintenance. As teachers they are familiar with actual teaching sites and are able to provide concrete campus planning advice. For universities, professors and researchers are involved and are scholars who have participated in campus-planning-related plans, or are scholars who had long focused on educational environment. In addition, they also teach environment-related courses at their university and are familiar with the requirements for a sustainable campus at elementary and junior high schools. With respect to the architectural business world, two highly experienced architects were invited who have long undertaken campus building design projects. These architects mainly focus on elementary and junior high school campus planning and building design businesses. Thus, they are highly familiar with campus-design-related businesses. An engineer who works at a construction firm doing campus reconstruction or maintenance projects was also involved in this study.

3.2. Fuzzy Delphi Survey

The Fuzzy Delphi method was used to identify the relative weightings among the items in the questionnaires, which is a structured technique for identifying the deterministic variables. The purpose of this method was to achieve relatively subjective determinations by a reciprocal information gathering process from the objective judgments of various experts. The process was carried out by consulting the anonymous experts twice. After the first consultation, experts' opinions were analyzed and passed forward to the same group of experts for the second consultation. The experts should express their second or new opinions based on the first results. Through this reciprocal process, the diverse opinions will gradually reach consistency, and a relative consistent agreement among experts is obtained. Following completion of the first draft, scholars and experts (Table 1) were invited to provide guidance and make modifications. This study used the simple center of gravity method to screen and select indicators on which experts had a consensus. The steps were as follows: (1) the triangular fuzzy number of each crucial preliminary indicator was calculated; we collected experts' assessed values of preliminary crucial indicators through the questionnaire. Fuzzy-weight-assessed values given by 32 experts were integrated to facilitate calculation of the triangular fuzzy number of each crucial preliminary indicator. (2) The fuzzy weight of each preliminary indicator WwK was converted to a singular value SK , while the fuzzy number minimum values, geometric mean, and maximum values of the overall original assessment indicators were used to create the triangular fuzzy number $WwK = (\text{fuzzy number minimum value, geometric mean, and maximum value})$. Subsequently, the simple center of gravity method was used to convert the fuzzy weight WwK of each preliminary indicator to a singular value SK . $SK = (\text{fuzzy number minimum value, geometric mean, and maximum value})/3$, and the SK value was the threshold value set to select suitable indicators. Following two screenings of the fuzzy Delphi survey, consensus was reached on 33 indicators out of 40 indicators in four major dimensions; the four dimensions (i.e., campus buildings, campus environment, athletic fields, and auxiliary facilities) had 10, 8, 6, and 9 items, respectively. The Likert's five scale questionnaire was used for the study. The subjects were asked to identify the degree of the agreement to the questions based on the five scales or to express their objective or subjective opinions of any form. The scales included: strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). Based on the Likert scale, each question was analyzed separately, while the grouped questions are averaged and are constructed as a group's scale to compare and analyze the differences among various groups, as well as the differences of the variables in the same groups.

Table 1. Experts and scholars who participated in questionnaire guidance.

Category	Position	School Level	Surveyed Individual (s)	
Campus users	Principal	Elementary school	1	
	Director of general affairs division	Elementary school	2	
	Chief of environmental education section	Elementary school	2	
	Chief of general affairs section	Elementary school	2	
	Principal	Junior high school	1	
	Director of general affairs division	Junior high school	2	
	Chief of environmental education section	Junior high school	3	
	Chief of general affairs section	Junior high school	2	
	Director of general affairs division	Senior high school	1	
	Chief of environmental education section	Senior high school	1	
	Chief of general affairs section	Senior high school	1	
	Academic researchers	Professor (who specialized in building design)	University	2
		Professor (who specialized in school architectural planning)	University	1
		Professor (who specialized in environmental education)	University	2
Professor (who specialized in technology education)		University	2	
Researcher (who specialized in environmental education)		University	1	
Architectural business world	Architect	-	2	
	Engineer (construction firm)	-	1	

3.3. Differences between Effects of User Variables on Demand for Campus Facility

Teachers and students are the most frequent users of school buildings. Therefore, the suitability of school environment planning and the adequacy of school buildings and facilities are highly relevant to

teachers, students, and teaching. However, because of different identities and backgrounds, teachers and students may have different expectations for a school campus. We thus used six items as teacher personal background independent variables (gender, age, teaching experience, education level, position, and lectures taught) and three items as student personal background independent variables [gender, grade, and class type (regular, athletic, and dancing programs)]. A total of 33 items of four dimensions were used as dependent variables of the level of school building and facility needs. We investigated the level of need for each dimension of the overall teacher and student body. Additionally, the relationship between independent variables and dependent variables and differences in each dimension was assessed. Questionnaires were randomly distributed to elementary school teachers in Kaohsiung City, Taiwan, and 71 valid questionnaires were obtained (Table 2). In terms of students, teacher guidance was needed because elementary school students may not necessarily have the reading ability needed to understand the text of the questionnaire. Therefore, 10 class teachers and their 10 classes of student participated together (Table 3).

Table 2. Statistics of sample size percentage and basic information of surveyed teachers (N = 71).

Variable	Basic Teacher Information	Sample Size	Percentage
Gender	Female	47	66.20%
	Male	24	38.80%
Age	25 years old or less	0	0%
	26 to 30 years old	16	22.53%
	31 to 40 years old	33	46.49%
	41 to 50 years old	16	22.53%
	51 years old and above	6	8.45%
Teaching experience	1. 10 years or less	17	23.94%
	2. 11 to 20 years	37	52.11%
	3. 21 to 30 years	14	19.72%
	4. 31 years and above	3	4.23%
Education level	1. Junior college	2	2.82%
	2. Bachelor's degree	36	50.70%
	3. Master's degree or higher	33	46.48%
Position	Class teacher	39	54.93%
	Subject teacher	19	26.76%
	Teacher and chief	9	12.68%
	Teacher and director	4	5.63%
Number of lectures conducted weekly	1 to 5 lectures	5	7.04%
	6 to 10 lectures	4	5.63%
	11 to 15 lectures	9	12.68%
	16 to 20 lectures	48	67.61%
	More than 21 lectures	5	7.04%

Table 3. Statistics of sample size percentage and basic information of surveyed students (N = 221).

Variable	Student Basic Information	Sample Size	Percentage
Gender	Female	120	54.3%
	Male	101	45.7%
Grade	Fourth grade	44	19.91%
	Fifth grade	98	44.34%
	Sixth grade	79	35.75%
Class type	Regular	134	60.63%
	Athletic	36	16.29%
	Dancing	51	23.08%

4. Results

4.1. The Level of Need for Different Dimensions among the Teacher and Student Body

Table 4 and Figure 1 presents the overall level of need assessment of four dimensions. Teachers ranked the athletic fields as the top dimension, followed campus buildings, auxiliary facilities, and campus environment; differences between the first three items were minimal, and the level of need for campus environment was relatively low. Students wanted athletic fields, campus buildings, auxiliary facilities, and a campus environment, as determined by their rankings in order of high to low. A post hoc test demonstrated that the need for athletic fields was significantly higher than that for the campus environment ($p = 0.05$). The dimension of campus environment was determined to be least needed by teacher and student groups. The dimension of the campus environment was highly related to the natural environment. In the comparison, the level of need for athletic fields was assessed to be the highest among the two groups of participants. This indicated that teachers and students preferred the actual constructions of an artificial environment. The Scheffe's test was adopted for pair-comparison of each aspects. As there are four aspects in the questionnaire, a total of six comparisons were conducted. The results showed that only the athletic field dimension (C) > auxiliary facility dimension (D) is significantly related with its p -value being 0.04, as shown in Table 4. The other five combinations are insignificant.

Table 4. Level of need ranking of each facility of school buildings.

Dimension	Do You Consider Such a Facility to be Necessary?	Mean (Teacher)	Standard Deviation (Teacher)	Mean (Student)	Standard Deviation (Student)	
Campus buildings	In-between corridor for two buildings connects them and provides shelter from wind and rain	4.28	0.75	4.79	0.94	
	Each subject field must have a subject-specific classroom	4.13	0.84	3.61	1.55	
	Classrooms require an in-classroom reading corner (reading zone)	4.08	0.97	2.91	1.51	
	Classrooms require a front and back balcony	3.97	1.03	3.07	1.55	
	Classroom space requires expansion	3.96	1.11	3.40	1.21	
	Classrooms require an electronic whiteboard	3.87	1.07	3.95	1.31	
	Classroom soundproofing requires improvement	3.86	1.07	4.51	1.27	
	Class ventilation requires improvement	3.63	1.17	3.22	1.36	
	Classroom lighting requires improvement	3.15	1.08	2.79	1.25	
	Roof garden	2.80	1.20	3.76	1.45	
	Mean for campus buildings dimension (A)	3.77	1.03	3.60	1.34	
	Campus environment	Flower gardens for teaching purposes	3.90	0.96	2.89	1.38
		Vegetable garden for teaching purposes	3.76	1.03	3.19	1.55
		Botanic garden	3.55	1.14	3.08	1.47
Ecological pool		3.52	1.24	3.67	1.28	
Additional entrances and exits on campus		2.79	1.17	3.31	1.48	
Replacement of enclosure walls with dwarf hedges in campus surroundings		2.51	1.34	2.50	1.51	
Mean for campus environment dimension (B)		3.34	1.15	3.11	1.45	
Athletic fields	Windproof and rainproof playground (indoor stadium)	4.85	0.58	4.81	0.86	
	Table tennis grounds	4.07	0.83	3.43	1.35	
	Dancing grounds	3.97	0.84	3.01	1.66	
	Football pitch	3.92	0.86	4.14	1.38	
	Chinese yoyo grounds	3.77	1.04	3.68	1.41	
	Basketball court	3.62	1.01	4.33	1.43	
	Increase of running tracks for athletic fields	3.04	1.18	3.92	1.74	
	Swimming pool	2.97	1.31	4.52	1.21	
	Mean for athletic field dimension (C)	3.78	0.96	3.98	1.38	
	Auxiliary facilities	The number of women's toilets must be higher than that of men's toilets	4.03	1.04	2.73	1.61
Air purifiers must be installed inside classrooms		3.99	1.11	4.44	1.08	
The number of drinking fountains must be increased		3.97	0.89	4.03	1.29	
The number of sinks must be increased		3.93	0.99	3.42	1.34	
Elevator		3.86	1.15	4.04	1.38	
The number of toilets must be increased		3.79	0.97	3.63	1.45	
Bulletin boards must be expanded		3.51	1.12	2.74	1.31	
Classrooms must have air conditioning		3.34	1.36	4.42	1.24	
The number of parking spaces must be increased		3.15	1.27	2.90	1.51	
Mean for auxiliary facility dimension (D)		3.73	1.10	3.59	1.36	
Scheffe's test		-	-	C > D	-	

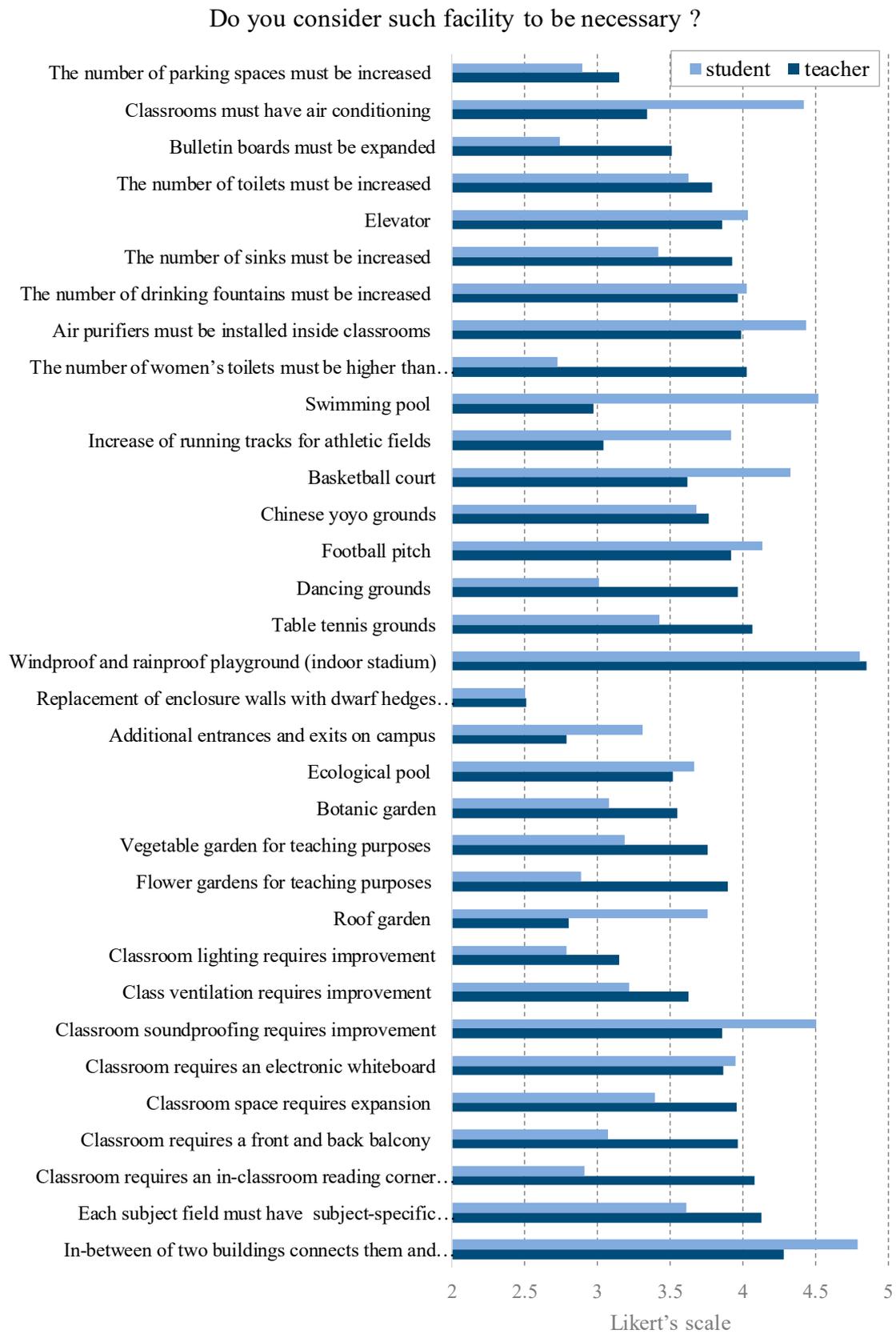


Figure 1. The level of demand for each facility by teachers and students.

4.1.1. Need of Campus Buildings

School building dimensions reflect the diverse and actual learning environment and teaching service. An 'in-between corridor for two buildings connects them and provides shelter from wind and rain' was selected as the item with the highest level of need. This reflects Taiwan's rainy and humid climate, which is especially apparent from April to October. The roof of an in-between corridor for two buildings prevents users from getting wet. A considerable difference in need existed between teachers and students for the item, 'having a reading corner in the classroom (reading zone)'. A reading zone is an extremely common design feature in Taiwanese elementary and middle school classrooms. The design creates a comfortable zone specifically for reading within the classroom, and entering the zone usually requires one to take off their shoes. The item ranked third in the assessed level of needs of teachers but ranked ninth in that of students. The fact that teachers wish to have a reading space inside classrooms but students consider it unnecessary is an unexpected phenomenon.

4.1.2. Campus Dimension Need

Campus design concepts in Taiwan in the past two decades have encouraged schools to open up, integrate with their communities, and welcome community residents to take a stroll in or a rest at school during nonclass hours. Increasingly, schools have used dwarf hedges to replace enclosure walls. However, campus safety awareness has been rising in recent years and the item 'replacing walls with dwarf hedges' was selected as the least needed item among teachers and students. A relatively large difference existed between teacher and student perceptions of the item "flower gardens for teaching purposes". Teachers considered it the most crucial item because it is related to biology teaching. However, students ranked it the second least important item.

4.1.3. Need of Athletic Fields

Indoor stadiums were assessed to be the most crucial item by teachers and students. An indoor stadium is a type of school building that has risen in popularity in recent years, but the item is not part of the standard construction of each school. Receiving a subsidy for construction of an indoor stadium usually requires a school's costs to be above a certain threshold. The fact that the field earned the highest level of needs by teachers and students suggests that they hope to have an athletic field that is not affected by rain and sunlight. With respect to items in which teacher and student responses differed considerably, a swimming pool was assessed as the least necessary item by teachers but was assessed as the second most important item by students. Conversely, dancing grounds were highly rated by teachers but had the lowest rating among students.

4.1.4. Need of Auxiliary Facilities

The number of women's toilets and men's toilets has consistently been one of the major issues of discussion for public architectural design. Women spend a longer time using a toilet compared with men, and thus providing a greater number of women's toilets is reasonable. The item 'the number of women's toilets must be higher than that of men's toilets' was rated by teachers as the most needed item. However, this might not considerably affect elementary school students, as evident by their rating it as the least important item. 'Installing air purifiers' has become a new trend in Taiwan in recent years. This is particularly true during fall and winter when air pollution is more serious and numerous schools usually cancel originally scheduled outdoor sports competitions. Air purifier installation has become one of the public sector's main subsidy projects for schools. 'Installing air conditioners inside classrooms' has also become a topic of discussion in recent years. Teachers consider air-conditioning to be unhealthy, whereas students consider it to be comfortable; thus, a considerable difference in rating existed.

4.2. Level of Needs Differences among Teachers and Students of Different Backgrounds

4.2.1. Level of Needs Differences among Teachers of Different Backgrounds

Elementary school teachers of different genders did not exhibit significantly different needs for each dimension of a school building, but different age groups did exhibit noticeable need differences. Specifically, teachers who were older than 51 expressed higher levels of needs in each dimension compared with other groups. A similar phenomenon was also found in teaching experience, and this was because teachers with longer teaching experience were generally older. Therefore, groups of teachers with 21 to 31 years of teaching experience and above 31 years of teaching experience had relatively higher levels of needs compared to other groups. Teachers of different education levels did not exhibit significantly different levels of needs for school buildings. However, examination of each dimension suggested that the lowest education level, the junior college group, exhibited the highest level of needs for three dimensions, namely campus buildings, athletic fields, and auxiliary facilities. Teachers with lower educational levels were usually more experienced teachers and were thus familiar with school administrative operations and exhibited higher demand for each aspect of the school environment. In terms of specific position, class teachers exhibited significantly higher demand levels for campus buildings than subject teachers (Mean: 4.01 > 3.51, $p = 0.04$). Class teachers must stay at school all day, whereas subject teachers only stay at school during scheduled lecture hours. Therefore, class teachers have more and significantly higher demands for campus buildings. Additionally, teachers with different numbers of teaching lectures did not express significantly different demands for each dimension. Observation of each mean value, however, indicated that the teacher group with the highest number of teaching lectures (21 lectures and above) exhibited higher demands than other groups in the three dimensions of campus buildings, athletic fields, and the campus environment. This suggested that teachers who have a higher number of teaching lectures and stay longer at school naturally exhibit higher demands.

4.2.2. Level of Needs for Variables of Different Backgrounds in Students

Students of different genders exhibited a significant difference in auxiliary facility dimensions (mean for females = 3.76 > mean for males = 3.46, $p = 0.05$). Detailed investigation of each item revealed that responses in two items, namely 'The number of women's toilets must be higher than that of men's toilets' and 'The number of toilets must be increased' differed significantly and had a relatively large standard deviation. Female students considered this dimension to have a high level of need, but male students considered it unimportant. Boys and girls did not differ significantly in the dimension of athletic fields, but had significantly different responses in the item, 'Increase of running tracks for athletic fields' (Mean for males = 4.25 > Mean for females = 3.60, $p = 0.01$). This demonstrated that elementary school boys had a higher demand level for running tracks than girls. Students at different grade levels exhibited significant differences in the dimensions of athletic fields and auxiliary facilities ($p = 0.04$; $p = 0.03$). Scheffe's post hoc comparative analysis indicated that demand in sixth grade students was significantly higher than that of fourth grade students. This indicated that higher grade students had higher demand for the two dimensions (athletic fields and auxiliary facilities). In terms of different class types, athletic class students (mean = 3.92) had higher demand in athletic fields than regular class students (mean = 3.39) and dancing class students (mean = 3.32); the difference was statistically significant ($p = 0.01$). Sports class appeals to students who really enjoy sports, and thus these students had higher a level of needs for athletic fields. For the three other remaining dimensions, no significant difference in each class type was found.

4.3. Needed Items for Which Teachers and Students Reached a Consensus

This section focuses on consensus opinions between teachers and students. We selected the items of each dimension that were ranked in the top 50% by teachers and students (Table 5). Table 5 presents data suggesting that for campus buildings, with the exception of the first item, these items were related

to daily life activities in classrooms. Demand for soundproofing appeared because soundproof facilities such as walls, floors, and windows of numerous schools were constructed according to old building laws before 1999 and thus have relatively weak soundproofing. Electronic whiteboards are healthier than traditional blackboards that generate chalk powder. Balconies in the front and back of a classroom help indoor space expansion. The area of a subject-specific classroom is 1.5 times to 2 times that of an average classroom, and the larger space facilitates teaching activity in any specific fields. We observed that teachers and students mostly prioritized spaces that they frequently interact with in their daily life. With respect to the campus environment, an ecological pool and a vegetable garden for teaching purposes earned consensus. In the last 10 years, numerous elementary and middle schools in Taiwan have constructed ecological pools, which have been used to help purify polluted water. Moreover, ecological pools also provide a resting place and scenery. Vegetable garden use for teaching purposes in coordination with food and agricultural education has been promoted in recent years; gardens were highly popular among students. The difference in assessment of the athletic fields dimension was relatively large among teachers and students. Only two out of eight items were selected and ranked in the top 50% of needs among the items of this dimension. An indoor stadium was rated at the highest level of demand and was the highest among all of the items. Another dimension of consensus was football pitch, but it was only rated as moderately important among teachers and students. In terms of auxiliary facilities, the air purifier dimension had the highest level of consensus. A standard allocation of drinking fountains is typically provided in schools, but the number was clearly considered insufficient by teachers and students. Strategies that limit elevator use were common because the school aimed for energy conservation and carbon reduction. In terms of toilets, although it was barely ranked in the top 50%, the perceived level of needs among girls was considerably higher than that of boys.

Table 5. Items with levels of needs that were agreed-upon by teachers and students as being in the top 50%.

Dimension	Items of Level of Needs	Mean Score of Teachers and Students
Campus buildings	In-between corridor of two buildings that provides shelter from wind and rain	4.54
	Soundproofing must be enhanced in classrooms	4.19
	Classrooms require electronic whiteboards	3.91
	Each subject field must have its subject-specific classrooms	3.87
	Classrooms require a front and back balcony	3.52
Campus environment	Ecological pool	3.60
	Vegetable garden for teaching purposes	3.48
Athletic fields	Windproof and rainproof playground (Indoor athletic stadium)	4.83
	Football pitch	4.03
Auxiliary facilities	Air purifiers must be installed inside classrooms	4.22
	The number drinking fountain must be increased	4.00
	Elevator	3.95
	The number of toilets must be increased	3.71

5. Discussion and Conclusions

Taiwan has 2630 elementary schools and, on average, US\$380 million was spent annually during 2016 to 2018 for school reconstruction and maintenance. A total of 13% of the budget was spent on construction, but regardless of construction or maintenance, the existing system stipulates that the school principal leads the discussion between the school administration team and architect team. The opinions of teachers and students are largely ignored during this process. The main purpose of a school building is to serve teachers and students, and therefore satisfaction of these two groups should be a major consideration [1].

5.1. The Highest Consensus Item between Students and Teachers

This study determined that the dimension of athletic fields is the most needed dimension of school buildings for both teachers and students. In that dimension, an indoor stadium was rated as the most needed item by the teachers and students. Moreover, to maintain campus safety, the replacement of

walls with dwarf hedges was not desirable among the teachers and students. Campus safety is usually an important consideration for strategy implementation in the campus environment as well [18]. Such opinions should become a key reference for campus planning.

5.2. Questionnaire Results Reflect Empathy

The survey results showed that teachers expressed more ration and empathy when filling out the questionnaire, and this quality was reflected in smaller differences in their responses. Specifically, the standard deviation of responses for 33 items was 1.10 for teachers and 1.36 for that of students' responses. The coefficient of variation of the teacher group and student group was 28% and 39%, respectively. This indicates a more noticeable difference between favorable and unfavorable responses of students. Significantly different responses can appear in questionnaires of different groups, and this is particularly true for subjective feelings toward architectures and indoor space. Characteristics of different groups only may lead to significantly different responses, and thus one should be extremely cautious when interpreting them [23,31].

5.3. Sustainable Green Campus is More Desirable than Installing Air-Conditioners

This study demonstrated that demand for air conditioners, a popular auxiliary facility for school buildings in recent years, was a low item of demand among teachers. Teachers take facility cost, electricity cost, and environmental protection into consideration and usually responded more rationally. However, students expressed a high level of needs and were anxious that heat may affect mood for learning and the quality of class. Schools can adopt diverse green energy measures (green buildings, sun visors, waterproofing, and heat insulation). Fans can also be installed and operated simultaneously to enhance classroom ventilation and reduce indoor temperature. For instance, a green campus is being promoted in Guangdong Province, China, and the green campus has conserved energy by 23.3% compared with regular campuses after using electricity through energy conservation facility and equipment [32]. An evaluation conducted in South Korea revealed that use of active equipment or facility including air conditioners, energy conserving lighting, power planning, and monitoring can reduce energy consumption by 6% to 29% [33]. Matera in Southern Italy conducted energy conservation improvement on eight school buildings and found that improving the design of the envelope of a school building could reduce 5% to 84% of energy consumption. Moreover, even improvement in sheltering or thermal insulation of vegetation can reduce energy consumption by 25% to 62% [34].

5.4. Sustainable Campus Design Thinking from the Perspectives of the Occupants

Past studies on school buildings have mostly focused on a discussion of guideline establishment, practical problem analysis and improvement, or architectural techniques. Few studies have used the perspective of users, and studies that have focused on the level of needs of teachers and students are even rarer. Schools should serve as an effective space oriented toward the needs of teachers and students. Schools should place their emphasis on student needs, interests, health, and achievements, maintain campus safety, and provide places for students to rest, study, and develop themselves. When school buildings become a participatory work of design, they can display outcomes that reflect the interaction between the campus, teachers, and students. This means schools need to highly regard human–environment interaction and enable the wills of teachers and students to become part of building the scenery of schools. School buildings are more than mere lifeless objects. If decision makers of school building planning and design highly regard dialogue between buildings and their users, the opinions of teachers and students should be taken into account. This could increase teacher and student identification with the campus and enable school buildings to be built with more emphasis on user needs to demonstrate the educational spirit of learning autonomy. This study reveals the local demands for Taiwanese schools. Although the demands for school buildings may vary and may not be suitable for analogizing to other regions or countries, this study's results do represent crucial local values and we think it might also be valuable for application in other countries.

Author Contributions: Conceptualization, J.C.W., M.Y.K. and K.-T.H.; Methodology, J.C.W.; Formal Analysis, J.C.W.; Investigation, M.Y.K.; Resources, J.C.W. and M.Y.K.; Data Curation, J.C.W.; Writing—Original Draft Preparation, J.C.W. and K.-T.H.; Writing—Review & Editing, J.C.W. and K.-T.H.; Visualization, J.C.W. and K.-T.H.; Supervision, J.C.W.; Project Administration, J.C.W. and K.-T.H.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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