Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management
Bali, Indonesia, January 7 – 9, 2014

Assessment on the Ergonomic Factors and Green Building Features of the Selected 2012 Green Classrooms in the Philippines Luzon Area

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Abstract

In this study, selected Green Classroom Projects in the Philippines in Luzon area were assessed based on the ergonomic factors and green building features of the design which are unique for each project. Ergonomic factors such as: sound level, illuminance, space utilization, temperature and humidity were measured, while green building features such as: ventilation, use of indigenous materials, heat insulation, sanitary system, aesthetic value, and rain harvesting system were rated for each classroom design. The researchers come up with the assessment using: measuring instruments, visual inspection, comparison on local classroom, interview, and Likert type questionnaires. Based on the results, the green classroom in San Cristobal Elementary School in San Pablo Laguna emerged as the green classroom design which showcased best ergonomic and green building features among eight classrooms assessed. The parameters considered in this study were taken based on the green engineering advocacy of the Project Green Engineering Philippines (PGEP) applied on the prescribed classroom features of the Department of Education (DepEd) and the Philippine Institute of Civil Engineers, Inc.

Keywords
Green Classroom, Ergonomic Factor, Green Features, Serviceability, Aesthetic Value

1. Intoduction

1.1 The Setting and Background

The Philippines consists of over 1000 islands, the largest of which is the Luzon Island. Philippines is located between 5 and 20^{O} N within the tropical cyclone track in the Western Pacific having an area of less than 300,000 square kilometer, generally with hot and humid climate (Schopka H.H., 2011). Due to the country's large population, the Philippine school system is among the largest in the World. According to De Guzman (2007) based on the Department of Education Fact sheet in 2005, there are 41, 989 public elementary and secondary schools and 7,790 private schools under its supervision (De Guzman, 2007). Currently, in the 2012 Fact Sheet Report of the Department of Education, there are 45,973 public schools and 12,834 private schools in the land (DepEd, 2013).

1.2 PICE initiative

Year 2012 when the Philippine Institute of Civil Engineers (PICE), Inc. launched the PhilGreen Schools Project that aims to promote the design and construct of Green Engineered School Buildings. This initiative is under the PICE program, Project Green Engineering Philippines (PGEP) launched in 2010 whose mission is to implement green building education and campaign (PGEP, 2012). The PhilGreen Schools Project of PGEP aims to provide comfortable classrooms, innovate use of sustainable recycled materials in the locality, minimize use of energy, utilize rain water, to advocate the benefits of green classroom technology especially in remote communities. This PhilGreen Schools concept was introduced by launching a Schools Design Competition among the 96 PICE Chapters in the country. PICE Chapters were encouraged to design a green classroom tailored based on the local climate and community they belong. Twenty classroom designs were chosen to be constructed in their community during the first phase of the competition. PICE sourced the funding from various private partners for the construction of 20 green school projects across Luzon, Visayas and Mindanao. This project of PICE is geared in minimizing classroom shortage in the Philippines. As what has been reported by Malipot (2012), France Castro, the Secretary General of the Alliance of Concerned Teachers (ACT) cited that the Department of Education should pay more attention in solving perennial problems in public schools such as lack of classrooms (Malipot, 2012).

1.3 Sustainability in Green Engineering

Sustainability in construction is a global concern that efforts have been made to create policies and practices throughout the world. From the procurement practices through reuse practices on operational phases is where the sustainable practices be applied. Since ideal solutions and practices may differ in different areas in the world, it is therefore expected that different rating systems may be developed as well as the techniques to consider. Energy efficiency is a major priority especially in countries experiencing winter, that much publications and research are devoted to improve energy efficiencies in new construction and retrofitting for existing buildings (Haselbach L., 2010). A good design of a building must be inherently green which is constructed in a way that it maximizes the benefits of sunlight and wind with a covering that is designed to create an ideal response to the local climate and has a system and components that saves energy and utilizes resources like rain water (Yellamraju, 2011). With the realization of the importance of Green Technology in structures, the Department of Education in the Philippines included in its Educational Facilities Manual, the recognition of Philippine Green Building Council's (PhilGBC) recommendation for the classroom design.

1.4 Ergonomics and Technology

In parallel with the consideration on green building features, the ergonomic factors of the design are evaluated based on the serviceability performance of the classrooms. The International Ergonomics Association defines ergonomics as (see http://www.iea.cc/ergonomics): *the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design, in order to optimize human well-being and overall system performance* (Vink P., (2006)). Based on the definition, the ergonomic consideration in the design is as important as the green features in terms of service performance of the green classrooms. Ergonomists or human factor professionals in the world do the same thing, that is, they are concerned with the design of systems involving human activities geared to improve health, safety, comfort and productivity, reduction of induced human error and improvement of quality (H.W., 2008).

In this study, the researchers assessed the green schools constructed in the following chapters, namely:Tarlac, Camarines Sur, Angeles, San Pablo City, Cavite, Bulacan, Albay and Laguna Chapter. The assessment focuses on the ergonomic factors and green building features of the green classroom design.

2 Methods

2.1 Assessment Study

The study was based on the assumption that certain ergonomic factors and green building features of one classroom can be proven better than another among eight classroom designs in Luzon. The green classrooms were selected for assessment with consideration on location. The two green classroom projects (Ifugao and Cagayan) were not considered due to their proximity from the home base of the researchers.

The study employs the use of qualitative and quantitative data across the different green classroom design. Methods such as visual inspection, interview, questionnaires and physical measurements were employed to determine the quality of each design in terms of the ergonomic factors and green building features. The study was biased in the sense

that the structuring of the questionnaires and interview questions were designed to obtain specific answers of interest from the respondents.

2.2 Visual Inspection

Being part of quality qualifier, visual inspection serves as the simplest form of gauging a product and a part of day to day unconscious activity, even so, on performed conscious structured program (Singh, 2012) The green classrooms were partly assessed using visual inspection and documented using snapshots depicting the green features and ergonomic factors. Indoor and outdoor shots were taken to capture the salient features that will highlight the uniqueness of the design from each other.

2.3 Interview

At times interviews are influenced by interviewers while depending on the skill and personality of the interviewee, this influence may not matter (Frey, 2012). Interviews were conducted among key persons who were directly involved in the construction of the green classrooms. Persons like the Project Manager, Project Engineer and School Principal served as resource persons in the study. Questions like the total construction cost, duration of work and material acquisitions were part of the documentation. The data disclosed by key personnel, say on the total cost of the project though, were given verbally but unsupported by paper documents.

2.4 Questionnaire

Likert method is commonly used as a standard psychometric scale to measure responses that facilitates survey construction and administration, and data coding and analysis." (Li, 2013). Likert type questionnaires were given among pupils and teachers occupying the green classrooms that will assess the *green features* and *ergonomic factors*, *aesthetic*, *serviceability* and *satisfaction* of the design based on the respondents' perception. *Green features* refer to the components like: use of sustainable (indigenous, recyclable) materials, rain water harvesting system, and heat insulating system. *Aesthetic* includes: uniqueness, beauty inside and out. *Serviceability* refers to the strength and safety of the design to resist wind loads and the destructive effect of flooding. *Satisfaction* covers the over-all impression on the ergonomic factors and green features of the classroom to provide value to the design and comfort to the users.

A 15 item set of questions was prepared to gauge the users' (pupils and teachers) perception on the green classroom constructed, and clustered according to what features or factors are they gauging in the design of the classroom. Each question was answered by checking a tick box rated 1 to 5, where 5 is the highest.

The 15 questions are as follows:

1. The classroom is obviously different compared to the other classrooms in the school.
2. The classroom is comfortable because of the cool air coming from the outside.
3. The classroom is well lighted even when the lights inside are turned off.
4. The classroom has a rainwater collecting system to water the plants and clean the toilet.
5. The classroom is free from noise coming from the outside.
6. The classroom is comfortable because there is enough space for the pupils inside.
7. The classroom is strong in resisting violent winds and heavy rains during typhoons.
8. The classroom looks beautiful when viewed from the outside.
9. The classroom has plants outside to block sunlight and insulate heat.
10. The classroom building made use of ordinary recycled materials.
11. The classroom is comfortable because of the roof and wall materials that do not emit too much heat.
12. The classroom offers comfortable condition for learning compared to other classrooms in the school.
13. The classroom has nearby toilets and faucets for sanitary purposes.
14. The classroom does not experience flooding during heavy rains.
15. The classroom has a beautiful view from the inside looking on the outside.

2.5 Physical Measurement on Environmental Conditions Attributed to Ergonomic Factors

The use of standard measuring devices to measure the physical condition of the classrooms like temperature, humidity, luminance and sound level were utilized. Nicol et al. (1995) stated that the preferable indoor temperature for thermal comfort varies according to cultural habits, race and location (Nicol, 1995). However, according to ASHRAE-IEC Standard 90.1, the recommended temperature for cooling must be close to the thermo-neutral temperature which ranges between 23.9 – 25.6^{O}C (Song, 2012). Also,Winterbottom and Wilkins (2009) reported that small scale studies show that there is link between lighting and student attainment (Winterbottom, 2009), while Zannin and Marcon

(2007) cited that teachers and pupils consider the noise in neighboring classrooms as the main sources of annoyance inside the classroom (Zannin, 2007). These facts prompted the authors to assess the environmental conditions of the green classrooms built in Luzon.

Physical conditions of each green classroom were compared with the physical condition of the local classroom found in the same school where it was located. The difference in physical measurement in each green classroom and the corresponding local classroom were tabulated. The percent difference reflects the rank of the ergonomic and green features of the classroom based on measured physical observations.

$$\textit{Percent Difference: \% Difference} = (\textit{Difference/Average}) \times 100\% \quad (1)$$

3 Data and Results

3.1 Data Acquisition

Data were gathered through scheduled site visit during weekdays when pupils and teachers are having class in the green classroom. Simultaneously, the picture taking on green classroom, interview on key personnel, questionnaires for students and teachers and physical condition measurement both for the green classroom and ordinary classroom in the school were done in each site visit.

Figure 1: Naic Coastal National High School Annex Green

3.2 Visual *Assessment on Green Classrooms in Luzon*

Naic Coastal National High School is situated in Cavite City situated 47 km from the heart of Manila. The green classroom built has a plain roof sloped in one direction to allow wide area at one side which is covered throughout the sides by sawali (woven bamboo skin) which allows sunlight and air to pass through from the outside. The walls of the classroom is made of concrete, though in the plan it is made of plastic bottle tapestry.

Figure 2. San Cristobal Elementary School, San Pablo Laguna Green Classroom

San Cristobal Elementary School in San Pablo Laguna is located in the southern portion and the largest province of Laguna. The green classroom built highlights a single sloped plain roofing with wide louver system for ventilation at its wide front opening . The louvered wall is protected by a metal exterior louver against gutsy winds. The louver system also served as lightning system during daytime since the sunlight can easily pass through. The aesthetic design

is integrated using *boulders* in the front wall. Based on the plan, there is a change in the slope orientation of the roof and the material used for external louver from coco lumber material to metal sheet material in the actual.

Figure 3: Mag-Asawang Sapa Elementary School, Sta. Maria, Bulacan Green Classroom

Mag-Asawang Sapa Elementary School is in Sta Maria Bulacan, situated 32 km from NorthEast of Manila at the Eastern portion of Bulacan. The peculiarity of the design lies on the louver system beneath the windows and wide louver ventilation created through difference in slope of roofs where one over extends another to allow an opening for the louvers. The walls are made of sawali from the outside and gypsum board in the inside. The studs for the wall and purlins are made of metal- C members.

Figure 4: Binauganan Elementary School, Binauganan Tarlac, Green Classroom

Binauganan Elementary School is in Tarlac within Region 3 in Luzon. The green classroom design in Tarlac appears to be the most unique among the green classrooms in Luzon. The classroom is made of 3 scrapped container vans joined together to form one classroom. The assembly of the container vans was made such that the floor and the roof of the classroom will be of 3 different levels. The ergonomic feature is seen on the design of ventilation at the 2 interface of union of the 3 container vans and on the multi-leveled floors of the classroom since it is elevated from the ground. Vines were planted on the sides to serve as insulation against heat due to the sunlight.

Figure 5: Gueco Balibago Elementary School, Angeles Pampanga

Gueco Balibago Elementary School is in Angeles Pampanga. Angeles City is locally classified as first class highly urbanized City. The uniqueness of the green classroom design in Angeles is found on its structural components. Almost all structural members are made of bamboo. The trusses are bamboo made as well as the wall studs. The wall is made of *sawali* and the roofing has its vent due to an elevated portion at the middle to allow heat exhaustion and cool air entry. Though the roof is conventionally made of GI sheets and the lower wall made of concrete.

Figure 6: Pawili ElementarySchool, Pawili Camarines Sur and Oro Site High School, Oro Site Legazpi City Green Classrooms

Pawili Elementary School and **Oro Site High School** are located in Camarines Sur and Legazpi City respectively. Both of these locations are found North of Luzon. The roof materials of these classrooms are made of *pawid* and GI sheets respectively, while the wall materials are made of concrete and composite concrete and *sawali* respectively. The main heat insulation in Pawili is through its roof and the surrounding trees, while in Oro Site, the insulation is in its wall and some trees. **The Niugan Elementary School** Green Classroom is in Cabuyao Laguna. As of this writing the Green Classroom in Cabuyao is not yet finished.

Figure 7: Niugan Elementary School Green Classrooom, Cabuyao Laguna

3.3 Interview Data

For the purpose of confidentiality, the following data on the specific cost of green classrooms visited in Luzon are not disclosed but given as follows:

Table 1: Total Cost of Labor / Materials and Duration of Green Classroom Construction

Green Classroom	*Total Construction Cost	Duration of Construction	Material Acquisition
A	Php 340,000.00	1.5 months	Local Construction Supplier
B	Php 350,000.00	2.0 months	Sourced from Local Products
C	Php 400,000.00	2.0 months	Sourced from Local Products
D	Php 450,000.00	3.0 months	Local Construction Supplier
E	Php 460,000.00	2.0 months	Sourced from Local Products
F	Php 320,000.00	4.5 months	Local Construction Supplier
G	Php 340,000.00	3.0 months	Local Construction Supplier
H	Php 300,000.00 (unfinished)	Not Applicable	Local Construction Supplier

**The Philippine Institute of Technology, PICE provided the Php 300,000.00 baseline budget for each project. Any excess needed to finish the green classroom were sourced from other financing agencies initiated by the local PICE Chapters.*

3.4 Data Derived from Questionnaires

The response taken from the pupils/students occupying the selected green classrooms were processed by clustering the question items according to the assessment area they belong, thereafter, the compounded scores were counted and then averaged. The clustered area of assessment are as follows: *Green Features* - Questions 4,10, 9 and 13, *Ergonomic Factors* - Questions 2, 3, 5, 11 and 6, *Aesthetic* - 1, 8 and 15, *Serviceability* - Questions 7 and 14, *Satisfaction* – Question 12. Based on the gathered data the responses in each assessed area were tabulated as shown:

Table 2: Mean Score for Green Classroom Area of Assessment

Green Classroom	Clustered Area of Assessment					TOTAL OF MEANS
	Green Feature	Ergonomic	Aesthetic	Serviceability	Satisfaction	
Naic Coastal National High School	2.69	2.81	3.42	3.00	0.0	11.92
San Cristobal Elementary School	3.65	4.26	4.54	4.78	4.70	21.93
Mag-Asawang Sapa Elementary School	4.00	4.75	4.67	5.00	0.00	18.42
Binauganan Elementary School	3.10	3.17	4.27	2.61	4.70	17.85
Gueco Balibago Elementary School	2.88	3.15	3.97	4.29	3.22	17.51
Pawili ElementarySchool	2.50	2.90	3.00	2.50	3.00	13.90
Oro Site High School	2.55	3.85	3.96	3.57	3.98	13.93
Niugan Elementary School	-	-	-	-	-	-

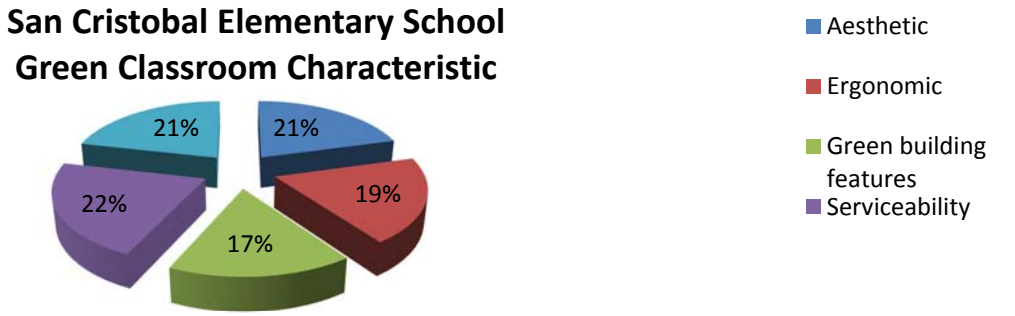

Figure 8: Percent Breakdown on the Characteristics of San Cristobal Elementary Green Classroom

The result shows that the classroom which obtained the highest rating based on the respondents' perception is the San Cristobal Elementary School green classroom in San Pablo City, Laguna. The breakdown on the classrooms characteristics is shown in Figure 8, where the serviceability ranks highest (22%) while the green feature as lowest (17%) in the pie chart.

3.5 Physical Measurement on Environmental Conditions Attributed to Ergonomic Factors

Standard measuring instruments yield the following data to compare the difference on environmental conditions between the green classroom and ordinary classroom in the school. Table 3 shows the temperature, humidity, luminance and sound level in the selected green as compared to the ordinary classroom within the school.

Table 3: Environmental Factors on Temperature, Humidity, Luminance and Sound level

Green Classroom	Temp (^{O}C)		Humidity (%)		Luminance (lux)		Sound level (dB)	
	GC	OC	GC	OC	GC	OC	GC	OC
Naic Coastal National High School	30	32	63	62	200	190	68.33	67.45
San Cristobal Elementary School	26	30	50	56	104	92	74.43	78.45
Mag-Asawang Sapa Elementary School	31	33	58	60	202	180	68.20	64.42
Binauganan Elementary School	33	32	55	55	112	120	82.77	80.15
Gueco Balibago Elementary School	32	34	51	55	250	234	67.5	52.50
Pawili ElementarySchool	28	32	73	52	46	96	70.63	78.10
Oro Site High School	28	31	65	53	163	177	70.67	82.33
Niugan Elementary School	-	-	-	-	-	-	-	-

GC – Green Classroom OC – Ordinary Classroom

Comparison on environmental condition between green classroom and ordinary classroom based on percent difference between the physical measurement on temperature, humidity, luminance and sound level is tabulated in Table 4:

Table 4 : Comparison Between Green Classroom and Ordinary Classroom Environmental Condition

Green Classroom	Compared Environmental Condition Between GC and OC											
	Temp (^{O}C)			Humidity (%)			Luminance (lux)			Sound level (dB)		
	Diff	Ave	% Diff	Diff	Ave	% Diff	Diff	Average	% Diff	Diff	Ave	% Diff
Naic Coastal National High School	-2	31	-6.45	1	62.5	1.6	10	195	5.13	0.88	67.89	1.30
San Cristobal Elementary School	-4	28	-14.29	-6	53	-11.32	12	98	12.24	-4.02	76.44	-5.26
Mag-Asawang Sapa Elementary School	-2	32	-6.25	-2	59	-3.39	22	191	11.51	3.78	66.31	5.7
Binauganan Elementary School	1	32.5	3.08	0	55	0	-8	-116	-6.90	2.62	81.46	3.22
Gueco Balibago Elementary School	-2	33	-6.06	-4	53	-7.54	16	242	6.61	15	60	25
Pawili ElementarySchool	-4	30	-13.33	21	62.5	33.6	-50	-71	-70.42	-7.47	74.37	-10.05
Oro Site High School	-3	29.5	-10.17	12	59	20.34	-14	-170	-8.23	-11.66	76.5	-15.24
Niugan Elementary School	-	-	-	-	-	-	-	-	-	-	-	-

*Difference = /GC – OC/ Average = (GC+OC)/2 % Difference = (Difference/Average)*100%*

Based on the results given in Table 4, the classroom which gave the largest discrepancy in terms of *temperature, humidity, luminance* and *sound level* is the San Cristobal Elementary School green classroom in San Pablo Laguna.

4. Conclusion

Though all of the green classrooms did not fully capture all the ideal features of a green classroom , each was able to showcase at least one or more features, like the use of sustainable covering materials on walls, maximization on the use of sunlight and wind, heat reduction using indigenous insulating materials like *sawali, bamboo and pawid*, and aesthetic in appearance combining uniqueness and creativity.

The missing green component common to all is the rain water harvesting system. Also, budget constraint in construction of green classrooms is validated based on the case in Niugan Cabuyao Laguna, which is still unfinished as of this writing. The total construction cost of a green classroom in Luzon ranges between Php 320,000.00 (around US$7,440.00) to Php 460,000.00 (around US$10,697.00) based on the data gathered from interview.

Results show that the green classroom of San Cristobal Elementary School in San Pablo Laguna has the highest score on the mean of green features and ergonomic factors, yielding a total mean score of 18.42 out of the perfect 25

points for the 5 point scale grading on 5 areas of assessment. Physical measurements attributing to the rating on ergonomic factors also points to the San Cristobal green classroom as the highest. The signed percent difference between the green classroom and ordinary classroom bears an ideal minus sign for temperature, humidity and sound level, while positive for luminance. These were all obtained by the San Pablo green classroom, turned out as highest on temperature, humidity and luminance's percent difference.

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Biography

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