Sustainable design guidelines for new and existing schools in Egypt

Sara Harb

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SUSTAINABLE DESIGN GUIDELINES FOR NEW AND EXISTING SCHOOLS IN EGYPT

A Thesis Submitted to Graduate Program in Sustainable Development in partial fulfillment of the requirements for the degree of Master of Science in Sustainable Development

by

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Abstract

As a global society, we are faced with an ever-growing number of sustainability challenges in the social, environmental and economic sectors. Visions for addressing such challenges have been put forward in international blueprints and policy agreements on advancing sustainable development. In these documents and agreements, education has been identified as a crucial avenue for pushing forward sustainable behaviors. Education is the fundamental element for the development of any nation, and its shortage has a direct effect on the social, environmental and economic development of the country (El Baradei & Baradei, 2004). Turning schools into sustainable schools has been a research and policy focus for years, especially throughout the UN Decade of Education for Sustainable Development. Building codes and practices play an important role in turning schools into places of sustainable learning and behavior. Previous research has addressed the concept of sustainable schools extensively, in the lights of the sustainable school design criteria and the positive impacts of having sustainable physical spaces for education. However, none cater for the Egyptian context, and are simultaneously based on building assessment standards, as well as the integration of appropriate social, environmental, and economic sustainability themes.

The research project explores the requirements of Egyptian schools in the implementation of sustainable school designs and architectural changes. The thesis takes a qualitative research method with an inductive approach, in which theory development is based on and evolves with the study’s findings. The thesis will make suggestions for the content of a new guideline, based on the available literature as well as on the analysis of detailed data collected based on the observation of school grounds and daily school routines and procedures during a series of school visits. The directing parameters of the guideline are based on sustainable building assessment guidelines, Egypt’s pressing social, economic and environmental concerns, pedagogy of educational environments, students’ social, psychological, and developmental needs, in order to develop a holistic framework. The guideline is divided into two main sections; new and existing schools. The guideline is further divided into three main sustainability categories: energy, water, and habitat; which is following the same category division adopted by EGGBC in the Tarsheed guidelines.

The procedures of the research use a case study approach that focuses on one public school in Cairo, Gamal Abd El-Nasser which is located in Bulaq El Dakrour (BD), one of the poorest informal areas located in the western urban area of Greater Cairo within the boundaries of Giza Governorate. Criteria for selecting the school as a case study included choosing a preparatory school where the overall school infrastructure and conditions were of medium quality standards, making the school a potential candidate for upgrading its school infrastructure and processes to become a sustainable school in the future. The developed guideline is implemented in the case study school to demonstrate the flexibility, affordability and simplicity of attaining the required credits within the guidelines. The school scores a total of 9 out of 26 points in the Energy category, 7 out of 18 points in the Water category, 3 out of 12 points in the Indoor Environmental Quality sub-category, 6 out of 6 points in the Materials
sub-category, and 36 out of 41 points in Sustainable Sites sub-category. This provides a sum of 56 out of 100 points, which awards the school a silver rating.
Acknowledgement

This research would not be possible without the contribution, motivation and dedication of a vast number of people, to whom I am deeply grateful.

Words are not enough to truly express my gratitude and thankfulness to the unwavering support of my two advisors Dr. Salah El-Haggar and Dr. Hani Sewilam. I'll be forever grateful for your gift of time, dedication, knowledge and support. I thank Dr. Salah El-Haggar for not only being my advisor but my teaching role model who leads by outstanding example of who I could only strive to be one day. I could not possibly express my gratitude to your guidance, patience and boundless encouragement.

I would like to seize this opportunity to thank Dr. Hani Sewilam for not hesitating in allowing me the opportunity to work on the EduCamp project, which has shaped the research outcomes in a profound way. Your endless support, guidance and most importantly your belief in me has driven me to aspire to achieve the highest standards of professional achievement.

I could not but genuinely thank my friends in the Center for Sustainable Development for their endless support, Khaled, Yomna, Ahmed, Hossam, Dina, Amira, and Dona; your technical advice and moral support were instrumental to the completion of this thesis. And Khaled, your effort, patience, and dedication to the program is commendable to not only me, but to every CSD graduate. I would also like to thank my friends, Amira and Reem for their infinite support, and Maha for her constant encouragement and devoting her time to proof-reading parts of this research.

Definitely, above all, special thanks and gratitude goes to my family. Without their emotional and moral support, this thesis would not have been possible. And since we must never forget that the highest appreciation is not to utter words, but to live by them. I would hope that I continue to make you proud.
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Chapter 1: Introduction

1.1. Background of the problem

The educational system in the Arab Republic of Egypt is the largest in the Middle East and North Africa (MENA) region (The World Bank, 2005). At the national level, the rapid growth of Egypt's population poses a serious challenge, and places additional burdens on the educational system. In 2017, Egypt's population reached 96 million, with 9.6 million in Cairo. In 2016-2017, and among 138 countries, Egypt ranked 89 in the basic requirements of health and education index, and 112 in the higher education and training index (CAPMAS, 2017). The key factors associated with the poor performance of the Egyptian educational system, are summarized in Table (1) (El Baradei & El Baradei, 2004):

<table>
<thead>
<tr>
<th>Key Factors</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial resources</td>
<td>• Scarcity financial resources</td>
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<td></td>
<td>• Absence of physical facilities</td>
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<td></td>
<td>• Ineffective utilization and allocation of resources</td>
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<td>Quality problems</td>
<td>• Private tutoring</td>
</tr>
<tr>
<td></td>
<td>• Overcrowded classrooms</td>
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<td>• High student/teacher ratio</td>
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<td>• High rates of grade repetition and dropouts</td>
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<td></td>
<td>• Textbooks and curricula</td>
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<td>Access to education</td>
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<td>• Gender inequality</td>
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<td>• Income inequality</td>
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<td>• Regional inequality</td>
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<td>Low economic returns on education</td>
<td>• Low-wage earnings</td>
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<td>• High household costs of education</td>
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<td>Management problems</td>
<td>• Absence of democracy and participation</td>
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<td>• Absence of scientific or reasonable decision making processes</td>
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<td>• Absence of effective systems and mechanisms for evaluating performance</td>
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<tr>
<td></td>
<td>• Overstaffing of the public administration agencies and organizations</td>
</tr>
<tr>
<td>Mismatch between the educational system and the labor market requirements</td>
<td>• Irrelevance of curricula</td>
</tr>
</tbody>
</table>
Educational reform has been a concerning matter to the Egyptian government since the early 1990s (El Baradei & El Baradei, 2004). In order to address the educational problems, several initiatives have instigated a quantitative expansion approach, rather than a qualitative one, which would focus on the quality of educational spaces. This is reflected in overcrowded classrooms, multiple-shift schools, poor school infrastructure and facilities, ineffective curricula, teaching tools and methods, in addition to incompetent teachers and school administrators (Ministry of Education, 2014). It thus comes as no surprise that the World Economic Forum classifies Egypt as one of the countries with the lowest quality of basic education. Egypt ranks 133 out of 137 countries, and 100 out of 137 in the global competitiveness index (World Economic Forum, 2017). This evaluation is reinforced by Said (2015), who estimates the annual rate of return on basic schooling in Egypt to be 1% for each academic year.

As shown in Figure (1), Egypt's public expenditure on education is high compared to countries of a similar national income. Therefore, the aforementioned problems, in addition to those displayed in Table (1), are in fact a result of ineffective and inefficient spending, rather than a shortage of resources (The World Bank, 2005).

![Figure (1): Egypt's public expenditure compared to other countries (The World Bank, 2005)](https://example.com/figure1.png)

Similarly, literature has shown that the infrastructure of school buildings is both underserved and inefficient (MENA Programme, 2012; The World Bank, 2005). Unfortunately, the infrastructure of school buildings is partly responsible for creating either a positive or an ineffective educational environment. Despite its important role for the educational process, educational infrastructure has been overlooked and given the least priority within the educational reform plans. The number of hours and years consumed within educational facilities should be sufficient to explore the physical environment's influence on children's educational attainment and behavior (Clark H., 2002).

The school building design and operation should be an expression of the ongoing search for solutions to the rising number of local and global challenges. The construction, operational and planning aspects of the campus should be manifested in the school design. From this
perspective, the campus would be congruous with the notion of sustainability. Inefficient structures constructed from energy-intensive materials and run on fossil fuels give off the impression that energy is cheap, the environment is not to be safeguarded, and natural resources are abundant. Similarly, the operation of a school campus reflects the philosophy of education that drives educational policy and practice: “In this way, our educational institutions teach us how we should act” (Rohwedder, 2004, 297). David Orr (1993, 226) highlights this pedagogical role in his claim:

“It is paradoxical that buildings on college and university campuses, places of intellect, characteristically show so little thought, imagination, sense of place, ecological awareness, and relation to any larger pedagogical intent.”

1.2. Research Questions

This research project is driven by a set of research questions that have informed the background research and literature review, as well as the design of the research methodology. These questions are:

1. How can the educational built environment, and the operation of the facility be congruous with the notion of sustainable development?
2. Which themes should be included within the proposed comprehensive sustainability framework for a more tangible and implementable building code for schools in Egypt?

1.3. Research Objective

The research seeks to develop a sustainability framework for an affordable and easily adapted design guideline, which addresses the educational built environment in Egypt, and will improve the sustainability of Egyptian schools. It aims to create responsible individuals capable of supporting a sustainable future, and thus has a subsequent direct effect on the sustainable development of the country. The developed guideline is implemented in one existing case study school to demonstrate the flexibility, affordability and simplicity of attaining the required credits within the guidelines.
1.4. Research Gap

As the literature review in this proposal will show, previous research has tackled the concept of sustainable schools extensively. This includes research on sustainable school design criteria and the positive impacts of having sustainable educational spaces. However, none of the suggested guidelines developed to help schools and educational ministries implement the proposed changes cater for the Egyptian context. Moreover, none of the existing guidelines are based on existing standards, and simultaneously safeguard the integration of appropriate social, environmental, and economic sustainability themes. This research will make an important contribution to developing a more appropriate sustainable building guideline for Egyptian schools by exploring current limitations to implementing sustainable school designs, by studying the situation, individual problems and needs of Egyptian schools, and by formulating a framework for an innovative, new guideline.

1.5. Research Methodology

The thesis takes a qualitative research method with an inductive approach, as substantial amount of data is collected and constitutes the basis of formulating the answers to the research questions. The research starts with the ways sustainability is defined in Egyptian schools using social, environmental and economic sustainability themes. These categories are compared with and contextualized in relation to international and local building assessment guidelines, such as LEED, BREEM, GPRS and Tarsheed. This thesis makes suggestions for the content of a new guideline, based on the available literature as well as on the analysis of detailed data collected based on the observation of school grounds and daily school routines and procedures during a series of school visits. The procedures of the research use a case study approach that focuses on one public school in Cairo, located in Boulaq El Dakrour (BD), one of the poorest informal areas located in the western urban area of Greater Cairo within the boundaries of Giza Governorate. Criteria for selecting the school as a case study included choosing a preparatory school where the overall school infrastructure and conditions were of medium quality standards, making the school a potential candidate for upgrading its school infrastructure and processes to become a sustainable school in the future.

The literature survey is tied with the collected data to develop a guideline which is simple, practical and easy to implement for Egyptian schools. The directing parameters of the guideline are based on sustainable building assessment guidelines, Egypt’s pressing social, economic and environmental concerns, pedagogy of educational environments, students’ social, psychological, and developmental needs, in order to develop a holistic framework. The guideline is divided into two main sections; new and existing schools. The guideline is further divided into three main sustainability categories: energy, water, and habitat; which is following the same category division adopted by EGGBC in the Tarsheed guidelines.
Chapter 2: Literature Review

2.1. Sustainable Development

As a global society, we are encountered with an ever-increasing amount of social, environmental and economic challenges. Currently more than 1 billion are still affected by basic food insecurity, whereas the unsustainable production and consumption patterns have led to massive economic and social damage (DESA, 2013). Therefore, even though conventional development has enhanced economic growth, it has failed in the social and environmental aspects. This led to a largely skewed distribution of income and resources favoring the rich in a ratio of 20/80, where developed countries comprising 20% of the global population, yet controlling 80% of the world income, and developing countries comprising 80% of the global population, are controlling only 20% of the world income (Salim, 2007). In addition, damage to the global environment has reached a critical level, which threatens to irreversibly modify the global ecosystems (DESA, 2013). Visions for addressing such challenges have been continuously addressed and developed. According to the United Nations (1987), the solution is to live and work sustainably, in order to fulfill the global peoples’ wants and needs, without degrading the natural resources which should be safeguarded for future generations use. Therefore, sustainable development must overhaul the conventional models of development, and balance the interests of social, environmental and economic aspects, drawing upon the interactive relationships between all three components (Castro 2004; Dale & Newman 2005; Salem 2007; and Sachs 2012). The term “sustainable development” was first endorsed by the Brundtland Report in 1987, and was defined as

“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, 41).

This was followed by Agenda 21 of the Earth Summit in Rio, through which countries committed to the advancement of sustainability through international cooperation, which addressed environmental concerns, education, poverty, hunger, ill health, and illiteracy (Tilbury, Stevenson, Fien, & Schreuder, 2002).

2.2. Education for Sustainable Development

International organizations have underlined the significant role that public awareness, training, and education have in achieving sustainable development (UNESCO, 2006). Dr. Mostafa Tolba, the Director of the United Nations Environment Programme stressed the importance of incorporating environmental education in schools as an imperative approach to face environmental challenges (UNESCO, 1977). The first internationally recognized definition of environmental education was drawn up in the International Union for the Conservation of Nature in Nevada (IUCN, 1970). It was defined as:
“A process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among humans, their culture and biophysical surroundings. Environmental education also entails practice in decision-making and self-formulation of a code of behaviors about issues concerning environmental quality”.

Moreover, in 1974, the UNESCO and UNEP sponsored a conference in Belgrade, which introduced environmental education through a global succession of national and regional meetings, which established the basis for the Intergovernmental conference on Environmental Education in Tbilisi in 1977. The Tbilisi declaration advocated for environmental education:

“(a) to foster clear awareness of, and concern about, economic, social, and political interdependence in urban and rural areas;

(b) to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;

(c) to create new patterns of behavior of individuals, groups and society as a whole towards the environment” (UNESCO-UNEP, 1978,3).

There was a prevalent adoption of environmental education in school systems globally, which included the development of curriculum and educational materials and the revision of syllabi to introduce the environmental aspect. Unfortunately, as critical voices have pointed out, the objectives of critical thinking, ethical obligation, active citizenship, and well-versed understanding called for by the Tbilisi conference were ignored by educators, until they were progressively removed from the curriculum. However, in the 1990s as the concern for poverty reduction raised more attention, a ‘second wave’ of environmental education emerged. This was discussed in the Agenda 21 report, in chapter 36 of the 1992 United Nations Conference on Environment and Development (UNCED), the Earth Summit, which discussed the pivotal role environmental education, plays in sustainability:

“Education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues...It is critical for achieving environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainable development and for effective public participation in decision-making (UNCED 1992, 2)”. 

During the 1990s, environmental education was superseded by education for sustainable development (ESD). It is based on the same principles; however, its focal concern is diverting education towards sustainable development, instead of just environmental sustainability. It
denotes the power education holds in altering student's behavior, in order to prepare them to be responsible individuals capable of supporting a sustainable future (UNCED, 1992). In 1996, The Commission on Sustainable Development (CSD), established by the United Nations to supervise the decisions of the UNCED, declared the importance of education for sustainable development as a means to amend the patterns of unsustainable consumption and production (UNESCO-UNEP, 1996). In December 2002, the United Nations General Assembly launched the 'Decade of Education for Sustainable Development', from 2005 to 2014. The implementation of the goals defined for this decade demands the efforts and cooperation of governments, international organizations, educational institutes, associations, communities, private sectors and citizens. The purpose of the initiative was to endorse and promote quality education, revise educational programs, spread public understanding and awareness, and provide practical training. The Decade also seeks to collaborate with other previous global initiatives, such as the Millennium Development Goals (MDGS), which addressed poverty reduction, Education for All (EFA) that focused on the universal access to education, and the United Nations Literacy Decade (UNLD), which targeted the provision of education to adults. All initiatives have a shared vision: education is a fundamental element of sustainable development (UNESCO, 2005).

In the ESD Toolkit, the UNESCO states the difficulty for communities to integrate all of the aspects discussed in Agenda 21, UN conferences and major conventions within a single ESD curriculum. Therefore, they should selectively choose the environmental, social, or economic aspects issues to include based on the local relevance within the community (UNESCO, 2006). Researchers such as Brković (2013) conclude that educational reform in a country is subsequently linked with the curriculum, teacher's educational methods, local educational goals and governance, availability of contemporary teaching methods, and the educational built environment. As previously reasoned, the built environment also plays a significant role in the way education shapes the school environment, and contributes to the sustainability of education. Sustainable schools are not only based on a design that saves energy and uses environmentally friendly materials, but they are also designed for students to learn in healthy, comfortable and positive school environments that teach sustainable practices.

Throughout this thesis, the educational built environment is considered to be comprised of: the architectural design of the school, and its operations, as well as the outdoor spaces enclosed within the school boundary. Looked at from this perspective, architects play a critical role in addressing the emerging number of social, environmental and economic challenges, and thus hold the role of educators (Papanek, 2009). As Gough (2005, 349) argues, a “…sustainable school is a most appropriate strategy for renovating educational processes and achieving quality education”. 

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2.3. Sustainable schools

Globally, building construction and operation account for 40% of the world’s energy usage, 30% of raw material consumption, 16% of fresh water removal, 35% of carbon dioxide emissions, 55% of harvested timber, and 40% of the municipal solid waste production, which is ultimately sent to landfills. These impacts are detrimental, since buildings have a long life cycle, and once a building is operational, its environmental footprint is not easily altered (Roodman & Lenssen, 1995). In addition, the Energy Information Administration forecasts reveal that the energy usage in buildings is estimated to increase by 32% between 2015 and 2040 (Energy Information Administration, 2017). In recognition of these impacts, there has been a significant development of diverse schemes to incorporate environmentally friendly materials and technology in the construction sector; which brings about the notion of green design and sustainable design (Fenner & Ryce, 2008).

Throughout the literature, the expressions ‘green’ and ‘sustainable’ are used conversely. This interchangeable use of terms has led to some confusion as to how green school designs are defined as opposed to sustainable school designs. Olson and Kellum (2003) state that “[s]ustainable schools, also referred to as green or high performance schools(…)”. Similarly, Taylor et al. (2013) propose a green schools approach that, despite not being labelled as sustainable schools, addresses the three pillars of sustainability. Huckle traces the inconsistency in terminology to “.. a lack of clarity in the meaning of … and even sustainability” (2010). Green buildings are defined by Earthman (2009) as mechanisms which conserve energy and water, and are constructed from environmentally-friendly materials. Bharma and Lofthouse (2007), in turn, note that green schools have a single focal point, for example the use of recycled materials. Fenner (2008, 55) underlines the environmental aspect too, by reflecting upon green buildings as:

“... structures that incorporate environmentally sensitive features and technologies from the initial design phase; they seek to meet or exceed resource and energy consumption targets that are set well above local requirements while taking into account the whole life cycle impact of the structure.”

Hence, green schools could be defined as having a strictly environmental focus, whereas sustainable schools are concerned with the impact of the school building on the three pillars of sustainability. To contribute to the clarity of the proposed discussion, since green design is involved with the environmental impact of the school building, it could be considered to be just a subset of sustainable design (Lippman, 2010). Appropriately, a sustainable school has been described by Stole (2010) to entail a whole system strategic approach that includes an understanding of the social, economic and environmental aspects, which should be addressed through the school design. A whole system approach also implies that sustainable schools require a holistic modification of the schools curriculum, teaching, operations, management of resources (i.e. water, energy, waste), and school's internal and external
relationships, in order to transition the school towards sustainability (Jensen, 2005). This entails the translation of sustainability principles, such as equity, deference, and democracy into the school curriculum through pedagogical practices, which will have an impact on the students' learning and engagement (Kadji-Beltran, Zachariou, & Stevenson, 2013).
2.4. Worldwide Green Building Rating Systems

Building assessment methods were introduced as environmental issues become more urgent, and in recognition of the building and construction industries’ accountability towards global energy usage, raw material consumption, fresh water removal, carbon dioxide emissions, harvested timber, and municipal solid waste production (Roodman & Lenssen, 1995). Since their introduction in the 1990s, building rating systems have emphasized the importance of green building practice, and have increased the awareness of environmental issues (Fenner & Ryce, 2008). Correspondingly, Ding (2008) states that more inclusive building assessment methods are needed in order to evaluate the environmental impact of building’s performance. In addition, by endorsing a comprehensive design approach, building assessment methods draw upon the multi-faceted association between the building’s construction, operation and consequential impact on the environment and human health (Trusty & Horst, 2002).

According to Fenner and Ryce (2008), building rating systems are comprised of three stages:

1. **Classification:** Inputs (e.g. resources) and outputs (waste generated) are allocated to various impact categories (resource depletion) based on the environmental change expectations.

2. **Characterization:** The effect of each input and output is identified relative to its impact category.

3. **Valuation:** Category weighting in accordance with other categories.

Even though building assessment systems contribute to the decrease of ‘unsustainable’ building practices, they do not necessarily promote the creation of sustainable buildings. Since rating systems predominantly address environmental impacts, but fail to tackle both social and economic aspects adequately,…. (Ferner & Ryce, 2008; Sev, 2009; Berardi, 2012). Awadah’s (2017) analysis of four of the most popular TQA systems: BREEAM, LEED, GSAS and Estidama, reveals that all four rating systems have a particular emphasis on the environmental pillar. In addition, LEED has not attributed any weight to the economic pillar. Similarly, BREEM, GSAS and Estidama have given very little importance to the economic credits. BREEAM allocates only 19% of the available points to the social pillar; GSAS gives it around 13%, whereas LEED and Estidama allocate less than 10% of the system’s points to social credits (Awadah, 2017).

According to Hastings and Wall (2007) building assessment systems can be categorized into:

1. **Cumulative Energy Demand (CED) systems:** Evaluation of energy consumption.

2. **Life Cycle Analysis (LCA) system:** Evaluation of environmental aspects.
3. **Total Quality Assessment (TQA) systems:** Evaluation of three aspects of building sustainability: social, economic, and environmental.

CED and LCA have qualitative approaches to building assessment, whereas TQA systems have a quantitative approach (Berardi, 2013).

**The British Building Research Establishment Environmental Assessment Method (BREEAM)**

The United Kingdom was the first country to release its TQA system, in 1993. The British Building Research Establishment Environmental Assessment Method (BREEAM) is widely spread in the United Kingdom. The system has been largely distributed in the United Kingdom, and is the most commonly applied environmental assessment method for buildings. Since 2009, an international version of BREEAM has been adapted for use in Canada, Hong Kong, and Australia (Berardi, 2013). It is currently applied in over 50 countries, and has certified over 260,000 buildings (BRE, 2014). The system consists of four rating schemes which assess the building’s environmental performance at various stages of its life cycle, and includes numerous building typologies: communities, courts, education, health care, homes, industrial, international, multi-residential, offices, prisons, and (BRE, 2014). Table (2) illustrates the weighting of the assessment categories in the BREEAM, where the highest weighting is allocated in the energy category. There are five certification levels, referred to as BREEAM rating benchmarks; the highest is outstanding with ≥ 85% of the total credits, and the lowest is pass with ≥ 30% of the allocated credits (BRE, 2014).

<table>
<thead>
<tr>
<th>Environmental section</th>
<th>Category Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>12%</td>
</tr>
<tr>
<td>Health &amp; Wellbeing</td>
<td>15%</td>
</tr>
<tr>
<td>Energy</td>
<td>15%</td>
</tr>
<tr>
<td>Transport</td>
<td>9%</td>
</tr>
<tr>
<td>Water</td>
<td>7%</td>
</tr>
<tr>
<td>Materials</td>
<td>13.5%</td>
</tr>
<tr>
<td>Waste</td>
<td>8.5%</td>
</tr>
<tr>
<td>Land use &amp; Ecology</td>
<td>10%</td>
</tr>
<tr>
<td>Pollution</td>
<td>10%</td>
</tr>
<tr>
<td>Innovation (additional)</td>
<td>10%</td>
</tr>
</tbody>
</table>
Leadership in Energy and Environmental Design (LEED)

The U.S. Green Building Council (USGBC), a non-profit organization established in 1993, released the first pilot version of Leadership in Energy and Environmental Design (LEED) in 1998. The latest LEED release, LEED v4 was released in November 2013. It includes some minor and some substantial modifications to the LEED 2009 credits. The changes take into consideration the need for improved materials, enhanced water efficiency, and accounts for human experience, in order to reduce building’s carbon emissions, and emphasize the importance of human health. In addition, flexibility, and adaptability to different locations and building types is an integral part of the LEED v4. To date, LEED projects are found in more than 140 countries worldwide. The LEED rating system assesses eight areas: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in design, and regional priority. There are four possible levels of certification in the LEED: (1) Certified, (2) Silver, (3) Gold, and (4) Platinum. A minimum of 40-49 credits are required for buildings to be “LEED certified”, whereas a project with 50-59 credits will receive the “Silver” certification, correspondingly a project with 60-79 credits will receive the “Gold” certification. A project with 80 credits and more would be rewarded the highest level of certification, the “Platinum”. Additionally, LEED v4 is applicable for use by 21 market sectors, and is divided into several main categories: LEED for Building Design and Construction, LEED for Interior Design and Construction, LEED for Homes, LEED for Building Operations and Maintenance, and LEED for Neighborhoods (USGBC, 2014).

The Green Pyramid Rating System (GPRS)

The Egyptian Green Building Council (EGBC) presented the Green Pyramid rating system (GPRS) in 2009. It was introduced in correspondence with an initiative by the Housing and Building National Research Center, represented in the Ministry of Housing, Utilities and Urban development, to promote green buildings, as an integral component of its sustainable development policies (The Housing and Building National Research Center, 2011). The GPRS is developed from the LEED green building rating system, and is therefore similarly based on credit weightings divided under the same six categories: sustainable sites, energy, water, materials and resources, indoor environment, and innovation. However, the innovation category exists as a bonus category, with no prerequisites. In addition, management is an additional category, and is not included in the LEED standards. The main objectives of the GPRS are to provide a baseline through which buildings in Egypt can be assessed based on their fulfillment of green qualifications, through a clear, reliable and practical environmental rating system. The GPRS does not intend to exist in isolation, but to enhance the national standard regulations. It attempts to do so through encouraging the design and construction of sustainable buildings, which were constructed using innovative construction solutions, with a minimal, the impact on the environment, and on the general well-being of the community as a
whole. Raising public awareness among designers, constructors, and developers is considered the steering factor behind the attainment of such goals. It includes awareness of resource scarcity, benefits of sustainable buildings and best building construction and operational practices (The Housing and Building National Research Center, 2011).

The credits are allocated points based on their relative importance based on the environmental impacts and human benefits of each credit within the existing Egyptian context. Table (3) illustrates the credits weighting of the different categories in the GPRS, where the highest weighting is allocated in the water efficiency category. Similar to the LEED standards, each category has prerequisites, or mandatory minimum requirements, which must be attained in order to obtain the allocated credits within each category. In addition, a building should satisfy the Egyptian National Codes in order to qualify for Green Pyramid assessment. There are four levels of certification in the GPRS: (1) Green Pyramid, (2) Gold Pyramid, (3) Silver Pyramid, and (4) GPRS certified. A minimum of 40-49 credits are required for new construction buildings to be “GPRS certified”, whereas a project with 50-59 credits will receive the “Silver Pyramid”, correspondingly a project with 60-70 credits will receive the “Gold Pyramid”. A project with 80 credits and more would be rewarded the highest level of certification, the “Green Pyramid” (The Housing and Building National Research Center, 2011).

<table>
<thead>
<tr>
<th>Green Pyramid Category</th>
<th>Category Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable Site, Accessibility, Ecology</td>
<td>15%</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>25%</td>
</tr>
<tr>
<td>Water Efficiency</td>
<td>30%</td>
</tr>
<tr>
<td>Materials and Resources</td>
<td>10%</td>
</tr>
<tr>
<td>Indoor Environmental Quality</td>
<td>10%</td>
</tr>
<tr>
<td>Management</td>
<td>10%</td>
</tr>
<tr>
<td>Innovation and Added Value</td>
<td>Bonus</td>
</tr>
</tbody>
</table>

Table (3); Category weighting of GPRS categories (The Housing and Building National Research Center, 2011)
TARSHEED

TARSHEED is a Green Building rating system developed and managed by The Egypt Green Building Council (EGGBC), which is a registered non-governmental organization, under the Ministry of Social Solidarity. EGGBC was founded in November 2012, and is a potential member of the World Green Building Council (WGBC). The EGGBC’s mission is to promote sustainability and sustainable buildings by increasing public awareness and shifting the market practice towards green buildings through the use of innovation, and ongoing development in the field of sustainable practices. In addition to the development of TARSHEED, EGGBC’s programs include education and research, and community outreach.

TARSHEED was developed after studying green building rating systems worldwide, which led to the conclusion that these systems cannot lead a market transformation in Egypt. Therefore, an easy, simple, affordable, rating system catered for the Egyptian market and developing countries is required (EGGBC, 2016). TARSHEED v1.0 issued in October 2015 addresses residential buildings, and has only three categories: (1) Energy; consists of 18 credits, (2) Water; consists of 7 credits, and (3) Habitat; consists of 19 credits. In order for a project to become TARSHEED certified, it has to attain a minimum of 20% reduction beyond the baseline set for the credits in energy, water and habitat within each category. The rating system is comprised of two stages: (1) initial assessment at the design stage, and (2) final assessment during the construction and handover of the project (EGGBC, 2016).

Building assessment methods provide a valuable method in conveying sustainability principles to building design. However, they do not consider the environmental, and in particular both social and economic conditions within the building’s direct context in the required way, which would contribute towards the sustainable development of the country. In addition they do not integrate other imperative parameters necessary for the effective learning and development of students, which is comprised of, but not limited to, the spatial environment. This includes the classroom density, arrangement and aesthetics of educational spaces and ergonomics of school furniture, visual environment; which includes the psychological effects of classroom colors and their role in creating an optimal learning environment. There is currently no rating system for schools in Egypt. An innovative sustainable school building guide for Egypt would help Egyptian schools create educational built environments that not only improve the sustainability of the schools’ operations, but also help shape educational spaces in which responsible individuals capable of supporting a sustainable future can thrive. The proposed guideline would cater for the Egyptian context, and would integrate building assessment guidelines such as the LEED for Schools, with the appropriate social, environmental, and economic sustainability parameters. In addition to incorporating further sustainability themes essential to the development of a sustainable educational learning environment as mentioned briefly earlier, the proposed guideline will be based on data generated through a thorough literature review, as well as data collected in a case study school in Boulaq El-Dakrour.
2.5. Relationship Between Architecture, Education & Society

Sustainable built environments for education are not only a prerequisite for sustainable development, but also shape the formation of citizens and society more broadly. Thus, the design of educational spaces plays an important role in the formation of a sustainable culture. Papanek (2009) claims that “[a]ll design is education of a sort. It may be education by studying or teaching at a school or university, or it may be education through design”. Brković (year, page number), in turn, analyzes the origin of both words, “building” and “education” in an attempt to draw a correlation between both. “Building” is defined as making, producing, and giving something shape. Similarly “education” is described as shaping human beings. Furthermore, he provides a deeper association between both terms by relating to the Latin terminologies. The word “build” is related to the word “colere”, from which the world “culture” originated, and means to “improve”, or “to care”, which is parallel to the social purpose of education (Brković, 2013). In addition, Taylor (2009) states that “[a]rchitects are educators of the environment, aesthetics, and creativity (...)” whereas “[e]ducators are designers of the mind.” The problem lies in architects not grasping the imperative role they have as educators within their design responsibilities (Elseragy, Gabr, & Elnokaly, 2011; Brković, 2013). The school design should exist as a physical response to the snowballing social, economic and environmental problems in both the global and regional context (Reynolds & Cavanagh, 2009; Elseragy, Gabr, & Elnokaly, 2011).

It is therefore essential to understand that the student’s learning experience is influenced by much more than the curriculum (Papanek, 2009; Elseragy, Gabr, & Elnokaly, 2011; Mcmillin & Dyball, 2009). Goldberger (2011) adds that the school can act as a lesson, in which its buildings can make student’s feel and think. Since numerous lessons are embedded within the educational physical environment, Rohwedder (2004) considers the school buildings as a ‘pedagogy of place’. Therefore, an educational campus could be considered to consist of both a “built environment” which includes buildings and landscapes, and a “learning environment” comprised of students, faculty, and classrooms; in which the relationship between both environments is pedagogic. Taylor (2009) explores a philosophy of education which considers the school’s physical environment as a silent curriculum that affects learning. She proposes a philosophical framework which is based on an assimilation between the architect’s design knowledge and the interdisciplinary education and student’s developmental requirements and educational methods. In addition, teachers, parents and students should expand their understanding of the built, natural and cultural environment associated with the school building and its role as a teaching tool. The ability to “read” the environment sets forwards what Taylor (2009) refers to as the “knowing eye”, and describes it as “a visual literacy that opens eyes and minds to the ideas and principles that are embedded in and govern the physical world, and that constitute the order in the universe.” The philosophical framework is based on five key points through which (Taylor, 2009) links architecture and education:
1. **Aesthetics and a philosophical frame of reference.**

The interdisciplinary order of the universe entails that humans are an integral part of it, and should therefore function within the ecological sustainability cycle. In addition, the quality of the physical environment is directly linked with the quality of learning, and a role reversal is allowed between teachers and architects when the suitable professional development is provided to both.

2. **Developing and using a curricular organizing system to govern the school facility planning and development process:**

The school design should respond to the student’s developmental needs, in terms of their body, mind and spirit, and should be manifested through the (1) health and safety codes, (2) functional support, and (3) psychological well-being and aesthetic contentment.

3. **Designing and learning from the environment as a three-dimensional textbook:**

The built, natural, and cultural environment deliver an educational value equivalent to that taught in subject matters. They also represent the ideas, laws, and principles which should be understood about the universe. In addition, the development of the “knowing eye” through the school design allows the students to not just learn, but also develop a thorough understanding of the relationship between them and the world, and its’ stewardship.

4. **Aiming for the future:**

Learning environments should be future-oriented in terms of the provision of a technology design center, flexible furniture, support structures for various age groups and sizes, and the variety of settings which allow for hands-on learning activities. In addition, instructional methods should correspond to the teacher’s professional development plans, and should expand to include various professionals into the school’s expertise bank to enhance the student’s learning experiences, such as including architects, doctors, lawyers, and artists. The school grounds should also be involved in the learning experience, by considering the outdoors spaces as “learning landscapes” for kinesthetic, academic, and ecological learning. This also extends to areas outside the school boundaries, in which areas of lands surrounding the school could be productive gardens which provide food for the students.
5. *Fostering ecological stewardship by nurturing the individual, the community and the world:*

The school does not function in isolation to its surrounding community, and should exist as a fundamental tool which maintains a democratic paradigm of participation, multiculturalism and equality. This could be through the school building serving as a community center which functions as an actual learning environment. In addition, the ecologically responsive design of schools fosters a sense of belonging and stewardship for prospective generations. The prominent role of school buildings expands to encompassing society as a whole, with a direct influence on community standards, and not just educational standards. Sustainable schools that respond to the social and economic conditions of the community have the capacity to influence the social behavior of students. This enhances the connection between them and the school bringing about the desired sense of belonging and collaboration between both the students and the surrounding community (Elseragy, Gabr, & Elnokaly, 2011). Türkkahraman (2012) refers to education as a process existing within a society, and not just an institution.

The main objective of educational systems are to maintain individual and societal improvement within the community through both tangible and moral extents. Therefore, the importance of educational facilities lies in their role in preventing the downfall of social and economic conditions within the community (Türkkahraman, 2012).

At the start of this proposal, it was outlined that Egypt is struggling to create and maintain a level of education that is not only available to all, but that also adheres to certain quality standards. The built environment, as it was shown, is often neglected as an important factor that shapes educational spaces, processes, atmospheres, and through them cultures and citizens. This research is concerned with the implementation of more sustainable built environments in the educational context in Egypt. In order to develop building guidelines that are more in tune with Egypt's social, cultural and infrastructural context, this research projects sets out to study the parameters that drive and hinder the implementation of sustainable building measures, looking at one school in particular. The following section outlines the research methodology of this research project in more detail.
Chapter 3: Proposed Guidelines of New and Existing Sustainable Schools

3.1. Introduction

The guideline is divided into two main sections; new and existing schools. The guideline is further divided into three main sustainability categories: energy, water, and habitat; which is following the same category division adopted by EGGBC in the Tarsheed guidelines. However, the habitat category is further divided into three sub-categories: indoor environmental quality, materials and sustainable sites. The criteria governing the proposed guidelines are affordability, simplicity, and flexibility. The rating system for the proposed guidelines are comprised of four levels as shown in Table (4).

Table (4): Proposed Guideline Rating System

<table>
<thead>
<tr>
<th>Certification Level</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze</td>
<td>40-49</td>
</tr>
<tr>
<td>Silver</td>
<td>50-59</td>
</tr>
<tr>
<td>Gold</td>
<td>60-69</td>
</tr>
<tr>
<td>Platinum</td>
<td>70 +</td>
</tr>
</tbody>
</table>

New and existing buildings should satisfy minimum requirements for design and construction according to national building codes. Therefore, the guidelines do not replace the existing codes, but are considered a supplementary document which is only used to rate the educational built environment, and the operation of the facility from a sustainable perspective. Credit weights are tentative where the logic behind grading sustainability measures is based on the importance of the credit within the educational environment and the Egyptian context, based on practice and the available literature.

Education and awareness program and innovation and creativity credits are given the largest weights given their pivotal role in an educational environment. Education is considered as an essential component of environmental awareness. Accordingly, through the five education and awareness programs the important connection between educational development and the sustainable learning environment is established. Such a connection is linked to the ability to transform fundamental knowledge into conscious action which empowers students to become ambassadors of sustainable development. The pivotal role of community collaboration in sustainable development is stressed upon by its allocation of numerous points across various credits; in order to broaden both the sustainable and scientific horizon of the community as a whole. Innovation and creativity credits are present within each of the three categories since creative solutions and notions are key components in our present knowledge-driven economy. Accordingly, the cultivation of creative learning and problem solving in the early school years allows students to develop higher order thinking.
processes which are required to create creative leaders in the future. It is not possible to do so without expanding beyond the conventional text-based learning approach and adopting more creative learning processes.

The philosophy behind the credit attainment process in new and existing schools is addressed in a way which considers the importance and ease or difficulty of credit attainment in both new schools and existing schools independently. In the sense that some credits are more difficult to achieve in existing schools than new schools, and some credits are more important to be achieved in existing schools than new schools. In the guidelines, in the case of Credit SS-03: Municipal Solid Waste Management, and Credit SS-04 Organic Waste Management, 4 and 3 points respectively were awarded for new schools, whereas 5 points were awarded for existing schools. This variation in credit weights was placed with the rationale that setting up a waste management system, and conducting waste audits in existing schools is more challenging than in new schools. In addition, in Credit SS08: Outdoor Playground Design, 3 and 5 points are allocated for new and existing schools respectively. Similarly, the justification in this case is that more planning efforts should be exerted in renovating the design an existing outdoor playground than creating an entirely new one, and it is more challenging to incorporate indoor classes with the outdoor spaces in existing schools than in new schools.

The proposed guideline makes an important contribution to research by transcending from the logic of basic credit attainment through a tabulated category and credit list, into a more experiential, changeable logical idea of sustainability in development, which is based on varying parameters which shape the credit attainment process. Such parameters include Egypt's pressing social, economic and environmental concerns, pedagogy of educational environments, and students' social, psychological, and developmental needs.
# 3.2. Guidelines of New and Existing Schools Checklist

## Table (5): Sustainable Guidelines of New and Existing Schools Checklist

<table>
<thead>
<tr>
<th>Energy</th>
<th>Possible Points:</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Y</td>
<td>Prerequisite E-01 Energy Management Plan</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Y</td>
<td>Prerequisite E-02 Commissioning</td>
<td>Required</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>E-03 On-Site Renewable Energy</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>E-04 Energy Metering</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>E-05 External Shading Devices</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>E-06 Building Controls Systems</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>E-07 External Wall Insulation</td>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>E-08 Roof Insulation</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Credit</td>
<td>E-09 High Performance Windows and Glazing</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>E-10 Window-Wall Ratio</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>E-11 Reflective Wall Coatings</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>E-12 Air Tightness</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>E-13 Energy Efficient Lighting</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>E-14 Pump Motor Efficiency</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>E-15 Energy Efficient HVAC Systems</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>E-16 Innovation and Creativity in Energy</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water</th>
<th>Possible Points:</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Prerequisite W-01 Integrated Water and Wastewater Management Plan</td>
<td>Required</td>
</tr>
<tr>
<td></td>
<td>W-02 Water Saving Devices</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>W-03 Water Metering</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>W-04 Water Efficient Landscaping</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>W-05 Treatment and Reuse of Greywater</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>W-06 Rain Water and AC Condensate Harvesting</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>W-07 Innovation and Creativity in Water</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indoor Environmental Quality</th>
<th>Possible Points:</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Prerequisite IEQ-01 Environmental Tobacco Smoke (ETS) Control Plan</td>
<td>Required</td>
</tr>
<tr>
<td>Y</td>
<td>Prerequisite IEQ-02 Construction Activity Pollution Prevention Plan</td>
<td>Required</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-03 Acoustical Performance</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-04 Indoor Chemical and Pollutant Source Control</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-05 Natural Ventilation</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-06 Daylight</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-07 Effective Seating Arrangements</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-08 Psychology of Color in the Educational Environment</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials</th>
<th>Possible Points:</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
<td>MAT-01 Local Materials</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>MAT-02 Low VOC Materials</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sustainable Sites</th>
<th>Possible Points:</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Prerequisite SS-01 Integrated Solid Waste Management Plan</td>
<td>Required</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-02 Construction Waste Management</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-03 Municipal Solid Waste Management</td>
<td>4</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-04 Organic Waste Management</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-05 Design for People with Special Educational Needs</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-06 Protect and/or Restore Existing Trees</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-07 Outdoor Playground Design</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-08 School Building Orientation</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-09 Safety and Security</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-10 Sustainability Expert</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-11 Education &amp; Awareness Program</td>
<td>6</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-12 Preventive and Corrective Maintenance</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-13 Innovation and Creativity in Habitat</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Totals</th>
<th>100</th>
</tr>
</thead>
</table>

Bronze: 40-49 points, Silver: 50-59 points, Gold: 60-69 points, Platinum: 70+ points
3.3. Energy

The notion of energy security is a fundamental element for achieving sustainable development in Egypt (El-Khayat & Ameen, 2011). Due to rapid urbanization and economic growth, studies indicate that the energy demand in Egypt is increasing at an estimated rate of 1500 to 2000 MW a year, which has led to severe power shortages and blackouts over the previous years (Comsan, 2010). The global contribution from the building sector represents a very high energy consumption percentage, reaching figures between 20-40% of the global energy demand in developed countries, which exceeds other major economic sectors such as industrial and transportation (Pérez-Lombard, Ortiz, & Pout, 2008). The educational sector depicts an immense source of energy wastage. According to the US Environmental Protection Agency and the US Department of Energy approximately 30% of the overall school energy budget is wasted (Doulgeropoulos, 2015), which amounts to an equivalent of $12 per square foot, and between $100,000 to $400,000 annually (Kats, 2006). Table (6) displays the prerequisites and credits comprised within the energy category.

Table (6): Energy category prerequisites and credits

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>Possible Points</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisite E-01 Energy Management Plan</td>
<td>Required</td>
<td>Required</td>
<td></td>
</tr>
<tr>
<td>Prerequisite E-02 Commissioning</td>
<td>Required</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Credit E-03 On-site Renewable Energy</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Credit E-04 Energy Metering</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Credit E-05 External Shading Devices</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Credit E-06 Building Controls Systems</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Credit E-07 External Wall Insulation</td>
<td>2</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Credit E-08 Roof Insulation</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Credit E-09 High Performance Windows and Glazing</td>
<td>1</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Credit E-10 Window-Wall Ratio</td>
<td>1</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Credit E-11 Reflective Wall Coatings</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Credit E-12 Air Tightness</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Credit E-13 Energy Efficient Lighting</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Credit E-14 Pump Motor Efficiency</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Credit E-15 Energy Efficient HVAC Systems</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Credit E-16 Innovation and Creativity in Energy</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>30</td>
<td>26</td>
<td></td>
</tr>
</tbody>
</table>
E-01 Prerequisite: Energy Management Plan

The overall goal of the energy management plan is to decrease the school utility costs by continuously improving the energy performance of its facilities. The key drivers of energy management in schools include: potential cost savings; reduced environmental impact, as the decrease in energy demand reduces the production of greenhouse gases, reduces air pollution, reduces the amount of mercury in the environment, reduces the disruption of aquatic environments, and reduces the environmental damage resulting from the consumption and transportation of fossil fuels; benefits beyond the school locale, as students apply and disseminate the energy conservation understandings learned in school with their families, thus magnifying the associated advantages through residential energy conservation; and learning and leadership opportunities for students through their interaction with the design and operating procedures of the school facility (Crosby & Metzger, 2013).

Intent
Provide a framework for the long-term and short-term strategic management of electricity consumption across the focus areas identified within the energy category credits.

Requirements
Develop an energy management plan which may include the following:

- Discuss how the energy management plan will be implemented.
- Describe the energy management objectives.
- Define the incremental stages of progress towards the energy management plan objectives and their implementation schedule.
- Describe the necessary funding and resources.
- Describe strategy for an education awareness approach on the importance of energy conservation across the focus areas identified within the energy category credits.
E-02 Prerequisite: Commissioning

Building commissioning is a quality assurance process to evaluate, and document that the performance of buildings, systems and assemblies are planned, designed, installed, tested, operated, and maintained in accordance with defined objectives and criteria (ASHRAE, 2012). As illustrated in Figure (2), the commissioning process starts from the pre-design phase through to the occupancy and operation phase, and ensures that the new building’s operation is in accordance with the owner’s project requirements, and that the building’s staff are adequately trained to run and maintain the building’s systems and equipment. As illustrated in Figure (3), retro-commissioning is the application of the commissioning procedure to existing buildings to enhance its overall performance, by improving a building’s operation and maintenance (O&M), through identifying and resolving operational issues of the building equipment and systems that occurred during the design, construction, or occupancy phase (Mills, 2009).

Figure (3): Commissioning process overview (Mills, 2009)  
Figure (2): Retro-commissioning process overview (Mills, 2009)
The commissioning processes can provide substantial social, economic, and environmental benefits. Findings by Mills (2009) demonstrate that commissioning is one of the most cost-effective means of improved energy efficiency, decreased operation costs, maintenance costs and greenhouse gas emissions in buildings. Results from the study indicate that the average cost to deliver commissioning for existing and new buildings was $3/m² and $12/m² respectively, whereas further studies demonstrated 16% and 13% energy savings in existing and new buildings respectively, upon the implementation of commissioning processes. Furthermore, the average payback period for a sample of 186 existing retro-commissioned buildings with average energy savings between 10-15% was 1.8 years. Figure (4) illustrates the relationship between commissioning and energy efficiency measures in a building. In addition, qualitative research examining the reasons for commissioning for 36 new projects, and 178 existing projects demonstrate that energy savings were the main cited driver in 90% of the researched sample, followed by improved air quality and thermal comfort, and enhanced occupant productivity. Ensuring the adequate performance of building systems was cited by 50% of the cases, whereas training the building staff and occupants was a driver in nearly 33% of the cases (Mills, 2009). Additional benefits include reduced contractor callbacks and a smoother construction process as a result of improved communication and reduced change-orders (EnergyIdeas Clearinghouse, 2005). Accordingly, without properly commissioning a school many sustainable design elements can be compromised.
Figure (4): Illustrative relationship between commissioning and energy efficiency measures (Mills, 2009)
Intent
Reduce the social, economic and environmental impact associated with the malfunctioning of building’s energy systems and assemblies, through verifying that the project’s energy-related systems are installed to function in accordance with the prescribed project requirements, design objectives and construction documents.

Requirements

- Document all commissioning activities from the pre-design phase through to the occupancy and operation phase, as indicated in Figure (2).
- Document all retro-commissioning activities from the planning phase through to the hand-off phase, as indicated in Figures (3).
- Develop and implement a commissioning plan for energy-related systems, as indicated in Figure (5).

Figure (5): Commissioning Plan for Energy-Related Systems
E-03 Credit: On-site Renewable Energy

Forecasts of Egypt's energy resources signify its inability to depend on national fossil fuel reserves of oil and gas to satisfy the energy requirements by the year 2050 (Comsan, 2010). Therefore, given its rapid depletion of limited fossil fuels resources and increased energy demand, Egypt has to diversify its energy portfolio to include a balanced combination of fossil fuels and renewable energy resources (El-Khayat & Ameen, 2011) (Patlitzianas, 2011) (Shouman & Khattab, 2015). Renewable energy resources address the continuous provision of energy while ensuring the social, environmental and economic sustainability within the energy sector (Shouman & Khattab, 2015). In addition, the introduction of renewable energy resources would reduce the pollution resulting from power plant emissions, which are responsible for 35% of carbon emissions (Patlitzianas, 2011). Egypt is endowed with abundant natural resources, which encompasses wind, solar, and hydropower energies (KPMG, 2017). Schools have the potential to generate their own renewable energy, however solar panels are the most viable options for use in schools due to the structure of educational facilities and its quiet and efficient operation. Most school buildings consist of flat rooftops that are ideal for the placement of solar photovoltaic (PV) installations (Deparment of Energy & Climate Change, 2014). Egypt is recognized for its highest potential for solar power worldwide, due to its location in the “sunbelt” area, which is the most strategic position for harvesting solar power. In addition, Egypt is endowed with long sun duration hours reaching between 9 to 11 hours per day, with some cloudy days, low rainfall, and a high intensity of direct solar radiation, ranging between 2000 KWh/m²/y and 3200 KWh/m²/y (El-Khayat & Ameen, 2011).

In schools, the installation of solar panels has several educational benefits as it provides students with a unique opportunity for hands-on learning about renewable energy technologies, energy efficiencies and the environment. In addition, data acquisition systems can be utilized and paired with interactive monitoring software to display to the school community the positive effect of utilizing PV systems on the electrical consumption within the school facility, through monitoring the daily and cumulative production of electricity. More direct engagement can be established by integrating derived concepts from the PV system into the school curricula in various subjects such as science, math, arts, geography and IT classes (NEED, 2017). This can also instigate environmental awareness by the wider community to address climate change, as the environmental benefit of mitigating the production of greenhouse gases throughout the lifespan of the system would be clearly demonstrated. The financial viability of the installed system exists in the cost savings form the reduction of the school's electricity bills which could then be spent in further educational and recreational programs (Deparment of Energy & Climate Change, 2014).

A successful renewable energy project should be grounded by 4 actions steps which layout the foundation of a successful effort to reach the common set of goals. These include: identifying a project team, to ensure that the project is addressed from different perspectives; identify project goals, to ensure that the steps are correctly implemented to satisfy a clear set
of goals; evaluate opportunities and limitations, to avoid wasted time in adopting technologies or applications that aren’t suitable for the school’s situation and the set goals; identify stakeholders and decision-makers, to allow the project team to address such entities from the beginning of the project to avoid time delay and ensure the project’s swift execution ( Minnesota Renewable Energy Society, 2011).

**Intent**

Encourage the utilization of renewable energy resources to reduce the environmental and economic impacts associated with the use of the limited fossil fuel energy resources, while securing the continuous provision of energy to meet the increased energy demand within the school facility.

**Requirements**

Install on-site renewable energy systems to reduce a portion of the annual building energy costs, as well as demonstrating the renewable energy systems as an alternative energy source for educational purposes.

**Credit Criteria**

<table>
<thead>
<tr>
<th>On-Site Renewable Energy</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 5% of the building’s annual energy cost reduced by renewable energy resources</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Renewable energy as an educational tool</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
E-04 Credit: Energy Metering

The growth in global energy demand has upraised apprehensions over supply problems, depletion of energy resources, and drastic environmental impacts, including global warming, ozone layer depletion, and climate change (Pérez-Lombard, Ortiz, & Pout, 2008). According to the BP Statistical Review of World Energy, as illustrated in Figure (6), global carbon dioxide emissions and electricity generation are rapidly increasing, reaching 33,432 million tonnes and 24,816 Tetravatt-hours, respectively in 2016, of which the majority of this energy comes from the burning of fossil fuels (BP Statistical Review of World Energy, 2017). GHG emissions resulting from the burning of fossil fuels have been considered to be the primary cause of anthropogenic climate change (IPCC, 2013).

![Figure (6): Shares of global fossil fuel consumption, electricity generation, and carbon dioxide emissions (BP Statistical Review of World Energy, 2017)](image)

In Egypt, electricity represents the largest source of energy consumption, which accounts for more than 50% of total energy consumed, followed by natural gas and LPG (liquefied petroleum gas) (Hanna, 2013). Population growth, rise in demand for building services and indoor comfort levels, together with the increase in time spent inside buildings, confirm that the upward trend in global energy demand will continue to grow in the future. For these reasons, energy efficiency in buildings is a principal objective for energy policy solutions at local, national and international levels (Pérez-Lombard, Ortiz, & Pout, 2008). Energy meters calculate the energy used by continuously detecting the instantaneous values of current and voltage. They play a substantial role in data-driven energy efficiency measures to reduce energy consumption and associated greenhouse gas emissions (Ahmad, Moursheed,
Mundow, Sisinni, & Rezgui, 2016). Energy metering also allows stakeholders, including: occupants, building owners, and energy managers, to analyze the performance of buildings in order to undertake energy efficiency measures, identify cost-cutting opportunities by spotting inefficiencies, benchmarking building’s internal and external energy use, and improve energy load planning and usage (Genet & Schubert, 2013).

**Intent**
Reduce the economic and environmental impact associated with excessive energy use, by achieving a minimum level of energy efficiency for the building and its systems.

**Requirements**

- Develop energy metering plan to monitor and evaluate all energy systems that account for 10% of the total energy use on the building. The plan may include the following:
  - Total annual energy use (MWh) of entire building, and each energy system.
  - Peak power demand (MW) of entire building, and each energy system.
  - Total amount of energy supplied by on-site or off-site renewable energy resources, as annual generation (MWh) and peak power demand (MW).
  - Description of how each energy system is measured.
  - Specifications of energy meters.
  - Single line diagram layouts for the distribution of energy meters.
  - Duration, accessibility and accuracy of energy meters.

- Install energy meters that comply with the energy metering plan requirements, and record monthly readings.

**Credit Criteria**

<table>
<thead>
<tr>
<th>Energy Metering</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop energy metering plan</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Install energy meters that comply with the energy metering plan requirements</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
E-05 Credit: External Shading Devices

The utilization of daylight through environmentally responsive and energy-conscious designs both decreases the energy consumption in buildings and creates productive, well-lit work environments (Gadelhak, Aly, & Sabry, 2013). Approximately 30-35% of heat gains in classroom is a result of direct solar radiation. Hot arid climates deem the most challenging in addressing daylight, since there is a dual conflict of providing shade from direct solar radiation, and having adequate light levels for conducting educational activities within the classroom (Wanas, 2013). Studies indicate that external shading devices are more effective by 30-35% than internal shading devices in impeding the transmission of solar radiation into the room (Olgyay & Olgyay, 1963). External shading devices are a solar shading strategy for architectural envelopes; their design and efficiency is based on the latitude and orientation of the building façade, and the sun’s seasonal path, which when designed properly allows both summer shading and winter solar gain to be achieved in climates with seasonal variations (Visser & Yeretzian, 2013). A number of studies have examined the effect of external shading devices on the thermal performance, and energy conservation in buildings. Bellia, et al. stated that modifying the length and type of shading device reduces the annual energy savings by 20% (2013). Similarly, Al-Tamimi & Fadzil, analyzed the impact of overhangs, louvers, and egg crates on the indoor air temperature, stating that egg-crate devices, shown in Figure (7) yielded the largest reduction in indoor air temperature and number of hours of thermal discomfort, due to their configuration that consists of both horizontal and vertical elements, which prevents solar radiation from various sun angles (2011). These findings differ from previous results reported by Steemers(1990) which conclude that overhangs are more effective than vertical fins and egg-crate devices in decreasing the amount of solar radiation on south, east and west building façades. In addition, he stated that vertical fins are more effective on the north façade than both overhangs and egg-crate devices.

Egypt is amongst the countries located in the Northern hemisphere, accordingly the sun rises due East, culminates in the South, and sets due West. Therefore, North exposed façades receive the lowest level of solar irradiance, which results in a minimum heat gain from solar radiation, and as such do not require solar shading strategies. Whereas, South exposed façades receive solar radiation throughout most of the day, and the sun is at its highest angle. Correspondingly, for energy saving, the installation of horizontal shading devices, shown in Figure (8) is the most effective in blocking the solar radiation. Vertical shading devices, shown in Figure (9) are most suitable for use in East and West façades, which are mainly exposed to diffuse radiation, of which the East façade receives the largest portion of radiation before noon, and the West facades receives the largest part in the afternoon. Shading devices have different levels of protection from solar radiation, which is indicated by their shading coefficient (SC); the higher the shading coefficient the more solar radiation is blocked. A study by Wanas (2013) on the thermal comfort in secondary schools in Egypt, indicated that installing external shading devices with a shading coefficient of 50% increases the number of hours of thermal comfort by 82 hours.
<table>
<thead>
<tr>
<th>Shading Device</th>
<th>Perspective View</th>
<th>Plan &amp; Side View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg-crate</td>
<td><img src="image1" alt="Perspective View" /></td>
<td><img src="image2" alt="Plan &amp; Side View" /></td>
</tr>
<tr>
<td>Egg-crate with slanted vertical fins</td>
<td><img src="image3" alt="Perspective View" /></td>
<td><img src="image4" alt="Plan &amp; Side View" /></td>
</tr>
<tr>
<td>Egg-crate with rotated horizontal louvers</td>
<td><img src="image5" alt="Perspective View" /></td>
<td><img src="image6" alt="Plan &amp; Side View" /></td>
</tr>
</tbody>
</table>

*Figure (7): Egg-crate Shading Devices (DeKay & Brown, 2001)*

<table>
<thead>
<tr>
<th>Shading Device</th>
<th>Perspective View</th>
<th>Side View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight overhangs</td>
<td><img src="image7" alt="Perspective View" /></td>
<td><img src="image8" alt="Side View" /></td>
</tr>
<tr>
<td>Louvers parallel to wall</td>
<td><img src="image9" alt="Perspective View" /></td>
<td><img src="image10" alt="Side View" /></td>
</tr>
<tr>
<td>Awnings</td>
<td><img src="image11" alt="Perspective View" /></td>
<td><img src="image12" alt="Side View" /></td>
</tr>
<tr>
<td>Horizontal louvers hung from solid overhangs</td>
<td><img src="image13" alt="Perspective View" /></td>
<td><img src="image14" alt="Side View" /></td>
</tr>
<tr>
<td>Vertical strip parallel to wall</td>
<td><img src="image15" alt="Perspective View" /></td>
<td><img src="image16" alt="Side View" /></td>
</tr>
<tr>
<td>Rotating horizontal louvers</td>
<td><img src="image17" alt="Perspective View" /></td>
<td><img src="image18" alt="Side View" /></td>
</tr>
</tbody>
</table>

*Figure (8): Horizontal Shading Devices (Galloway, 2004)*
Intent

Improve the energy efficiency of buildings and reduce cooling loads, by blocking incoming solar radiation and sunlight penetration through windows into the inner spaces, which enhances the indoor thermal comfort of occupants.

Requirements

- Install external shading for 50% of windows on East, South, and West façades (EGGBC, 2018).

Credit Criteria

<table>
<thead>
<tr>
<th>Shading Device</th>
<th>Perspective View</th>
<th>Plan View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical fins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slanted vertical fins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotating vertical fins</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure (9): Vertical Shading Devices (DeKay & Brown, 2001)

<table>
<thead>
<tr>
<th>External Shading Devices</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install external shading for 50% of windows on East, South, and West façades</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

45
E-06 Credit: Building Controls Systems

Energy consumption in schools varies depending on the building’s age, occupancy hours, renovation requirements, and the quantity and type of installed electrical equipment (Carbon Trust, 2012). Given the instructional nature of educational facilities, a huge emphasis is placed on the occupants’ comfort, which is sustained by a high level of thermal, visual comfort and ventilation; all utilizing energy intensive processes (Jovanovic, Pejic, Djoricc-Veljkovic, & Karamarkovic, 2014). Therefore, as such energy costs constitute the highest operational cost of the building, systems efficiency plays a key role to reduce the energy consumption within the school facility (Bulut, 2004). Technological advancement allows schools to incorporate advanced building controls systems to achieve significant cost and energy savings while enhancing the indoor thermal comfort and academic performance (Doulgeropoulos, 2015). Building controls systems can be configured to integrate a wide range of disciplines including heating and cooling, lighting, and ventilation to reduce energy costs by up to 30%. Occupancy sensors use different technologies including infrared, ultrasonic and microwaves to detect motion inside a room, and automatically adjust lights, temperature or ventilation systems. Schools save 5% in energy costs for every degree in temperature lowered or raised in the winter or summer season respectively. Likewise, eliminating the lighting of unoccupied rooms can reduce the overall lighting costs by up to 20%. Furthermore, ventilation controls improve indoor air quality in addition to providing more efficient fan use since the fans would operate only when needed supplying sufficient amounts of fresh outside air into the spaces, ensuring that CO\(_2\) levels are within acceptable limits.

**Intent**

Reduce the energy consumption of building, to reduce the overall demand for natural resources, cutting down on utility power bills and reducing the environmental impact of harmful emissions associated with power generation.

**Requirements**

Install building controls systems to monitor and control the building’s technical systems.

**Credit Criteria**

<table>
<thead>
<tr>
<th>Building Controls Systems</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install temperature sensors</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Install lighting control system</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Install ventilation control</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
E-07 Credit: External Wall Insulation

Thermal comfort is defined as “that condition of mind that expresses satisfaction with the thermal environment”. In the guidelines, it covers the following four categories: external wall insulation, roof insulation, high performance windows and glazing, and window-wall-ratio. The subjective evaluation of thermal comfort is influenced by psychological factors which have a direct influence on the mind, environmental factors: air temperature, radiant temperature, air speed, humidity; and non-environmental factors: metabolic rate, clothing insulation, gender and age. Given the subjectivity of thermal comfort, it can be affirmed that the same thermal environment may be perceived differently by different people (ASHRAE, 2013). Maslow’s hierarchy of needs denotes the significance of meeting the students’ basic needs within the classroom, prior to focusing on the educational attainment. It consists of five fundamental levels as shown in Figure (10), which are interrelated in the sense that one cannot consider one need without satisfying the other. According to Maslow, a student cannot focus on learning unless those five needs are met first. The physiological needs element encompasses all physical aspects of the classroom; such as seating arrangement, wall colors, acoustics, and thermal comfort, etc. (Fox & Hoffman, 2011). In Egypt, there are no standards that define the comfortable thermal ranges that should be present in buildings (Attia, 2012). ASHRAE (2013) recommends indoor temperatures in the winter to be kept between 20 and 24°C, while summer temperatures should be preserved between 23 and 26°C. These ranges are considered acceptable for light sedentary active persons, at 50% relative humidity and at mean airspeed ≤0.15 m/s. whereas, acceptable relative humidity range should be maintained between 30% and 60%. Levels below 30% would cause eye irritation and drying mucous membranes, whereas levels above 60% would lead to microbial growth.
Many studies indicate that thermal comfort has an influence on its occupants (Hussein & Rahman, 2009) (Wafi, Ismail, & Ahmed, 2011) (Puteh, Ibrahim, Adnan, Che Ahmad, & Noh, 2012). The thermal performance of classrooms has proven to not only affect the students’ health and comfort, but also their learning efficiency, attentiveness, and productivity (Abdallah, 2015). A study by Puteh, et al., (2012), to examine the students’ insights towards thermal comfort in a school in Malaysia, indicates that 45.5% of students participating in the survey reported feeling hot in the classroom, whereas 48.3% are generally dissatisfied with the thermal conditions of the classroom. Findings also reveal adverse effects on the occupants’ health, as many students attributed the following health conditions as a result of unfavorable thermal conditions: emotional problems (40%), stress (68.3%), dry skin (13.3%), breathing difficulties (16.7%), eye infection (30%), and asthma (20%). Results from a survey conducted by Sullivan & Trujillo in two halls at the United States Military Academy, reveal that students feel distracted when the temperature isn’t within comfortable parameters, and 34% of students felt that the warm temperature inside classrooms impacted their learning abilities. When the room was too hot, the students were visibly distracted as they would be wiping sweat off their faces, and so their concentration was largely impeded. According to Maslow, at uncomfortable thermal conditions students are more preoccupied with dealing with the discomfort they are experiencing, as their psychological needs are not met, than focusing on learning, which inhibits their ability to reach a higher level in the hierarchy (2015).

Only few studies have addressed the effect of thermal comfort on the learning environment in Egypt. Abdallah (2015) analyzed the thermal comfort and energy consumption
in educational halls in Assiut University. His results indicate that indoor temperature exceeds 28°C, which is far from the 90% acceptable limits of the Adaptive Comfort Standards (ACS), and accordingly 83% of surveyed students preferred a cooler indoor environment. He underlined the importance of incorporating sustainable design techniques, such as passive cooling strategies coupled with smart systems, to decrease the indoor air temperature. Gado & Mohamed (2009) analyzed the thermal comfort of students in a primary school in Al-Minya governorate. The results indicate that the majority of occupants felt warm, as the indoor air temperatures exceeded comfortable ranges for most of the time. These results are consistent with findings from research reported by Saleem, et al. (2014) and Abdelkader, et al. (2017). Thermal insulation in buildings is an important factor to achieving thermal comfort for building occupants and reducing the energy consumption (Wang, Yu, Zhao, Dai, & Ruan, 2016). The thermal transmittance of the building envelope is affected by the thermal insulating properties of walls, windows and roof structures (Sanga, Pan, & Kumaraswamy, 2014) (Muhaisen, 2015), which coincide with 8%, 20%, and 6% of energy loss in buildings, respectively (Mahdy & Barakat, 2017).

**Intent**

Provide a comfortable thermal environment that improves the occupants’ academic performance, and health and well-being, while reducing the energy consumption of buildings by the means of reducing heat transfer through the building walls.

**Requirements**

External wall insulation is necessary to prevent heat transmission between the external and internal environment, and maintain the temperature of the interior space.

- Use a double wall with a 10mm insulation material (polystyrene and/or polyurethane), with U-values not less than 0.55 W/m²K (EGGBC, 2018).

**Credit Criteria**

<table>
<thead>
<tr>
<th>External Wall Insulation</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use a double wall with a 10mm insulation material</td>
<td>2</td>
<td>N/A</td>
</tr>
</tbody>
</table>
E-08 Credit: Roof Insulation

Waterproofing and thermal insulation are fundamental characteristics of an effective roofing insulation system. Waterproofing membranes serve the essential function of preventing water penetration inside the building which affects the overall structure of the building. Humidity and moisture are two properties which cause great damage to the building, including mold growth, wall cracking, and peeling of paint work. Hence, a building with adequate waterproofing will not be susceptible to such negative effects of water damage, and accordingly will provide positive learning environments.

Solar reflectance is the most important feature of the thermal performance of a roof (Parker, McIlvaine, Barkaszi, Beal, & Anello, 2000). It is a measure of how much solar radiation is reflected by the surface, on a scale of 0 to 1; the larger the value the higher the solar reflectance, and the cooler the roof surface. Conventional roof materials redirect only 5 to 20% of incoming solar radiation, and accordingly the roof surface can reach temperatures higher than 66°C. Whereas surfaces with reflective roof materials redirect 55 to 90% of incoming solar radiation. As the roof operating temperatures are decreased, the roof service life is prolonged. Moreover, reflective roofs are a sustainable and cost-effective means of reducing the energy consumption of buildings by decreasing the cooling loads, while enhancing the indoor thermal comfort. The high thermal emittance of roofs mitigates urban heat islands and climate change. In addition, as local air temperatures are reduced; air quality is improved, and rate of smog formation is lowered. Likewise, by lowering the energy requirements within the building, reflective roofs decrease the production of greenhouse gas emissions and associated air pollution, and decreases the probability of power outages resulting from peak electric power demand (Urban & Roth, 2010). As illustrated in Table (7), there are several types of reflective roofing materials with varying values of solar reflectivity.

<table>
<thead>
<tr>
<th>Generic Roofing Materials</th>
<th>Solar Reflectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Cement Tiles</td>
<td>73%</td>
</tr>
<tr>
<td>PVC White</td>
<td>83%</td>
</tr>
<tr>
<td>White Coating: 1 coat, 0.2032 mm</td>
<td>80%</td>
</tr>
<tr>
<td>White Coating: 2 coats, 0.508 mm</td>
<td>85%</td>
</tr>
</tbody>
</table>

**Intent**

Reduce the solar gain of buildings by reducing heat transfer from the roof to lessen the environmental and economic problems resulting from increased energy loads, and mitigate urban heat islands by improving indoor air quality and thermal comfort. Protect the building structure from water damage caused by rain, moisture and leaks.
Requirements

Install roof waterproofing and thermal insulating membranes. The properties of some membranes offer both waterproofing insulation in addition to thermal resistance. Such materials would double count here for the provision of water and thermal insulation, and in the E-16 credit: Innovation and Creativity in Energy.

1. Install waterproofing roof membrane. Different types of locally manufactured waterproofing membranes include:
   - Liquid applied membranes, such as elastomeric liquid membranes produced by Bitumat Egypt. The technical data sheets are found in Appendix A.
   - Pre-formed sheet membranes, such as modified bituminous membranes produced by Henkel Polybit Egypt. The technical data sheets are found in Appendix A.

2. Thermal insulation of the roof slab may include any of the following strategies:
   - Install thermal insulating roof membrane
     The preferred U-value for the roof slab in naturally ventilated buildings in Cairo and the delta region is 0.37 W/m²K (Wanas, 2013). Roof insulation is necessary to prevent heat transmission between the external and internal environment through the roof. Polystyrene is a suitable additional layer of thermal insulation in prototypes where the U-value is higher than the desired value, since according to Attia (2007) it is locally produced in Egypt and is highly durable.
     - Use an insulation material (polystyrene and/or polyurethane) with U-values not less than 0.273 W/m²K (EGGBC, 2018).
     - Use roof surface materials with solar reflectivity ≥ 70%. Provide product data sheets indicating solar reflectivity percentage, physical properties and additional technical information.
   - Solar shading of the roof
     This strategy decreases the direct solar radiation incident on the roof. It is a more successful strategy than increasing thermal insulation layers of roof slab, since the it averts the direct solar radiation and allows the transmission of heat from inside the classroom to the outside through the roof slab. Different implementation methods include tensile structures, wooden pergolas or corrugated sheets (Wanas, 2013).
   - Install vegetated roofs
     Vegetated roofs decrease the indoor temperatures inside buildings based on three basic mechanisms: the obstruction of solar radiation by the shadows created by the vegetation, the evaporative cooling effect that occurs by evapotranspiration from the plants and the growing
substrate, and lastly the thermal insulation provided by both the vegetation and growing substrate, which reduces the heat flux through the roof (Getter & Rowe, 2006; Pérez, et al., 2009). Studies show that green roof surfaces provide temperatures which are up to 4°C cooler than conventional roofs (GSA, 2011). Vegetated roofs consist of three layers, a waterproofing membrane, growing substrate, and vegetation (Oberndorfer, et al., 2007). The type of plants used depends on the climate, type and depth of growing substrate, loading capacity, height and slope of the roof, maintenance requirements, and availability or lack of an irrigation system (Gelfand & Freed, 2010). There are four main types of rooftop gardens: intensive and extensive as shown in Figure (11). Extensive roofs are less expensive to install, and consist of a soil thickness between 7-15cm, and may not require irrigation, while intensive gardens have a soil thickness above 15cm, and provides a greater variety in vegetation, and needs irrigation. Table (8) demonstrates a comparison between the 4 types, which vary in terms of the type of grown vegetation, irrigation requirements, kind of drainage layers, and the type of growing substrate (GSA, 2011).
### Table (8): Types of Vegetated Roof Systems (GSA, 2011)

<table>
<thead>
<tr>
<th></th>
<th>SINGLE-COURSE EXTENSIVE</th>
<th>MULTI-COURSE EXTENSIVE</th>
<th>SEMI-INTENSIVE</th>
<th>INTENSIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>THICKNESS</strong></td>
<td>3-4 inches</td>
<td>4-6 inches&lt;sup&gt;(v)&lt;/sup&gt;</td>
<td>6-12 inches&lt;sup&gt;(v)&lt;/sup&gt;</td>
<td>over 12 inches</td>
</tr>
<tr>
<td><strong>DRAINAGE LAYER</strong></td>
<td>No discrete drainage layer.</td>
<td>Based on the growth, media thickness, plants selected, local climatic conditions, and rooftop hydrologic conditions. Synthetic geocomposite roof membrane is typically installed.</td>
<td>Discrete drainage layer.</td>
<td>Discrete drainage layer.</td>
</tr>
<tr>
<td><strong>VEGETATION LAYER</strong></td>
<td>Sedum or other succulents.</td>
<td>Sedum or other succulents. Potential for other plants as thickness increases or with permanent irrigation.</td>
<td>In the Mid-Atlantic and with irrigation, supports a variety of plants—meadow species, ornamental varieties, woody perennials, &amp; turf grass.</td>
<td>Supports plant communities similar to ground-level landscapes (depending on thickness and exposure).</td>
</tr>
<tr>
<td><strong>MEDIA TYPE</strong></td>
<td>Coarse media over moisture-management layer.</td>
<td>Finer-grained growth media over discrete drainage layer.</td>
<td>Multi-course over discrete drainage layer.</td>
<td>Intensive growth media layer over discrete drainage layer. Topping media may be used (includes higher organic content, greater density, greater water holding capacity, and lower permeability).</td>
</tr>
<tr>
<td><strong>IRRIGATION</strong></td>
<td>Typically none.</td>
<td>Typically necessary in the first year to establish growth in Mid-Atlantic.</td>
<td>Required if turf grass is used.</td>
<td>Required.</td>
</tr>
<tr>
<td><strong>PREVALENCE</strong></td>
<td>Common internationally. Areas with sufficient precipitation is necessary.</td>
<td>Nationally the most common green roof type.</td>
<td>Common. Provides more variety in vegetation.</td>
<td>Less common than the other types. Structural capacity and maintenance are limiting factors (see Section 4.4.1 and 4.3)</td>
</tr>
</tbody>
</table>

**Notes:**
- <sup>(v)</sup> Typical total media thickness (growth media, plus granular mineral drainage layer) is 4–6 inches (assemblies vary widely in thickness and complexity).
- <sup>(v)</sup> Pedestrian traffic (typically turf grass) requires a 10–12 inch thickness.
- <sup>(v)</sup> Common drainage layers are shown in Table 3.
- <sup>(v)</sup> Internationally, granular mineral media drain layers are more common and offer advantages in terms of costs and performance.
Figure (11): Vegetated Roof Types (GSA, 2011)

Credit Criteria

<table>
<thead>
<tr>
<th>Roof Insulation</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install thermal insulating roof membrane with U-value ≤ 0.273 W/m²K or solar reflectivity ≥ 70%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of solar shading devices on roof</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install green roofs for at least 5% of the total roof area</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install roof waterproofing roof membrane</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
E-09 Credit: High Performance Windows and Glazing

The thermal properties of windows can be improved by reducing heat conduction, and solar heat gain through glazing modifications (Bokyoung, Lee, Youngsub, & Kyudong, 2018). Accordingly, facades should be designed using high-performance windows and glazing systems within the designated range of window-to-wall-ratio according to the natural lighting conditions, in combination with external shading devices (Visser & Yeretzian, 2013).

**Intent**
Provide a comfortable thermal environment that improves the occupants’ academic performance, and health and well-being, while reducing the energy consumption of buildings by the means of reducing heat transfer through the building’s openings.

**Requirements**
- Use double glazing with U-Value not less than 2 W/m\(^2\)K, and solar heat gain coefficient (SHGC) not less than 0.7 (EGGBC, 2018).

**Credit Criteria**

<table>
<thead>
<tr>
<th>High Performance Windows and Glazing</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use double glazing with U-Value not less than 2 W/m(^2)K, and solar heat gain coefficient (SHGC) not less than 0.7</td>
<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>
E-10 Credit: Window-Wall-Ratio

Window-wall-ratio (WWR) is an important variable affecting the energy performance of a building, since it plays a critical role in terms of the building thermal insulation. It is calculated as a ratio of window area related to the total wall area.

Requirements

Consider a maximum WWR ≤ 40 %

Credit Criteria

<table>
<thead>
<tr>
<th>Window-Wall Ratio</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>(WWR) ≤ 40 %</td>
<td>1</td>
<td>NA</td>
</tr>
</tbody>
</table>
E-11 Credit: Reflective Wall Coatings

Solar reflective wall coatings reduce the cooling loads in buildings, and indoor air temperatures, in addition to enhancing the indoor thermal comfort in the built environment. The reduction of temperature fluctuations inside the walls avoids mechanical stress within the wall structure and extends its service life, and prevents the formation of cracks (Roberti, 2015). A study by Roberti examines the effect of reflective coating on the temperature profile within the external walls during both winter and summer. As shown in Figures (12) and (13), the reflective coating reduces the internal temperatures, which contributes to energy savings within the building (2015). The importance of reflective wall coatings in increasing the energy efficiency in buildings is the result of the significant proportion of wall surface areas which equals or exceeds that of the roof surface square footage in multi-storey buildings (EGGBC, 2018).

As illustrated in Table (9), there are several types of reflective wall coatings with varying values of solar reflectivity.

<table>
<thead>
<tr>
<th>Reflective Wall Coatings</th>
<th>Solar Reflectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Concrete</td>
<td>35-45%</td>
</tr>
<tr>
<td>New White Portland Cement Concrete</td>
<td>70-80%</td>
</tr>
<tr>
<td>White Acrylic Paint</td>
<td>80%</td>
</tr>
<tr>
<td>Fired Clay Bricks</td>
<td>17-56%</td>
</tr>
</tbody>
</table>
Intent

Reduce the solar gain of buildings by reducing heat transfer from walls to lessen the environmental and economic problems resulting from increased energy loads, and mitigate urban heat islands by improving indoor air quality and thermal comfort.

Requirements

- Use reflective wall coatings with solar reflectivity ≥ 35%. Provide product data sheets indicating solar reflectivity percentage, physical properties and additional technical information.

Credit Criteria

<table>
<thead>
<tr>
<th>Reflective Wall Coatings</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use reflective wall coatings with solar reflectivity ≥ 35%</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
E-12 Credit: Air Tightness

Air tightness is an essential component in increasing the energy efficiency of buildings, and enhancing both the thermal comfort of occupants, and indoor air quality (Bramiana, Entrop, & Halman, 2016). The term “airtightness” indicates the amount of unrestrained airflow across the building envelope due to substantial variances in air pressure amongst the interior and exterior of a building (Krštić, Koški, Otković, & Španić, 2014). Studies show that the conformance to a minimum level of building airtightness is necessary to ensure the building’s energy efficiency (Logue, Sherman, Walker, & Singer, 2013), since the differential pressure within the building envelope is affected by air leakage, which disturbs the air-to-air heat recovery installed in HVAC systems (Santos & Leal, 2012). In addition, air infiltration leads to undesirable heat losses within the building, which increases the energy consumption, as occupants increase the indoor temperature to compensate the thermal discomfort. The uncontrolled exchange of outdoor air reduces the indoor air quality, as air flows into the building through airtightness deficiencies, increasing the risk of distribution of outdoor air pollutants to the inside of the building. Moreover, the infiltration of air within the building envelope leads to “moisture convection”, through which warm air from the inside of the building mixes with colder air from outside and condenses and collects in areas of the building causing the development of mold and rot (Sandberg, Bankwall, Sikander, Wahlgren, & Larsson, 2007). The degree of airtightness is measured in terms of the quantity of air leakage (m³), per square meter of building envelope at a pressure differential of 50 Pascals, between the inside and outside of the building, expressed in \([\text{m}^3/\text{(h.m}^2)] \) at 50 Pa.

Intent

Enhance the airtightness within the school building’s envelope in order to enhance the indoor environment, and decrease the energy consumption.

Requirements

- Achieve airtightness of \(5 \text{ m}^3/\text{(m}^2\text{.h)}\) at 50 Pa following the use of a door blower test (EGGBC, 2018)
- Use appropriate sealants to ensure air tightness, such as hybrid or silicone sealants.

Credit Criteria

<table>
<thead>
<tr>
<th>Air Tightness</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieve airtightness of (5 \text{ m}^3/\text{(m}^2\text{.h)}) at 50 Pa following the use of a door blower test</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
E-13 Credit: Energy Efficient Lighting

The increase in lighting energy efficiency is a cost-effective investment in most public buildings (Abd El-Khalek, Youssef, & Yassin, 2017). In Egypt, the total share of lighting accounts for approximately 20% of the total energy consumption, and it constitutes one of the responsible factors of the electricity sector’s peak consumption; resulting in financially burdening the electricity to ensure the reliability and accessibility of the electrical supply (EEHC, 2015). Lighting systems are one of the aspects that can be easily controlled and changed to reduce the energy consumption and improve the students’ learning environment. The use of LED lighting in school facilities has a direct impact on the building’ sustainability, students’ health, wellbeing, and academic performance (TCP, 2017). LEDs consume 85% less electricity than incandescent light sources which are extensively used in Egypt (Abd El-Khalek, Youssef, & Yassin, 2017). Table (10) represents the wattage comparison between incandescent, CFLs and LEDs. The lower energy consumption decreases the demand on natural resources needed to power the energy grid. In addition, LEDs are energy-efficient, and do not emit as much heat as other light sources due to their efficient design and lack of filament (EYE Lighting, 2012). LED lights produce 3.4 btu’s/hour, which represents only 4% of the heat produced by incandescent bulbs. Accordingly, incandescent bulbs warm up and contribute to heat build-up in rooms, whereas LEDs do not (Eartheasy, 2014), which reduces the cooling loads and enhances the indoor thermal comfort. Although LEDs have a higher initial purchase cost, they lead to long term cost savings (EGGCC, 2016). The life span of LEDs can last up to 50,000 hours, in comparison with 1000 to 2000 hours for incandescent light bulbs, and 8000 to 10,000 hours for fluorescent light sources (Abd El-Khalek, Youssef, & Yassin, 2017). Since LEDs have a long life-span, they decrease the amount of waste disposal in landfills. Even upon disposal, LEDs can be processed in designated locations where the constituent parts can be disassembled and recycled (EYE Lighting, 2012). Furthermore, LEDs do not require a warm-up period and provide instant full illumination (Abd El-Khalek, Youssef, & Yassin, 2017).

Table (10): Wattage comparison between different light sources (Abd El-Khalek, et al., 2017, 96)

<table>
<thead>
<tr>
<th>Incandescent</th>
<th>Compact Fluorescents (CFLs)</th>
<th>LEDs</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-60</td>
<td>12-15</td>
<td>5-8</td>
</tr>
<tr>
<td>60-75</td>
<td>15-18</td>
<td>7-10</td>
</tr>
<tr>
<td>75-100</td>
<td>18-23</td>
<td>10-15</td>
</tr>
<tr>
<td>100-150</td>
<td>23-35</td>
<td>15-20</td>
</tr>
<tr>
<td>150-200</td>
<td>35-45</td>
<td>20-25</td>
</tr>
<tr>
<td>200-250</td>
<td>45-60</td>
<td>25-30</td>
</tr>
</tbody>
</table>

LEDs are also safe and contain no harmful contaminants, therefore they eliminate the risk of exposure to Polychlorinated Biphenyls (PCBs), which are present in fluorescent ballasts, and are carcinogenic with detrimental impacts on the immune, nervous and endocrine systems. Exposure to the contaminants do not only occur if the ballasts leak or break, but even during the normal-life use of the lighting fixture. Mercury is another hazard in school facilities,
present in outdated lighting systems, and leads to mercury contamination in the occurrence of a broken fluorescent tubes. Mercury is also responsible for the production of UV light, which can cause irreversible damage to skin and eyes’ tissues. Studies indicate the importance of cool color temperatures within the range 4100K to 5000K on students with learning and behavioral problems such as hyperactivity. The light color provided by LED light sources helps students focus and concentrate on academic tasks, since cooler color temperatures have proven to have positive effects on student's cognitive performance and enhances their visual skills. In addition, radiation emitted from fluorescent lighting fixtures aggravates the radiation stress conditions of hyperactive children, therefore the reduction of such radiation leads to a noticeable improvement in both students’ behavior and academic performance (TCP, 2017).

**Intent**

Reduce energy consumption and enhance the students’ health, wellbeing, and academic performance.

**Requirements**

Install LED lightbulbs within the educational facility.

**Credit Criteria**

<table>
<thead>
<tr>
<th>Energy Efficient Lighting</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install LED lighting fixtures in 50% of the spaces within the educational facility</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Install LED lighting fixtures in 100% of the spaces within the educational facility</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Pump motors are accountable for a substantial amount of electricity consumption worldwide. Accordingly, potential energy saving mechanisms would have a substantial positive economic, social and environmental impact. Data indicates that the total amount of energy wasted by the operation of all pumps in the European Community accounts to 46 TWh, which is equivalent to the electricity production of more than two large permanently operating power stations in the Netherlands (Vogelesang, 2008). The power factor is a critical aspect in the calculation of the pump motor efficiency rate. It is a measure of the utilization rate of electrical power on a scale from 0 to 1. A high power indicates efficiency in electrical power consumption, while a low power factor demonstrates an inefficient use of electrical power. The power factor (PF) is determined by dividing working power (kW); the power required to perform the actual work by apparent power (kVA); the power required to sustain the magnetic field. Typical power triangles illustrated in Figure (14) indicate the inverse relationship between kVA and PF, as kVA decreases, the power factor increases. Correspondingly, at a 70% power factor, it takes 35% more current to produce the same 100kW of power than that at a 90% PF, which results in an increase in utility bills, as the electrical power being paid for is not fully utilized. As illustrated in Figure (15), power factor correction capacitors enhance the power factor, as they function as reactive current generators, reducing the total amount of current drawn from the utility by the pump motor system. Consequently, power capacitors lead to reduced electric utility bills, improved system capacity, improved voltage, and reduced energy losses (Eaton, 2014).

![Figure (14): Typical Power Triangles (Eaton, 2014)](image1)

![Figure (15): Required Apparent Power Before and After Adding Capacitors (Eaton, 2014)](image2)
Intent

Reduce the energy consumption of building, to reduce the overall demand for natural resources, cutting down on utility power bills and reducing the environmental impact of harmful emissions associated with power generation.

Requirements

Install pump motor with an energy efficiency of 90% or more to satisfy the power demand equal to or exceeding 7.5 kW, with a power factor of 0.9 or more (EGGBC, 2018).

Credit Criteria

<table>
<thead>
<tr>
<th>Pump Motor Efficiency</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump motor efficiency ≥ 90% when pump motor KW ≥ 7.5 kW with power factor 0.9 or more</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
The building sector being the largest consumer of electrical energy, accounts for approximately a third of final energy consumption globally (IEA, 2011). The energy consumption in commercial buildings is larger than that of other building types, due to its functional and operational characteristics which results in a larger energy demand per unit area. In harsh climates, the heating, ventilating and air-conditioning (HVAC) system is one of the largest end-users of energy in commercial buildings. Accordingly, energy efficient design and operation of HVAC systems demonstrate a major potential source of reduction in energy consumption, and CO₂ emissions, as they are based on the consumption of fossil fuels used in the carbon-intensive electricity systems (Fasiuddin & Budaiwi, 2011; IEA, 2011). Conversely, the improper selection of energy conservation measures decreases the indoor environmental quality of interior spaces, exposing occupants to thermal discomfort and health risks (Fasiuddin & Budaiwi, 2011). Optimal performance of HVAC designs can be achieved by initially performing an accurate estimate of the building enclosure efficiency, in addition to evaluating potential areas of natural ventilation and shading, and considering the radiant temperature of surfaces. This will result in reducing the energy loads, and decreasing the operational costs of HVAC systems (Brković & Milošević, 2012).

**Intent**
Achieve increasing levels of energy performance to reduce environmental and economic impacts associated with excessive energy use.

**Requirements**
Install energy efficient HVAC system that follows or exceeds the requirements in the mandatory path of ASHRAE 90.1-2007.

**Credit Criteria**

<table>
<thead>
<tr>
<th>Energy Efficient HVAC Systems</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install energy efficient HVAC system that follows or exceeds the requirements in the mandatory path of ASHRAE 90.1-2007</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
E-16 Credit: Innovation and Creativity in Energy

The universal access to modern energy services has become an indispensable requirement in our modern era (Kurt, 2011). The global contribution from the building sector represents a very high energy consumption percentage, reaching figures between 20-40% of the global energy demand in developed countries, which exceeds other major economic sectors such as industrial and transportation (Pérez-Lombard, Ortiz, & Pout, 2008). Innovative solutions to enhance the economic utilization of energy resources, while reducing the heating and cooling loads of buildings are essential to reduce energy costs, and prevent further resource depletion, and consequential environmental impacts. Double-wall construction utilizing an intermediate thermal insulation layer or air gap is an effective way to lower the wall’s U-value, and prevent the thermal transmittance between the external and internal environment, to maintain internal thermal comfort with maximum financial benefits. The choice of thermal insulation is based on the purpose, environment, ease of handling, and installation cost (Kurt, 2011).

A simulation-based research was carried out by Mahdy & Nikolopoulou in three Egyptian climatic cones: Alexandria, Cairo, and Aswan; to assess the outcome of using four external wall constructions of different properties, illustrated in Table (11), on the energy consumption, indoor thermal comfort, and initial and operational costs of the building. Results recommended that the optimal wall configuration in Alexandria and Cairo is a double wall with a 5cm air gap in between, and a double wall with a 5cm insulation layer of expanded polystyrene in between in Aswan. Analyses indicated that the use of the double wall with air gap in Cairo is 57% more cost-efficient than the wall with the 2 cm of external expanded polystyrene. Similarly, in Alexandria the double wall with air gap is the only construction specification which is more cost-efficient than the regular half red-brick wall. Whereas in Aswan, only the double wall with a 5cm thermal insulation layer in between demonstrated acceptable values of thermal comfort (2013).

Table (11): External Walls Specifications (Mahdy & Nikolopoulou, 2013)

<table>
<thead>
<tr>
<th>External Walls</th>
<th>Thickness (cm)</th>
<th>U-Value (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half red-brick wall</td>
<td>12</td>
<td>2.519</td>
</tr>
<tr>
<td>Full red-brick wall plus additional 2 cm of external expanded polystyrene thermal insulation layer</td>
<td>27</td>
<td>0.897</td>
</tr>
<tr>
<td>Double wall of half red-brick with 5 cm air gap in between</td>
<td>29</td>
<td>1.463</td>
</tr>
<tr>
<td>Double wall of half red-brick with 5 cm of expanded polystyrene thermal insulation layer in between</td>
<td>29</td>
<td>0.503</td>
</tr>
</tbody>
</table>

Kurt (2011) performed a study investigating the effects of an air gap in an insulated, and uninsulated wall, on the total cost, energy savings, payback period, fuel consumption and emissions of harmful pollutants. The air gap thickness (e), and the insulation thickness (Xins)
illustrated in Figure (16), were investigated for a prototype building to determine the optimal thickness of both, for energy saving and harmful emissions. The application of 2, 4, and 6 cm of air gap thickness and insulation material thickness in the uninsulated and insulated building prototype respectively, resulted in a reduction in payback period and energy costs. However, the installation of both insulation material and air gaps in a composite wall yields the best economic and environmental advantages, while reducing the thermal transmittance within the building walls.

![Figure (16): Physical model external wall with air gap (Kurt, 2011)](image)

Energy harvesting is the process of collecting ambient energy and converting it into a usable electric power. Energy harvesting technologies can be directed towards large-scale energy harvesting such as speed bump energy harvester, energy-harvesting trees, highway energy harvesting using vertical axis wind turbines. Speed bump energy harvesters have the capability to generate energy upon contact with a moving vehicle utilizing a motion mechanism which converts upwards and downwards pulse motions of the speed bump into unidirectional rotation that drives a generator to produce electrical power. Figure (17) and (18) illustrate the units of the speed bump energy harvester (Todaria, et al., 2015).

![Figure (17): Speed bump cover unit (Todaria, et al., 2015)](image)  
![Figure (18): Energy harvesting unit (Todaria, et al., 2015)](image)
Energy harvesting trees utilize solar radiation or wind energy, or a combination of both to generate electricity. Such an example is demonstrated in the “wind trees” shown in Figure (19), which was fabricated in France and is comprised of 72 leaves in which each function as a silent wind turbine with incorporated generators, which generate small quantities of electrical power. The lightweight structure of the leaves shown in Figure (20) allows a minimal wind power of 4.4 miles per house to set the turbines in motion. A single tree of dimensions 8 x 11 meters produces only 2.1 kilowatts of power, however when grouped their cumulative energy harvesting is considerably magnified; a streetscape lined with them could generate sufficient electricity to power the streetlights or a small apartment building. In addition, they blend into both urban and rural environments, creating an attractive outdoor art sculpture (Pantsios, 2015).

Figure (19): Wind turbine trees (Pantsios, 2015)

Figure (20): Leaves sealed in protective casing (Pantsios, 2015)
Energy harvesting technologies could also be directed towards small-scale application such as the EnergyBugs system, which are energy harvesting wearables which are designed to transform children’s kinetic energy into electrical energy and also allows children to power a designated LED lamp with the energy they have personally harvested. As shown in Figure (21) the ‘bugs’ are self-powering units with dual energy generators which generate electricity when an integrated magnetic cylinder inside the ‘bug’ moves back and forth as a result of the child’s kinetic energy. Accordingly, vigorous shaking leads to a fast charge, and light shaking leads to a slow charge. As illustrated in Figure (22), the energy harvested in the ‘bug’ is powered by energy from one or more ‘bugs’. Upon connecting the ‘bugs’ to the lamp unit, the display indicates the amount of energy generated by each ‘bug’, and the time the harvested energy could power the lamp. When the energy from the ‘bug’ runs out the lamp goes dark, and the larger the quantity of harvested energy, the longer the lamp remains lit. The children’s language use during the interaction displayed ownership over their harvested energy, and an understanding of energy consumption as a negative event. Such interactions with the EnergyBugs system solicited a general sense of awareness about energy conservation, distribution, consumption and storage. Accordingly, developing an energy harvesting prototype allows children to be actively engaged through the process of materializing energy in a tangible form (Ryokai, Su, Kim, & Rollins, 2014)
Intent
Encourage the implementation of innovative approaches to enhance the economic utilization of energy resources and indoor thermal comfort, while reducing the heating and cooling loads of buildings, to prevent further resource depletion, and consequential environmental impacts.

Requirements
Implement innovative and creative approaches in energy in any of the following categories:

1. Material selection
   - Construct a double wall with 10mm insulation material (polystyrene and/or polyurethane), with U-values not less than 0.55 W/m²K. Or construct a double wall with an air gap of less than 10mm (EGGBC, 2018).
   - Install roofing membrane with waterproofing and thermal insulating properties. Examples of such materials include the locally manufactured modified bituminous waterproofing insulation membrane by InsuTech. The technical data sheets are found in Appendix A.

2. Educational tool
   - Implement an energy harvesting prototype as a sustainable educational tool.

3. Energy lighting system
   - Implement an innovative approach to improve workspace lighting and reduce energy consumption.

Credit Criteria

<table>
<thead>
<tr>
<th>Material Selection</th>
<th>Innovation and Creativity in Energy</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Construct a double wall with 10mm insulation material (polystyrene and/or polyurethane), with U-values not less than 0.55 W/m²K</td>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Construct a double wall with an air gap of less than 10mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Educational Tool</td>
<td>Implement energy harvesting educational tool</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Lighting System</td>
<td>Implement an innovative approach to improve workspace lighting and reduce energy consumption.</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
3.4. Water

Egypt is situated in an arid climatic zone, with scarce rainfall, except along the northern Mediterranean coastal region. Little amount of rainfall occurs in the winter and may reach 1.5 billion cubic meters (BCM) per year. This meager quantity is not a reliable source of water due to its spatial inconsistency. The River Nile represents the main water resource; however, it is restricted to only 55.5 billion cubic meters (BCM) per year. (Ashour, El Attar, Rafaat, & Mohamed, 2009). The existent water shortage in Egypt accounts to 13.5 Billion m³/year (Omar & Moussa, 2016). The water demand is estimated to continuously rise, due to the rapid population growth, increased economic activities, in addition to the ever-increasing living standards (Abu-Zeid, 2002). Water conservation is a local, national and global issue that will impact generations for years to come. As major consumers of water, the use of water conservation practices in schools serves two-fold benefits; help provide local solutions to a global issue and simultaneously decrease the school facility's operational costs (Lehman & Joiner, 2010). Table (12) displays the prerequisites and credits comprised within the water category.

Table (12): Water category prerequisites and credits

<table>
<thead>
<tr>
<th>Prerequisite</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-01 Integrated Water and Wastewater Management Plan</td>
<td>Required</td>
</tr>
<tr>
<td>W-02 Water Saving Devices</td>
<td>3</td>
</tr>
<tr>
<td>W-03 Water Metering</td>
<td>1</td>
</tr>
<tr>
<td>W-04 Water Efficient Landscaping</td>
<td>3</td>
</tr>
<tr>
<td>W-05 Treatment and Reuse of Greywater</td>
<td>3</td>
</tr>
<tr>
<td>W-06 Rain Water and AC Condensate Harvesting</td>
<td>2</td>
</tr>
<tr>
<td>W-07 Innovation and Creativity in Water</td>
<td>6</td>
</tr>
</tbody>
</table>

TOTAL 18 18
W-01 Prerequisite: Integrated Water and Wastewater Management Plan

Sustainable water management is an integral aspect of the overall drive towards sustainable development, through which social and economic development are reinforced by the efficient management and use of water, whilst the environment is protected from harmful pollutants. The key drivers of water management in schools include: climate change; demographic changes; environmental impact due to the increased water withdrawal; potential cost savings, particularly when linked with other efficiency measures such as energy efficiency; reducing surface runoff; and increasing the students’ awareness of the importance of water conservation (CIRIA, 2006).

Intent

Provide a framework for the long-term and short-term strategic management of water and wastewater use across the focus areas identified within the water category credits.

Requirements

Develop an integrated water and wastewater management plan which may include the following:

- Discuss how the water and wastewater management plan may be implemented.
- Identify hazards and ways to manage risks to the water supply.
- Describe the water management objectives.
- Define the incremental stages of progress towards the water management plan objectives and their implementation schedule.
- Describe the necessary funding and resources.
W-02 Credit: Water Saving Devices

The restricted availability of water supply constitutes the main challenge facing the water resources system in Egypt (FAO, 2016; Omar & Moussa, 2016). As illustrated in Figure (23), the present per capita water share is below 1000 m³/year, and it is expected to decrease to 600 m³/year in the year 2025, which is within the international threshold of “water scarcity” (Abdel-Gawad, 2008; FAO, 2016).

![Population growth and per capita water share in Egypt (m³/year) (Abdel-Gawad, 2008)](image)

**Intent**

Increase water efficiency within the educational facility to reduce the demand on the public water supply system, in addition to resulting in cost savings.

**Requirements**

- Install high-efficiency water closets, urinals and squat toilets.
- Install low-flow lavatory faucets.
- Install water-saving hose nozzles

**Credit Criteria**

<table>
<thead>
<tr>
<th>Water Saving Devices</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace existing fixtures and appliances with water-efficient ones</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
The proper management and reduction in a facility's water usage is based on monitoring and recording its water use, and educating the main building occupants including its teachers, staff and visitors about the importance of water management planning. Since the majority of water use within a facility is primarily based on user behavior, the efficient operation and maintenance of water-consuming activities and equipment leads to significant water savings. Monitoring and education are critical in a water management program in terms of the awareness they disseminate to facility users which brings about the required behavioral changes. An effective program would include the following two phases (EPA, 2012):

Water meters allow the facility to constantly track the existing water consumption, and detect sources of excessive water use. In addition, it recognizes otherwise undetected water leaks, and identifies efficient water saving opportunities. Source meters are used to calculate the amount of water being provided to the entire facility, whereas submeters are used for specific activities such as water use in irrigation and process water. Submeters have the additional benefit of detecting leaks and malfunctioning equipment (EPA, 2012).

Water meters work by tracking the flow of water through a pipe, and are classified into two basic kinds: positive displacement and velocity. Positive displacement meters calculate the flow rate of water based on the number of times a water compartment of a known volume is filled and emptied. Whereas, velocity meters assess the water flow based on analyzing the volume of flow of water within a known cross-sectional area with a calculated velocity. The choice of selection of water meter is based on various factors: rate of water flow, pipe size, pressure loss and safety concerns (Satterfield & Bhardwaj, 2004). An effective leak detection and repair scheme is an essential aspect of a water management plan, as it prevents a facility from wasting substantial amounts of water. Attach a y-filter ahead of the water meter to guarantee that the meter does not get clogged. It is estimated that more than six percent of a facility's water supply is wasted due to undetected leaks. Whereas, a malfunctioning toilet at a leaking flow rate of 0.5 gallons per minute (gpm) wastes 21,600 gallons of water per month (EPA, 2012).
**Intent**
Reduce potable water usage by supporting the water management in the facility through the use of water metering and leak detection systems. Tracking water consumption patterns, and detecting water leaks identifies possible water saving opportunities, and helps set water reduction targets.

**Requirements**
Install water meters

**Credit Criteria**

<table>
<thead>
<tr>
<th>Water Metering</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install water meters</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
School gardens have various benefits for students, teachers, parents, the local environment and the wider community. Drescher (2002) argues that the failure of previous school garden projects were a result of institutional mismanagement or preliminary planning mistakes. He proposes that for the successful implementation of school gardens, a number of key components must be provided. The design of the school garden should correspond to the social, cultural, climatic, and environmental characteristics of the area, particularly in terms of crop selection and garden management practices. Additionally, the school gardens should involve the participation of all stakeholders, including students, parents, and school administrators. The methodology of the students’ involvement should be based on a participatory approach, which includes aided self-management, and involvement in planning and decision-making. Moreover, for the achievement of the program’s objectives, gardens must establish links and synergies with education, health, nutrition, agriculture and sustainability where possible. The strength of school gardens lies in their ease of implementation, with restricted financial investment and basic manual labor requirements. Furthermore, the use of municipal organic waste for compost in the gardens provides a closed nutrient cycle and reuses otherwise wasted resources, which forms an environmentally conscious and sustainable system (Torquebiau, 1992). Varela-Losada, et al., state that the sustainability of school gardens lies not only within itself, but in its generation of other sustainable actions (2016).

Research findings suggest that school gardening programs can offer a range of potential benefits in several key benefit areas. While main beneficial functions such as sustainability education, academic achievement, health and nutrition benefits, agricultural knowledge and skills, social and emotional health, and school and community benefits, are categorized individually, they are actually interconnected and display complementary outcomes (Neilson, 2015).

Studies of garden-based education programs reveal that students can learn sustainability concepts such as reuse, conservation, and environmental issues, by experiencing how these garden sites recycle organic waste material (Altieri, et al., 1999), reduce water runoff, and improve water and soil quality through careful soil management, and the application of ground cover to prevent soil erosion (Pimentel, Hepperly, Hanson, Douds, & Seidel, 2005). Furthermore, participating in school gardens allows students to connect directly with their food source, which allows them to develop sustainability values such as relationships and interconnectedness, by understanding their spatial and psychological connection to the land (Burns & Miller, 2012). Sottile, et al. underlined an emerging theme that links education with relationships between humans and ecosystems, that includes nature activities; observation of vegetation and wildlife, impacts of daily activities; which includes education on waste recycling and segregation, water-use and energy saving, and agriculture. Such environmental themes are of integral importance since they address new generations.
and the ongoing conflict between current development and restrictions imposed by the Earth’s limited resources (2016).

School gardens provide fertile ground to reinforce science concepts and provide an opportunity for curriculum linkages, which allows teachers to incorporate various subjects and topics within a garden session (Habib & Doherty, 2007). Qualitative studies presented positive outcomes of school-gardening initiatives on the educational achievement of participating students in the area of science (Klemmer, Waliczek, & Zajicek, 2005) (Motsenbocker & Smith, 2005) (Blair, 2009). Furthermore, a study of third and fourth graders revealed that the garden enhances the students’ connection to the natural world, and helps them articulate meaningful questions (Habib & Doherty, 2007). Researchers related the positive educational outcomes resulting from school garden initiatives to the students enjoying the educational experience when classes are linked with the school garden settings (Canaris, 1995; Dirks & Orvis, 2005). Additionally, since reflective practice is an essential step in converting students’ knowledge to understanding, school gardens provide a platform for students to reflect upon their direct experiences, thus strengthening their understanding (Habib & Doherty, 2007).

Student’s involvement in school garden programs helps revise their food attitude and habits, by improving their nutrition knowledge and preferences for healthier food choices, such as fruits and vegetables (Dyment & Bell, 2006), that lasts into adulthood (Morris & Zidenberg-Cherr, 2002). In addition, students who are involved in school gardens were reported to eat healthier snacks (Koch, Waliczek, & Zajicek, 2006). These changes are all essential, particularly with the growing influence of the fast-food industry on children’s’ nutritional choices. The school gardens also equip the students with the adequate knowledge and skills for improved agricultural productivity and sustainable agricultural practices, as environmental education is studied from a practical and sustainable dimension (Drescher, 2002). Furthermore, as students partake in gardening activities, they are presented by opportunities for moderate outdoor exercise, and positive social interactions (Gross & Lane, 2007).

The experiential and participatory learning processes through gardening programs offers schools the opportunity to instill a sense of ownership and responsibility in students. When students are actively engaged in acquiring new skills and knowledge, they display more interest in learning. In addition, as students learn about sustainable food systems, they acquire the skills necessary to actively create change in the community. Studies showed that as students planted seeds, their perception of food as more than just an edible source has changed, as they understand its inherent value to the community (Burns & Miller, 2012). Research showed that school gardens equip students with necessary life skills, including interpersonal and cooperative skills required to work within a group, self-understanding (Robinson & Zajicek, 2005). In addition, a study by Dyment & Bell, revealed that children who participated in garden activities are more likely to be acceptant of people’s individual differences (2006). Findings also show that school gardens served as a “safe place” for
students, which promotes feelings of calm, happiness, and relaxation. These emotions are significant, since not all students are fortunate enough to be brought in a calm and happy environment, therefore the garden acts as their sanctuary from various situations. Such positive feelings also have a positive impact on students with learning challenges including attentional issues (Habib & Doherty, 2007).

The innate human inclination towards plants and other living things is referred to as biophilia. The addition of elements of nature induces progressive change in human cognition and emotion, which has a significant positive impact on stress level, health, and general well-being (Grinde & Patil, 2009). School gardens have several benefits to teachers and communities. Teachers employed in schools with garden programs reported having higher workplace morale and heightened sense of satisfaction with teaching (Skelly & Bradley, 2000). In addition, Habib & Doherty (2007) showed that 68% of surveyed students reported sharing the acquired skills and knowledge with their family and friends, which has the potential to distribute the benefits to a much larger community, unassociated with the school garden program (Miller, 2007). However, it is estimated that the improper design, installation and maintenance of irrigation systems results in the loss of 50% of water through evaporation, wind, or runoff. Both environmental and economic benefits are gained by using efficient irrigation practices as the demand for water is lowered, and maintenance and operation costs are reduced (EPA, 2017).

Intent
Reduce or eliminate the use of potable water for landscape irrigation practices, and use the school garden as outdoor classrooms for active and engaged learning that reflect the goals of sustainable education.
Requirements
The provision of the following conditions is necessary for the implementation of a successful school garden program:

- Reduce potable water consumption below the baseline using both the following strategies:
  - Use native plants and grass which are adapted to Egypt’s local conditions; this provides the combined benefits of reduced water needs and maintenance requirements.
  - Use irrigation systems that improve the irrigation efficiency above the base case, and provide supporting documents. Table (13) indicates the water efficiency of various irrigation systems.

<table>
<thead>
<tr>
<th>Irrigation System</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinkler irrigation</td>
<td>63%</td>
</tr>
<tr>
<td>Garden hose with spray nozzle</td>
<td>66%</td>
</tr>
<tr>
<td>Drip irrigation</td>
<td>90%</td>
</tr>
</tbody>
</table>

- Use sustainable approaches to enhance and maintain the soil quality.
- Provide teachers with the necessary training to acquire the necessary practical and theoretical skills, in the areas of garden management, financing, nutrition, sustainable gardening methods and curriculum linkages.
- The financial aspect of the school garden project should be addressed by several methods of financial support, to ensure the project’s economic sustainability. This includes integrating the project’s finances within the school budget, establishing self-financing methods such as market production, and achieving the involvement of the private sector, NGOs, and parents (Drescher, 2002).

Credit Criteria

<table>
<thead>
<tr>
<th>Water Efficient Landscaping</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student’s active engagement in gardening program</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>50-70%</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>70-90%</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
W-05 Credit: Treatment & Reuse of Greywater

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) has anticipated a severe water shortage in 2020, which would pose a critical worldwide problem. As water demands are multiplied due to overpopulation, industrial and agricultural expansion, and general advancement in living conditions, the availability of freshwater is becoming increasingly scarce, which accentuates the importance of switching to alternative sources of water (Mohamed & Ali, 2012). Greywater is described as wastewater from showers, baths, hand basins, dishwashers, washing and kitchen sinks, that has not come into contact with fecal contamination (Jefferson, Laine, Parsons, Stephenson, & Judd, 1999; Ottoson & Stenstrom, 2003). Currently, economically feasible uses of treated greywater include toilet flushing and irrigation, where potable water quality is not required (Abdel Kader & Abdel Rassoul, 2010). Possible additional uses include cleaning outdoor spaces and car washing. Since roughly seventy percent of the global water used for agricultural irrigation is pumped from underground water resources, reducing the potable water consumption lessens the burden on the municipal treatment system, as well as decreasing the amount of wastewater discharged in the environment (EGGBC, 2018).

Treating and reusing greywater can be as simple as installing a surge tank with a small pump in the toilets for the temporary storage of the water collected from sinks. The water could then be pumped to the irrigation system through which water is delivered in consistent doses through the irrigation tubing for its use in landscaping, or upon demand in the toilet flushing system. A stage of chemical treatment could be added prior to the water’s transfer to either system. The adaptation of a single treatment technology is based on different parameters including greywater quality, weather and climatic conditions, space constraints, hygiene risks, guidelines and standards for greywater reuse within the country (Ramon, Green, Semiar, & Dosoretz, 2004) (Friedler & Hadari, 2006), and thus should be determined by experts. A former study illustrates the use of simple cost-effective treatment method which includes the addition of alum and the adjustment of greywater pH using bicarbonate salts (Skudi, Wanjau, Murungi, & Onindo, 2011). The primary goal of installing the greywater recycling system is to use it as a hands-on sustainable education tool for students and community members.

Constructed wetlands are engineering systems designed to replicate the naturally occurring processes of a natural wetland, including wetland vegetation, substrate, and associated microorganisms for the treatment of wastewater. As the water runs through the wetland, concurrent physical, chemical and biological mechanisms take place and the wastewater is cleaned and released through the outlet pipe (Davis, 2015). Various studies have been published on the recognition of constructed wetlands as a successful wastewater treatment method, based on their low cost, high removal efficiency, water and nutrients reuse, and other secondary benefits (Ghermandi, Bixio, Traverso P, Cersosimo, & Thoeye, 2007; Kadlec & Wallaca, 2009; Llorens, Matamoros, Domingo, Bayona, & Garcia, 2009; Rousseau,
Lesage, Story, Vanrolleghem, & De Pauw, 2008). Jokerst, et al., examined the treatment efficiency of a pilot-scale constructed wetland system on the campus of Colorado State University (CSU) for graywater over a one-year sampling period. Findings revealed that the constructed wetland substantially reduced the amount of pathogenic microorganisms, nutrients, suspended solids, dissolved and particulate organic matter, and surfactants (2012).

Macrophytes have numerous benefits in the wastewater treatment process, which makes them an indispensable constituent of the design of wetlands. The most significant properties are the physical effects of the plant tissues which includes stabilizing the soil surface thus hindering the creation of erosion channels, providing the optimal conditions for the sedimentation of suspended solids, preventing blockage in vertical flow systems, providing a large surface area for attached microbial growth, and increasing the decomposition of organic matter and nitrification (Brix H., 1997). Another important property is the insulating layer provided by the plant material during different seasons (Brix H., 1995). Other functions not directly related to the water treatment process include providing a suitable habitat for wildlife, including birds and reptiles (Knight, 1997), and enhancing the aesthetic appearance of the wastewater system (Brix H., 1997). The substrates used for constructed wetlands consist of natural materials such as soil, sand, gravel, crushed rock, and organic materials such as compost. They act as a growing medium for the macrophyte plants, and its permeability characteristics allow the movement of wastewater through the wetland system. In addition, substrates support biological and chemical transformations, and provide storage for many pollutants (Davis, 2015).

There are different designs of constructed wetlands, classified according to the water flow mechanism: surface flow (SF) wetlands, subsurface flow (SSF) wetlands, and hybrid systems that incorporate both surface and subsurface flow wetlands. As illustrated in Figure (24), in surface flow wetlands, water is allowed to flow over the substrate through the wetland, by an inlet pipe. The substrate is comprised of soil or other medium to support the vegetation roots. In subsurface flow wetlands water flows below the porous substrate of rock or gravel. As illustrated in Figures (25) and (26), the water level remains below the top of the substrate, where the path of water flow can be either horizontal or vertical. SSF wetlands are most suitable for wastewaters with fairly low solids concentration due to the hydraulic constraints imposed by the substrate. Nonetheless, the porous substrate provides a greater surface area for water treatment than in SF wetlands, therefore the size of the SSF system can be smaller than a SF system for the same volume of wastewater to be treated. In addition, SSF wetlands have no exposed water surface, so public access is not a problem. Also, they have reduced odor and pest problems, and have greater tolerance in cold climates, due to the insulating effect of the upper media layer. The disadvantages of SSF wetlands are that their construction, maintenance, and repair costs are generally higher than a SF system (Davis, 2015).
Figure (24): Surface Flow (SF) Wetland (Jaipur, 2014)

Figure (25): Horizontal Subsurface Flow (SSF) Wetland (Zhang, et al., 2012)

Figure (26): Vertical Subsurface Flow (SSF) Wetland (Jaipur, 2014)
Intent
Reduce potable water usage and reduce the burden on the municipal sewage treatment system by collecting and reusing greywater (EGGBC, 2018).

Requirements
Install on-site greywater recycling system for the subsequent use of water in toilet flushing or irrigation, as well as demonstrating the water conservation system for educational purposes.

Credit Criteria

<table>
<thead>
<tr>
<th>Treatment and Reuse of Greywater</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install on-site greywater treatment and recycling system</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Greywater recycling system as an educational tool</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
W-06 Credit: Rainwater and AC Condensate Harvesting

Rainwater harvesting is an effective and economical technique, which encompasses the collection of run-off rainwater from rooftop or ground surfaces for toilet flushing, landscape irrigation, environmental management and other uses. The system is comprised of three basic components: a catchment surface, a delivery system, and a storage reservoir (Worm & Hattum, 2006). AC condensate is water produced from air-conditioning equipment, and denotes a potential source of greywater, since mechanical systems use and produces a substantial amount of water (Gelfand & Freed, 2010). The condensate water quality; low in mineral content and disinfectants makes it suitable for irrigation purposes, make-up water in cooling towers, toilet flushing and water features (Alliance for Water Efficiency, 2006).

Intent
Reduce potable water usage and reduce the burden on the municipal sewage treatment system by harvesting and reusing rainwater and/or AC condensate (EGGBC, 2018).

Requirements
Install appropriate rainwater harvesting and AC condensate collection and reuse system.

Credit Criteria

<table>
<thead>
<tr>
<th>Rain Water and AC Condensate Harvesting</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install AC condensate harvesting system</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Install rooftop rainwater harvesting system</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
W-07 Credit: Innovation and Creativity in Water

The need for alternative approaches in water saving and wastewater treatment is necessary to enhance the water efficiency within the educational facility, reduce the demand on the public water supply system, reduce water utility costs, and reduce the burden on the municipal sewage treatment system. Strategies to save water within school restrooms, and treat municipal greywater for its subsequent reuse in irrigation, include but are not limited to the examples described below:

1. **Demonstrate an innovative approach to increase water efficiency within the school**

   The insertion of a water displacement device in the tank of a conventional toilet decreases the volume of water required to fill the tank, therefore the toilet is flushed using less water (Raven, Berg, & Hassenzahl, 2012). This can be achieved by a combination of different ingenious, low-cost products. A simple, frugal method includes placing a recycled plastic water bottle in the toilet tank, after washing it and removing the labelling. Fill the bottle with water, and add a handful of pebbles or rocks, to prevent the bottle from floating in the toilet tank. Place the lid on the bottle tightly, and position it carefully within the toilet tank to avoid its interference with the flushing mechanism (Cross, 2009). The “toilet tank diverter valve” illustrated in Figure (27) takes excess water from the bowl and diverts it to the holding tank, saving up to 75% of the fill cycle water; the equivalent of roughly 1.9 liters per flush (Wayfair LLC, 2018). The “toilet optimizer bag” illustrated in Figure (28) is a more sophisticated water displacement method which is lightweight, and maintenance free. It functions in the same way as that of the plastic water bottle, and is filled with water and placed along the inside of the toilet tank wall, saving approximately 2.4 liters of water per flush (Wayfair LLC, 2018).

![Figure (27): Toilet tank diverter valve (Wayfair LLC, 2018)](image1)

![Figure (28): Toilet Optimizer bag (Wayfair LLC, 2018)](image2)
2. Demonstrate an innovative approach to enhance the water efficiency of landscaping:

Subsurface drip irrigation (SDI) is a planned irrigation system in which water and nutrients are delivered directly to the root zone by porous tubing assembled below the ground surface, at uniform low-flow rates. It provides the highest water efficiency method compared to other irrigation techniques mostly due to the reduced evaporation losses. In addition, since there is no water runoff, soil erosion and volume of wasted water is reduced. Accordingly, upon proper design, installation and maintenance, SDI systems provide a water efficiency of 95% or higher, which indicates the crop root zone holds 0.95 inch or more for every inch of water pumped (Irmak, 2005)

Intent
Encourage the implementation of innovative approaches to increase water efficiency and treat wastewater within the school. This reduces water utility bills, and consequently lessens the demand on the public water supply system, and municipal sewage treatment system.

Requirements
Demonstrate innovative approaches to reduce water consumption and treat wastewater within the school.

Credit Criteria

<table>
<thead>
<tr>
<th>Innovation and Creativity in Water</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate an innovative approach to increase water efficiency within the school</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>and/or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrate an innovative approach to enhance the water efficiency of landscaping</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
3.5. Habitat - Indoor Environmental Quality

Improved indoor air quality in schools has a momentous effect not only on students’ health and academic performance, but also on teacher’s health and retention (Daisey, Angell, & Apte, 2003; Mendell & Health, 2005). However, children are more susceptible to pollutants than adults for a number of reasons. First, since they have a larger air intake by volume compared to adults (Bearer, 1995). Second, they are closer to the ground, and so are more exposed to toxins near or at ground level. Third, they have less control over their environmental exposures, and are not always capable of communicating their feelings of illness or discomfort (Baker & Bernstein, 2012). The indoor air quality can be affected by various factors such as maintenance activities, the presence of contaminant sources, including construction materials, furnishing and equipment, the levels of outdoor contamination, the season, indoor thermal and humidity condition, and ventilation rates (Hall, Hardin, & Ellis, 2003). Studies conducted by the EPA show that the concentration of indoor air pollutants is two to five times higher than outdoor concentrations (Wallace, 1987). Table (15) displays the prerequisites and credits comprised within the Habitat: Indoor Environmental Quality category.

Table (14): Habitat – Indoor Environmental Quality category prerequisites and credits

<table>
<thead>
<tr>
<th>HABITAT</th>
<th>Indoor Environmental Quality</th>
<th>Possible Points</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>New Schools</td>
<td>Existing Schools</td>
<td></td>
</tr>
<tr>
<td>Prerequisite</td>
<td>IEQ-01</td>
<td>Environmental Tobacco Smoke (ETS) Control Plan</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Prerequisite</td>
<td>IEQ-02</td>
<td>Construction Activity Pollution Prevention Plan</td>
<td>Required</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-03</td>
<td>Acoustical Performance</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-04</td>
<td>Indoor Chemical and Pollutant Source Control</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-05</td>
<td>Natural Ventilation</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-06</td>
<td>Daylight</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-07</td>
<td>Effective Seating Arrangements</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-08</td>
<td>Psychology of Color in the Educational Environment</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
Environmental tobacco smoke (ETS) is the mixture of both the side stream smoke given off by the burning end of the tobacco product, and the mainstream smoke exhaled by the smoker, which pollutes the surrounding air in which it's being smoked. Epidemiologic studies assert that the exposure of children to ETS is associated with increased rates of lower respiratory illness, increased rates of middle ear effusion, asthma, increased risk of coronary heart disease, altered lipid profiles, and increased overall cancer risk. (American Academy of Pediatrics, 1997). Additional health issues include growth impedence, neurobehavioral problems, and decreased academic performance (Hwang, Hwang, Moon, & Lee, 2012). Consequently, ETS is considered one of the most critical and contentious public health issues. Compared to adults, children have higher ventilation rates so are more susceptible to health effects from ETS exposure. Furthermore, since children can’t remove themselves from areas of ETS exposure, they are primarily dependent on protective strategies and public policies to safeguard their health (Tutka, Wielosz, & Zatonski, 2002). Statistics reveal that 46% and 32.2% of Egyptian male and female students respectively, aged 13-15 year olds have reported to being exposed to second-hand smoking a week prior to the study date (UNICEF, 2014).

Intent
Minimize or eliminate the exposure of school occupants, indoor surfaces, and ventilation air distribution system to environmental tobacco smoke (USGBC, 2009).

Requirements
- Prohibit smoking in the school building (USGBC, 2009).
- Prohibit smoking within 8 meters of building entrances, outdoor air intakes and operable windows (USGBC, 2009).
- Permit smoking within school grounds only in designated smoking areas within the school yard, which are prohibited to students.
IEQ-02 Prerequisite: Construction Activity Pollution Prevention Plan

Construction is considered a key sector in the Egyptian economy, as it accounts for 5.4% of Egypt’s GDP in 2017 (The World Bank Group, 2017). However, despite its contribution to the economic and social development in the region, it is also the source of a considerable amount of pollution, energy consumption, waste production and other environmental concerns. The main concerns of construction site pollution are air, water, soil and noise pollution. The most immediate pollution experienced is derived from air pollution which contributes to poor air quality. Airborne contaminants include PM10 (particulate matter of a diameter less than 10 microns), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), asbestos, carbon monoxide, carbon dioxide, and nitrogen oxides (Environmental Pollution Centers, 2017). The construction industry produces 40-50% of global greenhouse gas (GHG) emissions and agents of acid rain (California Integrated Waste Management Board, 2000). Studies have demonstrated the detrimental effects attributed to short-term exposure to PM10, which are small enough to penetrate the bloodstream and respiratory system, thereby affecting both the lungs and heart (Anwar, 2003) (Kesavachandran, Kamal, Bihari, Pathak, & Singh, 2015). Problems from such exposure include: increased stress levels, impaired lung function, increased airway inflammatory cells and airway resistance (Kesavachandran, Kamal, Bihari, Pathak, & Singh, 2015). In addition to cancer (Anwar, 2003), irregular heartbeats, mild heart attacks, mortality in people with existent lung or heart conditions (EPA, 2016). Studies indicate that average dust emission rates of above 2.5 tons per hectare occur every month on construction sites where no dust control measures are implemented. (Break O'Day Council, 2008).

The pollution of both the surface run-off and ground water resources in Egypt constitutes a key challenge in water quality. This deterioration leads to serious health, and quality-of-life concerns (Abdel-Dayem, 2011). Water surfaces, and soil close to construction sites could become polluted by a variety of construction contaminants, including: VOCs, adhesives, diesel, oils, toxic substances and cement. Groundwater pollution affects users upon direct water consumption, and indirectly by affecting the indoor air quality through the evaporation of the volatile water contaminants (Environmental Pollution Centers, 2017). In Egypt, noise ranks second amongst environmental pollution concerns. It has an adverse impact on human health, and social development, as a result of its direct and indirect effect on life activities, such as education, economic processes and production. Noise from the construction industry is a temporary source caused by the operation of machinery and equipment. Exposure to high noise levels is amongst the main triggers of human errors leading to accidents. Which is of significant importance, given that a road accidents survey in Egypt shows that human error accounts for 73% of accidents (EEAA, 2008). Despite the adverse environmental impacts of construction sites on human health, social aspects and the ecosystem, environmental protection of construction sites remains inadequately addressed. According to Khan (2000), this is the result of the common understanding that activities within a construction site are temporary, and last for only a couple of years.
**Intent**
Reduce pollution from construction activities by controlling airborne dust generation, waterway sedimentation, harmful emissions of combustion, and waterway sedimentation.

**Requirements**
Create and implement a construction activity pollution prevention plan for all construction activities associated with the project. The plan should conform to the Egyptian law number 4 of 1994 (which includes articles 39, 40, 41, 42, 57, 59), pertaining to executive laws and executive regulations regarding construction site pollution and waste. The plan must depict the procedures implemented to achieve the following objectives:

- Prevent pollution of the air with dust and particulate matter.
- Control the harmful emissions of combustion.
- Ensure safe storage and transportation of construction debris.
- Provide suitable waste treatment to prevent the discharge of polluting substances into water bodies.

**Example**
Consider employing strategies such as:
- Install perimeter site fencing with heavy duty tarpaulins.
- Stabilize construction site entrance/exit. Site stabilization methods include: mulching, vegetation, erosion control blankets, dust suppression and controls.
- Provide for storm water drainage and construct curbing to prevent water erosion onto paved roads.
- Equip trucks with splash guards to prevent the vehicle, passengers, other vehicles and pedestrians from rocks, mud and flying debris picked by the vehicles wheels.
- Install sediment fences on all downhill sides of the property to protect water quality in nearby water bodies by preserving sediment in place where soil is being disturbed by construction processes, which would otherwise be lost due to storm water runoff.
- Install a wheel wash where vehicles and equipment exit/enter the construction site.
IEQ-03 Credit: Acoustical Performance

Speech communication is an integral constituent of the learning process. Within an educational setting, speaking and listening are involved in up to 60% of classroom activities between teachers and students and between students and each other. Therefore, good acoustical quality is a critical requirement of educational environments (Acoustical Society of America, 2010). A considerable amount of research has shown the detrimental effect noise has on the academic performance of students. This is of significant importance to younger students (Acoustical Society of America, 2010), as the ability to distinguish speech under adverse listening conditions is a developmental skill that does not develop until the teenage years (Bradley, 2007). In addition, classroom acoustics has a particular adverse effect upon children with special needs, such as hearing impairment (Acoustical Society of America, 2010; Nelson & Soli, 2000), learning difficulties (Acoustical Society of America, 2010; Bradlow, Krauss, & Hayes, 2003), language, speech, and attention deficits (Acoustical Society of America, 2010). In addition to the academic struggles, studies show that such students experience social and behavioral problems (Nelson & Soli, 2000). Learning activities affected by noise include reading, memory, enthusiasm, and attentiveness (Clark, et al., 2006; Evans & Lepore, 1993; Haines, Stansfeld, Head, & Job, 2002). Experimental tests conducted by Shield & Dockrell revealed that test scores were negatively interrelated with classroom noise levels (2008). Similarly, children were less motivated to solving difficult puzzles in noisier classroom environments. (Cohen, Evans, Krantz, & Stokols, 1980). Correspondingly, well-designed acoustical characteristics of a classroom make the teaching process more efficient, as there is a less stressful environment to teach in, with more verbal communication and less repetition of spoken words between teacher and students, since there is better speech intelligibility (Acoustical Society of America, 2010).

The lack of research into the importance of acoustics in architectural design in Egypt, along with the absence of acoustic performance standards in Egyptian buildings codes results in poor acoustic conditions in educational facilities in Egypt (Awad, Farag, Taha, & Hanafi, 2012). In 2002, The American National Standards Institute (ANSI) and the Acoustical Society of America (ASA) jointly developed a standard for acoustical design, ANSI S12.60-2002. Compliance with the acoustical performance criteria of the standard, would ensure good acoustical characteristics of learning spaces (Acoustical Society of America, 2010).

The three key acoustical issues affecting classroom design are background noise, reverberation time, and sound isolation (Acoustical Society of America, 2010; Gelfand & Freed, 2010). According to the Acoustical Society of America, background noise is defined as “Sound in a furnished, unoccupied learning space, including sounds from outdoor sources, building services and utilities (..)” (2010,3). The standard excludes sounds generated by building occupants, or sound created by educational equipment. The main sources of background noise include mechanical systems (HVAC and plumbing equipment), and exterior sources of noise, such as vehicular traffic and aircrafts (Gelfand & Freed, 2010).
Reverberation is defined as the time duration required for prolonged sound waves to drop by 60dB below the original sound (Acoustical Society of America, 2010). Gelfand & Freed, describe it in more simpler terms as the amount of time a sound remains in a room after the sound source has cease. In addition, three factors govern the reverberation time: room’s size, shape and finish materials (2010). Adequate sound isolation is necessary in schools due to the disparate use of educational spaces. In the planning stage, the location of noisy spaces and quiet spaces should be carefully considered, in order to minimize distractions to occupants (Acoustical Society of America, 2010).

**Intent**

Provide educational spaces that enhance speech communication between teachers and students and between students and each other through efficient acoustical design.

**Requirements**

Compliance with the ANSI S12.60 acoustical guidelines in order to achieve the minimum levels of background noise, reverberation time and sound isolation in classrooms and other learning spaces.

**Example**

- **Background noise**
  The background noise should be controlled in terms of noise reduction from exterior to interior spaces, between spaces within the school building, and inside the classroom space (USGBC, 2009). The careful consideration of the school building location away from external noise sources, and suitable landscape design (Trane, 2003), in addition to the use of thick and massive materials in walls and roofs would reduce the external to internal noise transmission (USGBC, 2009). Similar concern should be given to the placement of roof-mounted and grade-level equipment in order to not contribute to the background-sound level in educational spaces (Trane, 2003). Also, windows should be well-sealed and have sufficient air gaps in order to increase their insulating properties (USGBC, 2009). Similarly, doors should have door seals in order to prevent noise transmission from the gap under the door. Moreover, classrooms include various hard surfaces such as hard flooring, desks and plastic chairs, which have poor sound absorbing properties. Replacing plastic seating with upholstered chairs improves the sound absorption and has the extra advantage of enhancing the student comfort. Likewise, placing curtains or blinds at the windows absorbs sound in the classroom, and reduces the outdoor-to-indoor noise levels. Hard flooring is a major contributor to high background noise levels. Cushion-backed carpet tiles absorbs noise three times more than hard flooring, and 50% more than hardback carpet (Brown, 2016).
Reverberation time
Reverberation requirements can be achieved by the use of sound absorbent materials on ceilings and walls (USGBC, 2009) (Gelfand & Freed, 2010). Consider the use of absorbing ceiling materials (e.g., lay-in acoustical tiles, stretched fabric, and acoustical plaster), in addition to absorbing wall material (e.g., fabric-wrapped panel, perforated metal and wood) (Gelfand & Freed, 2010).

Credit Criteria

<table>
<thead>
<tr>
<th>Acoustical Performance</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compliance with the ANSI S12.60 acoustical guidelines in order to achieve the minimum levels of background noise, reverberation time and sound isolation in classrooms and other learning spaces.</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
IEQ-04 Credit: Indoor Chemical and Pollutant Source Control

There are numerous pollutants in school buildings. These pollutants include chemical fumes, biological particles, particulate matter, and dirt. It is necessary to contain the pollutants in order to prevent their transmission into educational spaces. The installation of permanent entryway systems enhances the indoor environmental quality by capturing up to 80 per cent of soil, which would otherwise contribute to indoor particulate pollution. (Belew, 2011). The physical arrangement of the laboratory and other spaces in which hazardous gases and/or chemical exist or are used is of critical importance. Since if an experiment involves the production of volatile materials, or chemical fumes, or usage of flammable solvents then it is essential to assess the ventilation needs and ensure the availability of sufficient fume hoods and ventilation to provide a safe environment (American Chemical Society, 2016).

Intent

Enhance the indoor environmental quality by reducing the transmission of chemical fumes, biological airborne substances, particulate matter, and dirt that pose a health or safety hazard to the building occupants.

Requirements

Minimize and control the entry of pollutants into buildings, which contribute to the cross-contamination of regularly used areas by implementing the following strategies:

- Employ permanent entryway systems at least one meter long at all outdoor accesses to capture dirt and particulates entering the school building at exterior entrances. Acceptable entryway systems include grilles and grates, since they can be easily cleaned underneath, and do not require the same level of maintenance as roll-out mats (EGGBC, 2018). Roll-out mats are acceptable only if they will be maintained on a weekly basis (USGBC, 2009).

- Exhaust each space where hazardous gases and/or chemical exist or are used. (e.g. science laboratories, prep rooms, art rooms, and photocopying and printing rooms. The exhaust rate must be at least 0.50 cubic feet per minute (cfm), per square foot, without air recirculation. These spaces should have deck-to-deck partitions or a fixed ceiling, both with a self-closing door, in order to prevent fumes or gases from penetrating adjacent spaces. In addition, a pressure difference of ≥ 1 Pascal (PA) at a minimum, and ≥ 5 Pa on average should be maintained with the adjacent spaces when the room doors are closed (USGBC, 2009).
In mechanically ventilated buildings, the filtration media should of the air cleaning devices located within the ventilation systems, should be installed after the construction process and prior to occupancy. They should also meet one of the following criteria (USGBC, 2009):

- Minimum efficiency reporting value (MERV) ≥ 13.
- Class F7 or higher.
- Minimum dust spot efficiency ≥ 80%, and filter arrestance ≥ 98% for particles sizes 3-10 μg.

Credit Criteria

<table>
<thead>
<tr>
<th>Indoor Chemical and Pollutant Source Control</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement indoor chemical and pollutant source control mechanisms</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Natural ventilation is the process of introducing and circulating outdoor air inside or outside a building utilizing natural ventilating systems to enhance the indoor air quality. It relies on the pressure differences between indoor and outdoor air instigated by thermal, wind, or humidity forces through intentional openings in the building to circulate fresh air into buildings (Akadiri, Chinyio, & Olomolaiye, 2012; ASHRAE, 2007; Atkinson, et al., 2009). The availability of fresh air in buildings is essential to relieve unpleasant odors, provide adequate amounts of oxygen for respiration, enhance the thermal comfort of spaces (Walker, 2016), as well as regulate indoor temperatures, pollution, and air movement (Akadiri, Chinyio, & Olomolaiye, 2012; Fordham, 2000). The application of natural ventilation in school buildings presents a cost-effective strategy to maintain ventilation rates that are consistent with acceptable levels of indoor quality; improve building energy efficiency; lower the building’s construction and operation costs; and decrease cooling loads in buildings (Emmerich, Dols, & Axley, 2001).

A review of the past literature, demonstrates that classroom ventilation has been recognized as an important element of indoor air quality (Duffield, 1927). Several researchers analyzed the relationship between ventilation rates in schools and students’ illness absenteeism. Findings indicated that lower ventilation rates are associated with higher illness absences (Mendell, et al., 2013; Simons, Hwang, Fitzgerald, Kleib, & Lin, 2010). Similarly, Smedje & Norbäck reported that the installation of a new ventilation system decreased the exposure to airborne pollutants, which resulted in less asthmatic symptoms amongst school occupants (2000). An observational study conveyed a linear relationship between reduced classroom ventilation rates and students’ lower academic achievement (Moschandreas, Haverinen-Shaughnessy, & Shaughnessy, 2011). Experiential hypotheses indicate that ventilation rates do not only affect the indoor levels of CO₂, but also levels of other indoor air pollutants (Satish, et al., 2012).

Naturally ventilated systems based on the incorporation of natural ventilation strategies such as cross-ventilation and stack effect are a key element of sustainable design (Mavrogianni & Mumovic, 2010). As illustrated in Figures (29) to (33); wind-driven cross ventilation, buoyancy-driven stack ventilation, and single-sided ventilation are three fundamental variants of natural ventilation approaches utilizing cross-ventilation and stack effect strategies. Wind-driven cross ventilation, illustrated in Figure (29) occurs via ventilation openings, typically windows, on opposite sides of an enclosed space, through which the ventilation flow must be controlled to remove heat and pollutants from the interior spaces. An adequate ventilation flow is maintained by a substantial difference in wind pressure between inlet and outlet openings and a minimal level of internal resistant to flow. Buoyancy-driven stack ventilation, illustrated in Figure (30) is based on density difference between cool, outdoor air at low ventilation openings, and warm, indoor air at higher ventilation openings. An atrium is frequently installed to generate a sufficient buoyancy force to achieve the needed air flow. However, wind effects are more integral to stack ventilation schemes, therefore
successful designs should incorporate both ventilation strategies (Emmerich, Dols, & Axley, 2001).

As illustrated in Figure (31), single-sided ventilation in a multi-room building is driven by room-scale buoyancy effects, and minimal pressure differences of the building envelope. It is the least appealing natural ventilation approach, since the driving forces tend to be comparatively low and highly variable. Mixed ventilation schemes can be integrated within a single building for optimal levels of indoor air quality. Figure (32) illustrates the combination of stack ventilation, cross-ventilation, and single-sided ventilation. Another mixed ventilation approach is demonstrated in Figure (33), which implicates the use of raised floors to provide more controlled distribution of fresh air across the building (Emmerich, Dols, & Axley, 2001).
Intent

Enhance the indoor environmental quality by providing adequate amounts of oxygen, and regulating indoor air temperatures, pollution, and air movement to promote occupant comfort and productivity.

Requirements

Apply wind-driven cross ventilation, buoyancy-driven stack ventilation, and/or single-sided ventilation to ensure that CO₂ levels in occupied indoor spaces does not exceed 1500 parts per million (ppm).

Credit Criteria

<table>
<thead>
<tr>
<th>Natural Ventilation</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
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<tbody>
<tr>
<td>Incorporate natural ventilation strategies which ensure that CO₂ levels in occupied indoor spaces does not exceed 1500 ppm</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Daylight is the primary source of illumination in buildings, and is considered an integral component of sustainable building design (Abdelatia, Marenne, & Semidor, 2010; Giarma, Tiskaloudaki, & Aravantinos, 2017). From a philosophical perspective, Gelfand & Freed depict light as the metaphor for learning and enlightenment, and accordingly consider daylight as the best investment in the design of an educational environment. Additional benefits of daylighting include reduced operational costs, as energy savings are cut by up to 20% due to decreased cooling loads; reduced peak usage, since daylight is provided during the day when the electrical demand is at its peak, thus reducing the burden on the power grid and infrastructure; decreased carbon footprint, as approximately 60% of electrical production required for artificial lighting is generated from burning fossil fuels; improved student performance and mood of the students and faculty (2010).

Further studies were conducted on the impact of daylighting in classrooms, which have demonstrated an improvement in students’ overall physical and mental health, and enhanced academic performance. Daylighting promotes a healthy educational environment; particularly through regulating the human circadian system, which maintains a regular sleep cycle, and adjusts the secretion of melatonin responsible for reducing chronic fatigue, depression and possibly even cancer; maintaining a healthy vitamin D status required for calcium absorption and bone formation; and aiding the healthful development of eye and vision (Baker, Fanchiotti, & Steemers, 1993; Figueiro & Rea, 2010; Stevens & Rea, 2001). Daylighting has a profound impact on the mental health of students and educators. Several studies have theorized the positive impact daylighting has on a student’s mood and classroom behavior; decreasing violent behavior, seasonal affective disorder and depression (Gelfand & Freed, 2010; Heschong, Wright, & Okura, 2002; Plympton, Conway, & Epstein, 2000). The positive impact of daylight on students’ academic performance has been thoroughly documented in literature (Plympton, Conway, & Epstein, 2000; Spector, 2012) (Gelfand & Freed, 2010). Recent studies by Heschong, et al. (2002) conducted on approximately 8000 students in 450 classrooms, demonstrated that direct sunlight, glare and inefficient use of windows had a negative effect on students. These findings are consistent with previous results, which revealed a 20-26%, and 7-18% improvement in reading and math test grades respectively, of more than 21,000 students in elementary classrooms with sufficient daylight levels in California (Heschong, et al., 1999).

As illustrated in Figure (34), Veitch, a specialized researcher in the interrelated relationship between the quality and usage of light, states that the evaluation of the lighting quality of a space involves a multitude of factors: individual wellbeing, economics, and architecture. The model recognizes that the occupant’s response to their lighting environment is rather contextual, depending on varying characteristics such as their personal preferences, room layout, and lighting installation (2001). Similarly, Gelfand & Freed assert that successful daylighting is based on the integration of various elements: building’s location, shape, and size; properties of openings in terms of their orientation, shading and technical details of
glazing; space planning of interior spaces, and buildings envelope design. However, the optimization of the aforementioned elements should be complemented with the users’ understanding and awareness of the correct and sustainable utilization methods of lighting systems. Furthermore, the lighting strategy should only admit the penetration of diffuse or reflected light, to reduce visual and thermal discomfort caused by direct sunlight and glare. Additionally, daylight openings should be located at the edge of a sloped or perpendicular surface allowing the provision of gentle uniform illumination that is reflected deep into the interior space. The amount of daylight should be controllable by means of cost-effective blinds and shades to darken the rooms according to user needs. The daylight and the electric lighting design should complement one another, so that the artificial lighting could be manually or automatically switched on or off according to the available daylight levels (2010).

**Intent**
Create healthy educational environments; to improve the children’s’ academic performance, and reduce the environmental impact associated with the consumption of fossil fuels, while resulting in significant cost savings.
Requirements
Incorporate daylighting strategy that demonstrates through records of indoor light measurements a minimum daylight illuminance level of 110 lux, and a maximum of 5400 lux in a clear sky condition (USGBC, 2009).

Credit Criteria

<table>
<thead>
<tr>
<th>Daylight</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate daylighting strategy that records a minimum daylight illuminance level of 110 lux, and a maximum of 5400 lux</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
IEQ-07 Credit: Effective Seating Arrangements

The physical setup of the classroom can significantly influence the students’ academic and behavioral outcomes (Wannarka & Ruhl, 2008). However, despite the intricate relation between the physical and social structures of the classroom, design education remains deficient in most educational systems, and the connection between design and behavior is overlooked (Sommer, 1977). Instructional communication theory indicates the correlation between seating arrangements and how the teacher communicates with students, and how the students interact with one another, both of which are critical to the teaching and learning process (McCorskey & McVetta, 1978; Oliver & Kostouros, 2014). Similarly, several researchers examined the relation between a student’s position in the classroom, and the number of questions they are likely to ask the teacher (Sommer, 1967; Moore, 1984; King, 1995; Marx, Fuhrer, & Hartig, 2000). This is a significant area of study, since “... questions serve many important educational functions, enabling individuals to seek information, obtain clarification, and receive information, among other uses” (Marx, Fuhrer, & Hartig, 2000, 252). Additionally, Granström claims that the students’ interaction level with one another is higher when seated at the back, which has an adverse impact on their attentiveness to the task at hand (1996).

The general conclusion drawn from an extensive body of literature is that there is no ideal classroom layout, however it is to be dictated by the nature of the academic task, and the anticipated kind of behavior, in order to attain the required educational goals (Sommer, 1977; McCorskey & McVetta, 1978; Marx, Fuhrer, & Hartig, 2000; Wannarka & Ruhl, 2008). While there is an endless number of possible classroom layouts, there are three most common: row-and-column, u-shaped, and modular, each has its own set of advantages and disadvantages. Despite vast amounts of research challenging the concept of the straight row arrangement, it remains the most dominate in the educational field (Oliver & Kostouros, 2014; Rosenfeld & Civikly, 1976; Watson, 2007). While on the contrary, teachers should make informed decisions regarding the seating configuration best suited for their students’ educational needs, and most conducive to the task in hand (Sommer, 1977; Watson, 2007; Wannarka & Ruhl, 2008).
**Row-and-column arrangement**

This is the traditional classroom layout in which students are placed in evenly spaced rows and columns facing the front of the class, as illustrated in Figure (35). This layout is suitable for teacher-centered instruction, where the purpose of the class is merely based on information dissemination, and students are required to be focused on individual assignments, and coursework (Sommer, 1977; Wannarka & Ruhl, 2008). Studies support the idea that if the teachers want to increase on-task behavior of students such as hand raising and writing, and decrease off-task behavior such as interaction with other students, then this appears to be the superior arrangement (Hastings & Schwieso, 1995; Lam & Wheldall, 1987; Wannarka & Ruhl, 2008). Furthermore, evidence from a study conducted by Lam & Wheldall (1987) indicate that on-task behavior doubled from 35% to 70% when the seating arrangement shifted from the modular arrangement to rows, and the rate of disruption was three times less. Hastings & Schweiso replicated a similar study of Lam & Wheldall. Their findings suggest that the row-and-column arrangement enhanced the on-task behavior of all students in the class, with the largest improvement in the initially most disruptive students (1995).

This seating arrangement is suitable for use in any classroom size, however students' position relative to the teacher within the classroom is an important physical aspect to be considered (George Patton Associates, 2015). An increasing number of studies have found that this layout leads to uneven levels of interaction as students in the front rows, and in the center of each row display the highest levels of interaction, whereas the ones at the back are most likely to lose focus (Adams & Biddle, 1970; Marx, Fuhrer, & Hartig, 2000; Sommer, 1967). Moreover, a vast number of specialists from a teaching methods approach consider the row-and-column arrangement to be the least desirable compared to other alternatives (McCorskey & McVetta, 1978). Rosenfeld and Civikly (1976) referred to this layout as...
“something like tombstones in a military cemetery” (161). McCorskey & McVetta support this notion, in asserting that " [t]his arrangement can also suggest that teachers are more concerned with controlling than teaching, and that school is not for learning". (2014,6). It is somewhat as Holt (as cited in Champagne & Tausky, 1976) suggested “.. a place where children are made to go, where they are told what to do, and where unquestioning obedience is demanded” (232). Moreover, Paulo Freire refers to this approach as the “banking model of education” (Alam, 2013), where knowledge is delivered to passive students of which the absorbed portion is later just regurgitated in exams (Oliver & Kostouros, 2014). Therefore, good teaching depends on co-creating a space where control and power is shared between both teachers and students (Oliver & Kostouros, 2014; Watson, 2007). This is supported by Reggio Emilia’s philosophy on education, in which the students, teachers and the environment are considered to be educators (Strong-Wilson & Ellis, 2007).

- **U-shaped arrangement**

![Figure (36): U-shaped seating arrangement](image)

The U-shaped arrangement illustrated in Figure (36) is suitable for both teacher-and student-centered instruction, as it fosters an interactive environment in which class discussion and participation are encouraged (McCorskey & McVetta, 1978). In addition, it enhances the relationship between both the students and one another, and the teacher (Marx, Fuhrer, & Hartig, 2000; Oliver & Kostouros, 2014). Studies have found that this layout leads to more frequent question-asking than in the row-and-column arrangement (Marx, Fuhrer, & Hartig, 2000). Sommer concurred and suggests that the unhindered eye contact between teacher and students, and between one another is a critical variable that affects the interaction in class (Sommer, 1967). In addition, students may develop deeper feelings once in close proximity to the teacher (King A. , 1994; Millard & Stimpson, 1980), and as such are more attentive and display more interest out of courtesy (Becker, Sommer, Bee, & Oxley, 1973). Moreover, this layout is most applicable only for small and medium sized classes, (George Patton Associates, 2015), because of the “dead space” in the center (McCorskey & McVetta,
Accordingly, it is difficult for students and teachers to engage in classroom discussions in larger sized classes. In addition, this arrangement generally makes it harder for teachers to control the students' behavior (George Patton Associates, 2015).

- **Modular arrangement**

The modular arrangement illustrated in Figure (37) is mostly used for student-centered instruction (George Patton Associates, 2015; Marx, Fuhrer, & Hartig, 2000; McCorskey & McVetta, 1978). This layout permits the highest interaction within individual groups, and minimizes the interaction between different groups. It also allows teachers to work closely with students on an individual basis or within small groups (McCorskey & McVetta, 1978). Like the U-shaped arrangement, it improves the interaction in class due to students' proximity and position (McCorskey & McVetta, 1978), which facilitates brainstorming activities (Rosenfield, Lambert, & Black, 1985) and question-asking (Marx, Fuhrer, & Hartig, 2000). It also allows students to acquire problem solving and communication skills, however, it makes it more difficult to assess individual student’s capabilities and understanding (George Patton Associates, 2015). In addition, this arrangement decreases productivity, and increases off-task behavior and disruption (George Patton Associates, 2015). This notion is supported by the study conducted by Lam & Wheldall, which reveals that on-task behavior in this layout is 50% less than when students are seated in the row-and-column arrangement, whereas the distraction rate is three times higher (1987). This layout is applicable for all classroom sizes (George Patton Associates, 2015), and is mostly used in specialized classrooms, such as home economics and science laboratories, and in primary school classrooms (McCorskey & McVetta, 1978).
Intent
Implement effective seating layouts within educational spaces, based on the nature of the academic task, in order to attain the required educational goals.

Requirements
The teacher's educational philosophy should be reflected in the layout of the classroom. The teacher should also be able to justify the arrangement of desks and chairs on the basis of the necessitated educational and behavioral outcomes.

Credit Criteria

<table>
<thead>
<tr>
<th>Effective Seating Arrangements</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement effective seating strategy</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
IEQ-08 Credit: Psychology of Color in the Educational Environment

Color in the educational environment constitutes a major design element, with a direct impact on the students’ achievement, and teacher and staff productivity (Daggett, Cobble, & Gertel, 2008; Grube, 2013). The energy carried in color has a major impact on the human body functions and influences the mind and emotion. It changes the level of alpha brain wave activity, which is a measure of human alertness. Additionally, color transferred through the human eye causes the brain to release the hypothalamus hormone, which consequently affects our mood, mental clarity, and energy level (Engelbrecht, 2003). Consequently, color selection in physical learning environments shouldn’t be considered a mere aesthetic aspect of an educational space, but holds an imperative functional purpose (Engelbrecht, 2003; Gaines & Curry, 2011; Grube, 2013; O'Brien, 2017). Humans perceive the greatest overall distribution of color that exists within a given space. In an educational setting, walls have more visual weight than furniture and other elements, and thus constitute the largest distribution of color; correspondingly, students’ feelings towards an environment are based on the stimulated effect of the wall color selection (Grube, 2013). Within an educational setting, the appropriate use of color enhances visual processes and reduces stress, whereas the induced visual stimulation assists in problem solving, visual thinking, and creative processes. In addition, color has a direct impact on reducing eye fatigue, glare, and increasing concentration levels. It also reduces hostility, vandalism, and disruptive behavior, modifies the perception of time, and decreases absenteeism (Daggett, Cobble, & Gertel, 2008).

Psychologists link color in educational environments with brain development, and the human evolution from child to adult. Therefore, the application of color should be sensitive to each age group’s different responses to color, in order to create an enabling environment, capable of supporting the child’s development process (Engelbrecht, 2003). Research has indicated that both warm color palettes such as shades of yellow and peach, and cool color palettes of shades of blue and green constitute the majority of recommended classroom wall colors (Warner & Myers, 2010; Grube, 2013).

- **Preschool and elementary school.** The use of warm, bright color schemes (Cobble, & Gertel, 2008; Mahnke, 1996; Daggett). This includes warm yellows, pale yellows, salmon, peach/orange (Daggett, Cobble, & Gertel, 2008). Since the hues within the warm spectrum induce feelings of security and comfort, they help young students feel relaxed within the educational environment, as it decreases the scale of otherwise perceived large spaces, whilst increasing their brain activity (O'Dell, 2018).

- **Middle school.** As students get older, there should be a transition from warmer colors to cooler colors (Daggett, Cobble, & Gertel, 2008). Warmer colors used in the preceding age group energizes students, whereas cooler colors provide a relaxing setting, which enhances the students’ ability to concentrate, and allows for more focus on tasks in hand (Grube, 2013). The appropriate color selection is bright medium-cool colors. This includes greens, blues and green-blues (Daggett, Cobble, & Gertel, 2008).
High school. As children mature into adolescence, they associate primary colors that were used in earlier age groups with immaturity (Daggett, Cobble, & Gertel, 2008). Preference is given to deeper, more subdued colors schemes. This includes olive green, violet and gray (O’Dell, 2018). In addition, more contemporary colors such as teal or orange, give older students the feeling that they are in modern, fashionable environments. In addition, the use of cooler tones, such as blue, green and violet has been found to increase the calmness of high school students, as well stabilize their hormone levels (O’Brien, 2017).

Since the 1920s, researchers and design specialists have rendered the importance of color variety on classroom walls (Grube, 2013). The use of a focal or accent wall of a darker or contrasting hue than the other three walls is recommended for several reasons. It attracts student’s focus to the front of the classroom, alleviates the visual monotony, and reduces eye fatigue as students look up during note taking. (Engelbrecht, 2003; Grube, 2013). Despite the use of color variety in reducing boredom and inactiveness, and refreshing the visual perception of students, its overuse however - more than six colors in a given space, would stress the mind’s cognitive capabilities. The diversity of color within a learning environment should be based on age, subject and activity. Therefore, as each educational space serves a different function, the color selection should correspond to each respectively (Daggett, Cobble, & Gertel, 2008):

- **Stairways and hallways.** The use of bright, complimentary and vibrant colors provides variety and stimulation as students and staff passes from one room to another (Cottieau, 2008). Since these areas serve for movement, the use of stronger colors would encourage activity and elevate the energy in the walk between classes (O’Brien, 2017). Additionally, the use of a more diverse range of color, than that present in classrooms gives the school an animated and distinguishing personality (Engelbrecht, 2003; Cottieau, 2008). Moreover, school entrances, and hallways constitute a perfect platform for the use of school colors if available. Utilizing school colors instills a sense of pride and belonging in students, and stimulates more school spirit (Cottieau, 2008; O’Brien, 2017). This has a direct impact on the students’ confidence levels and academic performance (O’Dell, 2018).

- **Library.** The use of various colors depending on the diverse functions in the library requires the creation of a harmonious balance between the incorporated multiple hues (O’Dell, 2018). Reading and study areas require calm colors that encourage discreetness and concentration. Recommended hues are pale or light green. (Engelbrecht, 2003; O’Dell, 2018). Whereas, areas which require social interaction should include more vibrant hues to stimulate engagement and conversation (O’Dell, 2018).

- **Athletic Facilities.** The use of dynamic colors, since gymnasiums are areas of motion. Recommended hues include yellow, red and orange, due to their association
with the heart and nervous system. Students with asthma have revealed a positive response to yellow (O'Dell, 2018). Additional suggested colors include peach tones, lime, and medium green (Daggett, Cobble, & Gertel, 2008). However, the overuse of orange and peach tones could be over stimulating, and so should be balanced out with complimentary cool tones. Such tones are also suitable for use in multimedia rooms (O'Brien, 2017).

- **Cafeteria.** The use of cool hues has proven to suppress the appetite, whereas applying warm neutral colors with bold splashes of orange and red have been shown to instigate the appetite (O'Dell, 2018). Daggett et al. support the use of orange and red, in addition to lime, and dark brown, and deplore the use of blue, yellow-green, and magenta (2008).

- **Toilet.** The use of comforting colors such as white and blue (Daggett, Cobble, & Gertel, 2008).

- **Clinic.** The use of refined colors to reduce anxiety levels. Colors that are to be avoided include bright yellow and red. Daggett et al. recommend the use of sky blue, pink, green, light yellow and white (2008).

- **Counseling.** The use of natural, balanced colors such as green (O'Brien, 2017). Daggett et al. support the use of green in addition to peach, medium brown and yellow, and disapproves the use of red and bright yellow (2008).

- **Science Lab.** The use of shades of blue have been shown to lower the heart rate, allowing concentration levels to rise. (Daggett, Cobble, & Gertel, 2008; O'Brien, 2017).

- **Computer Lab.** The use of encouraging medium colors that provide visual relief, and avoiding the usage of bright colors (Daggett, Cobble, & Gertel, 2008).

- **Creative Pursuit.** This includes classrooms dealing with art, languages, home economics, etc. Calm energy yellows are suitable for such educational spaces (O'Brien, 2017). Daggett et al. support the use of light yellow in addition to other colors which promote creativity such as green, violet, red, peach, and pink (2008).
Intent
Create an enabling environment, capable of supporting the child’s development process, through the appropriate use of wall colors.

Requirements
Implement appropriate color choices for the walls of learning environments, based on age, subject and activity. As each educational space serves a different function, the color selection should correspond to each respectively.

Credit Criteria

<table>
<thead>
<tr>
<th>Psychology of Color in the Educational Environment</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement appropriate wall color choices</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
3.6. Habitat – Materials

The use of locally harvested and manufactured materials where possible has a positive impact on social, economic and environmental issues of building construction to support the regional economy through maintaining high levels of local economic development and employment (Akadiri, Chinyio, & Olomolaiye, 2012). In addition, the use of local materials cuts down on transportation costs and distances, which has a positive environmental impact as is reduces the release of harmful emissions (Akadiri, Chinyio, & Olomolaiye, 2012; Halliday, 2008). Findings of a study conducted by Morel, et al., of the materials selection process in small residential buildings in Southern France indicate that the use of local materials decreases the embodied energy of building materials by 215%, while reducing the transportation impact by 453% since the use of local materials, decreases the amount of transported materials (2001). Furthermore, social sustainability is achieved as the use of local resources enhances the relationships with local suppliers, while providing job opportunities to community members (Akadiri, Chinyio, & Olomolaiye, 2012).

Additionally, according to the U.S. Environmental Protection Agency, volatile organic compounds (VOCs) can be defined as: "organic chemical compounds whose composition makes it possible for them to evaporate under normal indoor atmospheric conditions of temperature and pressure" (EPA, 2017). The health significance of children’s exposure to VOC’s is of substantial importance, since they are more sensitive to pollutants than adults (Faustman, Silbernagel, Fenske, Burbacher, & Ponce, 2000; Mendell & Health, 2005; Rumchev, Bulsara, Spickett, & Stick, 2004), yet they spend roughly 60-80% of their time in the classroom (Shaheen & Abdel Rahman, 2008).

Table (15): Habitat – Materials Category Prerequisites and Credits

<table>
<thead>
<tr>
<th>HABITAT</th>
<th>Materials</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>New Schools</td>
</tr>
<tr>
<td>Credit</td>
<td>MAT-01 Local Materials</td>
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</tr>
<tr>
<td>Credit</td>
<td>MAT-02 Low VOC Materials</td>
<td>3</td>
</tr>
</tbody>
</table>
MAT-01 Credit: Local Materials

The majority of building materials used in Egypt are manufactured locally; with the exception of a small quantity of imported materials, such as raw materials including scrap and billet used in the steel sector, and high quality double-glazed aluminum. In addition, the timber used in wooden flooring is imported, but processed in Egypt, which creates a competitive platform for local suppliers both regionally and internationally. Concrete structures use 100% regionally produced steel and cement, and 70% of marble used in flooring is regionally produced too. Whereas, 100% of porcelain and 90% of bathroom fixtures are manufactured in Egypt under license agreements. The steel industry in Egypt constitutes the second largest steel market in the MENA region in terms of production, and is a major contributor to Egypt's economic development, due to its contribution to other industries such as construction, housing, infrastructure, automotive and consumer goods. Figure (43) shows the steel production in Egypt in the last year. The steel sector in Egypt is comprised of three types of companies: producing steel final products from both raw and scrap materials, and rolling mills. The majority of steel sales are attributed to the production of rebars which account for around 80% of local steel sales. Generally, the Egyptian market produces three types of steel products: carbon steel, stainless steel, and special steel, and sells at $560 per ton (Flanders Investment & Trade, 2017).

The cement industry in Egypt is one of the oldest in the region, with the first production dating back to 1927 with the creation of Torah Cement Company. It was in the 1908s, that Egypt became one of the biggest cement importing countries in the world, but in 2004 Egypt stopped importing cement and established itself amongst the largest cement exporters in the region. Table (16) shows the growth of cement production in Egypt. In 2015, the cement industry produced around 62 million tons per year, however it is an energy-intensive sector consuming more than 9% of the total energy in the country (Ismail, Abd El-Hafeez, Hamouda, & Soliman, 2015).

Figure (38): Growth of steel production in Egypt (Trading Economics, 2018)
Table (16): Growth of cement production in Egypt (Ismail, Abd El-Hafeez, Hamouda, & Soliman, 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Production (million t)</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design capacity</td>
<td>47.36</td>
<td>46.94</td>
<td>50.10</td>
<td>48.80</td>
<td>57.10</td>
</tr>
<tr>
<td></td>
<td>Actual capacity</td>
<td>46.94</td>
<td>50.10</td>
<td>48.80</td>
<td>57.10</td>
<td>62.00</td>
</tr>
<tr>
<td></td>
<td>Capacity utilisation</td>
<td>59%</td>
<td>97%</td>
<td>87%</td>
<td>81%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Increase in design capacity</td>
<td>6%</td>
<td>10%</td>
<td>10%</td>
<td>29%</td>
<td>–</td>
</tr>
</tbody>
</table>

**Intent**

Increase the demand for regionally extracted and manufactured building materials and products, thereby supporting the use of local resources and reducing the environmental impacts resulting from long travel distances.

**Requirements**

Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within a 1000-kilometer radius of the project site, for a minimum of 50% or 75%, based on cost, of the total materials value. Include only materials permanently installed in the project. Furniture, mechanical, electrical and plumbing components, and specialty items such as elevators and equipment are excluded from the calculations.

**Credit Criteria**

<table>
<thead>
<tr>
<th>Local Materials</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>75% of total building materials cost</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>50% of total building materials cost</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
MAT-02 Credit: Low VOC Materials

VOCs are found in various indoor products, such as paints, aerosol sprays, wood preservatives, cleansers, air fresheners, furnishings and pesticides. They contribute to the formation of ozone and respirable suspended particulates (RSPs) in the air. High concentrations of ozone near ground level, can cause eye, nose and throat irritation. Further health effects include headaches, nausea, coordination imbalance, liver, kidney, and central nervous system damage (EPA, 2017). Ware, et al. conducted a study that revealed a relationship between VOC concentrations and asthma in children 7-13 years old (1993). This association is in line with further experimental studies, which have shown that VOCs may affect the airways and stimulate inflammation (Koren, Graham, & Devlin, 1992) and lead to airway obstruction (Harving, Dahl, & Molhave, 1991). The US Environmental Protection Agency (USEPA) and other public health advisory committees specify “source control” as one of the most effective means to achieving suitable indoor air quality. This includes the selection of materials and process with low VOC content, and releases the least VOC emissions into the air (Black, 2011).

**Intent**

Reduce the quantity of indoor air contaminants in the form of VOCs (volatile organic compounds) that are hazardous to air quality, and harmful to the comfort, productivity and health of installers and occupants.
Requirements

Ensure all paints and coatings comply with the following limits for VOC content, and provide supporting documents for each product (EGBC, 2018).

- Flat paints and coatings: 50g/L
- Non-flat paints and coatings: 150g/L
- Dry-fog coatings: 400g/L
- Primers, sealers, and undercoats: 200g/L
- Anticorrosive and antirust paints applied to ferrous metals: 250 g/L
- Zinc-rich industrial maintenance primers: 340g/L
- Pretreatment wash primers: 420g/L
- Clear wood finishes, varnishes: 350g/L
- Clear wood finishes, lacquers: 550g/L
- Floor coatings: 100g/L
- Shellacs, clear: 730 g/L
- Shellacs, pigmented: 550g/L
- Stains: 250g/L

Ensure all adhesives and sealants comply with the following limits for VOC content, and provide supporting documents for each product (EPA, 2013).

- Concrete curing compound: 60 g/L
- Concrete sealer: 10 g/L
- Concrete form release agents: 0g/L
- Garage deck sealer: 50g/L
- Wood glues: 20 g/L
- Millwork and casework adhesives: 20g/L
- Metal to metal adhesives: 30 g/L
- Adhesives for porous materials (except wood): 50 g/L
- Subfloor adhesives: 50 g/L
- Plastic foam adhesives: 50 g/L
- Carpet adhesives: 50 g/L
- Carpet pad adhesives: 50 g/L
- Carpet seam sealer: 50g/L
- VCT and sheet vinyl adhesives: 50 g/L
- Cove base adhesives: 50 g/L
- Rubber floor adhesives: 60 g/L
- Wood flooring adhesives: 100 g/L
- Ceramic tile adhesives: 65 g/L
- Gypsum board and panel adhesives: 50 g/L
- Gypsum drywall joint compound: 20 g/L
- Portland cement plaster: 20 g/L
- Multipurpose construction adhesives: 70 g/L
- Cast resin countertop silicone sealant: 20g/L
- Plastic laminate adhesives: 20 g/L
- General contact adhesive: 80 g/L
- Structural glazing adhesives and compounds: 100 g/L
- Silicone sealant: 50 g/L
- Pipe thread sealant: 50 g/L
- Duct sealant: 10 g/L
- Plastic cement welding compounds: 250 g/L
- ABS welding Compounds: 400 g/L
- CPVC welding Compounds: 270 g/L

Credit Criteria

<table>
<thead>
<tr>
<th>Low VOC Materials</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure all paints, coatings, adhesives, and sealants comply with the required limits for VOC content, and provide supporting documents for each product</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
3.7. Habitat - Sustainable Sites

Sustainable built environments for education are not only an essential criterion for sustainable development, but also shape the formation of citizens and society. The design of educational spaces plays an important role in the formation of a sustainable culture. Papanek (2009, 40) claims that “[a]ll design is education of a sort. It may be education by studying or teaching at a school or university, or it may be education through design”. It is essential to understand that the student’s learning experience is influenced by much more than the curriculum (Elseragy, Gabr, & Einokaly, 2011; Mcmillin & Dyball, 2009; Papanek, 2009). Goldberger (2011) adds that the school can act as a lesson, in which its buildings can make student’s feel and think. Because of the lessons incorporated within the physical space of the campus, Rohwedder (2004) refers to the structures and grounds of academic institutions as a ‘pedagogy of place’. Accordingly, an educational campus could be considered to consist of both a “built environment” which includes buildings and landscapes, and a “learning environment” comprised of students, faculty, and classrooms; in which the relationship between both environments is pedagogic, and the sustainable school design is considered to be an active pedagogical tool for environmental education. Table (17) displays the prerequisites and credits comprised within the Habitat: Sustainable Sites category.

Table (17): Habitat – Sustainable Sites category prerequisites and credits

<table>
<thead>
<tr>
<th>Prerequisite</th>
<th>HABITAT</th>
<th>Sustainable Sites</th>
<th>Possible Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
<td>SS-01</td>
<td>Integrated Solid Waste Management Plan</td>
<td>Required</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-02</td>
<td>Construction Waste Management</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-03</td>
<td>Municipal Solid Waste Management</td>
<td>4</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-04</td>
<td>Organic Waste Management</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-05</td>
<td>Design for People with Special Educational Needs</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-06</td>
<td>Protect and/or Restore Existing Trees</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-07</td>
<td>Outdoor playground design</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-08</td>
<td>School Building Orientation</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-09</td>
<td>Safety and security</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-10</td>
<td>Sustainability Expert</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-11</td>
<td>Education &amp; Awareness Program</td>
<td>6</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-12</td>
<td>Preventive and Corrective Maintenance</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-13</td>
<td>Innovation and Creativity in Habitat</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>34</strong></td>
</tr>
</tbody>
</table>
Solid Waste Management poses a critical public health and environmental concern for developing countries. In Egypt, the development of an efficient and sustainable solid waste management system is impeded by inadequate planning and legislation, lack of resources, institutional deficits and the absence of stakeholders’ participation. The magnitude of the problem is intensified with the rapid population growth and the fast rate of urbanization (GIZ, 2014). Solid waste management persists as a social, economic, technical, and environmental problem. Social problems include the lack of environmental awareness, and visual pollution and psychological problems caused by the pileup of solid waste on the streets. Similarly, environmental problems are caused by the odors and health diseases spread by the disposed waste (El-Haggar, 2007). Greenhouse gas emissions are produced from the waste sector, through waste incineration, wastewater handling, and solid waste disposal sites. The most predominant gas produced is methane, contributing to more than 99% of the total emissions produced in the waste sector, of which solid waste disposal on land entailed the largest source of emission (EEAA, 2010). Additional environmental impacts include: surface and ground water pollution, leachate generation, landfill gas migration, and toxic emissions, which pose direct and indirect public health risks (El-Messery, Ismail, & Arafa, 2009). Economic problems involve the cost of waste collection, sorting, incineration and landfill, and the waste of resources and energy. Technical problems include the shortage of appropriate technological innovations required to convert municipal solid waste into useful products (El-Haggar, 2007).

Intent
Provide a framework for the long-term and short-term strategic management of solid waste management across the focus areas identified within the Habitat category (SS-02, SS03, SS-04).

Requirements
Develop an integrated waste management plan which may include the following:

- Discuss how the integrated waste management plan will be implemented.
- Describe the solid waste management objectives.
- Define the incremental stages of progress towards the solid waste plan objectives and their implementation schedule.
- Describe the necessary funding and resources
SS-02 Credit: Construction Waste Management

The production of massive amounts of building materials waste from construction and demolition waste activities are the main obstacles for achieving sustainable construction objectives (Al-Ansary, El-Haggar, & Taha, 2004a). In 2012, Egypt produced 41.7 million tons of construction and demolition waste. It is common practice to dispose the waste illegally on public roads, highways, undeveloped lands, and alongside residential areas (Zaki, et al., 2013). Construction and demolition waste is a huge consumer of natural resources and energy, as well as the emitter of a large amount of greenhouse gases. (ElGizawy, El-Haggar, & Nassar, 2016). Therefore, the attained environmental benefits of construction waste management include reducing the amount of non-renewable waste and its harmful impact on the environment, in addition to the conservation of natural resources, and extending the life span on disposal sites (Ferguson, et al., 1995). Economic positive impacts of the implementation of such a plan includes decreasing the cost of waste disposal, cost of purchased materials, and material handling/processing cost, lost time, and any probable risks and liabilities (Environmental Agency for England and Wales, 2001). Table (18) shows the estimated percentage of waste materials from Egyptian construction sites (Al-Ansary, El-Haggar, & Taha, 2004b).

<table>
<thead>
<tr>
<th>Material</th>
<th>Min (%)</th>
<th>Max (%)</th>
<th>Average (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood/Lumber</td>
<td>7</td>
<td>11.5</td>
<td>15</td>
</tr>
<tr>
<td>Excavated soils</td>
<td>25</td>
<td>36</td>
<td>48</td>
</tr>
<tr>
<td>Steel</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Concrete</td>
<td>6</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Mortar</td>
<td>7</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Bricks</td>
<td>7</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Concrete blocks</td>
<td>7</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Plastics</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Ceramics</td>
<td>6</td>
<td>9.5</td>
<td>12</td>
</tr>
<tr>
<td>Chemicals</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Minerals</td>
<td>0</td>
<td>2.5</td>
<td>5</td>
</tr>
<tr>
<td>Prefabricated units</td>
<td>1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Mixed waste</td>
<td>N/D</td>
<td>25</td>
<td>N/D</td>
</tr>
<tr>
<td>Marble/Granite</td>
<td>N/D</td>
<td>2</td>
<td>N/D</td>
</tr>
<tr>
<td>Cables, ducting and pipes</td>
<td>N/D</td>
<td>17.5</td>
<td>N/D</td>
</tr>
<tr>
<td>Corner bead</td>
<td>N/D</td>
<td>4</td>
<td>N/D</td>
</tr>
<tr>
<td>Glass</td>
<td>N/D</td>
<td>0.5</td>
<td>N/D</td>
</tr>
<tr>
<td>HVAC insulation</td>
<td>N/D</td>
<td>4</td>
<td>N/D</td>
</tr>
</tbody>
</table>
Globally, the construction industry products 2 to 3 billion tons of waste annually, of which 30-40% is concrete (Nitivattananon & Borongan, 2007). The use of recycled concrete aggregates or demolition concrete deems an urgent matter, since the provision of aggregates in the construction industry is an energy-intensive procedure, in terms of its extraction from earth, and making it suitable for use in the concrete manufacturing process (Maier & Durham, 2012). It is therefore imperative to reduce the rate of generation of construction and demolition waste, and maximize their reuse and recycling towards achieving a sustainable construction and demolition waste management plan (ElGizawy, El-Haggar, & Nassar, 2016). Figure (38) depicts the process of on-site recycling of construction waste materials such as metal, wood, rocks, drywalls, and cardboard (Gavilan, 1994).
Intent
Divert construction waste from disposal in landfills and incineration facilities. Redirect recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites.

Requirements
Develop and implement a construction waste management plan to recycle and/or re-use nonhazardous construction and demolition waste. The plan should identify hazardous and nonhazardous waste, and sort the nonhazardous waste within a designated area on the construction site according to their respective materials, and whether they will be sorted on-site or comingled. Calculations can be based on weight or volume, but must remain consistent. The provision of the following conditions is necessary for the implementation of a successful construction and demolition waste management plan (Peng, Scorpio, & Kibert, 1997):

- Suitable site location adjacent to the construction site, with enough space for the placement of equipment and handling incoming wastes.
- Suitable equipment for the handling of construction and demolition waste, with trained personnel capable of operating the machinery.
- Sound understanding of construction and demolition waste recycling operations, which includes the equipment’s manufacturing process, quality control, and waste segregation procedures.
- Sound understanding of the market in order to be able to identify appropriate markets, and enhance customer relationships, to maximize the economic benefit of selling recovered material.
- Substantial financial capacity for the operation of the construction and demolition waste recycling process, which includes the operation of the equipment, and the business’s startup.
- Knowledge of safety regulations to protect the environment from air and water pollution.

Credit Criteria

<table>
<thead>
<tr>
<th>Construction Waste Management</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop construction waste management plan</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>50-75% recycling</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>75-100% recycling</td>
<td>2</td>
<td>N/A</td>
</tr>
</tbody>
</table>
The production of municipal solid waste in Arab countries accounts for a staggering 81.3 million tons annually, on an average daily rate of 0.7 kg per capita. According to available data, the amount of treated municipal solid waste is less than 20%, whilst recycled waste does not exceed 5% of the total waste produced (Abou-Elseoud, 2008). As indicated in Table (19), Egypt is amongst the largest producers of solid waste in Arab countries (El-Mabrouk, 2009).

Table (19): Solid Wastes Generation in Some Arab Countries (El-Mabrouk, 2009)

<table>
<thead>
<tr>
<th>Country</th>
<th>Municipal Waste (kg/capita/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahrain</td>
<td>1.60</td>
</tr>
<tr>
<td>Egypt</td>
<td>1.20</td>
</tr>
<tr>
<td>Jordan</td>
<td>0.90</td>
</tr>
<tr>
<td>Libya</td>
<td>0.95</td>
</tr>
<tr>
<td>Kuwait</td>
<td>1.80</td>
</tr>
<tr>
<td>Oman</td>
<td>0.70</td>
</tr>
<tr>
<td>Morocco</td>
<td>0.33</td>
</tr>
<tr>
<td>Qatar</td>
<td>1.30</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>1.30</td>
</tr>
<tr>
<td>Syria</td>
<td>0.50</td>
</tr>
<tr>
<td>Lebanon</td>
<td>1.10</td>
</tr>
<tr>
<td>Tunis</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Further statistical data shows that the average generated municipal solid waste per capita is 253.16 kg. This accounts for 21 million tons in Egypt, of which the average composition consists of: organic (56%); paper and cardboard (10%); plastics (13%); glass (4%); metals (2%); and others (15%) (Zaki, et al., 2013), as illustrated in Figure (39). All the aforementioned solid waste discards are highly recyclable materials constituting up to 50% of the waste stream, unfortunately of which only 4% are recycled on a national level (The World Bank, 2015). Projections reveal that waste generation would exceed 30 million tons annually by 2025 (Elfeki & Tkadlec, 2015).
Figure (40): Municipal Solid Waste Composition in Egypt. Adapted from (Zaki, et al., 2013)

Given the considerable amount of recyclable waste resources generated by students and staff within each educational facility, if each school established recycling programs, then this would collectively have a substantial positive impact on environmental, social, and economic concerns of communities at a local and global level. The overarching benefit of recycling programs in schools, lies in the notion of schools as “cradles of values formation”. Through which students are taught the needed behavior and approach towards the waste they produce, as they are guided to internalize the concept of waste as a valuable resource in the wrong place (Environmental Management Bureau, 2005). Such delivered values are disseminated to parents are home and later on to places of occupation, when students join the workforce. Effective recycling programs alter the user’s attitudes first, and adjusts their behaviors second. The allocation of bin’s placement signifies the basis for successful waste segregation at source as it facilitates the user’s participation, thus eliminating a major impediment to their contribution (Prestin & Pearce, 2010).
Intent
Reduce the amount of municipal solid waste disposed in landfills by raising students’ awareness to the social, economic and environmental implications of inadvertent waste generation.

Requirements
- Conduct solid waste audit.
- Prepare equipment, activities, allocated tasks, curriculum connections, and educational material.
- Promote the initiative within school grounds.
- Install equipment for managing the recycling process at school. Municipal solid wastes must be sorted into two segregation streams as shown in Figure (40), where recyclables are sent to recycling facilities, or used within the school in order to maximize the re-use of resources.

Credit Criteria

<table>
<thead>
<tr>
<th>Municipal Solid Waste Management</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct solid waste audit</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Sort solid wastes into 2 segregation streams; recyclables, and non-recyclables</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure (41): Municipal Solid Waste Segregation Streams
During recent years, the increased generation of food waste has received growing attention from policymakers, organizations, businesses, academics, and the general public (Schanes, Dobermig, & Gözet, 2018). As food production is a resource-intensive process, food waste is directly associated with environmental impacts, such as soil erosion, deforestation, and water and air pollution (Mourad, 2016). In response, there is a soaring evidence base on the amounts of food wasted and the associated emissions along the stages of the food production-consumption chain (Beretta, Stoessel, Baier, & Hellweg, 2013; Edjabou, Petersen, Scheutz, & Astrup, 2016). It is of utmost importance to prevent food waste at the final stages of the supply chain to preserve all the resources and embodied energy put into its production, such as processing, transportation, cooling, and preparation (Schanes, Dobermig, & Gözet, 2018), which is necessary to help avert further climate change (Parfitt, Barthel, & Macnaughton, 2010). While food waste at the household level signifies the largest source of consumption-level (BIOIS, 2011), the food service industry of institutional sectors such as schools, and hospitals also denotes a main source of food waste in developed countries (Cordingley, Reeve, & Stephenson, 2011).

The solid waste stream in Egypt is categorized by its high level of organic matter, of about 56%, which accounts to 12.88 x 10^6 tons. The recycled portion of organic waste does not exceed 20%, despite the allocation of 66 composting plants (Elfeki & Tkadlec, 2015). Whereas the operational effectiveness of composting plants in Egypt is low/moderate, and ranges between 15-50%, and the quality of the produced compost is generally poor (Zaki, et al., 2013). This amplifies the importance of effectual organic waste management practices, in order to elude further detrimental impacts of environmental and health issues (Elfeki & Tkadlec, 2015). Since organic material represents a substantial portion of school’s waste composition, recycling organic waste is considered a valued waste management strategy to reduce the amount of disposed waste and associated environmental and financial costs.

Composting programs in educational institutions present various opportunities for the school community. Through hands-on activities, students learn to become responsible consumers as they take responsibility for managing their waste, and understand the environmental and economic impacts of inadvertent waste generation (Hackney, 2012). Organics recycling reduces the production of methane, a harmful greenhouse gas that is released due to the decomposition of organic waste in landfills. Consequently, reducing the amount of organic waste disposed in landfills helps alleviate climate change, and extends the lifespan of existing landfills (Hennepin, 2015). Aside from curriculum connections in various subjects such as science, mathematics, and literature, and interdisciplinary learning, composting organic waste raises student’s cognizance to the importance and benefits of recycling, especially when the produced compost is used as fertilizer and soil conditioner within the school garden (Ricci, 2016).
The application of compost to soil has several benefits, and creates a valuable resource for use in school grounds (Hackney, 2012). As a result of the exceptionally versatile nature of compost, it has showed an improvement in the physical, chemical, and biological properties of soil, and growing medium. Physical benefits include providing the optimum conditions required for plant growth through improving the soil structure, porosity and density. Upon application in ample quantities compost increases the soils' water holding capacity, thus decreasing the amount of water loss and leaching in sandy soils. In addition, compost is rich in humus content, a stable residue with adhesive properties which hold soil particles together, which increases the soil's moisture holding capacity. Chemical benefits of the addition of compost to soil include improving and stabilizing soil pH, which makes the soil more resistant to pH change. Compost also improves the cation exchange capacity of soils enabling them to retain nutrients for a longer time. Similarly, compost provides the soil with an abundance of macro and micronutrients essential for plant growth. Biological benefits include providing beneficial microorganisms to the soil and growing media, which supply the soil with nutrients and promote root activity in plants enhancing their extraction of nutrients from soil. In addition, microorganisms have proven to subdue certain plant diseases (USCC, 2008). Further benefits of compost include their ability to remediate hazardous organic and metallic contaminants to innocuous levels or compounds (Barker & Bryson, 2002; USCC, 2008).

Organic waste from schools is collected from two main sources: school gardens and food waste generated from food services or packed lunches, as illustrated in Figure (41).

Figure (42): Sources of organic waste in schools
Trautmann & Krasny (1997) describe various types of composting options suitable for use in schools. These include: two-can bioreactors, plastic-bottle bioreactors, and vermi-composting bins. The two-can bioreactors configuration illustrated in Figure (42), helps alleviate odor and pest invasion issues, and allows a place for leachate collection within the outer can. If the provision of two cans is not possible due to economic or spatial reasons, then the process can be modified for composting within a single container.

Figure (43): Two-can bioreactors (Trautmann & Krasny, 1997)

Process:

1. Place 15 to 20 holes with a diameter of 1-2.5 cm diameter through the bottom of the 80-liter can (Trautmann & Krasny, 1997).
2. Place five 1-2.5 cm holes at the top of the 120-liter can - just below the rim, and cover the holes from the inside with a nylon mesh (Trautmann & Krasny, 1997).
3. Insert the small can within the larger can (Trautmann & Krasny, 1997).
4. Place a spigot at the bottom of the 120-liter can to drain the leachate material. The edges of the spigot are to be sealed with a waterproof sealant, and block the outer end of the spigot with a stopper that can be removed to drain the collected leachate. Cover the inner end the spigot with a nylon mesh to block the passage of solid particles (Trautmann & Krasny, 1997).
5. Place an object at the bottom of the 12-liter can to separate both cans, in order to allow space for the leachate collection (Trautmann & Krasny, 1997).
6. Place several centimeters of permeable material such as peat moss or finished compost around the bottom of the outer can. Drain the leachate regularly to avoid odor-causing anaerobic action. Pour the leachate back into the can of compost matter to hydrate the composition once it appears to be drying out. Otherwise, it is to be disposed off and not used for the irrigation of plants since it is harmful unless diluted (Trautmann & Krasny, 1997).
7. Fill the inner can starting with a 5-10 cm layer of high-carbon content such as finished compost, wood shavings, brown leaves, or tree branches (Trautmann & Krasny,
1997). Place the prepared compost mixture within the target ranges of four main factors: moisture content of 40-60%; carbon to nitrogen ratio of 30:1; temperature between 32°C to 60°C; continuous supply of oxygen (El-Haggar, 2007). Cover the mixture with another layer of high-carbon content to reduce the chance of odor and pest invasion (Trautmann & Krasny, 1997). Proper aeration is required to control the environment needed for biological activities, and thus ensure aerobic fermentation and optimal levels of efficiency (El-Haggar, 2007).

8. Monitor the composting process, which requires an approximate two to three-month period after the can is filled. After which the compost should be transferred to an outdoor pile or another container for the curing stage (Trautmann & Krasny, 1997).

Intent
Reduce the amount of organic waste disposed in landfills by raising students' awareness to the social, economic and environmental implications of inadvertent waste generation.

Requirements
- Conduct organic waste audit.
- Prepare equipment, activities, allocated tasks, curriculum connections, and educational material.
- Promote the initiative within school grounds.
- Install equipment for managing the composting process at school.

Credit Criteria

<table>
<thead>
<tr>
<th>Organic Waste Management</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct organic waste audit and collection</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Install equipment for managing the composting process at school</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
Every single child has the right to education, as affirmed in Goal 2 of the Millennium Development Goals (MDGs), to “Achieve universal primary education”, and in Goal 4, of the Sustainable Development Goals (SDGs) to “Ensure inclusive and equitable quality education for all and promote lifelong learning”. However, despite such efforts in addition to achievements of Education for All (EFA), children with disabilities continue to be marginalized from the educational system. The UN Convention on the Rights of Persons with Disabilities (CRPD) states the importance of not excluding children with disability from the general education system on the basis of their disability. There is a close association between education and employment opportunities, healthy life, social and economic security and community participation, which makes the prospects of students with disabilities who are denied their right to education to remain excluded from the society. This connection is stipulated in Goal 8 of the SDGs to “Promote sustainable, inclusive and sustainable economic growth, full and productive employment and decent work for all”, and Goal 10 to “Reduce inequality within and among countries” (UNICEF, 2016).

According to the Central Authority for Public Mobilization and Statistics (CAPMAS), the number of people reported with disabilities in 2016 in Egypt is around 12-15 million, which represents 12% of the population. Of this ration, 73% are with intellectual disability; followed by 14.5% with motor disability, and 12.5% with visual and hearing impairment (Handicap International, 2016). There is a huge discrepancy in figures between nationally reported statistics and international ones reported by organizations such as WHO and World Bank, which could be the result of various factors such as the undetermined definition of disability, inadequate data collection (El Refaei, 2016), and societal barriers where some families find it reprehensible to report disability (El Refaei, 2016; Handicap International, 2016). Therefore, the creation of an inclusive environment not only aids the development of students with disabilities into active members of the society, but also enables students without disabilities to learn from the experiences of students with disabilities, thus building on the individual differences and turning it into a learning opportunity for all (UNESCO, 2015). This would be an imperative tool in raising disability awareness to address the cultural and societal stigma of disability, and attain the social inclusion of people with disabilities.
Intent

Provide students with disabilities with equal educational opportunities within an inclusive educational environment to become effective members of the society.

Requirements

Verify that the following provisions are available within school environment and surroundings:

- Accessible school entrances
- Appropriate width of circulation routes
- Provision of suitable handrails in yard, corridors and stairs for students with motor disabilities
- ADA compliant bathrooms for students with motor disabilities
- Accessible room layout and furniture within educational spaces
- Install lifts in multi-story school buildings
- Install non-slippery ramps to aid students with motor disabilities
- Accessible playgrounds for students with mobility and cognitive impairment
- Lighting and paint schemes to aid visually impaired students
- Carpeting and acoustic tiling for educational spaces to aid hearing impaired students
- Signage using raised letters, Braille, and visual contrast to aid visually impaired students
- Door design with special consideration in terms of door widths, vision panels, ease of operation, and visual contrast between wall, door frames and door leads for students with visual impairment

Credit Criteria

<table>
<thead>
<tr>
<th>Design for People with Special Educational Needs</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable equal educational opportunities by the provision of an inclusive educational environment</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
SS-06 Credit: Protect and/or Restore Existing Trees

The rapid expansion of urban settlements has led to the loss of urban green spaces, which is an integral aspect of urban ecosystems. Trees provide many valuable environmental benefits. As a tree matures, it is capable of absorbing 21.6 kilograms of carbon per year, which makes it one of the most cost-efficient means of carbon sequestration. Trees also reduce atmospheric pollution by removing air pollutants such as sulphur dioxide, nitrogen oxides, carbon monoxide, cadmium, nickel, lead and particulate matter. In addition, they reduce storm water runoff by capturing rainwater, where contained impurities are filtered by bacteria and microorganisms within the soil. Studies reveal that one hundred mature trees can capture over one million liters of rainwater annually (GreenBlue Urban, 2016). Trees have also been found to reduce the heat island effect, as they lower air and surface temperatures by the combination of both shading and evapotranspiration, which decreases the building’s cooling requirements, thus reducing its energy use (Akbari, 2002). In addition to providing environmental benefits for human population, trees provide a natural habitat for wildlife, which is essential to maintain biodiversity (Akbari, 2002; GreenBlue Urban, 2016). In Cairo, the amount of green spaces is estimated to be less than 1 square meter per capita, which is far below the ideal average of 74 square meters per capita set by the African Green City Index (Economist Intelligence Unit, 2011). Accordingly, the adequate protection and maintenance of trees in Egypt contributes to the aforementioned benefits and increase the per capita green space provision.

Construction damage to the tree’s root system initiates a “mortality spiral”, that can lead to the tree’s death in 1 to 10 years’ time. Any form of construction activities which has an effect on the tree’s root system, is a potential root killer, including vehicular and pedestrian traffic, and storage of supplies and equipment. Restorative treatments need to be applied immediately after the damage to the roots occurs, before the tree reaches the stressed or declined stage. At the stressed stage, the construction damage weakens the tree and makes it more vulnerable to other forms of stress which would otherwise not pose a threat, such as drought and pest attacks. Signs of stress are minimal, and include a slight discoloration of the foliage and decrease in density. Once the tree reaches the declined stage, the tree can no longer be saved, and the top portion of the tree can’t support itself and dies. Signs of decline include a drastic decrease in leaf density and size, and leaves might look yellow. at this stage, the tree is prone to attack by wood borers and bark beetles. Further pest invasion, combined with structural failure, health degradation lead to the tree’s death (Dicke, Raymond, & Hubbard, 2008). Tree evaluations prior to construction are necessary to determine which trees require preservation and which are to be removed. This depends on the tree’s condition, size and species. Tree condition can be categorized into good, fair, or poor, and is a reflection of the tree’s location down the “mortality spiral”, as shown in Table (20). Good and fair condition trees, are the most appropriate for saving, whereas it would be more economically feasible to have poor condition trees removed. The tree’s percentage of survival rate is a
function of the protected critical root area, as shown in the Equation (1). The higher the tree protection zone, the higher the tree’s chance of survival. Only trees with $\geq 50\%$ Protected Critical root area should be protected (Dicke, Raymond, & Hubbard, 2008).

<table>
<thead>
<tr>
<th>Protected critical root area (%)</th>
<th>Proposed tree protection zone</th>
<th>Calculated critical root area</th>
</tr>
</thead>
</table>

Equation (1): Percentage of protected critical root area (Dicke, Raymond, & Hubbard, 2008)

Table (20): Guide to assess tree’s condition. Adapted from (Dicke, Raymond, & Hubbard, 2008)

<table>
<thead>
<tr>
<th>Evaluation characteristics</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch dieback</td>
<td>None</td>
<td>Present in one or two major upper branches</td>
<td>Present in three or more major upper branches</td>
</tr>
<tr>
<td>Stem and root collar damage</td>
<td>Minor</td>
<td>Up to 20% of circumference</td>
<td>Up to 40% of circumference</td>
</tr>
<tr>
<td>Rot and decay fungi</td>
<td>None</td>
<td>Minor</td>
<td>Major</td>
</tr>
<tr>
<td>Leaf density, color and size</td>
<td>Normal</td>
<td>Sparse, smaller, and some discoloration</td>
<td>Sparse, small, yellow leaves</td>
</tr>
</tbody>
</table>

Trees are comprised of two types of roots which are essential for the tree’s survival. As illustrated in Figure (44), these consist of the structural root plate (identified in red), and critical root area (identified in green). The structural plate consists of the tree’s most essential roots. Therefore, damage to the structural root plate is fatal to the tree’s endurance, as it would cause it to lose the ability to support itself. The critical root area is second in importance, and encompasses the area directly below the branches of the tree. It contains 85% of the root mass, and accordingly should be protected from construction damage, since any type of root damage reduces the survival rate of trees by half, once 25% of the critical roots are damaged. To ensure the tree’s survival, the critical root area should be protected from construction damage, by calculating the DBH and CRR as shown in Equation (2).

![Figure (44): Structural root plate and critical root area within the tree root system (Dicke, Raymond, & Hubbard, 2008)](image.png)

<table>
<thead>
<tr>
<th>Calculations</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Measure tree trunk’s diameter at breast height (DBH) – in.</td>
<td>Assume DBH = 4 in.</td>
</tr>
<tr>
<td>Measure thickness of tree trunk at 4.5 feet above ground level</td>
<td></td>
</tr>
<tr>
<td>2) Calculate critical root radius (CRR) – ft.</td>
<td>CRR = $4 \times 1.25 = 5$ ft.</td>
</tr>
<tr>
<td>DBH x 1.25</td>
<td></td>
</tr>
<tr>
<td>3) Calculate critical root area</td>
<td>$3.14 \times 5^2 = 79$ ft.</td>
</tr>
</tbody>
</table>

Equation (2): Critical root area calculations. (Dicke, Raymond, & Hubbard, 2008)
Intent

Preserve existing natural features to minimize site damage, and associated negative environmental impacts. Increase the amount of urban green spaces to provide a multitude of benefits including social, environmental, psychological, health, and economic.

Requirements

- Prepare a tree evaluation plan to determine which trees will be preserved, and which are to be removed (Dicke, Raymond, & Hubbard, 2008).
- Place a protective fence around the tree’s critical root area. It is to be assembled before construction work starts and kept intact until final inspection. The temporary barrier should be clearly visible, and at least 3 feet high and supported by stakes, as shown in Figure (45). Protection of groups of trees is recommended, as shown in Figure (46), instead of individual ones, by placing a protective barrier outside the critical root area of all trees in the group (Dicke, Raymond, & Hubbard, 2008).

\[
\begin{array}{c}
\text{Figure (45): Tree protective barriers} \\
\text{(Colorado State University, 1999)}
\end{array}
\]

\[
\begin{array}{c}
\text{Figure (46): Overhead view of critical root area for a group of trees} \\
\text{(Dicke, Raymond, & Hubbard, 2008)}
\end{array}
\]

- Provide ideal soil conditions within the protected critical root area prior to construction to stimulate new root growth. This includes placing organic mulch 4 to 6 inches deep, and fertilizing trees with necessary nutrients as indicated by a soil test (Dicke, Raymond, & Hubbard, 2008).
- If the placement of underground utility lines during trenching, within the critical root area cannot be avoided, it should be placed at least 18 inches below the critical root area to prevent the loss of critical root mass (Dicke, Raymond, & Hubbard, 2008).

Credit Criteria

<table>
<thead>
<tr>
<th>Protect and/or Restore Existing Trees</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preserve existing natural features</td>
<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>
The significance of the outdoor play environment for children's cognitive, social, emotional and physical development is grounded in a strong body of research (Bento & Dias, 2017; Burriss & Burriss, 2011; Frost, Wortham, & Reifel, 2005; Malone & Tranter, 2003). However, contrary to what the literature is affirming, prospects of outdoor play are decreasing due to a number of factors: including urban development, technology expansion, and globalization (Singer, Singer, D'Agnostino, & DeLong, 2009). In addition, some educators shorten or eliminate recess time because they consider that additional instructional time is more beneficial to the student's educational achievement than outdoor playtime (Pellegrini & Bjorkland, 1996). However, the contrary is true, since students require an unstructured recovery-time from highly structured classroom lessons, which is possible during recess, where children choose their type of recreational and social activity, and level of peer interaction (Burriss & Burriss, 2011). This substantiates Frost's correlation between lack of play-activity and child abuse; as the child's abilities are compromised in terms of growth, development or psychological functioning (Frost, Wortham, & Reifel, 2005). In addition, inadequate playground spaces, which are overcrowded, or have insufficient play activities have been associated with increased behavioral issues such as bullying and depression (Evans J., 1997).

Cognitive development denotes the development of thinking and problem solving skills (Acar, 2014) which are associated with school-based education (Pellegrini & Bohn, 2005). The social interactions that take place between students during recess is essential for their cognitive development, as they and encounter several challenges and engage in real-life situations (Bjorklund & Pellegrini, 2000; Burriss & Burriss, 2011). Such situations include playing a structured game with fellow students, playing with playground equipment, or initiating a friendship with peers. In each situation, children learn to negotiate, communicate, compromise, and utilize appropriate verbal and nonverbal forms of communication (Katz & McClellan, 1997). In addition, during play activities children test and refine their understanding of different concepts, such as mass, volume, and the nature of change (Burriss & Boyd, 2005). Cognitive play also allows children to experience and understand different relationships in the surrounding social, physical and natural environment based on their individual behavior; through solving, selecting, creating, realizing and discovering (Malone & Tranter, 2003). Furthermore, engaging in structured classroom lessons for prolonged periods leads to cognitive interference where children become less attentive to classroom tasks. Experiments conducted by Pellegrini & Bohn indicate that children are more attentive after recess, which proves that unstructured play activities reduce the cognitive interference of students (2005).

Play activities are integral aspects of both social and emotional development, as children learn to play and interact with peers, cooperate, respect other views, and express their ideas, feelings and needs openly without the external interference of adults. In addition, through play, children create their own identity through enacting different roles and behaviors.
A reciprocal relationship exists between the children’s increased social skills and frequency of acquired social roles (Pellegrini & Smith, 1998). Studies conducted on the school environment show a substantial connection between children’s quality of social interactions, and their academic achievement (Haynes, Emmons, & Ben-Avie, 1997). An important finding of importance in our society, are the opportunities provided to students during recess to interact with children of different social classes, and negotiate and manage conflict, while understanding each other’s individual differences (Mulryan-Kyne, 2014). Furthermore, findings indicate a correlation between children’s difficulty to initiate and maintain friendships to their quality of life in later years, as they have a tendency towards juvenile delinquency, school-dropouts, and experience psychiatric problems (Kostelnik, Soderman, Stein, & Whiren, 1993). During play activities, children also learn the impact that their actions have on other people’s thoughts, feelings, and behavior. In addition, play activities allow children to test their abilities, and acclaim one another for their noncurricular strengths in diverse activities such as running, jumping and climbing. This is of particular significance, since to many children recess is the only source of positive reinforcement in their lives (Burriss & Burriss, 2011).

Outdoor activities provide children with physical movement and exercise, which is essential to their weight maintenance, bone development, and mental well-being (Burriss & Harrison, 2004). Findings suggest that recess may be the children’s only source of physical development during the day, and that the lack of physical activities during recess is not compensated after-school. On the contrary, children displayed greater commitment to physical activities after-school, after engaging in physical activity during school (Dale, Corbin, & Dale, 2000). Regular exercise and physical instruction is necessary to improve children’s fundamental motor skills which are developed during the preschool years, and further enhanced during the elementary school years. In addition, physical development is necessary to enhance children’s confidence, self-esteem and individuality (Seefeldt, 1984). In addition to the developmental benefits of unstructured recess, the school playground offers further learning opportunities by the creation of the outdoor classroom, in which the curricula are integrated within the school grounds. The provision of flexible seating and tables facilitate the use of the outdoors as a classroom (Burriss & Burriss, 2011).

Titman examined the impact of school grounds’ design and management on the children’s attitude and behavior, and identified four key elements that children requested to have in school grounds (1994, 58).

- a place for **doing**: which offered opportunities for physical activities, for ‘doing’ all kinds of things, and which recognized their need to extend themselves, develop new skills, to find challenges and take risks.
- a place for **thinking**: which provided intellectual stimulation, things which they could discover and study and learn about by themselves and with friends, which allowed them to explore and discover and understand more about the world they live in.
- A place for feeling: which presented colour and beauty and interest, which engendered a sense of ownership and pride and belonging, in which they could be ‘small’ without feeling vulnerable, where they could care for the place and people in it and feel cared for themselves.

- A place for being: which allowed them to ‘be’ themselves, which recognised their individuality, their need to have a private persona in a public place, for privacy, for being alone and with friends, for being quiet in noise, for being a child.

There are four types of playground designs which were initially developed by Frost & Klein (1979) and later developed by further researchers. Traditional playgrounds primarily promote gross motor skills, with an emphasis on physical exercise and recreation. It consists of mass produced play equipment, grey asphalt and a large proportion of green cover used in the sports field. This type of playground promotes the notion of play presumed by the “surplus energy theory”; this is, children use the playground to discharge excess energy through physical activity (Malone & Tranter, 2003). Frost & Klein (1979) determined that most playgrounds in the United States fell in this category. This is the case in the majority of Egyptian playgrounds too, which are geared towards physical activity. Designer playgrounds incorporate aesthetics together with physical activity in a well-thought-out architectural approach. This type of playground allows a larger variety of play experiences than traditional playgrounds. However, its’ design approach creates spaces for predetermined play activities, which inhibits the full potential of play experiences as it views the child as a passive recipient rather than an active player. Adventure playgrounds encourage creative, imaginative and constructive play through the extensive use of natural elements such as hills, grass, water, mud and tires. It focuses on creating flexible spaces with minimal pre-designed features, which are often constructed through the child’s play activities. Comprehensive playgrounds are a combination of all other types, and encourages all types of play experiences. They are the most variant type and accommodate the greatest diversity of options for informal and formal play and educational opportunities, through the incorporation of play equipment within the natural environment (Malone & Tranter, 2003).

The design of school playgrounds should consider the cognitive, social, emotional and physical development needs of children; therefore, it holds a significant developmental dimension, just as an individual child does. Accordingly, as the use of the playground increases with the child’s age, it should be designed to enable, support and encourage this developmental growth (Uzzell, 1988). In addition, playground design and equipment should foster the social inclusion of children with special needs. Table (21) illustrates age-appropriate play activities through the different stages of children’s’ development. The design and management of the school playgrounds defines the child-environment relationship; hence, it should provide the maximum opportunity for the students’ interaction with each other and the environment (Malone & Tranter, 2003).
Table (21): Age-appropriate play activities. Adapted from (Kompan, n.d.) and (Kiley, 2016)

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Age appropriate play activities</th>
<th>Play values (Kompan, n.d.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>Physical exercise is necessary to build toddler’s sensory motor skills, and spatial understanding (Kompan, n.d.). Such play activities include “sensorimotor play”, “pretend play”, “symbolic play”, “simple construction”, and “solitary play” (Kiley, 2016). During preschool years, toddlers’ play equipment should be designed to allow for the shift from “solitary play” to “parallel play”, which includes significant social interaction within small groups, and also stimulates the development of their language skills (Kompan, n.d.).</td>
<td></td>
</tr>
<tr>
<td>3-6</td>
<td>Preschool children require play activities that advance their sensory, gross motor and fine motor skills. Physical activities that stimulate the cross-body coordination, balance and proprioception are recommended, such as jumping and running. At this phase, children engage in “role-play” activities with their peers which develops their imagination and communication skills. Therefore, the play grounds should provide easily identifiable themes that support this development, and include items which can be easily manipulated since children at this age experience elements in order to understand them through cause-and-effect play (Kompan, n.d.). In addition, play activities also shift from “parallel play” to “associative play” where they share play materials without organizing their play with peers (Kiley, 2016).</td>
<td></td>
</tr>
<tr>
<td>6-12</td>
<td>Play activities shift from “role-play” to “rule play” scenarios. This includes activities with a wide range of agility, balance and coordination challenges to develop their gross motor skills. Games with rules reinforce the sense of positive competition, and teach children to win and lose in a balanced and considerate manner. In addition, creating friendships is very important at this stage, and therefore places for socializing in large groups are necessary (Kompan, n.d.). At this phase, play activities shift from “associative play” to “cooperative play”, where children cooperate with one another to achieve a common goal (Kiley, 2016).</td>
<td></td>
</tr>
</tbody>
</table>
Activities that are challenging and test children's agility, balance, and coordination, and build up their strength, endurance and speed. This includes swings, climbing equipment, trim trails and ball games. Whereas girls do not prefer ball games, and opt for less energetic activities such as spinning and swings. In addition, social interaction with peers is very important, and therefore places for socializing in large groups are necessary (Kompan, n.d.). Cooperation, teamwork, rules, roles and peer groups are very essential for this age group, where an increased weight is placed on testing one's skills (Kiley, 2016).

Intent

Create outdoor play environments which enhance the children's cognitive, social, emotional and physical development, in addition to providing further learning opportunities by considering the outdoors as an extension of the learning environment.

Requirements

- Provide documentation indicating the criteria for the selection of playground equipment, and exploitation of the outdoor environment based on its contribution to the cognitive, social, emotional, physical, and educational development of the child.
- Provide a curriculum planning framework indicating the possible connections between students' outdoor play experiences and the formal curriculum in various subject areas.

Credit Criteria

<table>
<thead>
<tr>
<th>Outdoor Playground Design</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicate the criteria for the selection of playground equipment</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Provide a curriculum planning framework indicating the possible connections between</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>students’ outdoor play experiences and the formal curriculum in various subject areas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SS-08 Credit: School Building Orientation

The significance of building orientation as a design consideration has been analyzed in a number of studies, which demonstrate its strong correlation with solar radiation and air movement (Al-Tamimi, Fadzil, & Harun, 2011; Hai Ha, 2016; Prianto, Depecker, & Peneau, 2000). Accordingly, building orientation has an impact on daylighting, ventilation, and cooling loads, which directly contribute to the overall energy requirements of a building. Obtaining an optimized orientation reduces the building’s energy consumption and enhances its efficiency, as the demand for heating, cooling, and lighting loads are reduced (Abanda & Byers, 2016). Air movement within a building is affected by the building’s orientation, as the direction of prevailing winds flow impacts natural ventilation and cooling loads. Similarly, the reduction of the solar heat gain of a building is influenced by the building’s orientation in relation to the sun’s relative position. In countries North of the equator, like Egypt, the optimal building orientation is due East-West. Since the larger the exposed surface area to the sun’s path, the more the solar heat gain of the building, the smaller facades should be located on the East and West facades where the solar intensities are higher, and the largest elevation surfaces should face North and South, where solar exposure is less (Visser & Yeretzian, 2013).

Wanas conducted a computer-simulation based study on a school model situated in El-Menya governorate, to evaluate the impact of building orientation on the indoor thermal conditions of the school environment. Findings indicated that lowest average indoor temperatures were recorded when buildings were oriented due north, while the highest were recorded in the West and South-West orientation. The lowest average indoor temperature of 31.5 °C was recorded when building was oriented due north, whereas the maximum indoor temperature of 32.6 °C was recorded when the building was oriented due West. Comparably, findings revealed that the maximum duration of thermal discomfort within educational spaces of 54 school days were recorded when the building was oriented due West and South-West, whereas the least duration of 33 school days were recorded when the building was oriented due North. The incongruity in results is due to the lack of direct solar radiation in the North orientation, in addition to being in the prevailing winds direction (2013).
Intent

Provide a comfortable thermal environment that improves the occupants’ academic performance, and health and well-being, while reducing the energy consumption of buildings by the means of reducing the solar heat gain of the building, and increasing the potential for natural daylighting and ventilation.

Requirements

Optimize building orientation according to local climatic conditions, based on the external parameters of solar radiation and air movement.

Credit Criteria

<table>
<thead>
<tr>
<th>School Building Orientation</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimize building orientation</td>
<td>2</td>
<td>N/A</td>
</tr>
</tbody>
</table>
The primary responsibility of every school is to ensure a safe and secure environment for students, staff and visitors, that is conducive to the learning process (Lundberg, 1994), and is thus considered a requirement for productive education (Maslow, 1970; Piaget, 1936). Lacoe (2013) investigated the relationship between feelings of safety at school and educational achievement, over a three-year period from 2007-2010, in over 700 middle schools in New York City. Findings show a correlation between negative test scores and feelings of insecurity within educational spaces. This substantiates previous findings by Arum (2003), who determines that both positive academic and behavioral outcomes are correlated to feelings of safety. His findings reveal that both academic and behavioral associations with safety were influenced by gender, with feelings of safety having a larger positive correlation with academic achievement in females than males, and larger positive association with behaviors for males than females, as was indicated by a decrease in aggressive behavior for males than females.

Reid underscores the importance of the overall appearance of buildings as an indicator of the school's safety and security measures. He argues that the physical appearance of school buildings should be devoid of acts of vandalism such as deliberate destruction and graffiti, and provides a clean and comfortable educational environment, as a portrayal of the school's intolerance to security breaches, safety threats, and vandalistic acts (2000). In addition, landscape modification is a solution to make educational buildings less conducive to pest invasion. Specific types of vegetation which repel pests include mint plants and cacti (Dyer, 2018). Table (22) highlights significant safety concerns in educational institutions, which should be considered along with building regulations and codes to ensure the safety of school occupants.
<table>
<thead>
<tr>
<th>1- Building security</th>
<th></th>
</tr>
</thead>
</table>
| **Building access**  | - Ensure building access points implemented according to building code requirements.  
  - Control access to school building through keeping building access points to a minimum.  
  - Visitors screening takes place at main point of entry, which should be cleanly marked and located at the front of the school.  
  - Site entries provide sufficient passage for emergency vehicles.  
  - Exits from all the classrooms and the school premises should obstruction-free at all times.  |
| **Structural materials**  | - Ensure structural considerations are all implemented according to building code requirements.  
  - Additional issues of concern include floor-to-window heights, staircase handrail heights, and balcony heights along corridors.  |
| **Room furniture**  | - All items of furniture such as shelves, ceiling fans, blackboards, etc., should be safely secured to respective floors, ceilings, or walls to prevent injury to building occupants.  |
| **Building configuration**  | - Buildings should not present climbing opportunities from inside and outside the site.  |
| **Windows**  | - Ensure windows safety is implemented according to building code requirements.  
  - Windows should be protected from unauthorized entry by security grills.  |

<table>
<thead>
<tr>
<th>2- Site security</th>
<th></th>
</tr>
</thead>
</table>
| **Location and surroundings**  | - Provide efficient student pick-up/drop off plan, which reduces traffic and ensures the children’s’ safety. The plan should avoid pedestrian/vehicular conflicts, and provide a safe parking space.  
  - Roads leading to school’s main entrances should be safe for pedestrian crossing. School warning signs and advisory speed limit signs should be clearly placed, to ensure safe vehicular traffic.  |
| **Site boundary**  | - Provision of fencing options, which includes perimeter fences, block walls, and vegetation. The selection should be based on ensuring access control while maintaining an aesthetically pleasing, low maintenance option which deters climbing.  |
| **Landscaping**  | - Landscaping should reinforce access control, and territoriality, while maintaining adequate sight lines for effective surveillance.  |
| **Site lighting**  | - Lighting fixtures should be designed to not allow climbing onto the school through the use of handholds.  
  - Lighting fixtures should be well maintained to ensure that shaded areas are eliminated, to avoid trespassing and vandalistic acts.  |
| **Fire safety**  | - Fire detection and alarm systems should be regularly monitored to ensure their efficient operation.  
  - Fire extinguishers should be adequately located according to building codes and regulations.  |
Intent

Provide a safe school environment in order to safeguard and promote the welfare of students, and improve their academic and behavioral outcomes.

Requirements

- Provide a descriptive safety plan incorporating building and site security issues.
- Regularly audit building and site safety elements to ensure operational efficiency.

Credit Criteria

<table>
<thead>
<tr>
<th>Safety and Security</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide descriptive safety plan</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Provide regular audit reports of school safety inspections</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
**SS-10 Credit: Sustainability Expert**

Sustainability experts lead the school’s sustainability plan. Their role is integral to the implementation of a whole-school sustainability framework, through which the educational built environment, and the operation of the facility act as pedagogical tools for sustainable education. As illustrated in Figure (47), experts help schools embed sustainability parameters in light of the four major sustainability categories, with an emphasis on the school and community. The expert understands descriptive elements of the rating scheme, and can propose innovative sustainable approaches and operating practices to achieve the required credits, in light of current social, environmental, and economic issues at the local and global level. Additionally, the sustainability expert should educate project team members about sustainable building design and construction requirements.

![Whole-School Sustainability Framework](image-url)
Intent
Support the project team in the implementation of a whole-school sustainability framework, which has a subsequent direct effect on the sustainable development of the country.

Requirements
Hire a sustainability expert.

Credit Criteria

<table>
<thead>
<tr>
<th>Sustainability Expert</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hire a sustainability expert who provides and leads the school’s sustainability plan</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
SS-11 Credit: Education & Awareness Program

Education and awareness are fundamental tools necessary for the growth of a nation; since it is the human mind that makes development achievements possible. Education has the capacity to transform the society and make valuable knowledge available to the populace (King E., 2011). Accordingly, education stands as a solution to various societal problems, including environmental stewardship (Tilbury, Stevenson, Fien, & Schreuder, 2002), and changing negative behavioral patterns (Murre & Wijik, 1995). Environmental education for school students, including lessons on energy reduction, water conservation, and waste management are important tools to support environmental attitudes, and disseminate pro-environmental behaviors. There exists a strong, yet indirect link between environmental education lessons learned in school and knowledge, attitude, and behavior at home (Gill & Lang, 2018), due to intergenerational guidance between child and family, including energy-saving practices (Hanaki, Teraki, Nakamura, Kurisu, & Hiramatsu, 2014), recycling (Evans, Gill, & Marchant, 1996), and reduced household waste (Malgorzata, Bartosiewicz, Twardowska, & Ballantyne, 2002). Therefore, instilling the required behavior in students is beneficial to the entire community, with the rationale that children pass on this knowledge to their parents at home, who will consequently alter their attitudes (Rada, et al., 2016). In addition, education in sustainability enhances students’ ability to address existing environmental issues and enables them to become future stewards of their community (Sales, et al., 2006).

Similarly, according to Snel (2003), the benefits of school health and hygiene education (SSHE) goes beyond the school walls, as it influences the behavioral practices of students, teachers and staff, and has a positive impact on the health and hygiene conditions of the whole community. Since the learned information and adopted behaviors are carried to the home, the students act as vehicles of change within their families and community. The education and awareness program represents a win-win situation for the school and the community. The school wins as sustainable activities and processes are implemented within the educational facility, allowing credits to be attained in the respective categories; while the community is educated for sustainable development, allowing parents, teachers and students to implement the sustainable practices required to achieve the necessary social, economic and ecological systems for both present and future generations.

Credit Criteria

<table>
<thead>
<tr>
<th>Education &amp; Awareness Program</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Conservation Education Program</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Water Conservation Education Program</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Waste Management Education Program</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hygiene Education</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Vandalism Prevention</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>School-Community Collaboration</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Energy Conservation Education Program

Educational facilities are ideal grounds for energy conservation measures. Three complementary aspects lead to energy saving in schools: raising awareness among faculty, staff and students, managing school building operations, and upgrading mechanical equipment and controls. The first two aspects require minimal capital investment, yet capable of yielding significant results in energy conservation through utilizing a variety of behavioral and operational strategies (Crosby & Metzger, 2013). In a recent study, researchers denote a “synergistic relationship” between energy conservation programs in schools and enhanced student learning. In addition, findings suggest that such programs are capable of driving educational facilities towards a holistic approach to sustainability education (Schelly, Cross, Franzen, Hall, & Reeve, 2012).

Research conducted by Gill & Lang (2018) corroborate previous findings of literature on intergenerational learning by indicating a direct link between in-school energy lessons and energy-saving behaviors outside school, especially when the lesson plan includes direct action items for energy reduction. Results showed an eight percent reduction in electricity consumption at home on the same day an energy lesson about phantom loads was taught, which is the electrical energy consumed by an appliance when it is turned off, but still plugged in. Accordingly, students learnt the importance of turning off and unplugging electrical appliances to conserve energy, and understood basic concepts of electricity including types of energy, energy sources, and the electrical consumption of common household appliances. In addition, students were able to develop their own recommendations for means of electrical conservation at home. Similarly, an earlier study conducted in 1991 to evaluate the effect of an energy education program on energy-saving behaviors of low-income and senior consumers revealed a considerable improvement in their energy-related behavior, which resulted in increased energy conservation and reduced utility costs for the consumers (Marlowe, Meeks, Leiw, & Cottrell, 1996).

Intent
Increase the awareness of stakeholders within the educational facility of the importance of energy efficiency and resource conservation, to reduce the overall demand for natural resources, cut down on utility power bills and reduce the environmental impact of harmful emissions associated with power generation.

Requirements
Develop an energy conservation education program, based on the need of energy conserving practices, which includes the focus areas identified within the energy category credits. The program is to be developed in coordination with school administrators, and as a supplement to the standard curriculum.
Example

Action-oriented resources may include a combination of any of the following strategies:

1. **Educational websites**
   Various online websites allow students access to self-led learning opportunities. This includes online energy monitors and carbon calculators to assess the amount of energy consumed by electrical appliances, track energy savings from using different appliances, and calculate the carbon footprint of different energy consuming resources.

2. **Assemblies**
   Talks delivered by a teacher, or an energy company staff person and delivered to students about methods of energy conservation to save and sustain natural resources.

3. **Active class sessions**
   Deliver energy conservation education through the use of hands-on interactive activities. Effective measures include school plays run by students, board games and quizzes each based on various energy conservation topics.

4. **Site visits**
   Promote real energy connections outside the classroom by visiting local sites with a focal interest on energy such as renewable and non-renewable energy power plants.
Water Conservation Education Program

A water conservation education program should be based on a participatory approach, in which all stakeholders including users, planners and policy-makers are involved. Water availability will have a dismal impact on the socio-economic development of Egypt, if the awareness about water conservation is not addressed (MWRI, 2005). Within an educational facility, students are considered the main stakeholders, since the provision of a water conservation education program serves two benefits:

1. Children are the principal users; therefore, their collective water conservation behavior would be directly attributed to an increased amount of water savings within the school.
2. Children transfer the learned knowledge to their parents and onto further generations, which assists in creating responsible individuals capable of supporting a sustainable future.

Intent

Increase the awareness of stakeholders within the educational facility of the importance of water conservation, and the need to realize optimized water management practices to sustain the vital role of water as a precious community resource. This credit is closely linked with the W-02 Prerequisite, where students could learn the importance of choosing water conservation fixtures, and actions needed to realize the established water conservation goals.

Requirements

Develop a water conservation education program, based on the need of water conserving practices, which includes the focus areas identified within the water category credits. The program is to be developed in coordination with school administrators, and as a supplement to the standard curriculum.
**Example**

Action-oriented resources can include a combination of any of the following strategies:

1. **Educational websites**
   Various online websites allow students access to self-led learning opportunities. They consist of water education resources, including online activities, downloadable resources such as coloring-in sheets and puzzles, activity sheets, and water audit software (Bremner & Jordan, 2012).

2. **Assemblies**
   Talks delivered by a teacher, or a water company staff person and delivered to students around water efficiency, and the role of water as a vital resource on the local and global level (Bremner & Jordan, 2012).

3. **Active class sessions**
   Deliver water conservation education through the use of hands-on interactive activities. Effective measures include school plays run by students, board games, as illustrated in Figure (48), and quizzes each based on various water conservation topics. Board games are a valuable education tool which promotes student achievement through play. They support the critical thinking and problem solving processes, while achieving the objectives of the educational curricula (Crews, 2011).

4. **Site visits**
   Promote real water connections outside the classroom by visiting local sites with a focal interest on water such as a sewage treatment or water desalination plants (Bremner & Jordan, 2012).
Figure (48): Hoses and ladders game
Waste Management Education Program

The lack of the Egyptian’s community awareness on environmental aspects plays a key role in weakening the efforts to achieve positive results in solid waste management (Milik, 2010). Since all the approaches of waste prevention and waste management require public participation, awareness arises as an integral component of solid waste management, as it changes people’s perception of waste. Accordingly, awareness accompanied by participation in schools, allows students to be involved in waste management programs where successful and sustainable implementations of correct waste management practices could be achieved (Punongbayan, et al., 2014). This includes: waste segregation at source, reduction, re-using, recycling and composting in order to promote environmental awareness and public participation (Paghasian, 2017). The successful implementation of a school recycling program does not only shape current waste management, but also impacts and enhances future waste reduction efforts, since educating and training students about waste reduction practices has a long-term impact on their behavior (Evans L. D., 2000). In an urban environment, waste segregation at source is a straight-forward approach to apply values imperative to sustainable development (Ward, Wells, & Diyamandoglu, 2014).

Intent

Develop the desired behaviors, knowledge and awareness of stakeholders within the educational facility of proper waste management practices, in order to facilitate their effective involvement in sustainable development by making more informed and responsible decisions towards waste management.

Requirements

Develop a waste management education program based on the principles of waste reduction, reuse and recycling, and cover the focus areas identified within the waste management credits in the “Sustainable Sites” sub-category. The program is to be developed in coordination with school administrators, and as a supplement to the standard curriculum.
Example

Table (23) identifies various components to create an enabling environment that is conducive for the implementation of effective waste management practices in schools.

Table (23): Enabling environment components necessary to ensure the sustainability of waste management practices in schools.

<table>
<thead>
<tr>
<th>Enabling environment component</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste management as part of school curriculum</td>
<td>Engage students through curriculum links about ways to reduce waste, reusing items, composting and recycling (Griffiths, Richards, &amp; Winters, 2010).</td>
</tr>
<tr>
<td>Student groups</td>
<td>Form action teams that are responsible for developing, monitoring and implementing positive waste management practices.</td>
</tr>
<tr>
<td></td>
<td>- Develop communication tools such as posters to be displayed around the schools</td>
</tr>
<tr>
<td></td>
<td>- Perform school plays about waste management practices</td>
</tr>
<tr>
<td></td>
<td>- Hold events and present ideas to the wider community</td>
</tr>
<tr>
<td>Awareness training for students, administrators and teachers</td>
<td>Change the attitudes and waste management practices of students, teachers and administrators towards waste and litter. The reciprocated change will be eventually disseminated to their families and the community as a whole (Griffiths, Richards, &amp; Winters, 2010).</td>
</tr>
<tr>
<td>School activities</td>
<td><strong>1. Segregate</strong> Place dedicated indoor and outdoor collection bins. Sorting the different categories of waste by the users, gives them a sense of accountability towards the waste they are producing, as well as a sense of responsibility for the correct disposal of the waste (Rada, et al., 2016).</td>
</tr>
<tr>
<td></td>
<td><strong>2. Reduce</strong> Waste reduction is the preferable waste management practice. It is based on changes in producer’s and consumer’s practices (El-Haggar, 2007).</td>
</tr>
<tr>
<td></td>
<td>- Encourage students to purchase products with minimal packaging.</td>
</tr>
<tr>
<td></td>
<td><strong>3. Reuse</strong> Reuse waste into products of the same or different purpose, without the alteration of its physical and chemical characteristics (Paghasian, 2017). This practice saves both energy and resources that would have otherwise been used to produce new products, and results in the disposal of less waste in landfills (El-Haggar, 2007).</td>
</tr>
<tr>
<td></td>
<td>- Students collect paper scraps and turn them into notepads</td>
</tr>
<tr>
<td></td>
<td>- Incorporate the reuse of waste into art programs.</td>
</tr>
<tr>
<td></td>
<td>- Host competitions where children display their products made of otherwise recycled or disposed waste.</td>
</tr>
<tr>
<td></td>
<td><strong>4. Recycle</strong> Recycle the waste which cannot be reduced or reused at source. This is considered the least preferable practice in waste management, since it requires technical knowledge and possibly some capital investment in order to convert the waste to raw material, for its subsequent manufacturing of new</td>
</tr>
</tbody>
</table>
products (El-Haggar, 2007).
- Host a paper recycling competition to see which year group can collect the most paper.

5. **Compost**

- Set up compost piles or compact composters in the schoolyard or garden. The compost product can be used within the school, in the Credit H2-08: Enhanced Educational Opportunities, and Credit H2-11: School Gardens, or they can be donated or sold.

6. **Disposal**

- When waste reduction, reuse, and recycling do not apply, then responsible disposal of the waste is necessary. Irresponsible waste disposal includes littering, which is to be evaded by awareness campaigns.

**Awareness campaigns in the neighborhood and parents’ involvement**

- Involving the broader school community and parents engages people and helps develop the culture required to work together towards a common goal, in which shared successes and achievements are reported and celebrated to help generate commitment (Griffiths, Richards, & Winters, 2010).
Hygiene Education

The provision of adequate water, sanitation and hygiene (WASH) facilities in school is associated to the achievement of the Millennium Development Goals (MDGs) in terms of universal primary education, gender equality, and child mortality (Prince, et al., 2017). In addition, the importance of water and sanitation was highlighted in the new Sustainable Development Goals (SDGs), in particular Goal 6 “Clean Water and Sanitation”, which underlines the importance of investing in proper infrastructure, the provision of sanitation facilities, and encouraging hygienic practices (United Nations, 2017). There is a considerable amount of literature on the importance of access to adequate WASH services in schools, in order to improve the students’ academic performance by reducing absenteeism caused by illnesses, such as diarrhea and gastrointestinal diseases (Jasper, T.T., & Bartram, 2012; Lopez-Quintero, Freeman, & Neumark, 2009). In addition, the lack of private sanitation facilities for girls decreases the enrolment of girls in schools and leads to their drop out especially at puberty. Moreover, the availability of a safe, healthy, and clean environment reduces both environmental pollution, and health hazards for the community as a whole. Most importantly, the presence of a clean, and safe school environment is the basic right of any child, as they are fully entitled to a happy, healthy childhood (Snel, 2003). An estimated 94% of the causes of diarrheal diseases are attributed to adverse environmental factors, such as unsafe drinking water, and poor sanitation and hygiene levels (Prüss-Ustün & Corvalán, 2006). Out of the global 1.5 million diarrhea-related deaths in 2012, an estimated 502,000 and 280,000 deaths were linked with inadequate water and sanitation, respectively (Prüss-Ustün, et al., 2014). In addition, acute respiratory infections (ARIs) are responsible for more than four million annual deaths worldwide, which constitutes more than 7% of global deaths (Mathers, Boerma, & Ma Fat, 2008). Preventing the spread of ARIs is necessary in schools, since children are key actors in the transmission of influenza during community outbreaks, which has adverse health effects not only on the children themselves, but also on people of other age groups (Heikkinen, 2006).

In Egypt, despite the reduction in child mortality rates, diarrheal diseases and ARIs still account for 5 and 11% of deaths, respectively, in children under 5 years of age (World Health Organization, 2015). Since schools represent a vital setting for health promotion, and schoolchildren have been consistently associated with the spread of communicable diseases. Much work on the potential of hygiene interventions in schools has been carried out, as a key intervention to reduce the transmission of such diseases (Hetherington, Eggers, & Wamoyi, 2017; Lopez-Quintero, Freeman, & Neumark, 2009; Talaat, et al., 2011). Hand hygiene practices such as the use of antibacterial soap or alcohol-based sanitizers has been reported to lead to a significant decrease in the occurrence of diarrheal diseases (Ejemot, Ehiri, Meremikwu, & Critchley, 2008) and ARIs (Talaat, et al., 2011; World Health Organization Writing Group, 2006). An experimental study conducted by Talaat, et al., to evaluate the effectiveness of a hand hygiene campaign on reducing the absenteeism in schoolchildren in elementary schools in Cairo revealed that overall absences caused by influenza-like-illness
(ILI), diarrhea, conjunctivitis, and influenza, decreased by 40%, 30%, 67%, and 50% respectively (2011). However, despite the notable impact of enhanced WASH in schools to students' health and education, data shows that they are entirely dependent on the provision of several basic inputs such as water, soap and cleansing supplies (McMahon, Caruso, Obure, Okumu, & Rheingans, 2011; Saboori, et al., 2011). In addition, the success in sustaining these inputs requires the existence of an enabling environment, that includes the provision of sufficient funding, clearly identified roles and responsibilities of all stakeholders, supervision and liability, government monitoring and commitment, and a recognized supply chain (Lopez-Quintero , Freeman, & Neumark, 2009; Saboori, et al., 2011).

Intent

Provide a healthy and safe school environment in order to improve the students' academic performance, increase the enrolment of girls, reduce absenteeism caused by illnesses, promote environmental cleanliness, and attain children's rights.

Requirements

The provision of adequate water, sanitation and hygiene facilities must be attributed to any combination of the following items:

- Provision of adequately ventilated and well-lit sanitation facilities.
- Install high-efficiency, durable water fixtures.
- Connect all sinks to a grey water utilization tank, which is connected with main storage tank, and monitored with a lever control. Use the grey water for irrigation and flushing purposes.
- Provision of adequate number of washbasins, urinals and/or toilets in each sanitary facility as per code requirements.
Provision of enabling environment components as illustrated in Table (24)

Table (24): Enabling environment components necessary to ensure the sustainability of WASH activities in schools and associated problems and recommendations. Adapted from (Snel, 2003) (Saboori, et al., 2011).

<table>
<thead>
<tr>
<th>Enabling environment component</th>
<th>Problems</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial capacity (Saboori, et al., 2011)</td>
<td>Lack of sufficient funds for the repurchase of soap and cleansing supplies, and the repair and replacement of water taps (Saboori, et al., 2011).</td>
<td>Project implementers need to establish a school funding system for the formation, maintenance, repair and repurchase of needed inputs, since government funding is an inadequate financial resource in resource-poor locales. This could be possible by collaborating with relevant stakeholders at the local and national levels (Saboori, et al., 2011).</td>
</tr>
</tbody>
</table>
| Accountability (Saboori, et al., 2011) | There are three components of accountability: government officials; school administrators; and school stakeholders (students, teachers, parents) which need to be held accountable for the maintenance of sanitation facilities, and the provision of water, soap and cleaning supplies (Saboori, et al., 2011). | - School needs a well-defined system where teacher and student responsibilities are clearly identified (Saboori, et al., 2011).  
- The government officials should monitor the facilities in their regulatory visits, for oversight of water availability, maintenance of sanitation facilities and water treatment (Saboori, et al., 2011). |
| Technical feasibility and availability (Saboori, et al., 2011) | Schools sometimes cannot locate affordable repair services required for the ongoing maintenance of hardware components such as broken taps. Sometimes entire hand-washing containers are disused due to school’s inability to repair a single broken tap, or prevent the theft of soap (Saboori, et al., 2011). | - Hardware components to be selected based on their ease and low cost of replacement or repair (Saboori, et al., 2011)  
- Training staff members in carrying out basic tap repairs (Saboori, et al., 2011).  
- Replacement of bars of soap with soapy water tackles the soap theft issue (Saboori, et al., 2011). |
| Community support (Saboori, et al., 2011) | Insufficient community engagement (Saboori, et al., 2011). No programs are based around the community and related to health and hygiene education (Snel, 2003). | - Project implementers should facilitate activities that encourage community awareness and engagement. This includes inviting parents to attend school-day activities which involves competitions, and educational performances on the importance of WASH activities (Saboori, et al., 2011).  
- Families could provide financial and technical support in their areas |
of expertise in the repair and maintenance of school facilities (Snel, 2003).

<table>
<thead>
<tr>
<th>Student engagement (Saboori, et al., 2011)</th>
<th>Lack of motivation for student engagement (Saboori, et al., 2011).</th>
<th>Initiate a School Health Club (SHC) of child-centered activities to encourage student engagement. This includes structured educational campaigns which address WASH activities (Saboori, et al., 2011).</th>
</tr>
</thead>
</table>
| School leadership and management (Saboori, et al., 2011) | - The lack of motivation displayed by the head teacher has a direct effect on the commitment of teachers and community stakeholders (Saboori, et al., 2011).  
- Head teachers and assigned teachers are not trained (Snel, 2003).  
- Hygiene education not part of the curriculum (Snel, 2003).  
- Committed school personnel are not conducting programs which would address hygiene education (Snel, 2003). | - The barriers and incentives for head teacher involvement should be identified at an early stage and tackled before project implementation (Saboori, et al., 2011).  
- Project implementers to assign appropriate leaders for the School Health Club (SHC) which includes teachers and students (Saboori, et al., 2011).  
- The head teacher and assigned teachers should receive the appropriate training needed to educate the children on hygiene education and personal hygiene, and monitor and maintain the school facility (Snel, 2003). |

**Example**

The hand hygiene intervention campaign should address: students, teachers, head teachers, nurses and parents. The role of the School Health Club (SHC) is to ensure that the campaign's predesigned activities, as suggested in Table (25) are performed as per the specified timings.

<table>
<thead>
<tr>
<th>Activities</th>
<th>School initiatives</th>
</tr>
</thead>
</table>
| Germs and ladders game illustrated in Figure (49)  
Where do germs live? (experiment) | School trip to a soap plant  
School trip to a water purification plant  
Soap manufacturers provide hygiene education classes to students and teachers  
Display posters around the school, especially in toilets about the importance of proper hygiene  
Develop theatrical performances about hygiene education  
Best drawing contest on hand hygiene |

**Table (25): Activities and initiatives within the hand hygiene intervention campaign. Adapted from (Snel, 2003)**
Figure (49): Germs and ladders game
Vandalism Prevention

School vandalism is a major problem threatening the educational system. The U.S. National Institute of Education (NIE) noted that the annual estimates of replacing and repairing damaged items of school vandalism was about $200 million (National Institute of Education, 1977). Zwier & Vaughan underlined several successful strategies in reducing vandalism, and divided them into three ideological orientations: conservative, liberal and radical, as shown in Table (26). The most appropriate strategy to employ is dependent on the embodied values and attitudes of the responsible parties (teachers, parents, students), along with the school principal, who help determine which specific strategy changes the existing conditions in the best way possible for all concerned parties (1984).

Table (26): The relationship between Ideological Orientation, underlying cause of vandalism, and precautionary measures offered (Zwier & Vaughan, 1984).

<table>
<thead>
<tr>
<th>Ideological orientation and underlying cause</th>
<th>Precautionary measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative</td>
<td>Physical environment</td>
</tr>
<tr>
<td>Vandals are deviant. They must be caught and punished</td>
<td>- Protection of school and school ground, employment of security offices and caretakers</td>
</tr>
<tr>
<td></td>
<td>School system</td>
</tr>
<tr>
<td></td>
<td>- Encouragement and reinforcement of school rules</td>
</tr>
<tr>
<td></td>
<td>- Use of contingency contracts</td>
</tr>
<tr>
<td>Liberal</td>
<td>- Improvement of the design, appearance, and layout of the school and school grounds</td>
</tr>
<tr>
<td>The school system is malfunctioning. Vandalists capitalize on this</td>
<td>- Modification in school climate, curriculum,</td>
</tr>
<tr>
<td></td>
<td>- Use of special conflict management programs</td>
</tr>
<tr>
<td>Radical</td>
<td>- Promotion of radical changes in the structure and appearance of the school</td>
</tr>
<tr>
<td>The school system is debilitating. Vandalism is a response of normal individuals to abnormal conditions</td>
<td>- Approval of policy to decrease the size of large school and maintain small schools</td>
</tr>
<tr>
<td></td>
<td>- Provision of student involvement in decision-making processes</td>
</tr>
<tr>
<td></td>
<td>- Adoption of changes in assessment procedures.</td>
</tr>
<tr>
<td></td>
<td>- Exploration of alternative schooling methods</td>
</tr>
</tbody>
</table>

Attempts to underline the causes behind vandalistic behavior is based on its detrimental effect on the educational process, and the financial burden imposed on the school body (Zwier & Vaughan, 1984). However, social scientists have been incapable of reaching a general consensus about the causes or effective methods in addressing school vandalism. In addition, the causes behind the occurrences of vandalistic acts can be analyzed in different levels, which upholds the complexity of school vandalism. This is demonstrated in the simple question “Why does school vandalism occur?”, which can be answered by condemning the vandal, school administration, or as a result of indifference towards the school and community. Zwier & Vaughan (1984) believe that one level of explanation may be individually correct, or they may be connected in one of several possible chains of causal processes as shown in Figure (50) and (51).
In the field of psychology and sociology, various definitions of vandalism can be found. However, most of the definitions underline the intentional and destructive nature of the act (Horowitz & Tobaly, 2003). Panko has put forward the following definition, after the comprehensive study of 2516 statements: School vandalism is the “unauthorized intentional damage and theft of school and district property, excluding theft for material gain of the actor and associated damages, if any” (1979, 582); and the “voluntary degradation of the environment with no profit motive whatsoever, the results of which are considered damage by the actors(s) as well as the victim in relation to the norms that govern the situation” (Goldstein, 1996, 19). Whereas Cohen believes that vandals are driven by anger, boredom, feeling of liberation, and the want to destroy already damaged objects (1984).

Research shows that vandalism is not limited to areas of a low-socioeconomic status, but also occurs in more prosperous, middle-class areas (Horowitz & Tobaly, 2003; U.S. Department of Health, Education and Welfare, 1978). In congruence, a study conducted by Horowitz & Tobaly in four high schools in Israel to pinpoint the underlying reasons of destructive behavior revealed that the student’s social class and personal aspects did not influence their choice to engage in acts of vandalism. In contrast, the existing state of vandalism at school had a direct impact on the student’s likelihood to participate in vandalistic behavior. In addition, results revealed that punishing the students did not dissuade the recurrence of such unwanted behavior. In contrast, further studies have debated that punishment aggravates vandalism (2003). This substantiates previous findings in the literature which indicate the ineffectiveness of punishment as a preventative mechanism, since it is “person-oriented”, rather than “context-oriented” (Goldstein, 1996; Heller & White, 1975; Stoner, Shinn, & Walker, 1991).

The general conclusion drawn from an extensive body of literature is the importance of the social context in addressing adolescent vandalism. Accordingly, when the school fosters a supportive environment with a strong emphasis on team-work, and has fixed rules...
which create a fair educational system, and students find that schooling is relevant to their lives, and helps them achieve their objectives, the likelihood of vandalism would decrease (Casserly, Bass, & Garrett, 1982; Mayer, Butterworth, Nafpaktitis, & Sulzer-Azaroff, 1983). A successful approach is followed by SEKEM School, situated near Bilbeis, 60 km away from Cairo. The school focuses on enriching the student's character and integrity and fostering their social, cultural, and educational development. An example includes involving the children in their furniture repair which is either as a result of vandalism or the usual wear-and-tear. This would eliminate the likelihood of future vandalism since involving the children in the lengthy and tiresome repair process would instill a sense of ownership in them, as the students would view themselves as active, responsible members in their school, rather than vandals, or apathetic students. The cleaning tradition adopted by Japanese schools is consistent with the SEKEM school approach. The notion is to involve children in their classroom cleaning for only 15 minutes after school, in order to make them responsible for the mess they create, in order to learn to respect their surrounding spaces, and so would be less likely to litter the place again. From a social perspective, this approach enhances the bonds between students as cleaning is a team-building activity, in which students help one another, and older students can mentor younger ones. It is also an opportunity for teachers to interact with students outside the formal, learning environment. (Tokuyama, 2017)

Intent
Reduce school vandalism by addressing the social context in which learning takes place.

Requirements
Reductions in school vandalism must be attributed to any combination of the following items:

- Create a school-wide program that teaches students the importance of valuing the school and respecting its property.
- Create a mural where students can express themselves openly. This provides a healthy place for expression. Since sometimes vandalism is an expressive act, rather than an intentional violent behavior, and as the children were involved in its creation, they would be keen to keep it free from vandalism.
- Involve students in the school maintenance and repair plans. For example, children can be involved in school cleaning, wall painting, and furniture repair.
- Contact parents and obtain their support in preventing their children’s’ vandalistic behavior.
- Conduct a school-wide competition, where students are awarded for their good conduct in terms of caring for their educational spaces.
School-Community Collaboration

Educational institutions have a fundamental role as vehicles for driving community cohesion, and the school curriculum plays a significant part in supporting community cohesion within the school, its local community and the wider world. Embedding community cohesion within the curriculum aids the creation of assertive individuals and responsible citizens, who understand their rights and responsibilities within their communities, have a coherent sense of identity and self-esteem, and engage with people from different backgrounds with diverse cultural and religious beliefs (QCDA, 2010). Community engagement is deemed one of the keystones of environmental sustainability education. Through community engagement students understand the impact that certain experiences, individuals and communities have on the environment. Therefore, community engaged education allows students to explore the impact of pressing and complex issues, of which environmental sustainability is just one example. And as such, the community should be considered as center of the learning environment through which students are educated to be co-creators of change. Understanding issues of social, environmental, economic, and political justice are integral aspects of the change process. This process aids bridge the gap between opposing community participants, since models of change support the construction of decisions that are in the best interest of the entire community (Schmitz, Stinson, & James, 2000).

The use of local school buildings and facilities should be expanded to not only encompass the educational requirements of learners, but also address the social and recreational needs of the community as a whole. Different categories of community connections include cultural and social activities (community theaters); youth activities (athletic associations); resource use and information dissemination (community libraries); health, leisure, and recreation (fitness activities); and adult learning (remedial, informal, and advanced studies). Encouraging the broader community use of school facilities has positive impacts on a range of outcomes for the schools, students, families, and communities (Doyson, Kerr, Bottrill, & Boyd, 2016; Lyons, 2000). Grouping a wide spectrum of the community within the school helps form strong partnerships with groups and organizations which would have otherwise been distant from the educational community. Community awareness is raised when community activities are integrated within school grounds, which reduces the tendency of deliberate vandalism of school property, as a sense of “community ownership” is heightened. Furthermore, community support of schools is greater since community members are directly involved with the school, and more people are aware of what activities are undertaken in schools. This increases the potential opportunity for developing additional revenue streams and physical improvements to the school buildings (Lyons, 2000). Further benefits of community collaboration have been analyzed by a number of researchers. Walsh (1998) reports the probable outcome of improvements in student achievement and classroom behavior, and parent participation. In addition to notable reductions in suspension rates and unexcused absences, and grade repetitions. Similarly, Blank et al. claim that the evidence on school-community collaboration has positive impacts.
on student learning; reported by apparent student achievement in both academic and nonacademic aspects. In addition to improved family engagement, which is demonstrated by an increased communication with teachers and school involvements, and a greater sense of responsibility towards their children’s academic attainment. Consequently, the school facility fosters a more positive school environment when stronger parent-teacher relationships exist, which leads to an increased teacher satisfaction. In addition, when the school is considered the center of the community, a heightened sense of community pride, increased security and an enhanced rapport is created among students and residents (2003).

Intent

Create an educational environment that provides a platform to integrate sustainability principles for the collaborative use of the school and local community.

Requirements

- Create a school-community collaboration framework which addresses the pressing issues of the society, including social, economic, environmental and political
- Assign a team consisting of teachers, administrators, parents and community representatives to formulate an annual plan which includes the implementation and evaluation activities enclosed within the framework
Example

Epstein & Salinas developed a research-based framework consisting of six types of involvement that are integral components of a school-learning community. As illustrated in Table (27), the framework could be used by schools as a guide, however each school should plan its own approach in choosing practices to accommodate the particular needs of its families and students (2004). Many studies have examined the significance of such a framework and revealed that the parent-school-community triad focuses on school improvement goals, strengthens family connections, invigorates community support, and enhances students' academic achievement (Epstein, 2011; Henderson & Mapp, 2002; Karsna, Laws, & Hayre, 2010; Sheldon, 2003). The school should assign a team consisting of teachers, administrators, parents and community representatives to formulate an annual plan which includes the implementation and evaluation of the activities enclosed within the framework, to formulate a comprehensive range of school, family, and community practices designed to achieve the school's overall objectives (Epstein & Salinas, 2004).

Table (27): Framework of Six Types of Involvement for School-Community Partnerships (Epstein & Salinas, 2004, 2)

<table>
<thead>
<tr>
<th>Involvement Type</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type 1</strong> Parenting</td>
<td>Assist families with parenting skills, family support, understanding child and adolescent development, and setting home conditions to support learning at each age and grade level. Assist schools in understanding families' backgrounds, cultures, and goals for children.</td>
</tr>
<tr>
<td><strong>Type 2</strong> Communicating</td>
<td>Communicate with families about school programs and student progress. Create two-way communication channels between school and home.</td>
</tr>
<tr>
<td><strong>Type 3</strong> Volunteering</td>
<td>Improve recruitment, training, activities, and schedules to involve families as volunteers and as audiences at the school or in other locations. Enable educators to work with volunteers who support students and the school.</td>
</tr>
<tr>
<td><strong>Type 4</strong> Learning at home</td>
<td>Involve families with their children in academic learning at home, including homework, goal setting, and other curriculum-related activities. Encourage teachers to design homework that enables students to share and discuss interesting tasks.</td>
</tr>
<tr>
<td><strong>Type 5</strong> Decision making</td>
<td>Include families as participants in school decisions, governance, and advocacy activities through school councils or improvement teams, committees, and parent organizations.</td>
</tr>
<tr>
<td><strong>Type 6</strong> Collaborating with the community</td>
<td>Coordinate resources and services for families, students, and the school with community groups, including businesses, agencies, cultural and civic organizations, and colleges or universities. Enable all to contribute service to the community.</td>
</tr>
</tbody>
</table>

The school could provide an exhibition and project space to engage both the community and school, in order to demonstrate sustainability projects and promote sustainability concepts within the community. The exhibition space can be placed either inside or outside the education facility. As illustrated in Figures (52) and (53), decorating school fences using...
discarded waste materials creates a high-impact art installation that can connect the school and local community, as students and the community contribute to the decoration of the fence. Accordingly, it is viewed as a partnership that brings benefits to all, fostering a strong sense of place and community cohesion, through basic art-oriented sustainable education programs (Evans L. D., 2000).

Figure (52): Rainbow Trees from Up-cycled Plastic (Beaumont, 2015)
In Figure (54), the creative team including parents, teachers and students utilize the cut-out pattern of the fence as an embroidery canvas, which they combine with 2100 recyclable plastic bottles painted in traditional colors, and placed in the diamond-shaped holes of the fence to create a traditional weaving motive of the Greek island of Crete. This notion adds color to the schoolyard, as well as creates a cultural and ecological landmark within the neighborhood, which provides an approach of reclaiming public space for community members (Doumpa, 2013).
Corrective maintenance is carried out when the building component breaks down or the problem surfaces. This is the favored maintenance approach for several incorrect convictions. It employs just the minimal amount of staff required to complete the task, and it results in higher cost savings since only the damaged building components are repaired, and thus no effort or time are spent unless maintenance is required. However, the disadvantages are largely contradictory to the presumed advantages. Corrective maintenance has been cited to increase overtime labor and repair costs. Moreover, additional building components might be installed to replace the failing components, which leads to further costs. In the same way, failure to perform regular preventive maintenance increases emergency failures which results in higher service costs and overall life-cycle costs (Hemmerdinger, 2014). Therefore, it is important to implement strategic plans that focus on preventive maintenance and reduce corrective maintenance.

Preventive maintenance is the regular planned repair and maintenance of building components, such as HVAC systems, roof structures, plumbing and electrical systems (OLA, 2000). In order to ensure the building components efficient operation and to extend their useful life, preventive maintenance work is carried out within the expected lifecycle of the component before its failure or breakdown (Buildings Deparment, 2002). Effective preventive maintenance includes periodic inspections, lubrication, calibration, and equipment replacement. Key advantages of preventive maintenance include: extending the lifetime of building components, thus sustaining the building’s value; allowing buildings to function as intended and reducing inefficiencies in operations and energy usage; sustaining a safe and healthy environment for building occupants; preventing minor problems from escalating into major failures which would result in costly repair jobs. Most importantly, since building components are repaired or replaced before their permanent breakdown, this would decrease disruptions to the student educational environment (OLA, 2000). The study conducted on a sample of schools indicated that costs arising from energy failures were 65% less, and regular preventive maintenance in schools reduced both the amount of corrective work by 16% over a five-year period, and the average costs of maintenance work by 28.6% (SchoolDude, 2013).

Credit Criteria

<table>
<thead>
<tr>
<th>Preventive and Corrective Maintenance</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement preventive and corrective maintenance plan</td>
<td>N/A</td>
<td>4</td>
</tr>
</tbody>
</table>
SS-13 Credit: Innovation and Creativity in Habitat

The school’s built and natural environment offers immense opportunities to educate students about sustainability, conservation, science, and technology. The school facility should be designed with the notion of sustainable education and provide tools for hands-on, project-based learning, through which instructors utilize the intentional teaching tools within the built and natural environment as integral components of their classroom objectives. In order to invite students’ exploratory characteristics, the built and natural environment should be multisensory and accessible, enabling students to access the incorporated building systems, influence their function, and observe their personal impact on sustainability goals (Barr, Cross, & Dunbar, 2014). There are several strategies to utilize the school’s built and natural environment as a sustainable educational tool; these include but are not limited to the examples described below:

1. Visibility of sustainability measures

The exposure of sustainable building systems and construction methodologies, such as wall components, and water systems and its incorporation into project-based learning activities allows the school building to operate as a living laboratory, where students can be visually connected to the internal and external environments and systems. In addition, the exposure of sustainable design features and their use as hands-on learning tools with integrated design systems allows students to perceive their personal impact on a variety of sustainability features such as energy conservation, daylighting, and water reuse, as well as test assumptions and verify results. Similarly, the visibility of sustainable operational cycles, such as the process of composting organic waste within school gardens supports the students’ active engagement in the school’s recycling programs (Barr K., 2011). Furthermore, Barr, et al. depict an accurate analogy between buildings and a biological system, which are comprised of an input flow of elements such as energy, water, air and food to support the building’s function, and an output of generated heat and waste, and associated impacts. As students visually observe these flows, they would develop a solid understanding of the buildings’ system dynamics and identify their role in reducing the amount of unwanted output, such as waste (2014).

Vermicomposting bins are a valuable educational tool to educate children about recycling organic wastes in addition to an opportunity to research various topics such as: worm behavior, life cycles, feeding preferences, and the impact of invertebrates on the decomposition process (Trautmann & Krasny, 1997). Under suitable aeration, humidity and temperature, worms feed on the organic waste excreting worm castings, or vermi-compost. Chemicals released during this process break down the soil improving the soil texture, structure and aeration (El-Haggar, 2007). Vermicomposting enriches the soil, since it can be used as an organic, nutrient-rich organic fertilizer, rich in nitrogen, phosphorus and potassium. In addition, as a soil conditioner, vermi-compost has superior qualities to
traditional compost, since it improves soil structure and increases its water retention capacity. In addition, the worm leachate produced from the liquid runoff during vermi-composting makes a good natural liquid fertilizer but should be diluted with water at a ratio of 1:10 before its application on plants.

**Process:**

1. Select bin size based on the amount of accumulated waste. A general rule is to determine the required composting area is to have a 930 cm$^2$ of bin space for every 450 grams of waste composted per week. Consequently, conduct a weekly waste audit of organic waste from within the school premises to determine the corresponding weight of accumulated waste (Trautmann & Krasny, 1997).

2. Determine the type of bin to use for the vermi-composting process. These include but are not limited to: wooden boxes, styrofoam containers, and plastic tubs (Trautmann & Krasny, 1997). The stacked bin worm composter method illustrated in Figure (55) consists of a multiple stacking system comprised of 3 chambers placed on top of one another with drain holes at the base of the first two chambers, and a spigot for the collection of leachate at the base of the lowermost chamber. Place a few air holes at the sides of the 2 upper chambers to ensure proper aeration.

3. Prepare the bedding material, which could include: newspaper clippings, reused paper, paper egg cartons, leaves, sawdust, leaves, peat moss, or shredded cardboard. The purpose of the bedding material is to contain the moisture, and provide an adequate supply of air essential for the worms. The bedding should be soaked to the saturation point, and then drained to remove the excess water, prior to its placement in the bin. Place the damp bedding in the second working tray up to a depth of around 20 cm, without padding it down, in order to ensure the provision of air spaces for the worms.

4. Place the worms in the middle working tray, along with a mixture of organic waste such as coffee grounds, fruit or vegetable scraps in the bedding. Wait a several days for the worms to acclimatize to the surrounding conditions, then increase the amount of food based on its rate of consumption.

5. Place another layer of bedding material to cover the worms.

6. Cover the upper chamber with a lid made of plastic, wood, or fabric to conserve the moisture content of the mixture and provide shade.

7. Monitor the moisture level to provide the optimum moisture conditions for the worms’ metabolic functions. If the bedding seems dry, add moist food scraps, or spray water on the mixture. If the bedding seems soggy, add dry bedding material to the mixture, until the moisture level is well-adjusted.

8. Monitor the pH level by conducting periodic pH measurements by inserting pH paper. Eisenia foetida worms function best in the pH range between 6.5-8.5.
9. Regularly remove the collected leachate, and add food to the middle bin tray on top of the bedding material. The worms will feed on the organic waste added to the working tray, digesting them and depositing worm castings on top of the bedding material. Keep adding organic waste at regular intervals until the middle working tray is full. Then start adding the organic waste to the top working tray. The worms will follow the upward supply of food, and migrate to the top working tray leaving the middle tray, which gradually would consist of only worm castings, which can be harvested.

![Diagram of compost bin]

Figure (55): Vermi-compost stacked bin composter (Weir, 2017)

2. **Demonstrate an innovative approach to utilize discarded waste**

   The school system is a major waste-producing sector, thus provides an excellent opportunity to divert waste into recycled materials. The main challenge for school administrators is to provide not only recycling-supportive infrastructure, but to enhance the users’ recycling performance as well (Prestin & Pearce, 2010). Maximizing the diversion of reusable discarded materials from the solid waste stream into functional artwork instils a sense of environmental stewardship in the students through recycling and resource conservation.
Examples

As illustrated in Figures (56) through (58), waste materials can be upcycled to decorate the schoolyard, and classroom and building walls, which enhances the aesthetics of the educational environment.

Figure (56): Tree Decorated using Plastic Bottle Caps (Bishop, 2014)

Figure (57): Mural using Plastic Bottle Caps (Morris K., 2015)
Construct playground equipment and furniture using tires, as illustrated in Figure (59) through (61). When tires are not recycled, or reused, they are disposed of in landfills, which leads to two substantial hazards: mosquitoes and fires. Mosquitoes lead to the spread of disease, whereas the fires generate significant amount of heat and smoke which are harmful to the health and environment. In addition, tire fires are arduous to extinguish since a 75% void space exists in a whole tire, which makes it difficult to quench using water or cutting of the oxygen supply. In addition, whole tires occupy a large volume of space in landfill due to their incompressibility, and the 75% void space (California Integrated Waste Management Board, 1996).
Intent
Utilize the school’s built and natural environment as a sustainable educational tool which provides students the opportunity to develop a foundational knowledge of sustainable practices required to become future stewards of their community.

Requirements
Demonstrate innovative approaches to utilize the school’s built and natural environment as a sustainable educational tool.

Credit Criteria

<table>
<thead>
<tr>
<th>Innovation and Creativity in Habitat</th>
<th>New Schools</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate an innovative approach to expose sustainability measures</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Demonstrate an innovative approach to utilize discarded waste</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Chapter 4: Proposed Implementation of Guidelines

The case study school is located in Boulaq El Dakrour, one of the poorest informal areas located in the Western urban area of Greater Cairo within the boundaries of Giza Governorate. Criteria for selecting this school as a case study included choosing a school where the overall school infrastructure and conditions were of medium quality standards, making the school a potential candidate for upgrading its school infrastructure and processes to become a model for sustainable schools in the future.

4.1. School Description

The school building is based on a combination of three linear units and a central open courtyard model as shown in Figures (62) to (67), which is a prototype of public school buildings developed from a duplication of the traditional linear unit adopted by GAEB (General Authority for Educational Buildings).

Figure (63) School location on Google Maps

![Figure (62): Existing School site plan](image-url)
The school is located off Memfris Street, and the surrounding environment consists of a congested market place and medium rise residential buildings as shown in Figure (68)
The structural system is of a modular concrete skeleton, with a vertical and horizontal span of 3.75 and 9 meters respectively between each column. The building components are illustrated in Table (28).

### Table (28): Structural Building Components in School (Wanas, 2013)

<table>
<thead>
<tr>
<th>Building component</th>
<th>Description</th>
<th>U-value (W/m²k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thick external wall</td>
<td>250 mm sand brick plus 10 mm cement plaster interior finishing</td>
<td>2.83</td>
</tr>
<tr>
<td>Thin external wall</td>
<td>120 mm sand brick plus 10 mm cement plaster interior finishing</td>
<td>3.81</td>
</tr>
<tr>
<td>Internal wall</td>
<td>170 mm hollow clay brick</td>
<td>2.19</td>
</tr>
<tr>
<td>Slab on grade</td>
<td>20 mm mosaic tiles, 20 mm cement mortar, 60 mm sand, 100 mm concrete slab on top of compact soil</td>
<td>0.7</td>
</tr>
<tr>
<td>Typical floor slab</td>
<td>20 mm mosaic tiles, 20 mm cement mortar, 60 mm sand, 100 mm reinforced concrete slab, 10 mm cement plaster and 5 mm gypsum plastering from beneath</td>
<td>3.21</td>
</tr>
<tr>
<td>Roof</td>
<td>20 mm mosaic tiles, 20 mm cement mortar, 60 mm sand, bitumen impregnated paper, 100 mm reinforced concrete slab with foam slag and 5 mm gypsum finishing</td>
<td>0.62</td>
</tr>
<tr>
<td>Door</td>
<td>40 mm thick solid pine timber door</td>
<td>2.31</td>
</tr>
<tr>
<td>Window</td>
<td>Single glazed 4 mm sliding glass windows with aluminum frames. 1/3 of the window is fixed and the rest 2/3 are divided into four panes. Only two of the panes are operable at once</td>
<td>6</td>
</tr>
<tr>
<td>Concrete beams</td>
<td>300 mm concrete block with 10 mm cement plaster each side</td>
<td>2.75</td>
</tr>
</tbody>
</table>
As illustrated in Table (29), the school is comprised of four floors, within a building of 38 meters length, and 42 meters width. The school floor plans are shown in Appendix B.

Table (29): Areas in Gamal Abd El-Nasser School

<table>
<thead>
<tr>
<th>Area (m²)</th>
<th>Educational Spaces</th>
<th>Open Spaces</th>
<th>Staircases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Floor</td>
<td>427.6</td>
<td>278.4</td>
<td>53.5</td>
</tr>
<tr>
<td>First Floor</td>
<td>471.6</td>
<td>219.35</td>
<td>53.5</td>
</tr>
<tr>
<td>Second Floor</td>
<td>471.6</td>
<td>219.35</td>
<td>53.5</td>
</tr>
<tr>
<td>Third Floor</td>
<td>471.6</td>
<td>219.35</td>
<td>53.5</td>
</tr>
<tr>
<td>Fourth Floor</td>
<td>381.6</td>
<td>219.35</td>
<td>53.5</td>
</tr>
<tr>
<td>Total Area</td>
<td>2224</td>
<td>1155.8</td>
<td>214</td>
</tr>
</tbody>
</table>

As illustrated in Table (30) the ground floor is occupied by the computer labs, kindergarten, clinic, science lab, mosque, toilets, and three open staircases. The following floors contain the classrooms and additional educational spaces. The roofs are inaccessible, while only one roof is accessible, yet closed off against both students and teachers access.

Table (30): Room Classifications in Gamal Abd El-Nasser School

<table>
<thead>
<tr>
<th>Educational Space</th>
<th>Floor</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classrooms</td>
<td>1st/2nd/3rd/4th Floor</td>
<td>30</td>
</tr>
<tr>
<td>Library + storage</td>
<td>1st Floor</td>
<td>1</td>
</tr>
<tr>
<td>P.E room</td>
<td>1st Floor</td>
<td>1</td>
</tr>
<tr>
<td>Secretary’s room</td>
<td>1st Floor</td>
<td>1</td>
</tr>
<tr>
<td>Principal’s room</td>
<td>1st Floor</td>
<td>1</td>
</tr>
<tr>
<td>Toilet</td>
<td>GF/ 1st Floor</td>
<td>5</td>
</tr>
<tr>
<td>Mosque</td>
<td>GF</td>
<td>1</td>
</tr>
<tr>
<td>Computer lab</td>
<td>GF</td>
<td>2</td>
</tr>
<tr>
<td>Clinic</td>
<td>GF</td>
<td>1</td>
</tr>
<tr>
<td>Medical isolation room</td>
<td>GF</td>
<td>1</td>
</tr>
<tr>
<td>Science lab + storage room</td>
<td>GF</td>
<td>1</td>
</tr>
<tr>
<td>Multipurpose room (Home Economics / Agricultural)</td>
<td>2nd Floor</td>
<td>1</td>
</tr>
<tr>
<td>Educational Management room</td>
<td>1st Floor</td>
<td>1</td>
</tr>
<tr>
<td>Student affairs</td>
<td>2nd/3rd Floor</td>
<td>2</td>
</tr>
<tr>
<td>Employee affairs</td>
<td>2nd Floor</td>
<td>1</td>
</tr>
<tr>
<td>Social Counselor’s room</td>
<td>3rd/4th Floor</td>
<td>2</td>
</tr>
<tr>
<td>Staff room</td>
<td>4th Floor</td>
<td>2</td>
</tr>
<tr>
<td>Art Education room</td>
<td>4th Floor</td>
<td>1</td>
</tr>
</tbody>
</table>
### 4.2. Guideline

#### Table (31): Sustainable Guidelines of Case Study School Checklist

<table>
<thead>
<tr>
<th>Energy</th>
<th>Possible Points:</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisite</td>
<td>Required</td>
<td></td>
</tr>
<tr>
<td>E-01 Energy Management Plan</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>E-02 Comissioning</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>On-Site Renewable Energy</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Energy Metering</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>External Shading Devices</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Building Controls Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Wall Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof Insulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Performance Windows and Glazing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Window-Wall Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reflective Wall Coatings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Tightness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Efficient Lighting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump Motor Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Efficient HVAC Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovation and Creativity in Energy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water</th>
<th>Possible Points:</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-01 Integrated Water and Wastewater Management Plan</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Water Saving Devices</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Water Metering</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Water Efficient Landscaping</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Treatment and Reuse of Greywater</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Rain Water and AC Condensate Harvesting</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Innovation and Creativity in Water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indoor Environmental Quality</th>
<th>Possible Points:</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEQ-01 Environmental Tobacco Smoke (ETS) Control Plan</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>IEQ-02 Construction Activity Pollution Prevention Plan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acoustical Performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoor Chemical and Pollutant Source Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Ventilation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daylight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effective Seating Arrangements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychology of Color in the Educational Environment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials</th>
<th>Possible Points:</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-01 Local Materials</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MAT-02 Low VOC Materials</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sustainable Sites</th>
<th>Possible Points:</th>
<th>37</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS-01 Integrated Solid Waste Management Plan</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Construction Waste Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Municipal Solid Waste Management</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Organic Waste Management</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Design for People with Special Educational Needs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protect and/or Restore Existing Trees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor Playground Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School Building Orientation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety and Security</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainability Expert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education &amp; Awareness Program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preventive and Corrective Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovation and Creativity in Habitat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Totals</th>
<th>100</th>
</tr>
</thead>
</table>

Bronze: 40-49 points, Silver: 50-59 points, Gold: 60-69 points, Platinum: 70+ points
4.3. **Energy**

Table (32) displays the prerequisites and credits comprised within the energy category.

**Table (32): Energy Category Prerequisites and credits in Case Study School**

<table>
<thead>
<tr>
<th>ENERGY</th>
<th>Possible Points</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisite E-01 Energy Management Plan</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Prerequisite E-02 Commissioning</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit E-03 On-site Renewable Energy</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Credit E-04 Energy Metering</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit E-05 External Shading Devices</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Credit E-06 Building Controls Systems</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Credit E-07 External Wall Insulation</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit E-08 Roof Insulation</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Credit E-09 High Performance Windows and Glazing</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit E-10 Window-Wall Ratio</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit E-11 Reflective Wall Coatings</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit E-12 Air Tightness</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit E-13 Energy Efficient Lighting</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Credit E-14 Pump Motor Efficiency</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Credit E-15 Energy Efficient HVAC Systems</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Credit E-16 Innovation and Creativity in Energy</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>26</td>
<td>9</td>
</tr>
</tbody>
</table>
E-01 Prerequisite: Energy Management Plan

As illustrated in Figure (69) the plan should include a descriptive framework of how each of the ten energy management credits are addressed by the five core components.

The energy management objectives are as indicated below:

1. Reduce energy costs
2. Reduce the carbon footprint and emissions producing from the combustion of fossil fuels.
3. Transfer the funds saved from reduced energy bills into other school initiatives
4. Disseminate information and knowledge about the consumption and conservation of energy resources
5. Enhance public participation in energy management, and promote community-wide energy conservation programs.
6. Provide hands-on opportunities for students and community to learn about various forms of energy technologies, such as renewable energy and energy harvesting.
E-03 Credit: On-site Renewable Energy

Step 1. Identify project team
The project team includes 4 main players: teachers, students, parents, and renewable energy advocate from a local environmental group. These are two key qualities which need to be present in the project team candidates. First, they need to be motivated individuals, who are eager to have the school install a renewable energy system. Another quality is that they should work well in groups and understand the importance of cooperation to meet a common goal.

Step 2. Identify project goals
The primary goal of installing the renewable energy system is to use it as a hands-on sustainable education tool for students and community members on renewable energy potential. Derived concepts from the PV system can be integrated into the school curricula in various subjects such as science, math, arts, geography and IT classes (NEED, 2017). Educational outcomes from utilizing solar panels could include, but is not limited to the following:

- Students ability to describe how solar panels can be used to generate electricity.
- Students understand the impact of the sun angle on the efficiency of the solar panels.
- Students understand that energy can appear in different forms and can be both transferred and transformed.
- Students understand the interrelationships of matter and energy in living systems.
- Students understand the interrelationships among science, technology, and human activity and how they can affect the world.
- Students learn to distinguish between renewable and non-renewable sources of energy.
- Students understand the benefits and importance of utilizing renewable energy resources.
- Students understand the link between fossil fuel generation and climate change.
- Students understand the economic and environmental impact of generating and using power, which would alter their consumption behavior.

Secondary goals include lowering the school’s energy costs by displacing energy purchased from utilities by renewable energy system to reach a target percentage of ≥ 5% reduction in the building’s annual energy cost. Another objective includes reducing air pollution by decreasing the amount of pollutants released from fossil fuel burning mechanisms that cause several health-related illnesses in order to protect and improve the health and well-being of community members.
Step 3. Evaluate opportunities and limitations

As illustrated in Figure (70) the indicated roof area is readily accessible, and is comprised of a 90m² area. This provides an excellent opportunity for the placement of solar photovoltaic panels which can be easily accessed by students for sustainable education purposes. As illustrated in Figure (71), the roof is currently just used for the cluttering of wood work and various objects, and accordingly the proposed renewable system would pose a better utilization of an initially unused space. Solar energy systems engineer needs to conduct a site survey to collect necessary structural, electrical, and related site information for use in the design of the solar power system. The survey determines the roof surface’s suitability for installing a PV system and prevents planning mistakes. The following data should be recorded to form the foundation for good planning (Minnesota Renewable Energy Society, 2011):

- PV module type and method of installation
- Desired energy yield from PV power
- Financial framework
- Usable installation area
- Orientation and inclination angle
- Shading information
- Roof shape, structure and substructure
- Junction boxes installation points
- Cable lengths, wiring routes and routing system
- Roof surface height from ground level
- Distance and dimensions of shadow-casting objects from roof surface

Figure (70): Accessible Roof Area
After the initial visit, a 3D representation of the roof surface is constructed in a simulation program for shading analysis reasons. The usable installation area can be directly calculated from the shading simulation. However, for demonstrative purposes, the existing roof surface area of 90m$^2$ would yield approximately 8 to 9kW. Whereas, if the non-using area is calculated to account for approximately 20%, then the usable installation area consists of around 70m$^2$, which would provide an energy yield of 6 to 7kW. The size of the solar panels would be approximately 1m by 1.6m in size, four of such panels would provide 1kW of power, and the spacing between them would be determined by the installers. Limitations in placing the PV panels in the indicated roof lies in obtaining the necessary permits from the General Authority for educational buildings. The area can be secured by erecting the required parapet wall, and ensuring that the students do not have unsupervised access to the roof. In addition, a structural engineer needs to perform a site visit to conclude the structural integrity and soundness of the roof, since from first inspection the roof slab seemed sloping and uneven.

**Credit Criteria**

<table>
<thead>
<tr>
<th>On-Site Renewable Energy</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 5% of the building’s annual energy cost reduced by renewable energy resources</td>
<td>1</td>
</tr>
<tr>
<td>Renewable energy as an educational tool</td>
<td>2</td>
</tr>
</tbody>
</table>
E-04 Credit: Energy Metering

Install energy meters that comply with the energy metering plan requirements, and record monthly readings. They need to be in a readily accessible place in order to be used as a learning tool for resource management. Derived concepts from energy metering can be integrated into the school curricula, and the educational outcomes could include, but are not limited to the following:

- Students learn about the principles of energy efficiency and conservation
- Students explore the ways they can adopt energy efficient behaviors
- Students can contribute their ideas of energy conservation methods in school.

In addition to examining the data, it is essential to supervise the energy-related behaviors by students and teachers in the building.

The energy metering plan should include the following:

- Total annual energy use (MWh) of entire building, and each energy system.
- Peak power demand (MW) of entire building, and each energy system.

The school’s building’s energy systems are illustrated in Table (33)

Table (33): School’s Building Energy Systems

<table>
<thead>
<tr>
<th>Energy System</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC</td>
<td>Ceiling fans, window exhaust fans</td>
</tr>
<tr>
<td>Lighting</td>
<td>Lighting fixtures</td>
</tr>
<tr>
<td>Electrical devices</td>
<td>Copiers, printers, computers,</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>Roof-mounted PV solar panels</td>
</tr>
</tbody>
</table>

Credit Criteria

<table>
<thead>
<tr>
<th>Energy Metering</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop energy metering plan</td>
<td>1</td>
</tr>
<tr>
<td>Install energy meters that comply with the energy metering plan requirements</td>
<td>1</td>
</tr>
</tbody>
</table>
E-05 Credit: External Shading Devices

Install straight overhangs for a minimum of 10 and 25 windows on the East and West facades respectively, as illustrated in Figure (72). Install vertical fins for a minimum of 11 windows on the South façade, as illustrated in Figure (73). Use wooden shading devices fixed with nuts and bolts, or gypsum board panels attached by brackets. Table (34) indicates the quantity of windows in the school, where the majority is located along the West façade.

<table>
<thead>
<tr>
<th>Shading Device</th>
<th>Perspective View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight overhangs</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>Figure (72): Horizontal Shading Device on East and West Facades</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shading Device</th>
<th>Perspective View</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical fins</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>Figure (73): Vertical Shading Device on South Façade</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ground</th>
<th>1st Floor</th>
<th>2nd Floor</th>
<th>3rd Floor</th>
<th>4th Floor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>South</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>West</td>
<td>9</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>49</td>
</tr>
</tbody>
</table>

Table (34): Quantity of Windows in Gamal Abd El-Nasser School

Credit Criteria

<table>
<thead>
<tr>
<th>External Shading Devices</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install external shading for 50% of windows on East, South, and West façades</td>
<td>2</td>
</tr>
</tbody>
</table>
E-08 Credit: Roof Insulation

Place extruded polystyrene thermal insulating boards/tiles, or paint the roof with one layer of solar reflective white coating of a thickness of 0.2032mm to redirect approximately 80% of the incoming solar radiation, account for the total roof surface area of approximately 380 m².

Credit Criteria

<table>
<thead>
<tr>
<th>Roof Insulation</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use roof surface materials with solar reflectivity ≥ 70%</td>
<td>1</td>
</tr>
<tr>
<td>and</td>
<td></td>
</tr>
<tr>
<td>Place roof surface insulation material with U-value ≤ 0.273 W/m²K</td>
<td>1</td>
</tr>
</tbody>
</table>
**E-11 Credit: Reflective Wall Coatings**

Apply protective thermal coating for the school buildings external walls, with a solar reflectivity \( \geq 35\% \).

**Credit Criteria**

<table>
<thead>
<tr>
<th>Reflective Wall Coatings</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use reflective wall coatings with solar reflectivity ( \geq 35% )</td>
<td>1</td>
</tr>
</tbody>
</table>
E-12 Credit: Air Tightness

A visual inspection should be conducted to identify obvious air leakage pathways, whereas the use of a door blower device helps detect air leakage sources that are not easily identified with just a visual inspection. A cost-effective method to locate areas of air leakage is to create a manual draft meter using a piece of paper, pencil, and tape. The piece of paper is taped around the pencil and held close to a window or door. If the paper moves, this indicates an air leakage (The NEED Project, 2016). Use appropriate sealants such as hybrid or silicone sealants, to ensure an airtightness of 5 m$^3$/ (m$^2$.h) at 50 Pa following the use of a door blower test. Table (35) identifies air leakage pathways that require inspection within the school.

<table>
<thead>
<tr>
<th>Building Component</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Junctions in Building Envelope</td>
<td>Exterior wall to roof</td>
</tr>
<tr>
<td></td>
<td>Floor to walls</td>
</tr>
<tr>
<td></td>
<td>Walls to foundations</td>
</tr>
<tr>
<td></td>
<td>Walls to ceilings</td>
</tr>
<tr>
<td></td>
<td>Walls and window/door frames</td>
</tr>
<tr>
<td></td>
<td>Light fittings</td>
</tr>
<tr>
<td></td>
<td>Service penetrations through the ceiling</td>
</tr>
<tr>
<td>Exterior Wall Openings</td>
<td>External doors</td>
</tr>
<tr>
<td></td>
<td>Electrical penetrations in exterior walls</td>
</tr>
<tr>
<td></td>
<td>Exhaust fans</td>
</tr>
<tr>
<td></td>
<td>Windows</td>
</tr>
<tr>
<td>Interior Walls and Openings</td>
<td>Plumbing holes</td>
</tr>
<tr>
<td></td>
<td>Electrical and communication conduit</td>
</tr>
<tr>
<td></td>
<td>Ductwork penetrations</td>
</tr>
<tr>
<td>Shafts</td>
<td></td>
</tr>
</tbody>
</table>

Table (35): Air Leakage by Building Component. Adapted from (Cheung, 2008)

Credit Criteria

<table>
<thead>
<tr>
<th>Air Tightness</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieve airtightness of 5 m$^3$/ (m$^2$.h) at 50 Pa following the use of a door blower test</td>
<td>1</td>
</tr>
</tbody>
</table>
E-13 Credit: Energy Efficient Lighting

Replace all incandescent bulbs with LED bulbs. Table (36) illustrates the number of lightbulbs required in each space.

Table (36): Number of lightbulbs in Gamal Abd El-Nasser School

<table>
<thead>
<tr>
<th>Space</th>
<th>Floor</th>
<th>Number of light bulbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corridors</td>
<td>GF/1st/2nd/3rd/4th</td>
<td>77</td>
</tr>
<tr>
<td>Classrooms</td>
<td>1st/2nd/3rd/4th</td>
<td>352</td>
</tr>
<tr>
<td>Library + storage</td>
<td>1st Floor</td>
<td>18</td>
</tr>
<tr>
<td>P.E room</td>
<td>1st Floor</td>
<td>3</td>
</tr>
<tr>
<td>Secretary’s room</td>
<td>1st Floor</td>
<td>2</td>
</tr>
<tr>
<td>Principal’s room</td>
<td>1st Floor</td>
<td>6</td>
</tr>
<tr>
<td>Toilet</td>
<td>GF/1st Floor</td>
<td>20</td>
</tr>
<tr>
<td>Mosque</td>
<td>GF</td>
<td>2</td>
</tr>
<tr>
<td>Computer lab</td>
<td>GF</td>
<td>32</td>
</tr>
<tr>
<td>Clinic</td>
<td>GF</td>
<td>4</td>
</tr>
<tr>
<td>Medical isolation room</td>
<td>GF</td>
<td>2</td>
</tr>
<tr>
<td>Science lab + storage room</td>
<td>GF</td>
<td>27</td>
</tr>
<tr>
<td>Multipurpose room</td>
<td>2nd Floor</td>
<td>14</td>
</tr>
<tr>
<td>Industrial tools storage room</td>
<td>2nd Floor</td>
<td>4</td>
</tr>
<tr>
<td>Industrial Education room</td>
<td>1st Floor</td>
<td>4</td>
</tr>
<tr>
<td>Student affairs</td>
<td>2nd/3rd Floor</td>
<td>6</td>
</tr>
<tr>
<td>Employee affairs</td>
<td>2nd Floor</td>
<td>2</td>
</tr>
<tr>
<td>Social counselor’s room</td>
<td>4th Floor</td>
<td>3</td>
</tr>
<tr>
<td>Teacher’s room</td>
<td>4th Floor</td>
<td>7</td>
</tr>
<tr>
<td>Art Education room</td>
<td>4th Floor</td>
<td>3</td>
</tr>
</tbody>
</table>

TOTAL NO. OF LIGHTBULBS 561

Credit Criteria

<table>
<thead>
<tr>
<th>Energy Efficient Lighting</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install LED lighting fixtures in 100% of the spaces within the educational facility</td>
<td>2</td>
</tr>
</tbody>
</table>
E-14 Credit: Pump Motor Efficiency

Install pump motor with an energy efficiency of 90% or more to satisfy the power demand equal to or exceeding 7.5 kW, with a power factor of 0.9 or more.

Credit Criteria

<table>
<thead>
<tr>
<th>Pump Motor Efficiency</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump motor efficiency ≥ 90% when pump motor KW ≥ 7.5 kW with power factor 0.9 or more</td>
<td>1</td>
</tr>
</tbody>
</table>
E-16 Credit: Innovation and Creativity in Energy

Implement an energy harvesting prototype as a sustainable educational tool to solicit a general sense of awareness about energy conservation, distribution, consumption and storage.

Credit Criteria

<table>
<thead>
<tr>
<th>Innovation and Creativity in Energy</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy harvesting educational tool</td>
<td>2</td>
</tr>
</tbody>
</table>
4.4. Water

Table (37) displays the prerequisites and credits comprised within the water category.

Table (37): Water Category Prerequisites and credits in Case Study School

<table>
<thead>
<tr>
<th>Prerequisite</th>
<th>WATER</th>
<th>Possible Points</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>W-01</td>
<td>Integrated Water and Wastewater Management Plan</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Credit</td>
<td>W-02</td>
<td>Water Saving Devices</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>W-03</td>
<td>Water Metering</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>W-04</td>
<td>Water Efficient Landscaping</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>W-05</td>
<td>Treatment and Reuse of Greywater</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>W-06</td>
<td>Rain Water and AC Condensate Harvesting</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>W-07</td>
<td>Innovation and Creativity in Water</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>18</td>
<td>7</td>
</tr>
</tbody>
</table>
W-01 Prerequisite: Integrated Water and Wastewater Management Plan

As illustrated in Figure (74) the plan should include a descriptive framework of how each of the six sustainable water management credits are addressed by the five core components.

![Figure (74): Integrated Water and Wastewater Management Framework](image_url)

The water and wastewater management objectives are as indicated below:

1. Reduce water and energy bills
2. Reduce greenhouse gas emissions which have a significant impact on climate change
3. Reduce the carbon footprint of water by reducing the amount of energy and chemicals utilized in the water treatment process
4. Transfer the funds saved from reduced water bills into other school initiatives
5. Disseminate information and knowledge about the consumption and conservation of water resources
6. Enhance public participation in water resources management, and promote community-wide water conservation programs
**W-02 Credit: Water Saving Devices**

Replace the existing fixtures and appliances in the toilets with water-saving devices. Table (38) indicates the number of water fixtures in the school.

- Install high-efficiency water closets, urinals and squat toilets
- Install low-flow lavatory faucets
- Install water-saving hose nozzles

<table>
<thead>
<tr>
<th>Space</th>
<th>Squat toilet</th>
<th>Water hose</th>
<th>Urinal</th>
<th>Water closet</th>
<th>Faucet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girl’s toilet</td>
<td>8</td>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Boy’s toilet</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Admin. Toilet</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Teacher’s toilet</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Principal’s toilet</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Credit Criteria**

<table>
<thead>
<tr>
<th>Water Saving Devices</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replace existing fixtures and appliances with water-efficient ones</td>
<td>3</td>
</tr>
</tbody>
</table>
W-03 Credit: Water Metering

Install water meters in the school, the quantity and type is to be determined by specialists. A group of students can be supervised by the maintenance personnel to take water meter readings. As illustrated in Table (39), meter readings are recorded two times a day, at approximately the same time each day, and the total daily used is derived by subtracting the morning reading from the afternoon reading. The primary goal of water metering is to help reduce the water consumption in the school. A secondary goal is to use the water meters as a hands-on sustainable education tool for students. Derived concepts from water metering can be integrated into the school curricula, and the educational outcomes could include, but are not limited to the following:

- Students learn about the need to conserve water resources.
- Students explore the ways they can alter their water consumption attitudes.
- Students can contribute their ideas of water conservation methods in school.

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Time (AM)</th>
<th>Morning reading</th>
<th>Time (PM)</th>
<th>Afternoon reading</th>
<th>Total Daily use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thursday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunday</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition, regular water meter readings would help detect leaks in water pipes, fitting and appliances. Since if the water consumption increases dramatically without an apparent reason, this could identify a hidden leak. Students, teachers and staff should be instructed to notify the maintenance staff of any identified or suspected leaks in the school. Table (40) illustrates a leakage planning sheet. Both tables could be mounted on the toilet doors in order to be visible by the school consumers for educational purposes.

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Water fixture</th>
<th>Issue</th>
<th>Action</th>
<th>Reported person</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Credit Criteria

<table>
<thead>
<tr>
<th>Water Metering</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install water meters</td>
<td>3</td>
</tr>
</tbody>
</table>
W-04 Credit: Water Efficient Landscaping

As shown in Figure (75), there are green spaces along the school periphery and at several trees within the school, which account to approximately 75m². The current base case efficiency for irrigation is 40%, as hand-watering using a garden hose is used. The simple application of adding a spray nozzle to the garden house, would improve the irrigation efficiency to 66%.

![Figure (75): Trees in the School](image)

Figure (76) indicates the location of an approximate 48m² of usable wall surface area that can be used to create a vertical wall garden, which would supplement the adjacent ground plantation area shown in Figure (77). The wall surface provides an ideal location for the incorporation of recycled materials within the gardening program, such as suspended soda bottles and PVC pipes. Currently, the green areas are looked after by agriculture teacher, and students are not involved in any planting activities.

![Figure (76): Ground Plantation Area](image) ![Figure (77): Landscaping areas in the school](image)
The wall provides an opportunity for the incorporation of various planting ideas through which the students’ active engagement is key to the success of those concepts. A plastic bottle vertical garden, illustrated in Figure (78) can be created by suspending recycled soda bottles on string horizontally in a grid. A similar approach is illustrated in Figure (79), which consists of recycled PVC pipes, which students can paint, and teachers can help them assemble the system. In each of these approaches, the student is responsible for their designated planter, either the soda bottle or individual pots placed within the PVC tubing system.

Credit Criteria

<table>
<thead>
<tr>
<th>Water Efficient Landscaping</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student’s active engagement in gardening program</td>
<td>1</td>
</tr>
<tr>
<td>Irrigation efficiency of 50-70%</td>
<td>1</td>
</tr>
</tbody>
</table>
W-05 Credit: Treatment and Reuse of Greywater

Washbasins in the toilets provide a suitable low risk source of greywater, which could be subsequently used in toilet flushing or irrigation of the landscape areas located around the school periphery. Greywater could be used in toilet flushing and irrigation with little or no treatment. Collect the greywater from washbasins using a separate plumbing system, and route it to the greywater system. A simple system starts with connecting all the washbasins in the toilet with a surge tank with a 1 HP pump, which is used to temporarily store the collected water and deliver it to the irrigation and/ or toilet flushing system. The tank should have two filters as a preliminary method of fine and coarse particle filtration. As indicated in the Guidelines page --, a stage of chemical treatment could be added prior to the water’s transfer to the irrigation or toilet flushing system. Derived concepts from the greywater recycling system can be integrated into the school curricula in various subjects such as biology and chemistry. Educational outcomes from installing the greywater recycling may include, but is not limited to the following:

- Students understand the difference between greywater and blackwater.
- Students learn how to measure the pH of water.
- Students develop an increasing responsibility for their health and wellbeing as they learn about water sanitation and how it can affect their health.
- Students learn about the need to conserve water resources.
- Students identify ways to reduce water pollution.
- Students explore the ways they can alter their water consumption attitudes.
- Students design and build their own water filtering system.

Credit Criteria

<table>
<thead>
<tr>
<th>Treatment and Reuse of Greywater</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install on-site greywater treatment and recycling system</td>
<td>2</td>
</tr>
<tr>
<td>Greywater recycling system as an educational tool</td>
<td>1</td>
</tr>
</tbody>
</table>
W-06 Credit: Rainwater and AC Condensate Harvesting

Place waterproofing membranes on the roof to prevent water infiltration through the building envelope. In addition, install rooftop rainwater harvesting system which collects precipitation from the roof areas and diverts it to either plants in the landscape or for its subsequent use in toilet flushing. If the roof membrane consists of both thermal and water insulating properties then it is also double-counted in the EE-08 Credit: Thermal Comfort – Roof Insulation.

Credit Criteria

<table>
<thead>
<tr>
<th>Rainwater and AC Condensate Harvesting</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install rooftop rainwater harvesting system</td>
<td>1</td>
</tr>
</tbody>
</table>
**W-07 Credit: Innovation and Creativity in Water**

An innovative approach to increase water efficiency within the school involves the insertion of a water displacement device in the tank of a conventional toilet as described in the Guidelines, page 75. Table (41) identifies the amount of water closets in the school.

<table>
<thead>
<tr>
<th>Space</th>
<th>Water closet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girl’s toilet</td>
<td>-</td>
</tr>
<tr>
<td>Boy’s toilet</td>
<td>-</td>
</tr>
<tr>
<td>Admin. Toilet</td>
<td>5</td>
</tr>
<tr>
<td>Teacher’s toilet</td>
<td>2</td>
</tr>
<tr>
<td>Principal’s toilet</td>
<td>1</td>
</tr>
</tbody>
</table>

**Credit Criteria**

<table>
<thead>
<tr>
<th>Innovation and Creativity in Water</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate an innovative approach to increase water efficiency within the school</td>
<td>3</td>
</tr>
</tbody>
</table>
4.5. **Habitat – Indoor Environmental Quality**

Table (42) displays the prerequisites and credits comprised within the Habitat: Indoor Environmental Quality category.

<table>
<thead>
<tr>
<th>HABITAT</th>
<th>Indoor Environmental Quality</th>
<th>Possible Points</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisite</td>
<td>IEQ-01</td>
<td>Environmental Tobacco Smoke (ETS) Control Plan</td>
<td>Required</td>
</tr>
<tr>
<td>Prerequisite</td>
<td>IEQ-02</td>
<td>Construction Activity Pollution Prevention Plan</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-03</td>
<td>Acoustical Performance</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-04</td>
<td>Indoor Chemical and Pollutant Source Control</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-05</td>
<td>Natural Ventilation</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-06</td>
<td>Daylight</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-07</td>
<td>Effective Seating Arrangements</td>
<td>1</td>
</tr>
<tr>
<td>Credit</td>
<td>IEQ-08</td>
<td>Psychology of Color in the Educational Environment</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>
IEQ-01 Prerequisite: Environmental Tobacco Smoke (ETS) Control Plan

1. Erect no-smoking signs at each of the three entrances of the school premises.
2. Since the school is in a congested area it would not be possible to enforce the ban to prohibit smoking within 8 meters of building entrances, outdoor air intakes and operable windows. Nevertheless, it is possible to make tobacco education information available to raise community awareness of the harmful effects of tobacco consumption.
3. Permit smoking within school grounds only in designated smoking areas within the school yard, which are prohibited to students.
IEQ-04 Credit: Indoor Chemical and Pollutant Source Control

Employ permanent entryway systems at the four outdoor accesses indicated in Figure (80) to capture dirt and particulates entering the school building at exterior entrances. Install grates at all four entrances.

The Science lab located in the ground floor is the only source of hazardous gases and chemicals in the school.

- Consult specialists and install window exhaust fans which satisfy the min. flow rate of 266 cfm derived from the calculation below.

**Area Method:**

- Room Area = 49.35m² = 532 ft²
- The exhaust rate must be at least 0.50 cfm, per square foot.
- 0.50 cfm x 532 ft² = min. flow rate of 266 cfm

- Install self-closing door hinges in the two doors to prevent fumes from penetrating adjacent spaces.

Credit Criteria

<table>
<thead>
<tr>
<th>Indoor Chemical and Pollutant Source Control</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement indoor chemical and pollutant source control mechanisms</td>
<td>1</td>
</tr>
</tbody>
</table>
IEQ-05 Credit: Natural Ventilation

Apply wind-driven cross ventilation by opening all three windows as illustrated in Figure (81) in the morning based on a fixed time schedule at around 7 am before the beginning of the school day to ensure the flow of fresh air inside the classroom.

Figure (81): Classroom Floor Plan and Ventilation Points

Credit Criteria

<table>
<thead>
<tr>
<th>Natural Ventilation</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate natural ventilation strategies which ensure that CO₂ levels in occupied indoor spaces does not exceed 1500 ppm</td>
<td>3</td>
</tr>
</tbody>
</table>
IEQ-06 Credit: Daylight

Install transparent glass of low emissivity to admit natural daylight, yet prevent the admission of radiant heat into the educational spaces. Currently the effect of unfavorable direct solar radiation on the windows is improperly addressed by placing thick curtains or painting windows or sticking colored paper over the window surfaces, as illustrated in Figure (82).

Figure (82): Improper means of addressing unwanted direct solar radiation from windows

Credit Criteria

<table>
<thead>
<tr>
<th>Daylight</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporate daylighting strategy that records a minimum daylight illuminance level of 110 lux, and a maximum of 5400 lux</td>
<td>2</td>
</tr>
</tbody>
</table>
IEQ-07 Credit: Effective Seating Arrangements

1. Classrooms

The existing classroom setting is portrayed in Figure (83)

The proposed seating arrangement allows for the allocation of 60 students. The existing setting has fewer desks, and one seat of 1.10m length is used for seating 3 students. The proposed row-and-column arrangement illustrated in Figure (84) enhances the students’ comfort, as 60 students are seated with 2 students per seat. As illustrated in Figures (85) and (86), an alternative seating arrangement which allows for the allocation of 42 and 56 students respectively. The layout can be implemented as combination of both a U-shaped arrangement, which fosters an interactive environment in which class discussion and participation are encouraged; and a modular arrangement, which is used for student-centered instruction, and allows teachers to work closely with students on an individual basis or within small groups. This layout can be arranged when student-centered instruction is required, and the educational task requires group work.

Figure (83): Existing Classroom Setting

Figure (84): Proposed row-and-column arrangement

Figure (85): Proposed alternative seating arrangement, 42 students seating capacity

Figure (86): Proposed alternative seating arrangement, 56 students seating capacity
2. Science lab + Storage room

The existing science lab setting is portrayed in Figure (87).

![Figure (87): Existing laboratory setting](image)

The proposed layout indicated in Figure (88) is based on a combination of both a U-shaped and modular arrangement which is suitable for both teacher-and student-centered instruction, that is required during science class. The seating arrangement allows for the allocation of 60 students, and replaces the regular seating with laboratory double-sided benches that suit the educational objectives of the particular subject area.

![Figure (88): Proposed laboratory setting](image)
3. **Multipurpose room**

The existing multipurpose room is portrayed in Figure (89).

![Figure (89): Existing multipurpose room setting](image1)

The proposed layout indicated in Figure (90) is based on a combination of both a U-shaped and modular arrangement which is suitable for both teacher-and student-centered instruction, that is required during the home economics and agricultural class. The seating arrangement allows for the allocation of 60 students, and replaces the regular seating with double-sided benches that suit the educational objectives of the particular subject area.

![Figure (90): Proposed multipurpose room setting](image2)
4. Computer Lab

The existing computer lab is portrayed in Figure (91).

![Figure (91): Existing computer lab setting](image)

The proposed layout indicated in Figure (92) allows for the allocation of 30 students. The central space is utilized to place an additional double sided row of computer zones.

![Figure (92): Proposed computer lab setting](image)
5. Library

The existing library is portrayed in Figure (93).

Figure (93): Existing Library Setting

The design includes three zones as indicated in Figure (94), which helps establish the library as an appealing hub of learning and reading that is vital to student achievement. The design objective is to shift the role of the library to become the focal point of the school, which is eye-catching and enlivens the educational campus, creating an attractive destination for students, teachers, and community users, as shown in Figures (95) to (97).

Figure (94): Proposed Library Setting
Figure (95): Proposed library design perspective

Figure (96): Proposed library design perspective

Figure (97): Proposed library design perspective
Modular seating/shelving unit
The modular multipurpose unit illustrated in Figures (98) to (99) is designed to incorporate a seating area and a colorful double-sided shelving unit to encourage students to borrow books and sit and read them in the library.

Seating cubes
The multi-colored cubes illustrated in Figure (100) are designed to be modular light-weight structurers. The flexibility of the structures allows the students to arrange the cubes to form an individual reading area, or grouped to form a more collaborative space, which is central to creating a flexible learning environment.
Tree bookshelf
The tree bookshelf illustrated in Figure (101) is designed to encourage students to read and borrow books by creating a visually appealing interactive, central element in the library.

![Tree bookshelf](image)

Figure (101): Proposed tree bookshelf perspective and front view

Competition Board
The board illustrated in Figure (102) is used to display the collaborative and individual achievements of students of different year groups. Their display in the library accentuates the role of the library as a central focal point of the school, where educational achievements are recognized. The board's location in the center of the accent wall accentuates the importance of healthy competition amongst students.

![Competition board](image)

Figure (102): Proposed competition board

Credit Criteria

<table>
<thead>
<tr>
<th>Effective Seating Arrangements</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement effective seating strategy</td>
<td>1</td>
</tr>
</tbody>
</table>
IEQ-08 Credit: Psychology of Color in the Educational Environment

Color is a powerful communication tool that influences one’s actions, mood and physiological reactions. Therefore, it would be useful for teachers to explain to students the psychology behind the use of color; since it is these children who will be taking informed decisions of color applications in their future homes and workplaces.

1. Classrooms
In primary schools, the use of hues within the warm spectrum induce feelings of security and comfort, they help young students feel relaxed within the educational environment, as it decreases the scale of otherwise perceived large spaces, whilst increasing their brain activity (O’Dell, 2018). The proposed color palette is indicated in Figure (103).

![Figure (103): Proposed classroom color palette](image1)

2. Science lab + Storage room
In science labs, the use of shades of blue have been shown to lower the heart rate, allowing concentration levels to rise. (Daggett, Cobble, & Gertel, 2008; O’Brien, 2017). The proposed color palette is indicated in Figure (104).

![Figure (104): Proposed science lab color palette](image2)
3. Multipurpose room
The use of colors such as light yellow, green, violet, red, peach, and pink promote creativity which is required in educational spaces requiring creative pursuit, such as the multipurpose room which is used for home economics and agricultural education (Daggett, Cobble, & Gertel, 2008). The proposed color palette is indicated in Figure (105).

4. Computer Lab
Computer labs call for the use of encouraging medium colors providing visual relief, and avoiding the usage of bright colors (Daggett, Cobble, & Gertel, 2008). The proposed color palette is indicated in Figure (106).
5. Library

**Side walls:**

The use of a calm color such as a pale blue soothes the mind, and aids the concentration process. The proposed color is indicated in Figure (107).

![Proposed library side walls color](image)

**Back wall:**

The creation of an eye-catching accent wall in the library has a number of objectives. It refreshes the visual perception of students which enhances their minds’ cognitive capabilities. In addition, it drives the attention to the central wall which is used to display the competition board, and breaks the sense of visual monotony created by the stacked bookshelves. The proposed color scheme is indicated in Figure (108).

![Proposed library back wall color scheme](image)

**Credit Criteria**

<table>
<thead>
<tr>
<th>Psychology of Color in the Educational Environment</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement appropriate wall color choices</td>
<td>2</td>
</tr>
</tbody>
</table>
4.6. Habitat – Materials

Table (43) displays the credits comprised within the Habitat: Materials category.

Table (43): Habitat - Materials Category Prerequisites and credits in Case Study School

<table>
<thead>
<tr>
<th>HABITAT</th>
<th>Sustainable Sites</th>
<th>Possible Points</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
<td>MAT-01 Local Materials</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>MAT-02 Low VOC Materials</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL</strong></td>
<td><strong>6</strong></td>
<td><strong>6</strong></td>
</tr>
</tbody>
</table>
**MAT-01 Credit: Local Materials**

Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within a 1000-kilometer radius off the project site, for 75% of the total materials value, based on cost. This includes sealants, wall coatings and roofing membranes.

**Credit Criteria**

<table>
<thead>
<tr>
<th>Local Materials</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>75% of total building materials cost</td>
<td>3</td>
</tr>
</tbody>
</table>
MAT-02 Credit: Low VOC Materials

Ensure all paints, coatings, adhesives and sealants comply with the required limits for VOC content in the guideline, and provide supporting documents for each product.

Credit Criteria

<table>
<thead>
<tr>
<th>Low VOC Materials</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure all paints, coatings, adhesives, and sealants comply with the required limits for VOC content, and provide supporting documents for each product</td>
<td>3</td>
</tr>
</tbody>
</table>
4.7. Habitat – Sustainable Sites

Table (44) displays the prerequisites and credits comprised within the Habitat: Sustainable Sites category.

Table (44): Habitat - Sustainable Sites Category Prerequisites and credits in Case Study School

<table>
<thead>
<tr>
<th>Prerequisite</th>
<th>SS-01</th>
<th>Sustainable Sites</th>
<th>Possible Points</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
<td>SS-02</td>
<td>Integrated Solid Waste Management Plan</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-03</td>
<td>Construction Waste Management</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-04</td>
<td>Municipal Solid Waste Management</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-05</td>
<td>Organic Waste Management</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-06</td>
<td>Design for People with Special Educational Needs</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-07</td>
<td>Protect and/or Restore Existing Trees</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-08</td>
<td>Outdoor playground design</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-09</td>
<td>School Building Orientation</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-10</td>
<td>Safety and security</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-11</td>
<td>Sustainability Expert</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-12</td>
<td>Education &amp; Awareness Program</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-13</td>
<td>Preventive and Corrective Maintenance</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Credit</td>
<td>SS-14</td>
<td>Innovation and Creativity in Habitat</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

| TOTAL | 37 | 31 |
SS-01 Prerequisite: Integrated Solid Waste Management Plan

As illustrated in Figure (109) the plan should include a descriptive framework of how each of the three sustainable waste management credits are addressed by the five core components.

![Diagram showing integrated solid waste management plan framework]

The waste management objectives are as indicated below:

1. Reduce the overall waste generation
2. Reduce the greenhouse gas emissions associated with excessive waste generation
3. Increase the proportion of recycled waste
4. Increase awareness on sustainable waste disposal practices
5. Increase public participation in solid waste management
6. Rethink the community’s perception of waste as garbage, and treat discarded materials as valuable resources
SS-03 Credit: Municipal Solid Waste Management

The recycling initiative can be promoted within school grounds through the use of visually appealing separation bins in order to encourage the student's active involvement in the waste management process. As shown in Figure (110), Waste Management Unit A is used to segregate paper, plastic, metal, and glass. Whereas, as shown in Figure (111), Waste Management Unit B is used to segregate organics and non-recyclables. The recycling units will be located within the school yard as indicated in Figure (112) in order to promote the interest and participation of community members of the sustainability projects within the school.
Conduct a school waste audit to explain to students the importance and benefits of recycling, and allow them to recognize the contents of their waste, and monitor their produced volumes of waste as they record and analyze the waste data. In addition, students are encouraged to explore effective waste reduction strategies. The waste audit recording sheet shown in Table (45) is to be shared by students for them to fill out after the waste has been collected in the respective bins and audited, on an ‘average’ school day. The waste audit could be easily integrated into the school curricula in various subjects such as science, arts and math. Several calculations can be derived from the waste audit data, and discussed with children.

Table (45): Solid waste audit recording sheet

<table>
<thead>
<tr>
<th>Waste Material</th>
<th>Paper (kg)</th>
<th>Plastic (kg)</th>
<th>Glass (kg)</th>
<th>Metal (kg)</th>
<th>Non-Recyclables (kg)</th>
<th>Organics (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd Floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th Floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Weight (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Total Weights (kg)</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Calculations

Equation (3) indicates the calculation required to calculate the amount of recyclable waste per day:

\[
\text{Total Kg}_A + \text{Total Kg}_C = \text{Total Kg}_D
\]

Equation (3): Amount of Recyclable Waste per Day

Equation (4) indicates the calculation required to calculate the amount of recycling per student per year:

\[
\text{Total Kg}_D \times \frac{\text{number of school days in a year}}{\text{number of students in the school}}
\]

Equation (4): Amount of Recycling per student per year

Equation (5) indicates the calculation required to calculate the school’s waste diversion rate per day:

\[
\frac{\text{Total Kg}_D}{\text{Total Kg}_D + \text{Total Kg}_B} \times 100\%
\]

Equation (5): School’s Waste Diversion Rate per Day

Credit Criteria

<table>
<thead>
<tr>
<th>Municipal Solid Waste Management</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct solid waste audit</td>
<td>3</td>
</tr>
<tr>
<td>Sort solid wastes into 2 segregation streams; recyclables, and non-recyclables</td>
<td>2</td>
</tr>
</tbody>
</table>
SS-04 Credit: Organic Waste Management

Place a two can bioreactor in the gardening area as indicated in Figure (113). The process for its installation is discussed in the guidelines. The organic waste will be utilized from the organic waste audit conducted in the SS-03 credit, within the Waste Management Unit B. The compost can then be added to the school garden, saving on the cost of fertilizer and other chemicals. The organic waste audit credit has been achieved in the solid waste management credit, since organic waste has been collected as part of the solid waste audit.

![Figure (113): Location of two can bioreactor in the gardening area](image)

<table>
<thead>
<tr>
<th>Credit Criteria</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organic Waste Management</strong></td>
<td></td>
</tr>
<tr>
<td>Conduct organic waste audit and collection</td>
<td>3</td>
</tr>
<tr>
<td>Install equipment for managing the composting process at school</td>
<td>2</td>
</tr>
</tbody>
</table>
SS-07 Credit: Outdoor Playground Design

The existing playground conditions were studied, and visually represented in Figure (114).

Figure (114): Existing playground conditions
The proposed playground design is represented in Figure (115).

1. Exhibition space (indicated in blue)

Remove the partition door and the clutter on the other side of the door, in order to merge both spaces and create an exhibition space that is open to the community. A direct path for public access is allowed from the main school entrance at the North. Student's work would be exhibited on the school boundary wall as shown.

2. Outdoor board game (indicated in pink)

In the SS-12 Credit: Education & Awareness program, educational board games are incorporated in both the hygiene and water conservation education program. Life-size board
games are an inexpensive approach to enliven the school playground and cultivate an educational outdoor setting. As illustrated in Figure (116), the slide down characters (snakes/hoses/germs) - depending on the educational theme of the game, dice, and the ladders can be drawn and cut by students as an educational task in the respective subject area. The educational prompts should be printed and placed inside a plastic case with a transparent top cover, this ensures the game’s flexibility, as they can be easily replaced each game, and stored for later use. The number of squares can be adjusted as per game requirements; a game of 50 squares would require 25 cases, educational prompts as needed, one dice, ladders and slide down characters.

Figure (116): Life-size snakes and ladders game (CSW, n.d.)

3. Outdoor seating (indicated in orange)

The playground lacks seating areas, other than a couple of benches. As shown in Table (12) in the guidelines, it is important for children within the age group 6-12 years to have seating areas in order to allow social interaction of students, which is essential for their development. Playground furniture should be designed to be flexible, sustainable and multipurpose. Construct playground furniture using recycled materials with the help of students, as shown in SS-13 Credit in the Guidelines. In addition, modular cubes like the ones placed in the library can be placed in the playground, which can be easily formed into a tiered seating area, as illustrated in Figure (117).

Figure (117): Tiered seating area
1. Recycled materials play area (indicated in purple)

As shown in Table (20) in the Guidelines, the age group 6-12 years old requires playground equipment which would aid the development of students’ motor skills. Such equipment should reinforce agility, balance and coordination challenges. Figure (118) is an indicative illustration of a low-cost playground area which would address those challenges. In addition, since the play activities in this age group should shift towards “cooperative” play, examples of such games appropriate to primary school students would include the following (PCSP, 2007):

- Touch the ball
- Rocket launch
- Pattern ball
- Hoop circle
- Frogs and lily pads
- Ball relay
- Suspension bridge
- Co-operative sitting circle
- The blindfold trust walk
- Co-operative great big jump

![Figure (118): Low-Cost Playground Area (Lurkoi, n.d.)](image)

Credit Criteria

<table>
<thead>
<tr>
<th>Outdoor Playground Design</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicate the criteria for the selection of playground equipment</td>
<td>2</td>
</tr>
<tr>
<td>Provide a curriculum planning framework indicating the possible connections between students’ outdoor play experiences and the formal curriculum in various subject areas</td>
<td>3</td>
</tr>
</tbody>
</table>
### SS-09 Credit: Safety and Security

Table (46) illustrates a descriptive analysis of building and site security issues which need to be addressed.

**Table (46): Descriptive analysis of building and site security issue**

<table>
<thead>
<tr>
<th>1. Building security</th>
<th>Room furniture</th>
<th>Tables and chairs have sharp edges and rough surfaces. In addition, some furniture has missing backrests and seats, exposed nails, and splinters which are extremely dangerous to the children’s health, and significantly impacts their indoor comfort levels.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room furniture</td>
<td></td>
<td><img src="image1.jpg" alt="Table and chairs" /> <img src="image2.jpg" alt="Table and chairs" /></td>
</tr>
<tr>
<td>Structural materials</td>
<td>Railing height/ spacing at staircase:</td>
<td>Existing height = 98cm. Required height = 110cm Total quantity: 12 staircases The difference of 12cm can be addressed by raising the metal railing. In addition, the vertical components in the metal railing must not be more than 125mm apart.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><img src="image3.jpg" alt="Staircase" /></td>
</tr>
</tbody>
</table>
### Handrail height/ spacing:

Existing height = 80cm. Required height = min. 110cm  
Total quantity: 12 staircases

### Windows

Around 10m² of hollow polycarbonate material are required to account for the broken glass panes. Place metal steel bars (for forge) on all windows for internal and external security

### 2. Site security

**School Fence**  
Remove the barb wire off the fence. It gives a sense of prison-like protection, which is not the image the school facility wants to send through to the community. In addition, it poses a serious danger to the children in the yard by being wrapped around the trees. Replace with a chain-link fence which could be decorated in a sustainable approach, and counts towards the “School-Community Collaboration” sub-category in the SS-12 Credit: Education & Awareness Program, or in the SS-13 Credit: Innovation and Creativity in Habitat.  
The indicated secondary access gate to the school is not operable, it needs to be fixed or replaced in order to be accessible in times of emergency.
Fire safety

The fire extinguisher is missing from fire cabinet, and there is no water supply in the fire supply pipe.

Credit Criteria

<table>
<thead>
<tr>
<th>Safety and security</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide descriptive safety plan</td>
<td>1</td>
</tr>
<tr>
<td>Provide regular audit reports of school safety inspections</td>
<td>1</td>
</tr>
</tbody>
</table>
SS-10 Credit: Sustainability Expert

Hire sustainability expert

<table>
<thead>
<tr>
<th>Credit Criteria</th>
<th>Sustainability expert</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hire a sustainability expert who provides and leads the school’s sustainability plan</td>
<td>3</td>
</tr>
</tbody>
</table>
SS-11 Credit: Education & Awareness Program

Implement education and awareness programs in the areas of: energy conservation, water conservation, waste management, hygiene education, vandalism prevention, and school-community collaboration, as indicated in the Guideline. These programs were chosen based on the available literature and the data collected in site visits which called upon education as an instrument for behavioral change and awareness. The improper waste disposal shown in Figures (119) to (122) pose a serious to the school occupants. In addition, there are no rubbish bins in the school. Accordingly, littering is in classrooms, school yard, even the teacher’s closets are used for garbage disposal. The solid waste management units should address the improper dumping of garbage and encourage students to keep their school clean.
The school toilet facilities are dirty, smelly, poorly maintained and unhygienic, as indicated in Figures (123) to (126), which is a major health hazard. A few of the problems include: missing sanitary fixtures, blocked toilet, human feces on the ground, stained urinals, and wash basins are absent in the student's toilet in the ground floor as indicated. The toilet's need a renovation plan which includes maintenance and/or replacement of electrical fixtures, plumbing work, doors, windows, and wall finishes.

Install sustainable education monitor at close proximity to the main entrance of the school building. The purpose of the sustainable education monitor is to raise awareness about sustainable building measures and demonstrate the sustainable practices in the school where the teachers’ and students’ effort would be showcased. This increases the education and awareness of sustainability throughout the community, as staff, students and the wider community are motivated to translate the transmitted education into actual sustainable practices which have a significant impact on both present and future generations to come.
Appoint a sustainability team, as illustrated in Figure (127), comprised of a group of students and teachers to take responsibility of the sustainable initiatives within the school. The role of the sustainability team includes communicating the water and wastewater management, solid waste management, and energy management plans to teachers, students and staff; since if the school community are aware of the sustainability plans and the reason why they are being implemented, then the chances of their success are much higher.

![Sustainability Team Diagram](image)

Figure (127): Sustainability team

The role of the WWM team includes:

1. Displaying the progress of the plans clearly within the school.
2. Conducting a water efficiency audit. In which they identify the location and condition of every visible water connection, this includes: taps, plumbing pipes, wash basins, and appliances. The three water consuming sources in the school are the toilets, landscaping, and some educational spaces, such as the laboratory and multipurpose room.
3. Preparing a plan to determine and implement the corresponding water efficiency measures, and rank and prioritize them to ensure that the most cost-efficient initiatives are the first to be addressed.
4. Checking water meter readings to see if implemented changes are reducing the amount of water consumption within the school facility.

The role of the SWM team includes:

1. Displaying the progress of the plans clearly within the school.
2. Taking the lead on the waste management audit described in Credit SS-03.
3. Promoting the waste management initiatives within the school grounds, including utilizing recycled waste to enhance the aesthetic appearance of the school, described in Credit SS-13 and “School-Community Collaboration” sub-category in the SS-12 Credit.
4. Monitoring the waste generated utilizing the allocated waste management units in Credit SS-03, to see if implemented changes are reducing the amount of waste generation within the school facility.

The role of the EM team includes:
1. Displaying the progress of the plans clearly within the school.
2. Promoting energy awareness and encourage energy efficient behaviors among all staff and students.
3. Taking the lead on the energy audit described in Credit E-04.

Credit Criteria

<table>
<thead>
<tr>
<th>Education &amp; Awareness Program</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Conservation Education Program</td>
<td>1</td>
</tr>
<tr>
<td>Water Conservation Education Program</td>
<td>1</td>
</tr>
<tr>
<td>Waste Management Education Program</td>
<td>1</td>
</tr>
<tr>
<td>Hygiene Education</td>
<td>1</td>
</tr>
<tr>
<td>Vandalism Prevention</td>
<td>1</td>
</tr>
<tr>
<td>School-Community Collaboration</td>
<td>1</td>
</tr>
</tbody>
</table>
SS-12 Credit: Preventive and Corrective Maintenance

Implement a preventive and corrective maintenance plan which includes the following items:

1. Site inspection:
   - Fence
   - Grounds
   - Pavement
   - Drainage system
   - Drinking water fountain

2. Building exterior:
   - Entrances
   - Landscaping
   - Roof
   - Playground equipment
   - Staircases
   - Hallways

3. Building interior:
   - Educational spaces
   - Restrooms

4. Building systems:
   - Structural
   - Electrical
   - Mechanical
   - Plumbing
   - Fire safety

Credit Criteria

<table>
<thead>
<tr>
<th>Preventive and Corrective Maintenance</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement preventive and corrective maintenance plan</td>
<td>5</td>
</tr>
</tbody>
</table>
SS-13 Credit: Innovation and Creativity in Habitat

1. Visibility of sustainability measures
The exposure of sustainable design features and their use as hands-on learning tools with integrated design systems allows students to perceive their personal impact on a variety of sustainability features. These are addressed in the following credits E-03 Credit: On-site Renewable Energy; W-05 Credit: Treatment and Reuse of Greywater; SS-04 Credit: Organic Waste Management. In addition, place one vermi-compost stacked bin composter in the gardening area; the process for its’ installation as discussed in the Guidelines, page 116.

2. Demonstrate an innovative approach to utilize discarded waste
The aesthetic enhancement of the school facility using recycled waste materials as discussed in the Guidelines, “Figure (57): Mural using plastic bottle caps” can be used to decorate the school hallways and inner school walls. This approach serves different objectives: educating students about the benefits of recycling, instilling a sense of ownership in students as they are actively engaged in enhancing the aesthetic appearance of their school buildings, fostering a more inviting learning environment, changing student’s perception of “waste”, and encourage students to make more informed and responsible decisions towards waste management. As illustrated in “Figure (56) and Figure (58), recycled materials can be used to decorate trees and create bottle cap sculptures, in the locations indicated in Figure (128) below.

![Figure (128): Locations where recycled materials can be used for the aesthetic enhancement of the school yard](image)

<table>
<thead>
<tr>
<th>Credit Criteria</th>
<th>Innovation and Creativity in Habitat</th>
<th>Existing Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate an innovative approach to expose sustainability measures</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Demonstrate an innovative approach to utilize discarded waste</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>
Chapter 5: Conclusions and Recommendations

5.1. Conclusion

Existing building assessment methods provide a valuable method in conveying sustainability principles to building design. However, they do not account for the environmental, and in particular both social and economic conditions within the building’s direct context in the required way, which would contribute towards the sustainable development of the country. In addition they do not integrate other imperative parameters necessary for the effective learning and development of students. Sustainable schools should be considered as educational built environments in which the school building design and operations should be an expression of the ongoing search for solutions to the rising number of local and global challenges. Sustainable built environments for education are not only a prerequisite for sustainable development, but also shape the formation of citizens and society more broadly. Thus, the design of educational spaces plays an important role in the formation of a sustainable culture.

The proposed guideline is divided into two main sections; new and existing schools. The guideline is further divided into three main sustainability categories: energy, water, and habitat; which is following the same category division adopted by EGGBC in the Tarsheed guidelines. The Habitat category is divided into three sub-categories, indoor environmental quality, materials and sustainable sites. The total possible points in the Energy category for new and existing schools is 30 and 26 points respectively; the possible points in the Water category for new and existing schools is 18 for each; the possible points in the Indoor Environmental Quality sub-category for new and existing schools is 12 for each, whereas the possible points in the Materials sub-category for new and existing schools is 6 for each, and the possible points in Sustainable Sites sub-category for new and existing schools is 34 and 37 respectively.

The criteria governing the proposed guidelines are affordability, simplicity, and flexibility. The rating system for the proposed guidelines are comprised of four levels: Bronze (40-49 points); Silver (50-59 points); Gold (60-69 points); Platinum (70+ points). The directing parameters of the guideline are based on sustainable building assessment guidelines, Egypt’s pressing social, economic and environmental concerns, pedagogy of educational environments, students’ social, psychological, and developmental needs, in order to develop a holistic framework. Education and awareness program and innovation and creativity credits are given the largest weights given their pivotal role in an educational environment. Similarly, the pivotal role of community collaboration in sustainable development is stressed upon by its allocation of numerous points across various credits; in order to broaden both the sustainable and scientific horizon of the community as a whole. Innovation and creativity credits are present within each of the three categories since creative solutions and notions are key components in our present knowledge-driven economy.

The procedures of the research use a case study approach that focuses on one public school in Cairo, Gamal Abd El-Nasser which is located in Boulaq El Dakrour (BD), one
of the poorest informal areas located in the western urban area of Greater Cairo within the boundaries of Giza Governorate. Criteria for selecting the school as a case study included choosing a preparatory school where the overall school infrastructure and conditions were of medium quality standards, making the school a potential candidate for upgrading its school infrastructure and processes to become a sustainable school in the future. The developed guideline is implemented in the case study school to demonstrate the flexibility, affordability and simplicity of attaining the required credits within the guidelines. The school scores a total of 9 out of 26 points in the Energy category, 7 out of 18 points in the Water category, 3 out of 12 points in the Indoor Environmental Quality sub-category, 6 out of 6 points in the Materials sub-category, and 31 out of 37 points in Sustainable Sites sub-category. This provides a sum of 56 out of 100 points, which awards the school a silver rating.

5.2. Limitations

The major limitation of the study was that no impact evaluation was conducted to measure the effectiveness of the proposed changes. Impact measurements include student's educational performance, student’s and teacher’s satisfaction survey, water and energy metering, level of sustainability literacy within school occupants and surrounding community. Similarly, specific measurements of educational spaces were not added to the documenting procedure to be able to assess the degree of impact. These include present energy and water costs; and acoustics, ventilation, thermal comfort, and lighting conditions within the educational spaces.

Additionally, the social, economic and environmental impact assessment were considered in a preliminary context, and not implemented to drive the decision-taking process with a high degree of scientific and technical certainty. The social analysis would determine the degree of success in the incorporation of school-community collaboration to measure the project’s social impact on the community, schools and teachers. Whereas the economic assessment would identify the financial feasibility of proposed concepts and seek alternative solutions where necessary. Moreover, the environmental impact assessment would provide projections of the environmental effects of proposed concepts, in order to reevaluate decisions.

5.3. Recommendations

Suitable recommendations are categorized for different stakeholders who play significant roles in enhancing the sustainability of educational environments, as follows:

5.3.1. Recommendations for Ministry Officials

1. It is essential for ministry officials to design schools which address the educational and teaching needs of students and teachers, rather than continue implementing the same building prototypes regardless of the current functional needs of the educational environment.
2. It is necessary to understand the importance of character and moral education for staff and students, in order to incorporate them in the curriculum and staff training. This would mold the character of students into being successful, honorable members of the society.

5.3.2. Recommendations for Design Consultants

1. It is necessary to recognize the importance of participatory approaches to improve the quality of the educational environments. Responsible stakeholders include the architects, teachers, students, and community members.
2. The credit attainment process should be specifically tailored for the specific requirements of the school, since each school is governed by a different set of needs and requirements. Therefore, the collected data and measurements are critical determinants in deciding the correct means of credit fulfillment.

5.3.3. Recommendations for Policy Makers & the Media

1. The media has a significant influence in promoting sustainability measures and foster the public's general awareness of sustainability. Displaying the sustainable efforts of contributing schools would encourage other educational facilities to implement the proposed sustainability guidelines, which would assist the mobilization of the community towards sustainable development.
2. It is important for policy makers to understand the importance of sustainable development, and the significant role educational facilities play in educating students and instilling the required sustainable behaviors within them as they act as vehicles of change within their families and community.

5.4. Directions for Further Research

1. The guideline subsists as a first step towards a nationwide system which starts with a public school in an informal settlement in Cairo. However, it despite its flexibility, it is not designed as a one-size-fits-all. It is important to use this guideline as a base to perform comparative studies with different types of schools, such as private schools, and schools in rural and remote areas.
2. More interest should be given to creating such guidelines which are based on the three basic criteria of: simplicity, affordability and flexibility. New guidelines should address different kinds of educational facilities such as universities and kindergartens.
3. The guidelines should incorporate the expertise of different stakeholders to create a holistic framework which encompasses research from different disciplines, such as child psychology, sociology, and sustainability and pedagogical experts.
4. The sustainability factor of the project should be considered in order to assess the sustainability of the proposed design considerations throughout the project’s life-cycle.
Bibliography


Burns, H., & Miller, W. (2012). The Learning Gardens Laboratory: Teaching sustainability and developing sustainable food systems through unique


Heller, M. C., & White, M. A. (1975). Rates of teacher verbal approval and disapproval to higher and lower ability classes. Journal of Educational Psychology, 67, 796-800.


Student Dorm Rooms: Physical and Simulated Daylighting Parameters' Values Compared to Subjective Survey Results. Energy Build, 77, 158-170.


Paghasian, M. C. (2017). Awareness and Practices on Solid Waste Management among College Students in Mindanao State University Maigo School of Arts


A. Technical Data Sheets

1. Elastomeric liquid membranes produced by Bitumat Egypt.

RUBBER COAT
ELASTOMERIC LIQUID MEMBRANE

RUBBER COAT is an elastomeric liquid membrane that is water-based and environmentally safe. It is a tough yet extremely flexible material that can be efficiently applied to any thickness by roller or squeegee creating a fully-adhered, monolithic waterproofing membrane with no waste. Since it is water-based with no VOC’s it is considered a “green” product that is sustainable for years as a waterproofing system.

PRODUCT VERSATILITY AND USES

RUBBER COAT is typically used as a waterproofing membrane for WET AREAS & BELOW GROUND STRUCTURES. But it is also used for general waterproofing of Existing & New Roof, foundations, plaza decks, Bridge Decks, interior and exterior walls, walking decks, steel or wood beams, and a wide range of specialty waterproofing applications. RUBBER COAT is a waterproofing solution for the entire building envelope and beyond. RUBBER COAT can also be used as a waterproofing solution over spray applied polyurethane foam under roof screed laid in slabs.

INSTALLATION

Surface preparation is generally limited to compressed air cleaning for RUBBER COAT to bond to. RUBBER COAT can be easily applied with brush / roller or rubber squeegee. Although RUBBER COAT is UV stable and weather resistant, RUBBER COAT is lightweight so it can be applied directly over an existing roof system, eliminating the need for wasteful and costly tear-off.

SURFACE PREPARATION

All old surfaces must be pressure washed or clean with compressed air, then allowed to dry, free of loose materials, oils, form release agents and other contaminants. Any damaged areas of existing substrate or old roofing membrane should be properly patched or sealed with appropriate repair materials that will bond to the existing substrate and will accept RUBBER COAT to bond well to it. Priming is recommended on some substrates prior to application of RUBBER COAT. Tritoprime is used for asphaltic based substrates as well as for concrete to create a superior bond with the RUBBER COAT membrane.

APPLICATION

RUBBER COAT can be applied at a rate of 1.5ltr/ sqm or approximately 13sqm per 20ltr pail to achieve a dry film thickness of 1mm. Coverage may vary depending on the profile and texture of the substrate it is being applied and in general application conditions.

DETAILING

If required, use RUBBER COAT as a flashing and patching component to complete the RUBBER COAT membrane system. RUBBER COAT is used to quickly repair any and all anomalies in the cured RUBBER COAT membrane that may exist after careful examination. RUBBER COAT is reinforced with micro-fibers for excellent tensile strength when used at the higher stress points on a roof such as curb corners, pipe or conduit penetrations, 90 degree spray angles, etc. RUBBER COAT is also excellent for sealing ducting seams, metal flashing seams, and many other roofs related waterproofing problem areas. Curing time is dependent on weather and temperature conditions as RUBBER COAT is a water-based product that requires drying time. Typical full cure time of the membrane is 12 hours with good conditions.
**PACKING**

20 ltr Pail.

**WARNINGS AND HAZARDS**

Although minimal odor and mist exists while spraying, wear a respirator in areas of limited ventilation. Otherwise a basic nose mask and goggles are recommended while spraying. Avoid eye contact with the products. Refer to MSDS for specific warning and product information.

**STORAGE**

Store material in shaded / covered area.

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**TECHNICAL SPECIFICATION**

<table>
<thead>
<tr>
<th>Physical Properties (Liquid Form)</th>
<th>Typical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Brown to black</td>
</tr>
<tr>
<td>Volatile Organic Compounds</td>
<td>Contains no solvents (no VOC’s)</td>
</tr>
<tr>
<td>Shelf life</td>
<td>1 year</td>
</tr>
<tr>
<td>Packaging</td>
<td>20 ltr Pail</td>
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<tr>
<td>Properties (Tested on 1.5mm Cured film)</td>
<td>Test Method</td>
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<tr>
<td>Solid Content</td>
<td>ASTM D 1644</td>
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<tr>
<td>Tensile Strength of the cured film</td>
<td>ASTM D 412</td>
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<tr>
<td>Water permeability</td>
<td>BS EN 12390 part 8</td>
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<tr>
<td>Water vapour transmission</td>
<td>ASTM E96</td>
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<tr>
<td>Puncture Resistance</td>
<td>ASTM E154</td>
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<td>Elongation</td>
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<tr>
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<tr>
<td>Tear Resistance</td>
<td>ASTM D1004</td>
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<tr>
<td>Peel adhesion to concrete</td>
<td>ASTM D4541</td>
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<tr>
<td>Chemical Resistance [pH 2.0-11.5]</td>
<td>ASTM D543</td>
</tr>
</tbody>
</table>
3. Modified Bituminous membrane with waterproofing and thermal insulating properties produced by InsuTech

**INSUSOL (PES)**

INSUSOL (PES) is a plastomeric Modified Bitumen Membrane used for various waterproofing applications. It is manufactured in a high-tech calendaring process, which involves the saturation and coating of a polyester carrier with an APP polymer-modified bitumen compound. The polymer additives are used to improve the thermal, chemical and ageing properties of the bitumen compound. Meanwhile, the mechanical characteristics such as tensile strength, elongation and tear resistance are boosted by the non-woven polyester carrier, which acts as a reinforcement to the product.

**SURFACE FINISH**

The lower surface of the membrane is laminated with a thin thermo-fusible polyethylene turn-off film. The membrane is available with a wide range of upper surface finish options including different colored slates, aluminium foil, sand and polyethylene film.

**KEY FEATURES**

- Absolute impermeability to water
- High chemical resistance to alkaline solutions, light acidic solutions and bacteria
- Thermal resistance under a wide range of temperature fluctuation
- Excellent U.V. resistance where surface is finished with slates
- Ease of adhesion to a wide variety of surfaces
- Applicable for above and below grade usages.

**APPLICATION**

INSUSOL (PES) membranes are used for a wide variety of waterproofing requirements and in applications subject to high mechanical stresses, such as:

- Roofing or re-roofing for single or multi-layer systems
- Stepped and flat roofs
- Tunnels, wet areas, swimming pools and toilets
- Foundations and underground structures
- Slab on grade.

**STORAGE**

All Modified Bitumen Membranes should be stored in an upright position in a dry, flat and ventilated storage area away from direct sunlight.

**INSTALLATION**

Please refer to the InsuTech Applicator Guide for complete instructions on the application of the product.
B. School Plans

1. Site Plan
2. Ground Floor Plan
3. First Floor Plan
4. Second Floor Plan
5. Third Floor Plan
6. Fourth Floor Plan