

UTILIZE SUSTAINABLE BUILDING DESIGN VIA APPLYING LEED® V4 PROPOSED FRAMEWORK FOR UNDERGRADUATE ARCHITECTURE STUDENTS

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ABSTRACT

This paper aims to develop a simplified framework for sustainable buildings to be utilizing a focused training for architecture students on the broad concepts of sustainability and sustainable buildings, through the use of one of the most widely used sustainable building assessment systems, (LEED®) Leadership in Energy and Environmental. The proposed framework is designed to utilize the aforementioned certificate and apply it via filtering the main Credits in LEED® V4 scorecard and checklists, then selecting the appropriate items for undergraduate education. In addition to the above, the integrative processes of the credits are filtered and simplified. This is followed by a classification and prioritization process for the credits to integrate with the educational process, the current study is oriented to sophomore, junior and senior students; those enrolled in architectural design (II, III, IV, V and VI), graduation project, and interior design. LEED® for BD+C (Building design and construction) certificate developed for architectural design courses, the results of the current study indicate that LEED® credits appropriate to apply to undergraduate students. Eventually, the results of the study presented solutions and treatments to be applied in the design studio to enhance the use of building sustainability by providing a simplified LEED® framework.

KEYWORDS : *Sustainable building; LEED V4; sustainability; sustainable developm*

1- INTRODUCTION

Sustainable building concept has emerged because it has positive implications on life and human beings. The application of sustainable development in urban societies and urbanization leads to the preservation of natural resources. Harmoniously, the concepts and principles of sustainability should be applied to their energy saving, Human life is affected by the built environment; moreover, the negative or positive environmental influences affect the life of human being in a significant and considerable extent. The proportion of the population living in cities is expected to increase from 70 percent in 2050 (Anthopoulos, L 2015)[1]. Consequently, the sustainable building should have tremendous momentum. Respectively, the buildings and represent 31% of global final energy demand [2](Felgueiras, et al. 2017). The construction sector provides the highest potential for significant reductions in **energy** and carbon dioxide emissions, at least in developing countries. It is worth mentioning that the residential sector, which accounts for 27% of global energy [3], correspondingly, plays major role in reducing climate change [4]. The growth in population and the time spent indoors confirms that the increasing in energy consumption will rise [5]. Reducing energy consumption in general and fossil fuels in particular is a globally

recognized priority, in order to response to the need for a sustainable economy. Because of the dependency on fossil resources the efficient use of energy is vital; the fossil resources are being exhausted, resulting in carbon dioxide emissions [6].

2- STUDY METHODOLOGY

Sustainable development has become an urgent necessity. In light of the lack of resources resulting from the depletion of non-renewable sources of energy, countries should consume their resources in a rational behavior in order to achieve energy efficiency for future generations, and the status quo as well. The current study aims to develop a conceptual framework for sustainable design for use at the level of undergraduate education in the Department of Architecture, to be utilized by students in various courses correlated to architectural design studio. The proposed framework aims to train students in the design process. Sustainable development and design of sustainable buildings that promote the optimal use of energy and develop energy resources in the community, this paper is designed in the following methodology: First, through an analytical study of the basic elements of sustainable development in general and the sustainability of buildings in particular, second: Conclusion of basic elements in sustainable design and development to suit university education. he above

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has been accomplished through an analysis of the LEED certificate in the New design and Construction. LEED v.4 utilized in the study, the study simplifies the basic elements of sustainability and LEED, furthermore, selection of elements appropriate for the level of pre-graduate education; Third: design the proposed framework. Fourth: apply the framework via case study at the Department of Architecture Canadian International College-Egypt (CIC). Fifth: the results were validated by distributing a questionnaire to 22 professors in different universities and colleges to verify the success of the study's results.

3- BACKGROUND

3-1- SUSTAINABILITY

Sustainability means a lot to human society and it has many concepts, many scientists believe that sustainability is the organizational principle of preserving existing but limited resources to deliver resource desired for future generations [7]. In addition to the above, sustainability has been widely recognized as a multidisciplinary domain that requires close interdisciplinary cooperation with various disciplines [8]. In the period the (1960s) that stimulated public concern about the degradation of nature, environmental movement recognized only very conflicting interests: in one hand terms of ecological integrity and, on the other hand, economic development. In the ensuing international discourse, the social dimension was added [9].

3-2- SUSTAINABLE BUILDING RATING SYSTEMS

Types of Systems for sustainability assessment:

Systems for sustainability assessment divided into, sustainability assessment systems for buildings, sustainability assessment systems, neighborhoods sustainability assessment systems for urban communities, sustainability assessment systems for cities [10]. Which criteria of assessment methods were assigned into the pillar of sustainability (social, environmental, and economic) was analyzed.

3-3- LEED® OVERVIEW:

Many organizations have responded to the rapid growth of a sustainable, green building. Widely, in the United States and all over the worlds the Leadership in Energy and Environmental Design (LEED®) system is the most used method for assessing the environmental performance of a building [11]. It is available for almost all types of construction projects, communities and homes project types, besides, LEED provides a framework for the construction of healthy, efficient and cost-effective green buildings. LEED certification is a globally recognized symbol of achieving sus-

tainability [12]. LEED program was produced to promote integration, raise awareness, stimulate green competition, save the environment and institutionalize green buildings [13]. LEED works for all buildings in all stages of development, from new construction to existing buildings, as well as all building construction sectors, from homes [14] to shopping malls to hotels and hospitality building, hospitals to company headquarters [15].

LEED Certification Overview:

More than one phase passed by LEED, progressed to reach the current stage - the 4th issue - released in 2013, the first edition began in 1998, then the second issue in 2000 developed, followed by the third issue in 2007, the 2009 issue was released in the same year. Finally, the fourth version, released in 2013 [16], controlled by buildings established after this number.

LEED Certification Level:

Projects that pass LEED certification earn points via several categories. According to the number of points fulfilled, the project is then awarded one of four LEED rating levels: certified, silver, gold or platinum. Certificate: 40-49 points, Silver: 50-59 points, Gold: 60-79 points, Platinum: 80 points and above [17].

4- THE PROPOSED FRAMEWORK

After reviewing the literature on sustainability in general and environmental assessment systems, in particular, the requirements of the LEED certificate will be applied to the courses in the undergraduate education phase, to achieve and communicate the concepts of sustainability and its various dimensions to the students through the courses. The LEED certificate scorecard was used for architectural and interior design courses, then, simplify and filtering the elements suitable for students' design projects.

LIMITATIONS OF THE PROPOSED FRAMEWORK

First, the proposed framework is applied from architectural design II, because of architectural design I is a preliminary level, where only simple concepts of sustainability are explained as a result of the analysis of sustainability concepts and their main pillars in applying environmental considerations to the design of the nominated residential building.

Second: The proposed framework is applied to architectural design courses and interior design course, and out of the scope of the study, urban planning courses that need to be studied in the future study.

Third: The 4th version of LEED, the latest version, which is released in 2013 utilized in the current study. The study select LEED certificate because

it's the most used rating systems internationally.

The design of the proposed framework depends on the following steps:

First step:

Selecting the certificates and L EED programs for the project in accordance with the architectural design projects.

Step 2:

An accurate study of the educational courses in the program provided by the college in which the framework is applied, in terms of number and integration with the theoretical courses. The courses that fit the LEED certificates for the new building & construction, in addition to, the interior design and construction (Arch. design courses including graduation project and interior design project), the contents of the courses, the educa-

tional objectives and the required outputs were analyzed.

Step 3: Take into consideration the educational outcomes required in the internal bylaw of the Department of Architecture, which have been commenced since 2012.

Step 4: Quality requirements are also taken into consideration to reach an integrated framework for implementation in architectural design courses. As for the case study in this research, the quality standards adopted by the Department of Architecture are Academic Reference Standards Adopted (NARS). Table (1) shows the steps of applying the proposed framework, followed by applying the proposed framework to the case study of one of the faculties of architecture.

Table 1- the steps of applying the proposed framework. Source, Author

LEED v4	1- Leed certificate type	2- Courses	3- Integrative Process						4- Bylaw	5- quality	
BD+C	LEED for New Construction	Architectural Design courses. Graduation Project	Location and Transportation	Sustainable Sites	Water efficiency	Energy and atmosphere	Materials and Resource	Indoor Environmental Quality	Innovation	Learning outcomes	Intended learning outcomes. National Academic Reference Standards (NARS).
	LEED for Core & Shell										
	LEED for Schools										
	LEED for Hospitality										
	LEED for Health care										
ID+C	LEED for Commercial	Interior design Interior design									
	LEED for Retail										

5-VALIDATION OF PROPOSED FRAMEWORK

A questionnaire was designed to ascertain the findings of the study in the application of sustainable design of buildings at the undergraduate level. The survey was filled by 22 academic architects, the first part of the questionnaire is: Taking the applicant's opinion on the issue of the proposed framework and the findings. This part is answered with yes or no. The second part is answered when answering the first part is yes, consequently, is answered by selecting from non-linear qualitative rating scale. Generally, when the applicant answer part (1) with yes part (2) asking them about his opinion about the impact of the application this issue on developing sustainable building in 5 scales as the following:

Very high, High, Medium. Low. Very Low.

The question and answer results hereafter:

A. Is the application of sustainability principles at undergraduate level in architectural design courses useful for promoting the utilization of sustainable buildings in the community? Yes No

AA. What is the degree of impact of the above that you see in applying the sustainable design of buildings?

- Very high. High. Medium. Low.
- Very low.

The results of the first question were as follows:

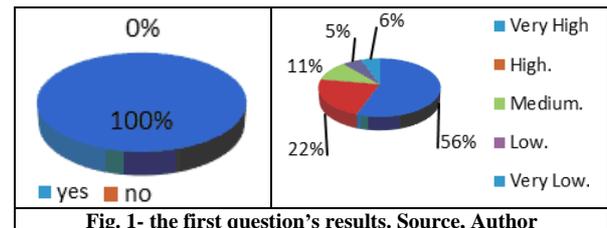


Fig. 1- the first question's results. Source, Author

B. Is setting a framework for the utilization of sustainable buildings better attention to the sustainability? Yes No

BB. What is the degree of impact of the above that you see in applying the sustainable design of buildings?

- Very high. High. Medium. Low.
- Very low.

As for the second question, the results were illustrated as follows

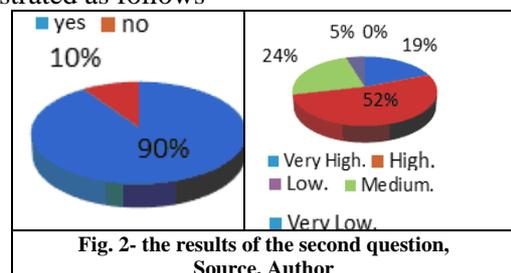


Fig. 2- the results of the second question, Source, Author

C. Is taking into account the learning outcomes in the bylaw within the above framework beneficial

issue for you? Yes No

CC. What is the degree of impact of the above that you see in applying the sustainable design of buildings?

- Very high. High. Medium. Low.
- Very low.

The third question's results were as follows:

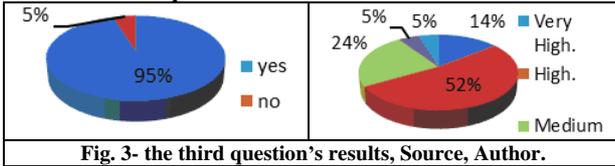


Fig. 3- the third question's results, Source, Author.

D. Do you think the consideration of the intended learning outcomes within the above framework will help you train students on sustainability?

- Yes No

DD. What is the degree of impact of the above that you see in applying the sustainable design of buildings?

- Very high. High. Medium. Low.
- Very low.

The results of the fourth question are as follows:

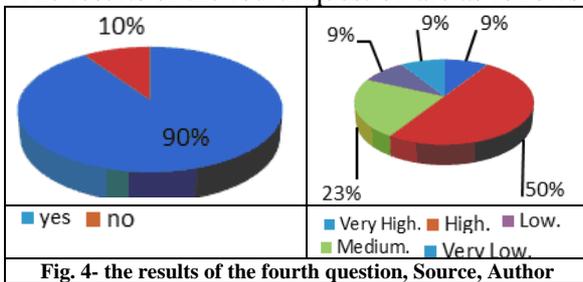


Fig. 4- the results of the fourth question, Source, Author

E. Is it useful to summarize the LEED certificate in simple form for students in architectural design courses? Yes No

EE. What is the degree of impact of the above that you see in applying the sustainable design of buildings?

- Very high. High. Medium. Low.
- Very low.

The results of the fifth question are explained below:

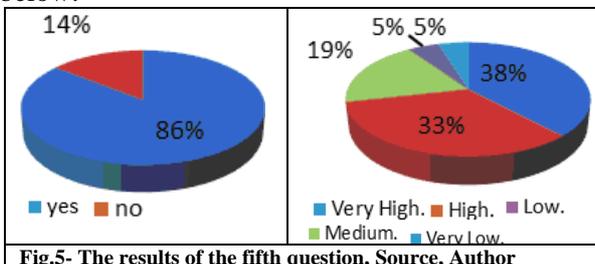


Fig.5- The results of the fifth question, Source, Author

Clearly, the results of the validation questionnaire illustrating the importance of the current paper as in question A, B and E, obviously, all opinions supported the development of student courses to suit the sustainability of the students and the architectural community. Correspondingly,

86% agreed with the idea of developing a framework for students to implement the LEED certificate. In addition, 90% agreed with the importance of taking into account the intended learning outcomes. As for the implementation of the content of the bylaw with the proposed framework, 95% agreed with it was an appropriate concept to study, besides, the applicants are concerned about the impact of the implementation of the above on the sustainable buildings, moreover, the applicants' answers ranged from high to very high impact, which supports the concept of development of architectural courses to suit the sustainability of buildings is a very positive influence.

6- CASE STUDY

The proposed framework will be applied to a case study conducted on the Canadian International College on 6th of October in Giza Governorate. It follows the Egyptian Society for Advanced Education and Development.

Program Title: Bachelor of Architectural Engineering, Graduation from the Department of Architecture requires at least 165 credit hours. Compulsory: 128 hrs. Elective: 26hrs. The Department of Architecture does not contain a branches, however, the graduation requires study the requirements of the architecture major only. The following figure (8), which includes the courses selected in order to apply the proposed framework [18]. Moreover, table (2) shows the types of projects proposed by the internal bylaw.

Table 2- project types proposed in the internal bylaw. Source, CIC Bylaw

Course Code	Course Name	Project 1	Project 2
ARC 252	Architectural Design II	School building	Shopping mall
ARC 253	Architectural Design III	5 Stars hotel	
ARC 354	Architectural Design IV	Hospital	
ARC 355	Architectural Design V	Cultural center	
ARC 356	Architectural Design VI	Complex building project	
ARC 491	Project 1	Graduation project 1	
ARC 492	Project 2	Graduation project 2	

7- THE RESULTS

The current study resulted in a set of insights to simplify the concepts of LEED certificate, the main elements and sub-elements of the LEED were summarized, in order to apply it to the design courses in accordance with the content of each course. Table (3) contains the types of certificates of LEED and then projects that can be applied to them with the priority of application on projects. Where the symbol (•) expresses the priority value as follows:

Table 3- priorities of the main elements of the new construction and renovation LEED certificate, Source, Author

LEED v4 certificate		Courses	Integrative Process						
			Location and Transportation	Sustainable Sites	Water Efficiency	Energy and Atmosphere	Materials and Resources	Indoor Environmental Quality	Innovation
BD+C	LEED for New Construction	Design V-VI-G. Project	....	....	.	..	....	...	....
	LEED for Core & Shell	Design II	...	....	.	.	..	..	..
	LEED for Schools	Design II	...	....	.	.	..	..	..
	LEED for Hospitality	Design III	...	....	.	.	..	..	..
	LEED for Health care	Design IV	....	....	..	...	..	..	.
	LEED for Retail	Design II	...	....	.	.	..	..	..
ID+C	LEED for Commercial	Interior design	.	.	.	..	...	....	...
	LEED for Retail	Interior design	.	.	.	..	...	....	...
	....	First priority	...	Second priority	..	Third priority	.	Fourth priority	

The aim of design II as in the bylaw: Studying the functional relationship between design elements and their relationship within the site layout. This means that this course focuses on the student's understanding of the context surrounding the project, nonetheless at this level the professor of design studio determines the location of the project and not the student himself, for that reason the second priority was set for location & transportation, while sustainable site was prioritize as the first priority, The rest of the items are less important according to the content of the course objectives. The following is the objectives of design 3: (The student should master the medium project focusing on multi-functions and more complex relationships, circulation issues and the structural concepts) [19]. The third level focuses on medium size projects, which demonstrate the student's need to understand the concepts of sustainability in general. Accordingly, the sustainable sites importance emphasized, furthermore, prioritized as the first priority because of its impact on projects of this size. For the fourth level, the texts of the bylaw as follow:

Solving composite multi-function problems having different circulation patterns with due concern to structural concepts. Constraints of the site and environment are addressed. Exercises include projects in urban settings with due concern to social and economic factors as well as circulation issues [20]. This level focuses on the Constraints of the site and environment, which indicates the importance of the location and transportation elements and sustainable site as a first and second priority, followed by Water Efficiency, as third priority as presented in Table (3). In terms of the fifth level the bylaw specify the follows aims: To train students to design large-scale projects, in the urban context, understand how to take into account the different circulations, pedestrians, cars environ-

mental and cultural limitations should considered. The following is Design VI objectives in bylaw: training the students on the design of complex and multifunctional buildings. The design should use of large span structure and consider socio-environmental issues, Application of new technologies. The graduation project is divided into the stage of data gathering and analysis of the site in the first semester, while, the second semester is the phase of architectural design and design critique, in both phases the bylaw stipulates that: Analysis of collected data of proposed site. Analysis and discussion of similar projects and preparing a technical report concerning the environmental analysis of the site. Based on the technical report prepared by the student for the graduation project, he is supposed to design a graduation project that will benefit from all the skills, experience and architectural courses that he had mastered during the years of architecture study. In design V,6, and the graduation project, which are the design courses for the Junior level, Innovations, materials and resources, was prioritize as first priority, because the bylaw focuses on the selection of modern technological building methods, in addition to, The bylaw correspondingly concerned with the elements of the urban context and the general location of the project, Therefore, the importance of all components of the fourth version of LEED certificate is clear, except water efficiency, which is the least important given the level of university education, and that there are some elements that are difficult to actualize in the undergraduate level.

In Table (4) the sub-elements of the LEED were filtered into the appropriate elements of the application in undergraduate education, posteriorly, priorities were set to apply in two levels, Sophomore and Junior in one column, and senior level in the second column, the sophomore is the first level, the junior is the second level, the senior is the third

and fourth level, the courses of the sophomore students are design II, the projects types for this level are (commercial center), however, Junior level courses are the design (3-4) The projects

specified for this level are the complex building, while the junior courses are design (5-6-grad. Project, the projects specified for this level (hospital - a cultural center).

Table 4- the priorities and solutions for applying the Proposed LEED v4 for Building design & construction, Source, Author

LEED V4.		Student level		Proposed solution
Credit	Integrative Process	Sophomore +Junior student level (design 2-3-4)	Senior student level (desing5-6+ Grad)	Proposed solution
Location and Transportation				
Credit	Surrounding Density and Diverse Uses	••	••••	1. Adding these elements in the project description
Credit	Access to Quality Transit	••••	•••	
Credit	Bicycle Facilities	•	••	
Credit	Reduced Parking Footprint	••	•••	
Sustainable Sites				
Credit	Site Assessment	••	••••	1. Site selection by students themselves. 2. Enlargement of open spaces in the master plan. 3. The students present an environmental assessment study for the project site
Credit	Open Space	••••	••	
Water Efficiency				
Prereq	Indoor Water Use Reduction	•	••••	1. Calculate the wet areas accurately and design them to the minimum areas of data references. 2. Calculation of external landscape and diminish the areas soft-soaped the require irrigation.
Credit	Outdoor Water Use Reduction	••	•••	
Energy and Atmosphere				
Credit	Renewable Energy Production	••	•••	1. Encourage students to generate the necessary energy for the project from renewable and green energy
Credit	Green Power and Carbon Offsets	••	•••	
Materials and Resources				
Prereq	Storage and Collection of Recyclables	•••	••••	1. The students should present a report on the sustainable materials used in the project. 2. Designing a space for collecting recycled materials in the project
Indoor Environmental Quality				
Prereq	Minimum Indoor Air Quality Performance	•	••	1. The project should include the following in the design guidelines: Natural daylight, Direct views of the outdoor landscape, thermal comfort and environmental treatments, as well as optimal treatment of acoustics. Provide an authentic simulation with environmental software and report and evaluate the project forms alternatives in terms of sustainability.
Prereq	Environmental Tobacco Smoke Control	••	••	
Credit	Indoor Air Quality Assessment	•	••	
Credit	Thermal Comfort	••	••••	
Credit	Interior Lighting	••	•••	
Credit	Daylight	••••	••••	
Credit	Quality Views	••••	••••	
Credit	Acoustic Performance			

The final column in the Table (5) explains solutions and proposals for implementation of LEED

elements in the acquisition and strategies of education in the architectural design studio.

Table 5- the priorities and solutions for applying the Proposed LEED v4 for Building design & construction

LEED V4		student level	Proposed solution
Credit	Integrative Process	Senior student level (desing5-6+Grad.)	Proposed solution
Water Efficiency			
Prereq	Indoor Water Use Reduction	••••	1. Calculate the wet areas accurately and design them to the minimum areas of data references. 2. Calculation of external landscape and diminish the areas soft-soaped the require irrigation
Energy and Atmosphere			
Credit	Renewable Energy Production	••	1. Encourage students to generate the necessary energy for the project from renewable and green energy
Credit	Green Power and Carbon Offsets	•••	
Materials and Resources			
Prereq	Storage and Collection of Recyclables	••••	1. Sample Board, materials and materials schemes was presented and, classified based on their environmental impact and the importance of their use in the projects and evaluation of the proposed alternatives 2. Designing a space for collecting recycled materials in the project
Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	••	
Indoor Environmental Quality			
Prereq	Enhanced Indoor Air Quality Strategies	•••	1. Encourage students to use modern technology in energy-saving lighting, and to use innovative contemporary technologies to entering the natural lighting of non-naturally lighting spaces. 2. Pay the students' attention to the importance of using low-emission finishing materials 3. The interior spaces of the project should be with natural day-light, and enhance The amounts of the views of the landscape, taking into account the thermal comfort and environmental treatments. Appropriately, treat the acoustics based on to the nature of spaces, especially large noise spaces.
Prereq	Low-Emitting Materials	••••	
Credit	Indoor Air Quality Assessment	•••	
Credit	Thermal Comfort	••	
Credit	Interior Lighting	••••	
Credit	Daylight	••••	
Credit	Quality Views	••••	
Credit	Acoustic Performance	••••	
Innovation			
Credit	Innovation		

In addition to the above, a framework for the sub-elements (integrative process) was designed for

interior design projects. It is one course in which two projects are taught, one of which is the interior

design of a residential project and the other a commercial project. The priorities of the subelements to serve the content of the course, besides, the learning outcomes to achieve it, over and above proposals and solutions to accomplish the goals of the certificate of the appropriate for this type of projects, as illustrated in Table (5). (LEED) projects are gaining points in nine key areas that address key aspects of green building: 1 Integrative process. 2 Location and transportation. In the proposed framework for the interior design, appropriate elements of the student level were filtered and selected. The course is designed for interior projects and internal space design for residential and commercial projects. Therefore, the site component and transportation, as well as the sustainability component of the site, have been removed while the indoor environmental quality and materials and resources is extremely important.

8 DISCUSSION & CONCLUSIONS:

In general, it was found that there could be a brief model of the LEED for the university education level, this model simply applied to architectural design projects and courses. Obviously, There is a similarity between these different visions of applying the LEED certificate to architectural design projects, the certificate of buildings design and constructions is used in the junior level students and senior level as well, similarly, there is single insight applied for interior design project. In terms of architectural Design 1 course, the architectural design certificate will not be fully implemented. The current study presented a concept of the priorities of the main and secondary elements so that the LEED credits can be applied based on priorities, or applying some results if the framework cannot be fully applied. The importance of the elements prioritized based on the objectives of each course was assessed in the internal bylaw in the Department of Architecture. Clearly, the most important elements for architectural design course are: sustainable site, Location & transportation, 3. Materials and resources, the prior elements are manageable in student design projects. While the least important and

priority elements are energy and atmosphere, which is uncontrollable in student design projects, the prior analysis of architectural design courses, in contrast, in interior design course the most important element is indoor environmental quality, and less important is location and transportation, because of the concentration on interior spaces. The current study illustrates that the most important elements for students' architectural design projects are: sustainable site, materials and resource and indoor environmental quality and location and transportation.

After completing the literature review to analyze, simplify and summarize the concepts of sustainability in general and the systems of environmental assessment, LEED certificate was applied to the courses of the university education stage to achieve and communicate the concepts of sustainability and its various dimensions to students through courses, This study came out with a set of concepts to simplify the concept of LEED, so that the main elements and the sub-elements can be summarized, so as to apply it for the design courses according to the content of each course. The study proposed credits, and then presented a vision for the application of integrative credits process, with the introduction of solutions to be applied in the courses to achieve a knowledge, background for students and a general consensus on the concepts of sustainable buildings and sustainability in general. The study presented an integrated vision to apply the LEED certificate to the students' projects, because of its importance in modern projects, while not neglecting the required outputs from the administrative bylaws governing the departments of architecture, as well as attention to the quality standards required, and to achieve quality assurance requirements. Various solutions were explained for application in architectural design studio. These solutions are specific to each element of the fourth edition of LEED. These solutions represent a roadmap that guides the professors and tutors of architectural design studio; moreover, they can develop and add to it, based on their requirements.

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