Inclusion of Sustainability Concepts in Architectural Education The Current and Expected Situation in Egypt

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Abstract

Technology is the actual motor for sustainable development. The construction industry is witnessing an unprecedented technological boom in materials, tools, and methods of execution which necessitates good preparation for newly graduated architects to deal with these technologies, be aware of the sustainable development principles and use the most contemporary techniques to apply these principles. This analytical survey research aims at studying the inclusion of sustainable development principles in the credit hours architectural programs in Egyptian universities in the light of the last National Academic Reference Standards (NARS-2018) and its learning outcomes (LOs.). The authors analyzed three Egyptian architectural programs (Cairo, Helwan, and Benha universities) and compared the results with three international programs in (MIT-USA, Bath-UK, and Malaya-Malaysia). The survey included the principal educational process parties – students, instructors, and courses curricula – to examine the achievement of the related necessary skills and competencies in these programs. The comparison and survey declared that although the recent Egyptian programs emphasize the sustainability concepts and principles in different courses, the application in the professional field still waits for more regardless of some individual efforts from a few academic staff members. Thus, more enhancements in courses curricula – especially in architectural design and planning courses -, methods of learning and applications are crucial to coping with the needs of applying sustainable development principles in the professional field.

Key Words

Development of Education Programs – Architectural Education Programs – Inclusion of Sustainability – Labor Market

1. Introduction

Both knowledge and mental production are the basis of our current civilization. In his book "Head-to-Head: The Economic Battle Among Japan, Europe, and America - 2004", Lester Thurow pointed out that new future industries will depend on mental capabilities rather than the availability of natural resources. [1]

There is no doubt that global warming climate change, environmental pollution, and irrational use of natural resources have led to many ecological problems that urged most of the world's countries to take many tough decisions to protect the planet earth. The construction sector consumes almost 40% of the total energy worldwide, 30% of the raw materials, 25% of potable water, and 12% of the land use while producing 25% of the landfill and 20% of wastewater.

Resources consumption and environmental pollution will increase unless sustainability concepts are applied. [2]

António Guterres, The United Nations secretary-general in 2021, said:

"The sustainable development goals are more important now than ever. Now is the time to secure the well-being of people, economies, societies, and our planet-It is possible. So, we must make it happen together." [3]

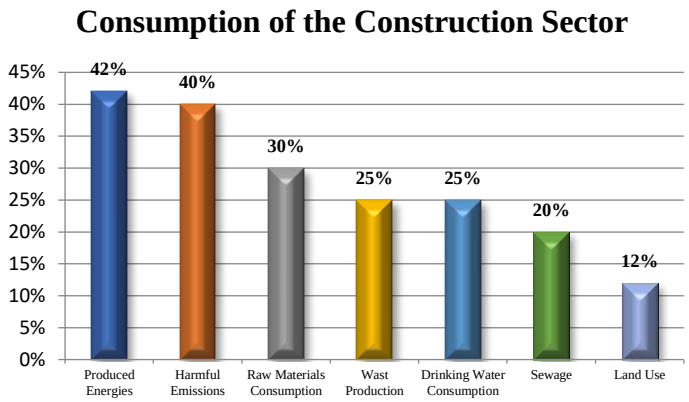

Fig.1: Environmental Pollution [2]

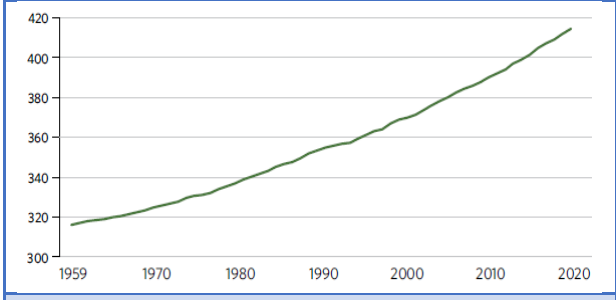

Fig.2: Concentrations of carbon dioxide, 1959–2020 (parts per million) [4]

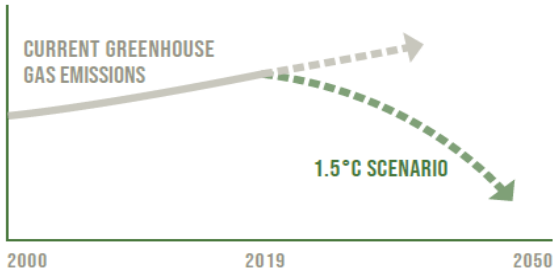

Fig.3: Greenhouse gas emissions require shifting economies towards carbon neutrality [4]

The accelerating development in the information and technological systems constitutes a real challenge to architectural education institutions to prepare an architect who can understand and cope with these developments. The digital revolution made a technological breakthrough in the buildings' modeling software that enabled architects to create sustainable designs through changing and replacing the building materials, building orientation, natural lighting calculations, and the rational energy consumption in a framework that simulates the actual building's performance.

Architectural institutions - by their nature - are those places where knowledge production, the practice of creativity, transformation, development, and application of technology are the core of architectural education's philosophy. Since the qualified architect is that person who can apply these technologies to maximize efficiency in the use of resources, thus he should be well trained to use these modern technological tools that enrich our lives. At the same time, these technologies imposed different challenges that all architecture education programs should consider as main goals and try in a relentless pursuit to achieve to face the future needs.

Architectural education is responsible for the graduation of an architect capable of dealing with the environment and social life as well as scientific and professional skills to achieve a sustainable environment.

1.1.Research Goals

The research aims to include sustainability topics in most courses of architectural programs - both theoretically and practically - to graduate an architect supported with professional competencies that enable him to achieve sustainability principles and encounter the new trends in other fields.

1.2.Research Methodology

This study deals with the research problem in *two main phases:*

1.2.1. Phase one: Data collection and analysis

Since the main target of this research is to examine the status of the current architectural programs, it was crucial to refer to the official websites of many higher education institutions in Egypt. The authors obtained the study plan and the courses' descriptions of architectural programs – that adopt the credit hours system - in three Egyptian Faculties of Engineering. The Faculties of Engineering are in Cairo, Helwan, and Benha universities. In addition, the researchers considered one of the significant international architectural programs – The University of Bath-United Kingdom, The Massachusetts Institute of Technology (MIT)-USA, and University Malaya-Malaysia - to be the datum of comparison.

1.2.2. Phase two: Survey Study

The authors designed and passed a Google form questionnaire to a group of academic staff and senior students in different architectural programs to measure the achievement of sustainability topics in the program.

2. The digital revolution and the sustainable technological development

The digital revolution led to a significant change in the concept of architecture and the architectural product. In the middle of the last century, computers have come to play an evolving role in architectural drawings and rendering. Later, and after many technological achievements, the software designers developed different applications to measure, simulate, and analyze the buildings' environmental performance and energy consumption. This digital revolution led to the development of architecture and building physics, the evolution of analysis operations, environmental, operational simulation, and the prediction of indoor spaces' environment conditions such as temperature, humidity, natural lighting, thermal loads, and energy consumption during the year. Such digital revolutions enabled the architect to study, change, and enhance the indoor environmental parameters and shifted the building from just a composition of rigid masses to a living entity. **[5, 6, 7]**

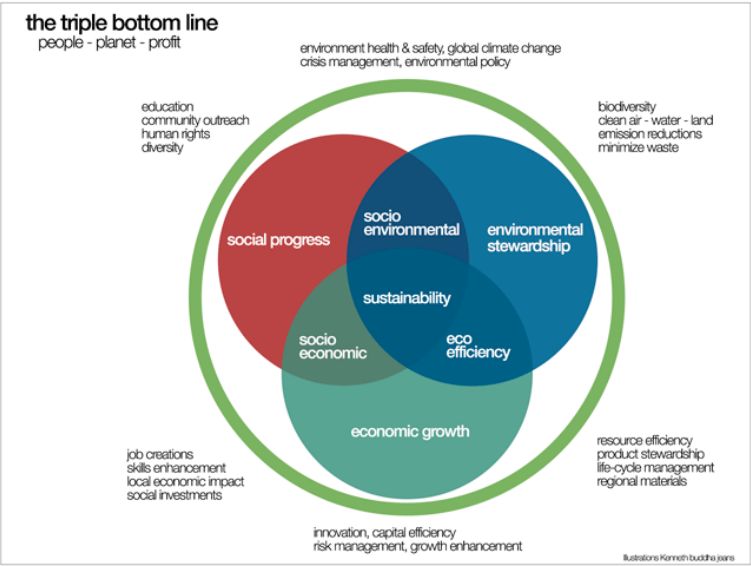

Fig.4: The concept of sustainability **[8]**

Meanwhile, focusing on sustainability principles in architectural education aligns with Egypt 2030's vision and its strategic plan to achieve the principles and goals of sustainable development in the social, economic, and environmental aspects. This vision emphasizes the principles of social equality, the achievement of economic growth, strengthening the investment in humans, and linking their creative and research capabilities with scientific research, education, and development. At the same time, Egypt 2030's vision targets environmental conservation through the rational consumption of resources - to enable future generations to satisfy their needs to face the harmful effects of climate change and reinforce the ecological systems' ability to face natural disasters. In addition, increasing renewable energy opportunities and adopting sustainable consumption are norms. Hence, architects must produce sustainable designs that have the minimum harmful impact on the natural environment and at the same time achieve thermal and psychological comfort for its users. **[9]**

3. Architectural education for sustainability

The International Union of Architects (UIA) published a framework for architectural education and professional practice and collaborated with UNESCO to introduce the architectural education charter to guide designing the architectural programs for the world. Thus, the inclusion and application of sustainability principles became mandatory in any architectural education institution. Also, the charter pointed out those architectural students should acquire knowledge in sustainable design and rational energy consumption side by side with the architectural design's basic sciences and building technologies. **[10]**

3.1.Sustainability principles in architecture

The embodiment of the sustainability concepts in architecture is latent in integrating the architecture design and the natural environment and through the rational use of the resources as architecture has always been the safe shelter from the harsh external climate conditions. The United Nations determined *five principles for sustainability:*

3.1.1. Healthy indoor environment

Architecture gives a paramount priority to public safety through studying the effects of construction materials on indoor air quality, assuring zero harmful emissions, and activating the natural air movement without compromising the building's capability to resist natural disasters.

3.1.2. Efficiency use of resources

Reducing the building use of resources and energy consumptions for HVAC and lighting systems or replacing them with environmentally friendly techniques that consume less energy, in addition to water recycling systems.

3.1.3. Environmentally friendly materials

The use of environmentally friendly construction materials, increasing the awareness of sustainability, considering the life cycle cost of construction materials production, and encouraging the reuse/recycling of natural resources.

3.1.4. Ecological forms

Buildings should integrate with nature and emphasize the harmony between site, design, context, and climate so that buildings become a part of the surrounding environment and interact with the different climate elements to achieve thermal balance and thermal comfort for their occupants.

3.1.5. Quality of design

This item discusses the achievement of a symbolic and historical relationship between the building and the surrounding environment in harmony with social customs and traditions that reflect the human civilization, society, spiritual character of the location, the form, and construction technologies. **[11, 12]**

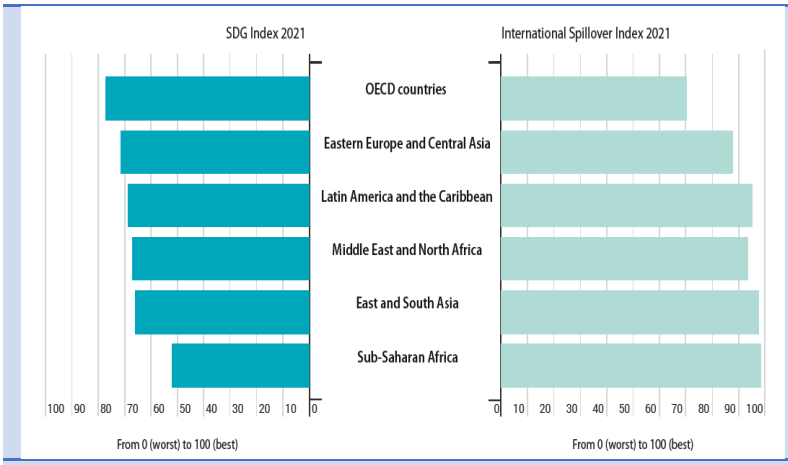

Fig.5: Regional average SDG Index score against International Spillover Index score **[13]**

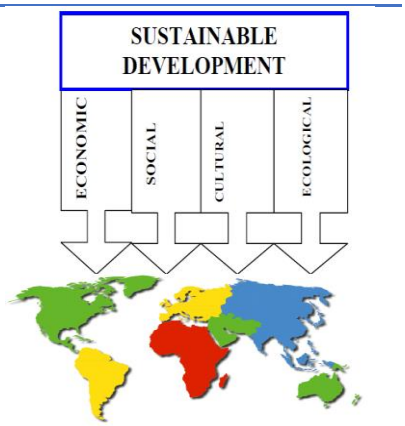

Fig.6: Spatial Dimension of Sustainable Development **[14]**

3.2.Quality of architectural education in Egypt

The Egyptian law number 82/2006 organized the establishment of the National Authority for Quality Assurance and Accreditation of Education (NAQQAE). Since then, NAQAAE has become responsible for educational institutions' quality, supporting them to cope with international standards, enhance the quality of their learning outcomes, increase their competitive opportunities locally, regionally, and internationally, and serve sustainable development goals in Egypt. NAQAAE published the first edition of the national academic reference standard for engineering

(NARS) in 2009 and determined the Bachelor of Engineering to be a fifth-level qualification according to the Egyptian National Qualification Framework (NQF). [15, 16]

NARS-2009 represented the minimum requirement for academic quality - specified (17) attributes that any architectural engineer should have, (3) related to the environment and sustainable development with a percentage of 20% of the total attributes.

After revising NARS-2009 and the accreditation of many Egyptian engineering faculties, NAQAAE published the developed edition NARS-2018 to match the international engineering criteria. While NARS-2009 was based on the Intended Learning Outcomes (ILOs.), NARS-2018 was based on the competencies that any engineer should master.

NARS-2018 specified (10) attributes that any engineer should have (3) related to the environment and sustainable development with a percentage of 33% of the total attributes. In addition, (10) competencies which are primary for any engineer, (3) related to the environment and sustainable development with a percentage of 33% of the total engineering competencies, and (5) competencies for any architect (2) related to the environment and sustainable development with a percentage of 40% of the total engineering competencies. [17]

Table-1: Features of the Graduate of the Architectural Programs in the Universities in Question [18, 19, 20]

University	Program	Features of the graduate			The competency of the graduate		
		Skills	Inclusion of Sustainability	Ratio	Competency	Inclusion of Sustainability	Ratio
Cairo University	Architectural engineering and technology	17	3	17.7%	17	6	35.3%
Benha University	Architectural engineering program	8	1	12.5%	17	3	17.7%
Helwan University	Architecture by digital technology	15	2	13.3%	17	4	23.5%

(Table-1). The average of the graduate attributes emphasizes the environment and sustainable development is 14.5%. The average percentage is 25.5% in both engineer and architect competencies.

4. The role of university education to achieve sustainable development

The architect plays a significant role beyond just achieving sustainable development; he is responsible for formulating social awareness about sustainability and its principles. According to the official database of the Egyptian Engineers Syndicate for the year 2021, the total number of Egyptian architects is around 80000, serving around 102000000 of the total population inside Egypt with an average ratio of 1:1300. Comparing the ratio in Egypt to other countries, 1:1800 in the United Kingdom, 1:1500 in Australia, and 1:1350 in the United States point out the architect's significant role in sustainable development. [21]

Thus, the recent Egyptian architectural education should target to graduate an architect who isn't only creative, professional and expressing the society identity but also can compete in an international level. The architectural faculty of engineering would not reach this aim without the main educational process themes, the curricula of architectural programs, the instructors, and the student.

4.1.The role of architectural curricula to achieve sustainable development

This study in the second phase focuses on classifying and analyzing the architectural curricula in four Egyptian faculties of engineering regarding *the following:*

- Compulsory courses that include topics about environmental protection and sustainability principles.
- Elective courses that include topics about environmental protection and sustainability principles.

Table-2: Programs of Egyptian Universities in Question According to Credit Hours **[18, 19, 20]**

University	Courses	Credit Hours			Inclusion of Sustainability				Total
		Compulsory	Elective	Total	Compulsory	Ratio	Elective	Ratio	
Cairo University	**69**	156	19	175	26	14.9%	15	8.6%	**23.5%**
Benha University	**65**	147	13	160	18	11.3%	5	3.1%	**14.4%**
Helwan University	**61**	146	14	160	34	21.3%	8	5%	**26.3%**

(Table-2) illustrates the status of the three credit hours programs in the universities under analysis regarding the total credit hours in each program and the number of credit hours that include topics about sustainable development principles. From the table, the authors found that the total percentage of credit hours that include topics about sustainable development principles ranges between 14.4% and 26.3%, with an average of 21.4%.

Table-3: Programs at Egyptian Universities in Terms of Inclusion the Principles of Sustainable Development **[18, 19, 20]**

University	Program		Courses Inclusion of Sustainability	Ratio	Courses can Include Sustainability	Ratio	Courses can't Include Sustainability	Ratio
Cairo University	Architectural engineering and technology	Compulsory Courses	**26**	**14.9%**	**17**	**9.7%**	**111**	**63.4%**
		Elective Courses	**15**	**8.6%**	**0**	**0%**	**6**	**3.4%**
		Total	**41**	**23.4%**	**17**	**9.7%**	**117**	**66.9%**
Benha University	Architectural engineering program	Compulsory Courses	**18**	**11.3%**	**30**	**18.8%**	**99**	**61.9%**
		Elective Courses	**5**	**3.1%**	**0**	**0%**	**8**	**5%**
		Total	**23**	**14.4%**	**30**	**18.8%**	**107**	**66.9%**
Helwan University	Architecture by digital technology	Compulsory Courses	**34**	**21.3%**	**29**	**18.1%**	**83**	**51.9%**
		Elective Courses	**8**	**5%**	**2**	**1.3%**	**4**	**2.5%**
		Total	**42**	**26.3%**	**31**	**19.4%**	**87**	**54.4%**

(Table-3) illustrates the percentages of program courses in each university that already include topics about sustainable development principles. In addition, the table demonstrates the courses that are allowable by their nature - to include topics about sustainable development principles and those that are not allowable including these topics. The authors suggest this proposal after comparing the courses' descriptions in all the programs under analysis.

Table-4: Credit Hours for Urban (Planning &Design and Landscape) in Terms of Including the Principles of Sustainable Development **[18, 19, 20]**

University	Program	Credit Hours	Architecture Design Courses				Urban Planning & Design Courses				Total Ratio
			Arch. Design/H	Inclusion of Sustainability	Ratio For Arch. Design/H	Ratio For Total/H	Urban/H	Inclusion of Sustainability	Ratio For Urban planning, Design./H	Ratio For Total/H	
Cairo University	Architectural engineering and technology	175	24	10	41.7%	5.7%	9	3	33.3%	1.7%	**7.4%**
Benha University	Architectural engineering program	160	28	4	14.3%	2.5%	8	2	25%	1.3%	**3.8%**
Helwan University	Architecture by digital technology	160	40	16	40%	10%	9	3	33.3%	1.9%	**11.9%**

(Table-4) summarizes the analysis of architectural design, planning, urban design, and landscape courses in the four programs regarding the inclusion of sustainable development principles' topics. The analysis declares that only 3.8% to 11.9% of the total credit hours include topics about sustainable development principles. These low percentages assure the urgent need to increase the students' awareness about the environment and sustainable development principles in the mentioned courses.

Table-5: Programs at (Bath University, Massachusetts Institute of Technology (MIT), and University Malaya in Terms of Inclusion the Principles of Sustainable Development **[22, 23]**

University	Program	No. Years	Sustainability Inclusion in courses		Architecture Design Courses inclusion of sustainability		Courses include sustainability		Principles of sustainability applications				
			Courses	Applications	Courses	Applications	Courses	Applications	Energy Efficiency	Healthy Indoor Environment	Efficiency Use of Resources	Environmentally friendly materials	Ecological Forms
Bath University	Department of architecture & civil engineering	4	27.7%	12	25.7%	11	2.9%	5	24.8%	18.8%	9.9%	14.9%	18.6%
MIT Massachusetts institute of technology	School of architecture and planning creates climate action plan	4	31.4%	11	29.6%	11	3.1%	5	29.9%	15.7%	11.2%	10.7%	22.9%
University Malaya	Science in Architectures	4	28.3%	13	26.3%	12	3.3%	3	28.2%	17.3%	8.4%	13.4%	20.5%

(Table-5) illustrates the extent of interest in including the principles of sustainability in architectural programs in foreign universities, although the number of years of study is four years. We find that the percentage of courses that include sustainability content ranges from (27.7%-31.4%), with the inclusion of sustainable architecture applications from (11-13) applications,

which confirms the study of most applications related to sustainability in its various branches. The inclusion of sustainability principles in architectural design courses ranges between (25.7%-29.6%) with the inclusion of (11-12) applications of inferred architecture. The courses other than architectural design include sustainability from (2.9%-3.3%) with the inclusion of sustainable architecture applications from (3-5) applications. The inclusion of sustainability principles in energy conservation ranges (24.8%-29.9%), the quality of the internal environment (15.7%-18.8%), the rationalization of the use of materials and resources ranges (8.4%-11.2%), and climate adaptation ranges (10.7%-14.9%). As for respecting the environment of the construction site and adapting the design to it, it ranges between (18.6%-22.9%).

The gap appears between the inclusion of the principles of sustainable development in international universities and Egyptian universities, which requires a reconsideration of the inclusion of the principles and concepts of sustainable architecture in the curricula of architectural programs in Egyptian universities.

4.2.Individual efforts from staff members to accomplish sustainability

There are few personal endeavors, such as the utilization of plastic water bottles to carry on a passive solar heating experiment. In this experiment, the instructors of the environmental control course encouraged the students to build an experimental thermal mass consisting of plastic water bottles and divided the class into small groups. Each group is responsible for monitoring the recording the air temperature in four different spaces on the campus throughout 24 hours. The students then compared the recorded readings in the four spaces to measure the effect of thermal mass on indoor thermal comfort. A quick survey to measure the students' satisfaction showed that the experiment increased the awareness of more than 93% of the students about the positive effect of using water for thermal mass in elevating the indoor space temperature in cold seasons. [24]

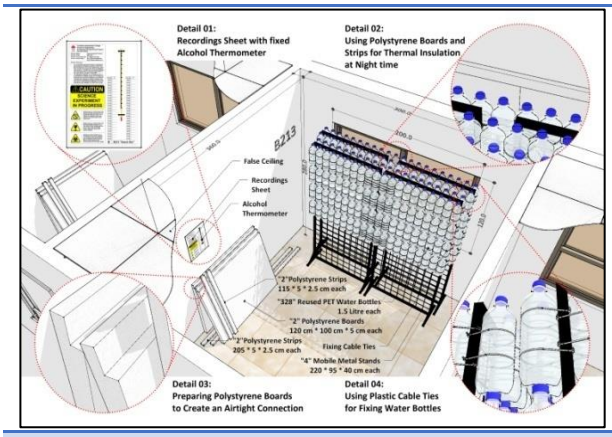

Fig.7: The selected spaces and thermal mass detail [24]

Fig.8 :The work of students in preparing the thermal mass [24]

5. Concepts of sustainability in architectural programs

5.1.The role of academic member to achieve sustainable development

Since the primary role of the academic member is to coordinate the educational process throughout its different stages, he has a significant effect in formulating the students' perception about different types of problems, developing their analytical and critical skills, as well as the continuous self-learning and preparing them to join the professional society. Thus, the authors

designed and passed a Google form questionnaire to a sample of (50) academic staff members in different (10) Egyptian engineering faculties to measure the inclusion of sustainable development principles in the programs under analysis.

The questionnaire focused on *the following items:*

- The academic references/resources
- Inclusion of sustainable development principles in architectural education in Egypt
- Inclusion of sustainable development principles in the courses' curricula
- Preparation of students to join the professional society

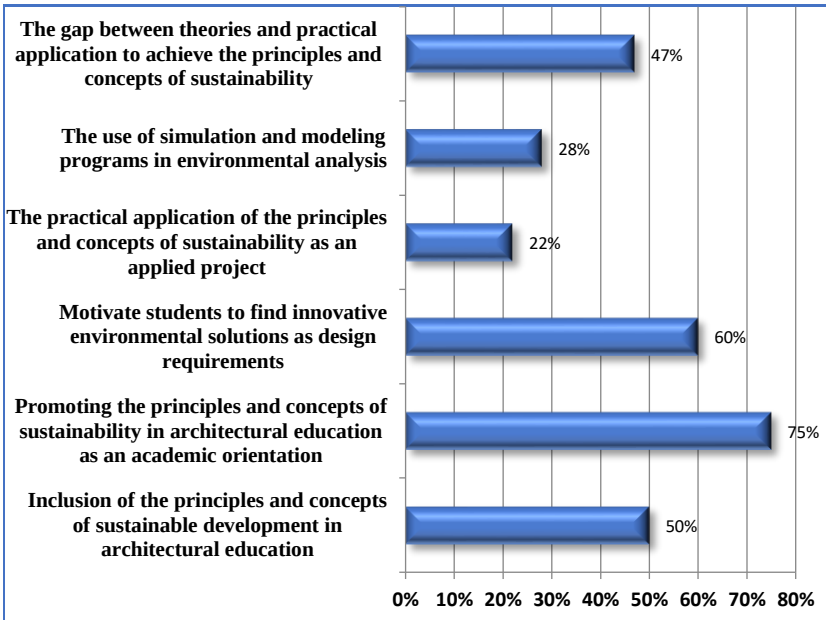

Fig.9: Sustainability in architectural education **[25]**

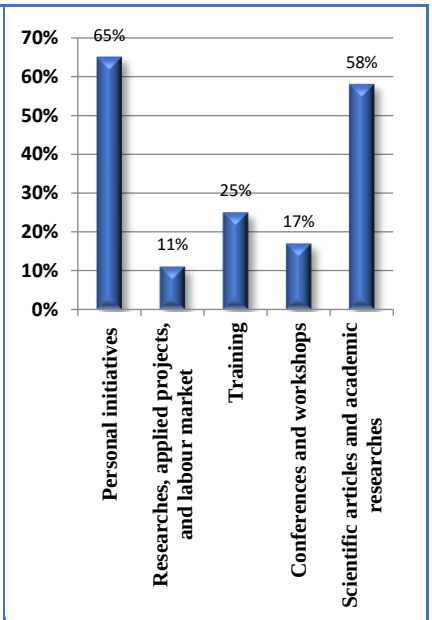

Fig.10: Information sources **[25]**

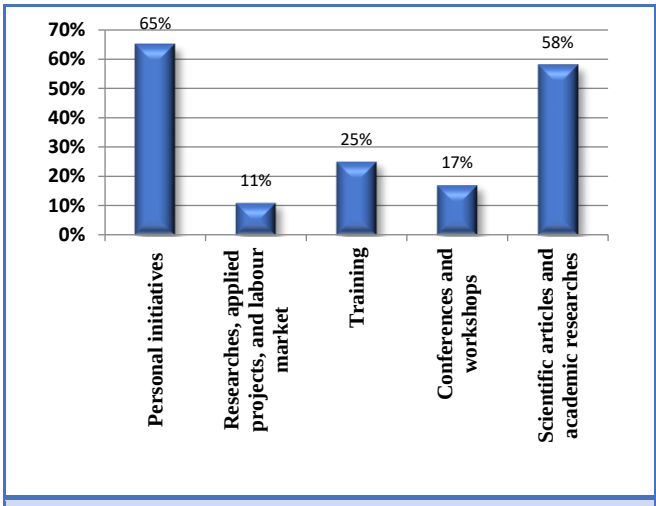

Fig.11: Sustainability in architectural education**[25]**

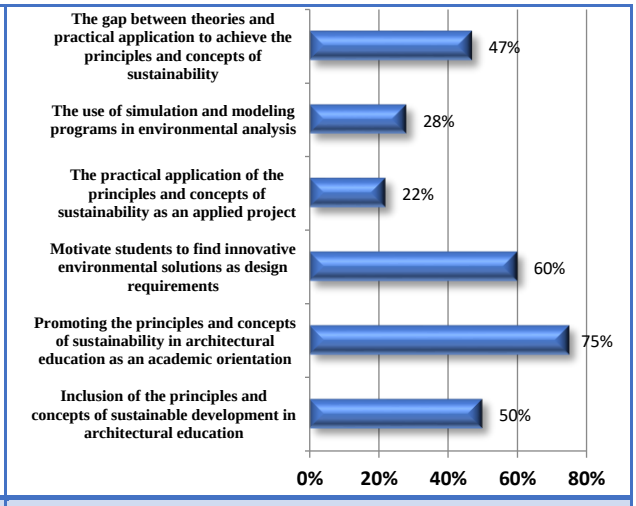

Fig.12: Information sources **[25]**

The survey results conclude academic staff members' high capability to deal with sustainable development principles because of their updated academic background. Meanwhile, the survey results point out the gap between theoretical academic studies and the professional and practical side.

In a few related courses, such personal efforts could perfectly enhance students' perception and awareness to better understand the importance of sustainability concepts. And encourage more instructors to take similar paces in architectural design and planning courses, thus, enhancing the students' capabilities to select the most suitable applications and practically examine its results.

5.2.Preparing the undergraduate architect to create sustainable designs

The undergraduate architect is the only product of the educational process; thus, it is crucial to qualify the students to cope with the high technology of the third millennia through presenting the proper social, environmental, and economic norms to enable them to encounter the future's problems with creative concepts. Thus, the authors designed and passed another Google form questionnaire to a sample of (300) students in different (10) Egyptian engineering faculties to measure the inclusion of sustainable development principles in the programs under analysis and its ILOs, and their reflections on the professional career.

The questionnaire focused on *the following items:*

- The academic references and resources
- The awareness of sustainable development principles
- Utilization of computer software
- Inclusion of sustainable development principles in the courses' curricula
- Applying sustainable development principles in architectural design and planning projects.

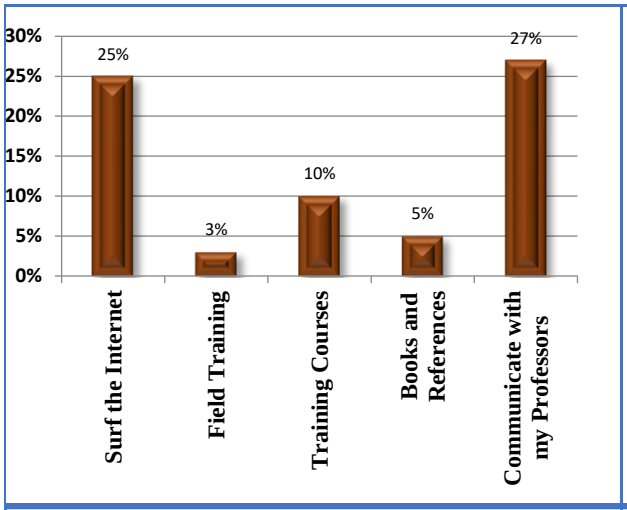

Fig.13: Information sources [25]

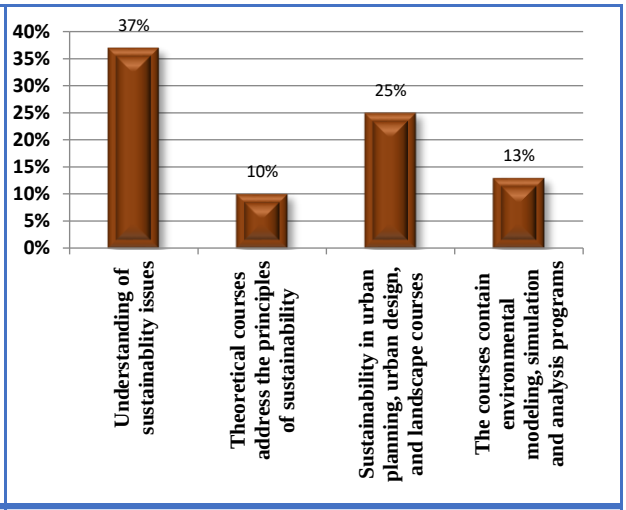

Fig.14: Sustainability principles and concepts [25]

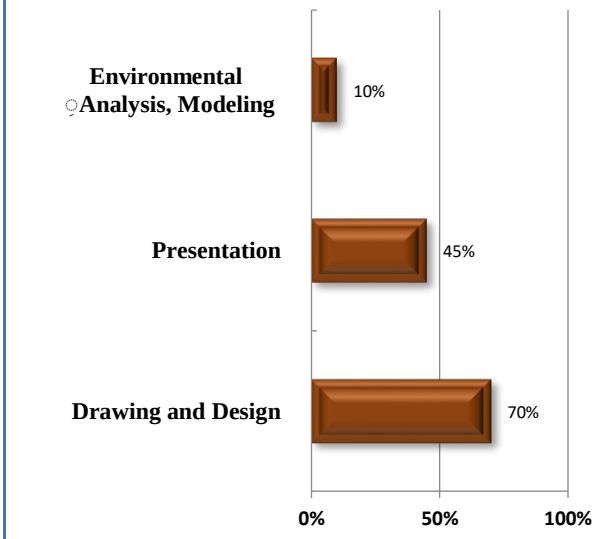

Fig. 15: Use of computers and specialized software **[25]**

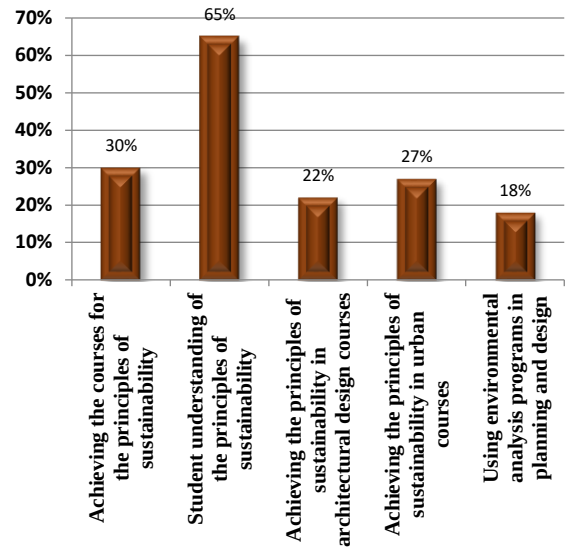

Fig.16: Apply the concepts of sustainability **[25]**

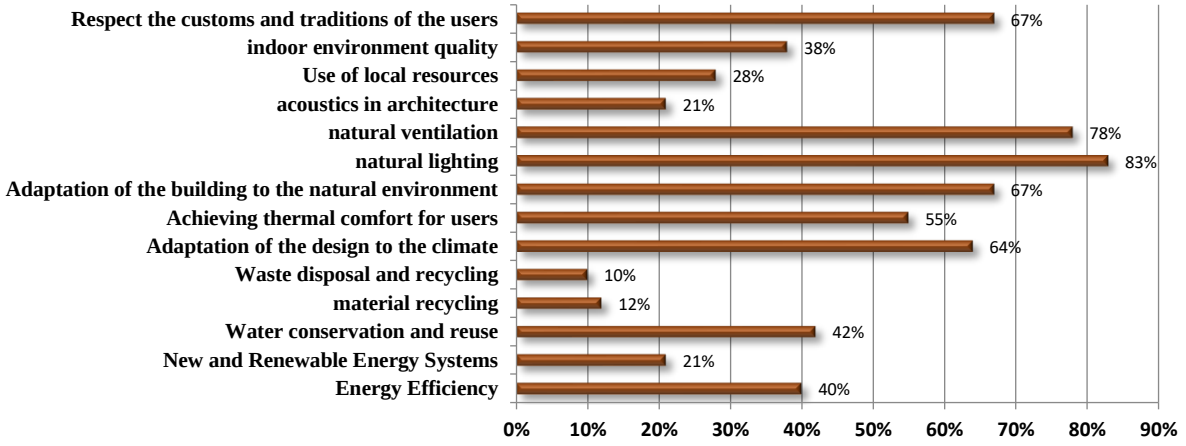

Fig.17: Targeting sustainability axes in the educational process **[25]**

The professors are the student's sources of information despite Egypt's distinguishing academic staff, which reduces the student's reliance on searching for information from various sources, which the questionnaire showed. The questionnaire indicated the weakness of the courses strengthen the principles and concepts of sustainable development in planning, urban planning, landscape, and architectural design courses. These principles and concepts concern preserving the environment, working with it to achieve the highest comfort for the user, and preserving materials and resources. The students stressed that environmental analysis and modeling programs at the latest in their interests despite the multiple solutions they provide according to the intellectual, economic, social, and environment to achieve the experimentation of preconceptions, which maximizes self-education. The professors were accessible sources of information for residents. The questionnaire concluded a relationship between knowledge of sustainable development principles and concepts and students' application in architectural design and planning projects. The students have little understanding of and investment in sustainable development, resulting from

not including them in their courses and not concretely applying them, underscoring the importance of sustainable architecture.

5.3.Freshly graduate architect and the applicability of sustainability concepts

The architect is a product of the architectural education process. He is responsible for achieving safety, functionality, beauty, and comfort of the building's users and reducing the harmful effects of his designs on the natural environment to the minimum. Since the architect is the pivot of sustainable development in the construction industry, developing his awareness and understanding of environmental problems and sustainability concepts is highly recommended. That is why the authors designed and passed a Google form questionnaire to a sample of (50) graduate architects in the last five years to measure the inclusion of sustainable development principles in the current designs and the awareness and acceptance of the construction market in Egypt of the sustainability concepts.

The questionnaire focused on *the following items:*

- The references and resources that newly graduated architects depend on
- Applicability of sustainable development principles in the construction market
- The construction market requirements from the newly graduated architects

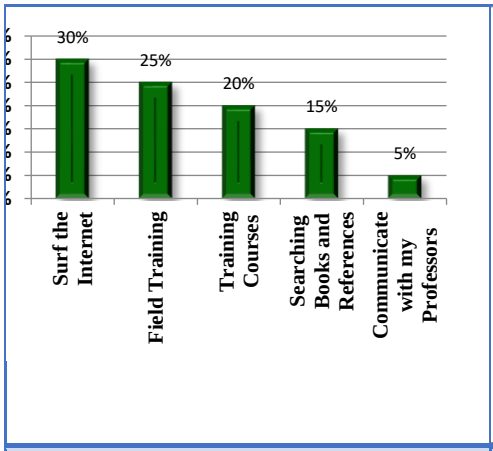

Fig.18: Information sources **[25]**

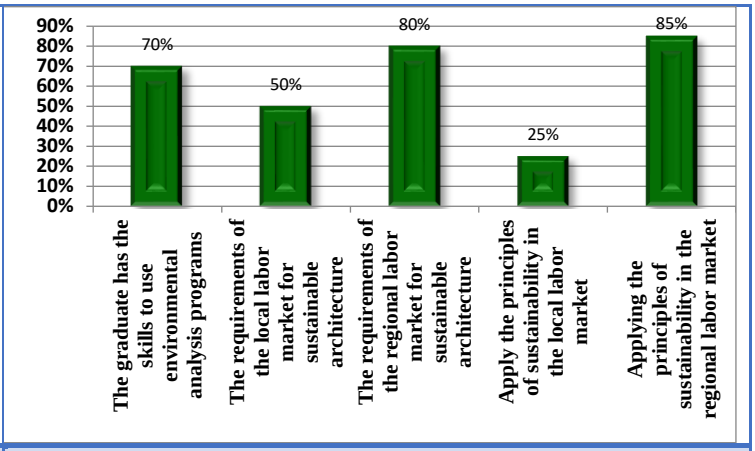

Fig.19: The requirements of the labor market from the graduate. **[25]**

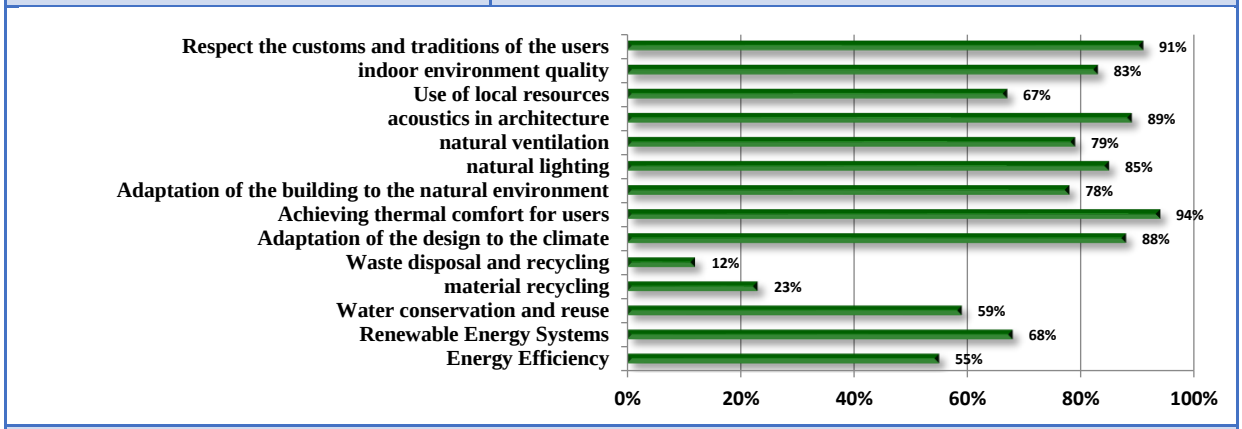

Fig.20: Applying the principles of sustainability in the labor market **[25]**

Although the initial costs of applying sustainable development principles in construction projects seem to be relatively high, it results in overall operation and maintenance cost reduction in the long run. The higher initial cost discourages most owners from adopting the sustainability concepts in their new projects. Thus, it necessitates nontraditional technologies that can make the optimum balance between costs and efficiency. Awareness of sustainability needs coping with the rapid development in their technologies. Egypt's construction market is trying to shift rapidly towards sustainable development - in most new projects - as global demand and as a thinking trend for protecting the natural environment, especially after similar large projects have succeeded regionally and internationally (Masdar City, United Arab Emirates, and Neum City, Saudi Arabia).

The survey emphasized the urgent need for qualified architects who are aware of the needs of sustainability and who are dealing with the rapid evolution of their technologies. **[26, 27]**

6. Discussion

The survey results point out that despite a few individual cases; most academic staff still consider applying sustainable development principles in architectural design and planning projects as a complementary topic rather than a primary target. Those individual cases proved the enhancement of students' awareness of the applicability of sustainability principles through their participation in actual experiments and disseminating its results on an international level.

Although the vitality of sustainable development generally in all aspects, and specially in the field of construction, there still a gap between the academic education and practical field applications which necessitates more inclusion of sustainability concepts and principles in the current architectural programs' curricula.

7. Conclusion

This study aimed to inspect the inclusion level of sustainable development principles in the current architectural programs' curricula. The authors inspected and analyzed the course description in three current architectural programs in Egyptian universities and compared the results with three international institutions. In addition, the authors designed and passed three different questionnaires to academic members, senior students, and newly graduate architects to measure the inclusion of sustainable development principles in both academic and practical levels.

The study concludes to:

- There is no rigid framework to guide the inclusion of sustainable development concepts and principles in the current architectural programs' curricula, rather than depending on individual efforts from academic staff members.
- There is less interest in including sustainable development concepts and principles in architectural design and planning courses and the utilization of related simulation software. In contrast, more concern should be the main target to increase the awareness and understanding of undergraduate students and newly graduated architects of these crucial topics.
- There is a lack of the revising criteria for new architectural programs' curricula regarding the inclusion of topics related to sustainable development concepts and principles, both theoretically and practically.
- To enhance and increase the awareness, understanding, and applying sustainable development concepts and principles in architectural work, academic institutions should give great attention to *the following points:*

- Encouraging the students to depend on more sustainable solutions during design stages to become one of the primary design targets.
- Enable the students to examine the alternative design/planning/landscape solutions through well-prepared lab facilities and updated simulation software.
- Provide more training and workshops to academic staff members to become more familiar with current pedagogy in sustainable development education.

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