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A Framework for Implementing Sustainability in the Architectural Curriculum in Egypt

R. M. M. Mohie El-Din [1,*] ✉

[1] *Department of Architecture, Modern Academy for Engineering and Technology, Cairo, Egypt.*

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ABSTRACT

Developing countries encounter more challenges than developed countries when aiming for sustainability [1]. However, nowadays Egypt is living in a new era where there is an increased awareness of the sustainability concept, its goals, and its needs in various aspects of life. Different notions arose such as climate ambassadors, women for climate, and many others. Workshops were held in educational institutions, among many others, to enhance awareness at the undergraduate level, since education is the core answer to various problems that people face and universities can shape future leaders' minds and views [1]. Thus, if sustainability is successfully implemented in the architecture educational system, most of the hardships it faces today will disappear. Hence, the research strives to develop a framework for the best implementation of sustainability in the architecture curriculum in Egypt, through evaluating existing experiences. Consequently, the research methodology focused on studying, analyzing, and comparing the curricula of a Private Egyptian Institution with findings from prior research and another Public Egyptian Institution. The findings will give insight into architecture higher institutions' curriculum role in enhancing sustainability. Based on the results, it was determined that sustainability is implemented adequately in non-sustainable concentrations. The results, of the institution under examination, were generally encouraging, still greater attention should be paid to the ratio of compulsory to elective courses, which was enhanced within the proposed framework.

1. Introduction

A. Motivation

One of the most important recommendations, in most of the research, is education. If you educate people correctly about what is requested, you will always succeed in achieving the goal required. In America for example, some designers refrain from using sustainability in their work,

*** Corresponding author**

E-mail address: *eng_rehammostafa@yahoo.com*

due to the high level of confusion it causes them [2]. Thus, to succeed with sustainability, it is needed to start from the educational system with students, to create educated generations that embrace sustainable concepts, where undergraduates will be well informed about environmental problems and their sustainable solutions in their field of study. Since 2009 the American Institute of Architects (AIA) made it mandatory to learn the requirements of sustainable design in the education requirements [3]. Furthermore, studies were conducted to understand sustainability challenges in higher education and propose some frameworks [1]. The challenges are enormous [4]. Some believe that developing integrated sustainable curriculums fails. That is due to the academic traditions of the educational system and the inattentive academic community [2]. On the contrary, the optimists believe that the credit hour system and the continuous upgrading and development of the educational institutions' bylaws and curriculums provide a great opportunity for all enhancements needed; sustainability included. Accordingly, a need was identified in Egypt to create a framework for implementing sustainability in the architectural educational system curriculum.

B. Egypt Overview

Being one of the world's oldest civilizations, Egypt has always been seen as a global center of knowledge and science throughout antiquity. It has been crucial to the development of the MENA region. Additionally, Egypt is considered the world's 14th most populous nation and the 1st most populous country in the Arab world, with an expanding rate of around 2.5% a year [5]. In the Arab region, Egypt plays a major intellectual, cultural, and political role, bearing an important share in striving for stability, peace, progress, and a renaissance in the Arab world and the Middle East. Education has always been a priority for the Egyptian government in its agenda, and as stated in Egypt's vision for 2030, so is sustainable development. 2030 strategy is based on concepts of sustainable growth and balanced regional development. This ensures everyone's participation in the process of construction and development. At the same time, it guarantees that all parties benefit from the fruits of this development. The strategy considered the optimal use of resources and support for fair use, to ensure the rights of future generations [6]. As a result, COP27 was held in Sharm El-Sheikh, Egypt, to establish the concept of sustainability locally. This was a great event that generated great awareness within the local community about diverse issues.

Furthermore, Egypt is continuously witnessing the development of old and new cities, with Egypt's new administrative capital as an example. Thus, providing architects, who are well-educated about local issues, global needs, and environmental awareness requirements is mandatory [7]. This will be achieved by developing a fulfilling architectural educational system with a successful implementation of sustainability in its curriculum. Therefore, the Ministry of Higher Education and Scientific Research always updates the benchmark standards it issues, for higher institutes and universities in Egypt, to convoy with the latest worldwide educational standards. The architectural program can be found within Faculties of Engineering or Fine Arts faculties [8]. Previously, the architecture educational system was based on the two-semester system for 5 years of study, however, in the last 10 years, there has been an increase in the number of institutions that have converted to the Credit Hours (CHs) system with a total of 180 CHs. However, in the latest benchmark 2020, the ministry allowed the institutions to create engineering programs ranging from 144 to 165 CHs for students to graduate [9].

Additionally, all institutions that seek to obtain the accreditation of the National Authority for Quality Assurance and Accreditation of Education (NAQAAE), which has become crucial lately to achieve, must fulfil many requirements regarding the quality of the education they provide. For example, the courses' specifications must be transferred from intended learning outcomes (ILOs) to competencies. As for the implementation of sustainability in the curriculum; it is left totally to the institutions, according to the goals of their architectural program and as designed in their bylaws. Some universities get validation for their certificates from foreign bodies such as the Royal Institute of British Architects (RIBA). The concern of implementing sustainability into architectural educational systems has been occupying many Arab educators, as well as the whole

world. They are concerned about graduating future architects who lack knowledge of their local challenges. They also emphasized the need for integrating the environmental domains into the design studio courses, to enhance the students' practical skills [8].

C. Literature Review

In recent years many notions were adopted, and conferences were held by various organizations and countries, to emphasize and promote the importance of sustainability and sustainable development for the world's future. For example, there is the United Nations Environment Program (UNEP) developed by the World-Wide Fund for Nature (WWF), the Brundtland Report, the proceedings of the 1992 Earth Summit in Rio de Janeiro, the Copenhagen 2009 conference on climate change, the Fifteenth session of the Conference of the Parties (COP15), the COP27 in Sharm El-Sheikh, Egypt in 2022, and COP28 in UAE in 2023. In almost every summit, education was of the utmost importance for enhancing environmental awareness and achieving sustainable development [7]. Furthermore, workshops were held such as the "Designs of the Planets" workshop series, which took place in the United Kingdom. It addressed the sustainable challenge while considering enhancing the environmental awareness of future architects. The Royal Institute of British Architects (RIBA) and the Centre for Education in the Built Environment (CEBE) supported these workshops along with Oxford Brookes University, Cardiff University, and the University of Nottingham [8].

All these notions, and more, were followed by various research related to the implementation and the evaluation of sustainability in the educational system in general, and architecture curriculums specifically. Additionally, with the need for new cities worldwide, architecture plays a crucial role in sustainable development. For example, a study made by Santiago Porras Álvarez et al analyzed the curricula of 20 important schools in 11 different Asian countries. The results showed that sustainability education was organized differently, related to the various contents, intensity, and sequence. The research found that the percentages of sustainable courses ranged from less than 5% to 25% at most. Additionally, they examined the contents of the courses concerning ecology, society, and economy. They found that ecology received the most attention. Economic aspects were either absent or had a small presence at best, which created an unbalanced sustainability education. Society and culture appeared more often, by implementing traditional philosophies and principles in the course's syllabus [7]. Basak Gucyeter in another research stated that a responsive architecture curriculum must establish lifelong learning and achieve sustainability concepts. He believed this approach would help with the criticism facing sustainability when implemented into the design curriculum, letting the engineering and technology aspects exceed the humanities and artistic aspects of the discipline. Additionally, the study provided the steps necessary for adopting a responsive curriculum that focuses on sustainability. It was concluded that the lack of a real understanding of sustainability in architectural education affected greatly the architecture profession and the aim of achieving a sustainable built environment [10].

Another study conducted by Ashraf Salama surveyed 8 architecture institutions in 2002. From Egypt there were Cairo and El-Azhar Universities, from Ethiopia there was Addis Ababa University, from Nigeria there were Nigeria and Ahmadu Bello universities, from Syria there was Damascus University, and finally from Turkey, there were Gazi and Middle East Technical Universities. It was found that sustainability was not included in these universities' programs; neither in the course title nor the description. The study recommended revising the architecture programs, curricula, and how they were implemented. It also illustrated the variations between the economic/environmental domains, which sometimes prevailed over the socio/cultural domains. On the other hand, when the undergraduate architecture program at Misr International University in Egypt was studied, a balance was found between the economic/environmental and the socio/cultural domains [11]. Furthermore, a study conducted on UAE's eight architectural programs being taught in the country, illustrated that sustainability was rarely applied in the design studio courses, the main output of any architectural curriculum. This was caused due to the absence

of coordination between the studio and the theory courses. That is in addition to the lack of adequate awareness of the importance of sustainability to the architect of today and tomorrow among most faculty members. The study analyzed the content of each program by using its pedagogic documentation throughout the use of specific keywords that represented three aspects; environmental/physical, sociocultural, and economic. It was found that the courses discussing topics concerning sustainability vary from 45% to 8% of the core courses, with the physical aspects being on top, while rarely addressing the golf region's environmental context. These numbers are higher than the Asian numbers research, which may be due to the wide range of keywords that were selected. Additionally, it emphasized the ongoing lack of understanding of sustainability within the architectural community [12].

Regarding Egypt, a study was conducted in 2018 that explored the implementation of sustainability into architectural education, throughout interviewing 16 members of the architectural community; both academic and practitioner, from six different institutions. The majority agreed that sustainability is a necessary holistic concept. They summarized the sustainability problems and solutions into five main issues; first, there is a gap between architectural education and practice, where some institutions deal with sustainability as a luxury option or just theories. For example, LEED should be necessary for building codes rather than just being a course. Secondly, there is the problem of the community's ignorance, where raising awareness about the main three aspects of sustainability (social, economic, and environmental) is a must. Additionally, there are even instructors who don't understand its importance, due to cheap electricity rates and; the geographical location of Egypt which allows for good ventilation and daylight, with no swings in temperature. However, due to climate change Egypt's weather is changing and so is the importance of sustainability and its application in architecture, and more people began to view the urgency. Thirdly, sustainability was just used to offer guidelines and thus was qualitative. Currently, it has become quantified and measurable by using computers. However, this became more of a constraint since there is a need to provide expensive resources and equipment; such as labs, environmental examination tools, software, and simulators, in addition to the qualified human factor or it will remain just theories. Fourthly, the limited total credit hours, which are currently being decreased in the new benchmark do not allow for the development of many courses to be added to the curriculum. Lastly, the large number of students in the courses limits, if not prevents, field visits and appropriate internships in some institutions. Thus, the best methodology was concluded to deal with sustainability as an interdisciplinary collaboration between different majors and students from various fields. Finally, despite all the efforts exerted; such as producing the Green Pyramid Rating System (GPRS - the Egyptian LEED), they remained insufficient. When it comes to curricula, old curricula must be updated and upgraded, to cope with the current society's requirements. It was also advised that proper attention must be paid to infiltrating sustainability in the curriculum until the very end while monitoring and tracking it [8].

D. Research Objective

As demonstrated, nowadays, it has become mandatory to create well-educated professionals with a well-balanced and integrated knowledge of local and global issues, including sustainability. That requires its right implementation and application in the educational system, especially architecture education, to create a sustainable built environment. Existing research demonstrates, both the interest in and challenges involved in cross-national and multicenter comparative analyses of architectural education curricula [7]. This raised an important question; whether current programs and curricula are designed in a balanced and sufficient way when implementing sustainability.

This paper will be concerned with Egyptian Architectural Education, and its main problem and aim will be to create a general framework for moderately implementing sustainability in the architecture curricula. Other problems are beyond the scope of this paper. This will be achieved throughout shedding light on how sustainability is implemented within an educational institution's curriculum in Egypt. The curriculum under investigation will not be of sustainability concentration, that is to assess its impact on different architecture specializations which represent

the majority of architecture students. Accordingly, the paper will illustrate the various opportunities and constraints faced.

2. Research Methodology

This is exploratory research, like previously discussed ones [7] which intends to identify and analyze the implementation of sustainability in the curricula of architecture programs in Egypt and develop a deduced framework. To achieve its goal the methodology employed worked at the Bylaw/curriculum level, as demonstrated in Fig.1. It used the theoretical, inductive analytical, comparative, quantitative, and qualitative approaches.

Using the theoretical and analytical approaches, the first part established a clear understanding of the study area, through the introduction with its literature review. That is followed by providing a deduced framework for past studies demonstrated in Table 1. It is used for benchmarking, followed by the research-induced framework in Table 2. Table 2 follows the same aspects of work and analyses as in Table 1.

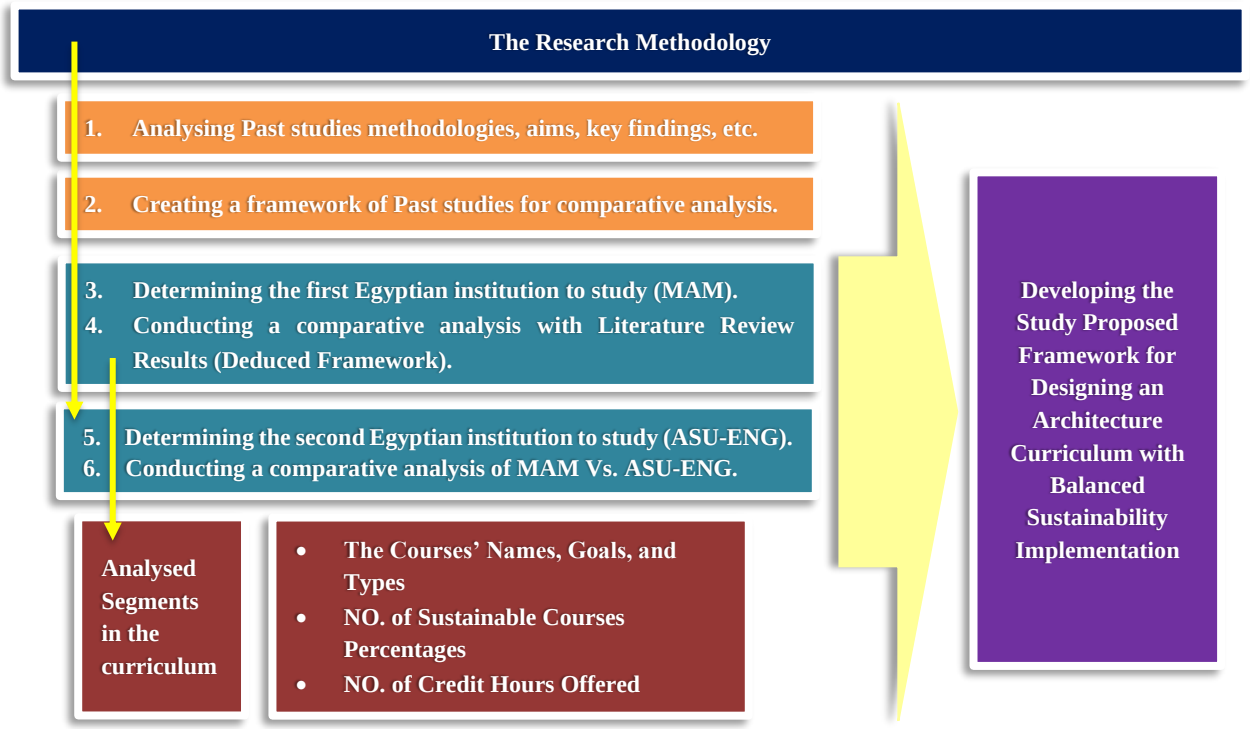

Figure 1 The methodology followed by the study to develop its proposed framework

Then the research used the analytical approach in discussing the reasons for selecting the Egyptian educational higher institute under study. The institute's Bylaws were illustrated, and the curricula were analyzed regarding three dimensions; the number of available sustainable courses in the program in relation to the main goal of the course, the number of credit hours offered, and the distribution of the courses over the academic levels. That is because the educational timeline is often neglected [7]. The results were compared in relation to previous results conducted by studies in the same field in the point of similarity. Additionally, they were compared with another ranked educational institution in Egypt in regard to the course title, the number of credit hours offered, and the distribution of the courses over the academic levels, based on the published information by the institution on its website. The curriculum analysis used all approaches and the results were presented in tables and graphs. The last part of the study presented a deduced framework for designing an architecture curriculum with balanced sustainability implementation.

Finally, it must be acknowledged that the conclusions were based on the information supported online by Ain Shams University and provided by the Modern Academy for Engineering and Technology in 2022. This caused some limitations to the study; in conducting further analysis of some additional segments and parameters. Additionally, the program selected for studying was for Technology, not sustainability concentration.

3. Previous Studies Deduced Framework Vs. Current Research Adopted Framework

A. Past Studies Deduced Framework

A thorough collective framework was developed including each of the five studies previously stated in the literature review section as shown in Table 1. This framework is created to assist in directing this study's aims, methodology, and approach. It will also be used as a benchmark for the current research results. The framework included; the main aims, countries under study for application, the methodology, the criteria for selecting the methodology and case studies, how the results are presented, and the key findings of the studies.

Table 1. A deduced framework for past studies to help in developing the study's framework and benchmarking its results

Past Studies	Study (1) by Santiago Porras Álvarez et al [7]	Study (2) by Basak Gucyeter [10]	Study (3) by Ashraf Salama [11]	Study (4) by N. Benkari [12]	Study (5) by S. El-Feki et al [8]
Main Aims	• Curricula and Content Analysis • Determine trends and regional or personal distinctiveness	• Curriculum Analysis • Addresses the ways of including sustainability principles into a responsive architecture curriculum.	• Curricula and Content Analysis • Analyze if architecture academics began to restructure their programs to emphasize sustainability	• Curricula and Content Analysis	• Implementation of sustainability into architectural education
Countries under Study	Limited to Asian Countries	None Specified	African and Middle Eastern Countries	United Arab Emirates	Egypt
Methodology	• A comparative study that analyzed the curricula and content of 20 Institutions in 11 different Asian Countries. • It depended on analyzing the number of courses, and their academic credits in relation to the total credits offered.	• A theoretical approach. • It discusses the eight factors that create a comprehensive sustainability approach in architectural education. • Discussing postgraduate students and specialization of the architectural profession.	• Surveyed 8 architecture institutions. This included classifying courses, in addition to analyzing their weight, title, and description. • Analyzing a specific Egyptian Institution.	• Analyzed 8 architectural programs. • The content was analyzed throughout the use of specific keywords representing environmental, sociocultural, and economic aspects.	• Theoretical Analysis to introduce sustainability in the architectural curriculum. • Interviewing 16 members of the architectural community from six different institutions (public and private).
Criteria of Selection	• Prestigious universities in their countries. • To be a specialized course, at least one-third of its content must be dedicated to incorporating sustainability.	• None	• The surveyed institutions were chosen without any specific selection criteria. • A newly developed program at the time in the Egyptian University.	All 8 available programs are taught in the country.	The sample was selected depending on their knowledge, institutions involved with covering the mentioned modules, and classification from faculty members to practitioners.

Results Presentation	Qualitative tables (course matrix) and quantitative graphs.	Theoretical discussions using tables and figures.	Theoretical discussions.	Theoretical discussions & graphs.	A Qualitative Analysis & Empirical Study.
Key Findings	• **Organization** is different, related to the various contents, intensity, and sequence.	• Constructing a flexible curriculum based on **pedagogies** that integrate technical and comprehensive environmental issues.	• Sustainability was not included either in the course **title** or in the course **description**.	• Sustainability was rarely applied in **design studio** courses.	• Summarized the sustainability **problems** and solutions into five main issues.
	• The **percentages** of sustainable courses ranged from less than 5% to 25% at most.	• Provided the **steps** for a responsive curriculum that adopts sustainability where every course's curriculum should be responsible for addressing **topics** that will prompt it.	• The economic/ environmental domain prevailed sometimes (less than 8% of the overall program courses) over the socio/cultural domain.	• Courses discussing topics in relation to sustainability vary from 45% to 8% of the **core courses**, with the physical aspects being on top.	• Sustainability is included from all to none of the design **studios** and from one **theoretical course** to more elective courses.
	• General **theory courses** assist in addressing sustainability concerns using conventional and regionally appropriate traditional and vernacular concepts, technologies, and techniques.	• There is alack of a real **understanding** of sustainability in architectural education which is endangering the architecture profession and facing the danger of remaining in a theoretical realm.	• Misr International University in Egypt had a balance between both the economic/ environmental domain and the socio/cultural domain.	• Courses rarely address the golf region's **environmental context** addressing Western contexts and standards.	• Old curricula must be updated and upgraded. It was also advised that proper attention must be paid to infiltrating sustainability in the curriculum until the very end while **monitoring** and **tracking it**.

B. Research Adopted Framework

In alliance with the framework discussed in Table 1 for past studies, Table 2 demonstrates the study-adopted framework. Table 2 shows the same factors analysed in Table 1. They are aims, countries under study, Methodology and Architectural Curriculum Analysis Parameters, Criteria of Selection, Results presentation, and finally the key findings. However, at this point in the research, the key findings in Table 2 present only the domain of the findings in general. The following sections will discuss the detailed findings of the study.

Table 2. The adopted framework the study followed

Current Study Framework	
Main Aims	• Creating a Framework for a balanced program curriculum with sufficient sustainability implementation. This requires analyzing other programs and curricula.
Countries under Study	Egypt
Methodology And	• An analytical comparative study of architectural curriculum design. • Using Theoretical analysis in the literature review for past studies and developing a framework for them for benchmarking.

Architectural Curriculum Analysis Parameters	• Selecting Two Prestigious Higher Educational Institutions in Egypt and comparing their results to each other and the general findings of past studies findings when available. • Only courses that have dedicated an average of more than 75% of their content to sustainability topics as illustrated in their Bylaw description were selected for calculation when weighing the sustainability implementation in the program. • It analyzed the number of courses and their academic credits to the total credits offered. • Organization and timeline (levels of courses) will be analyzed using comparative analysis methodology between the two Egyptian institutions for the number and levels of the sustainability courses. • Implementation of strategies and ranges will be achieved by comparing the two institutions in terms of their achievement percentage in implementing sustainability and with past studies' percentages.
Criteria of Selection	• Well-known Prestigious Private and Public Higher Educational Institutions in Egypt. • The availability of the Information needed.
Results Presentation	• They will be provided as theoretical analyses and discussions. • They will be provided as tables and graphs.
Key Findings	• They will be related to current Programs and curriculum design concerning sustainability implementation in Egypt.

4. Egyptian Higher Educational Institutions' Architecture Curricula Comparative Analysis

A. First Higher Educational Institution; MAM Selection Criteria

Modern Academy for Engineering & Technology (MAM) is an educational higher institute, in Cairo, Egypt. It was selected for studying and analyzing its curriculum, since it was, one of the first, if not the first institute to comply with the benchmark 2020, issued by the Ministry of Higher Education and Scientific Research, for higher institutes and universities. This benchmark is a compulsory framework for developing new or updated bylaws and curriculums in all Higher Educational institutions in Egypt [13]. This benchmarking aims to unify the standards of the various programs in the different universities and institutions, to have a clear and specific image. It also creates Bylaws that comply with the most commonly used international educational systems, increasing Egyptian graduates' chances in the regional and global work field and facilitating students' mobility between universities in different countries worldwide. Finally, it takes advantage of the abundance, diversity, and development of the currently available learning resources, while changing the concept of the educational process by transforming it from education to learning [9].

Additionally, according to the ranking of the web of universities in 2022, MAM ranked 49th place out of 75 institutions in Egypt, where Cairo, Alexandria, Mansoura, Ain Shams, and American universities took the first 5 ranks, however, relative to the world ranking, it took the 4th rank over the private higher institutes in Egypt, the same in its category [14]. Furthermore, the architecture program at MAM was accredited by the National Authority for Quality Assurance and Accreditation of Education (NAQAAE) in April 2024 for 5 Years till April 2029 [15].

B. MAM Bylaw and Curriculum Analyses Compared to Past Studies

MAM has four active still Bylaws. In the latest Bylaw 2020, the institution adopted the benchmark 2020, where architectural students study 67 courses with 165 CHs as a total to graduate. The Bylaw was designed to incorporate 10 courses directly related to sustainable goals with a total of 22 CHs, representing 13.3 % of the total credit hours.

The methodology of selecting the courses depended on the main goal of the course and the percentage of sustainable-related topics discussed in the course syllabus and dedicated to sustainability whether it is social, physical, or economical. The researcher did not use the keyword methodology adopted in a previous study, although it will increase the resulting percentages because it was believed to be a not true increase. The keywords methodology can make courses be

included when they in reality have a low implementation of sustainability unless combined with a frequency analysis of the keywords and creating a standardization for it.

All the courses selected have at least 75% sustainability concentration according to their goals and content and reach 100% in many of them; compulsory and elective. Only the graduation project has different percentages; part (A) has at least 50% concentration and part (B) has at least 10% to 20% concentration. These numbers can increase greatly depending on the student, instructor, and themes adopted by the department. This analysing method was chosen because, in contrast to other methodologies adopted in previous studies that could incorporate courses with more generic aspects, it focuses on sustainability courses and their physical, environmental, sociocultural, and economic domains. The courses with their sustainable contents' main goals are illustrated in detail in Table 3 [16]. Additionally, Table 3 shows the continuity of the goals from one level to another, without repetition of aims.

In the fifth study, made by El-Feki et al., in Table 1, for the six Egyptian institutions under investigation, sustainability was discovered to be covered in all or none of the design studios, as well as in one theoretical course or more supplementary elective courses [8]. The study did not go into detail regarding the percentage of sustainable implementation in those courses to get to that amount. Thus, in this study, Table 3 shows how; two design studios, one practical elective course, three compulsory theoretical courses, and three elective theoretical courses incorporate sustainability. In comparison to El-Feki's research, this demonstrates that this curriculum has more than sufficient theoretical courses, however, it is at an intermediate level in terms of design studios. Additionally, when compared to the findings of the first study conducted by Santiago Porras Alvarez et al. for a few Asian countries, where the total number of sustainable courses ranges from 4 to 14 [7], this curriculum displays a total of 9 courses, placing it once more at the intermediate level. Moreover, the two studies demonstrate an equally balanced and diversified implementation of theories, technology, applications, and design studios in the curricula. However, given that the curricula are intended to build a technology speciality, technology is more excessive. Last but not least both studies showed that general theory courses address sustainability issues using conventional and locally relevant traditional and vernacular methods, technologies, and techniques.

Table 3. The analyses of the sustainability courses in Bylaw 2020 [16]

Level	Semester	Course Name	Course Sustainable Goal	Credit Hours	Course Type
Level Two	**Spring**	Environmental Control	It introduces the basics and fundamentals of environmental design.	2	Compulsory/ Theoretical
Level Three	**Fall**	Technical Installations (1)	It allows the student to understand and calculate thermal comfort in relation to air-conditioning. In addition to how to calculate artificial lighting.	2	Compulsory/ Theoretical
		Risk Management	It aims at implementing environmental concepts in the field of risk management.	2	Elective/ Theoretical
		Simulation Programs	It aims at teaching students computer software that can simulate and calculate various sustainable factors.	2	Elective/ Practical
	Spring	Technical Installations (2)	It allows the student to understand and calculate acoustics, plumbing work, and fire protection.	2	Compulsory/ Theoretical
		Architectural Design (6)	It requires studying the surrounding context and environment and implementing environmental strategies.	3	Compulsory/ Studio
		Sustainable Architecture	It aims to provide students with knowledge of various trends in sustainable architecture so students can design green buildings.	2	Elective/ Theoretical (With each other)
		Design, Environmental Planning & Power	It aims at studying environmental design in relation to conserving and optimizing energy consumption.		

Level Four	**Fall**	Graduation Project (A)	Students research for their graduation projects in relation to multiple factors and sustainability is one of them.	1	Compulsory/ Studio
	Spring	Urban & Environmental Conservation	It deals with the conservation of urban areas in relation to the limited resources and protection from degradation.	2	Elective/ Theoretical
		Graduation Project (B)	Implementation of all acquired sustainable skills and knowledge in the design process.	4	Compulsory/ Studio

Numerous methods and strategies can be used to arrange the sequencing or distribution of the courses along curricula [7]. As demonstrated in Fig. 2, when analyzing the selected sustainability-related courses over the academic years (levels), after illuminating the first preparatory year, since it is not related to the architecture specialization, it was found that the courses gave a skewed distribution. This so-called left-tailed distribution is optimum for creating a well-balanced curriculum concerning the students' academic levels.

Level one (semesters three and four) is an introductory year for the basics of architecture, followed by the appearance of sustainability courses that give the student basic knowledge in level two (semesters five and six). The third level (semesters seven and eight) is the year for increasing awareness and the start of mandatory application in the design studio. Finally, the fourth level is for the advanced level of implementation and application in the graduation project. Although this is an optimum distribution, however, an increase in the number of courses and applications is advised in level two.

This distribution is similar to what was found by Malik and Rahman at University Sains Malaya (USM) where the curriculum attempted to overcome the isolation of sustainability courses by systematically integrating them, over the span of the five-year architectural program [7]. On the other hand, this distribution is slightly different from that conducted in the study by Santiago Porras Alvarez et al., which discovered that the majority of sustainability courses in some Asian countries are located in the middle of their curricula, peaking between the fifth and seventh semesters [7]. As for the ratio between compulsory to elective courses; it was found adequate for a none sustainable architecture concentration program, at this stage.

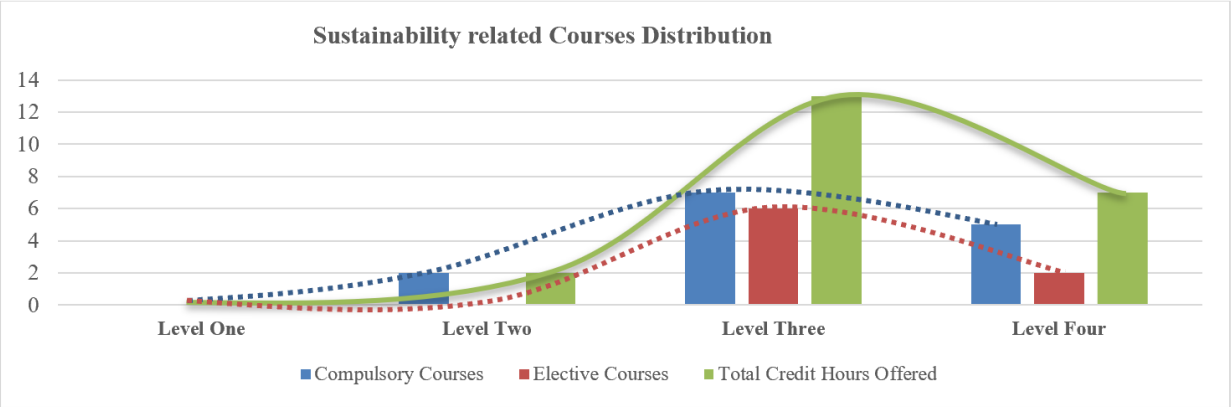

Figure 2 Sustainability courses' distribution in relation to academic level and course type.

When analyzing the sustainability courses percentage in the curriculum, as illustrated in Table 4 the 13.3% percentage relative to total credit hours required for graduation (classification 1) reached 17.05 % when only the four years of studying architecture were considered while excluding the first year which consists mainly of basic science, humanitarian, and cultural courses (classification 2). Additionally, it became 20.18% in another analysis (classification 3) that included only the courses required for achieving the general and specific specialization of the program as illustrated in Table 4 [16].

Furthermore, as demonstrated by Fig. 3, there is a linear increase in the courses' percentage with the highest when compared to specialization courses. These percentages are considered median when compared with the literature review and previous studies. For example, in contrast to

Santiago's study, which considered any course with one-third or more of its content dedicated to sustainability [7], this study's selection of specialized courses had an average of 75% of their content devoted to sustainability, despite that, the proportion of all implemented sustainable courses was still acceptable.

The sustainability courses ratio in this study ranged from 13.3% to 20.18% using the three different methods of calculation indicated above, as opposed to Santiago's study, which ranged from less than 5% to 25% at most. On the other hand, it is anticipated that these percentages will rise if the courses are analyzed using the methods used by Benkari in his research for UAE, where more courses would be included as sustainable. Benkari used certain keywords that gave a percentage between 8% to 45% for sustainable courses [12].

Determining the adequacy of the sustainability courses' percentage in the architecture curriculum is one of the research's main goals. Thus, to further evaluate it in the MAM curriculum relative to the Egyptian reality, a detailed comparative analysis with one of the 5 top-ranked institutions in Egypt will be conducted. The selected institution must also be internationally acknowledged and have a similar program concentration as the MAM program, which is the building technology and not environmental design concentration. The same methods used in analyzing MAM will be used in analyzing the newly selected institution, to be fairer when comparing.

Table 4. Three comparative analyses classifications of the sustainability courses percentages in Bylaw 2020 [16]

Classification (1)	CH	Classification (2)	CH	Classification (3)	CH
Total Credit Hours Required for Graduation (5 Years of study with 10 semesters.)	**165**	**Preparatory Year (Zero Level)** (Consists mainly of basic science, humanitarian, and cultural courses).	**36**	**University Requirements** (These are courses aiming at building the graduate's cultural personality and developing his personal skills and general awareness of community issues while focusing on identity and his connection to the homeland.)	**16**
Sustainability Courses	**22**	**Levels One, Two, Three & Four**	**129**	**Faculty / Institute Requirements** (These are courses that provide the minimum knowledge and skills of basic sciences, engineering culture, and basic engineering sciences that must be available in the graduate on all specialities allow it to allow him the minimum ability to communicate with engineers in other specialities and integrate into multi -specialized projects to be an effective member)	**40**
Sustainability Relative to Total Credit	**13.3%**	**Sustainability Courses**	**22**	**Requirements of the general specialization of the program**	**59**
		Sustainability relative to 4 years of Architecture Study	**17.05%**	**Requirements of the specific specialization of the program**	**50**
				Sustainability Courses	**22**
				Sustainability Relative to Courses Specialization	**20.18%**

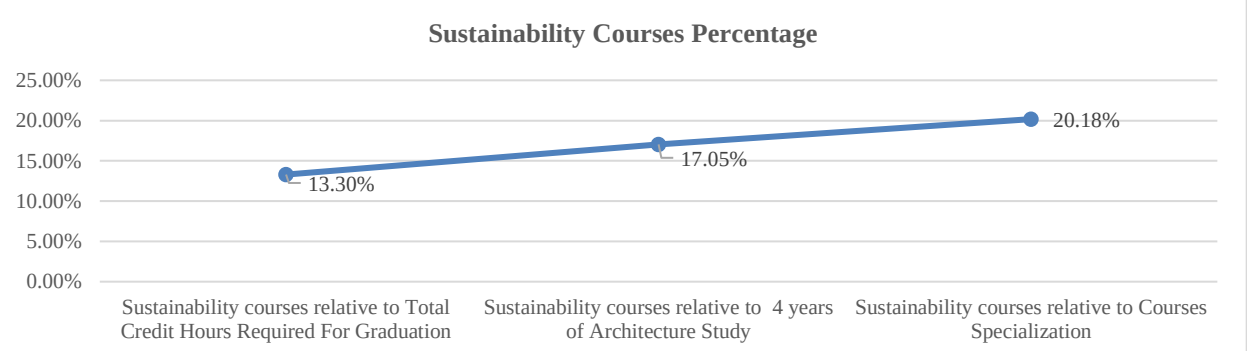

Figure 3 Sustainability-related courses analysis in relation to three classifications

C. Second Institution; Ain Shams University, Faculty of Engineering Selection Criteria

Founded in 1950, Ain Shams University (ASU) is one of the most important governmental (public) universities in Cairo, Egypt [17]. Ain Shams University, Faculty of Engineering ranked the 2nd out of 38 institutions in Egypt, the 5th out of 231 in Africa, and the 610th out of 4626 in the world. This ranking was based on non-academic reputation, research performance (publications and citations), and the impact of 58 valuable alumni. As for its Architectural engineering, it ranked 4th in Egypt and Africa, and 228th in the world [18]. It offers four concentrations; architecture, Building Technology, Urban Design, and Urban Planning. Students must finish 170 CHs to graduate [19]. The Curriculum dedicated to Building Technology was selected for comparison with the MAM curriculum. As previously mentioned, the program offered by MAM is "Architecture & Building Technology".

D. MAM Vs. ASU-ENG Curricula Comparative Analysis

The comparative analysis of the courses related to sustainability offered by the two institutions is demonstrated in Table 5. Graduation project courses (parts one and two) will be excluded from the analysis since they almost include the same sustainable implementation process but with different weighting values. Thus, as demonstrated in Table 5, the sustainable courses in the MAM curriculum have 17 CHs out of the 165 total credit hours, with a total percentage of 10.3% while the ASU-ENG offers 18 CHs with a total percentage of 10.6%. Thus, as shown in Fig. 4, it is obvious, that the two institutions have similar sustainability implementation percentages to the same concentration; the building technology.

When comparing the number of theoretical compulsory courses, it was found that ASU-ENG has 5 courses with 10 credits and 5.88%, while in the MAM curriculum, there are 3 courses with 6 credits and 3.64%. This percentage is a little low, thus at least one additional course related to sustainability should be converted to a compulsory course in any new curriculum for MAM.

Additionally, further analysis showed that there are some variations in the courses' titles and contents, which reflect different aspects when dealing with sustainability; however, there are still major similarities. The variations could be considered an advantage where different institutions provide, to the community, graduates with diverse skills and knowledge when approaching sustainability in the work field.

As for the main course, with the direct terminology sustainability, in MAM it is for the architecture as a whole while in ASU it is for rehabilitation of the built environment, however, in ASU it is a compulsory course and in MAM it is an elective course. Thus, it is advised that this is the course which needs to be converted to being compulsory in MAM's curriculum.

Table 5. A Comparative analysis of the sustainability courses in Bylaws of the two institutions (ASU and MAM), with the same concentration; Architecture & Building Technology [16, 19]

Level	Semester	Modern Academy Bylaw (2020) Architecture & Building Technology Program (165 CH)			Ain Shams University Bylaw (2018) Architecture Building Technology Concentration (170 CH)		
		Course Name	Credit Hours	Course Type	Course Name	Credit Hours	Course Type
Level One	Fall				Building Information Modeling (BIM)	2	Elective/ Practical
Level Two	Spring	Environmental Control	2	Compulsory/ Theoretical	Control of Thermal Environment	2	Compulsory/ Theoretical
					Human Behavior and the Built Environment	2	Elective/ Theoretical
Level Three	Fall	Technical Installations (1)	2	Compulsory/ Theoretical	Lighting in Architecture	2	Compulsory/ Theoretical
		Risk Management	2	Elective/ Theoretical	Built Environment Accessibility	2	Elective/ Theoretical
		Simulation Programs	2	Elective/ Practical			

	Spring	Technical Installations (2)	2	Compulsory/ Theoretical	Acoustics in Architecture	2	Compulsory/ Theoretical
		Architectural Design (6)	3	Compulsory/ Studio			
		Sustainable Architecture	2	Elective/ Theoretical (With each other)			
		Design, Environmental Planning & Power					
Level Four	**Fall**	Graduation Project (A)	1	Compulsory/ Studio	Graduation Project (1)	2	Compulsory/ Studio
		Urban & Environmental Conservation	2	Elective/ Theoretical	Daylighting and Thermal Performance	2	Compulsory/ Theoretical
					Sustainable Rehabilitation of The Built Environment	2	Compulsory/ Theoretical
	Spring				Renewable Energy and Buildings	2	Elective/ Theoretical
		Graduation Project (B)	4	Compulsory/ Studio	Graduation Project (2)	6	Compulsory/ Studio
Total	**5 Sem.**	**10 Courses**	**22 CH**	**6 M +4 E**	**11 Courses**	**26 CH**	**7 M+ 4 E**

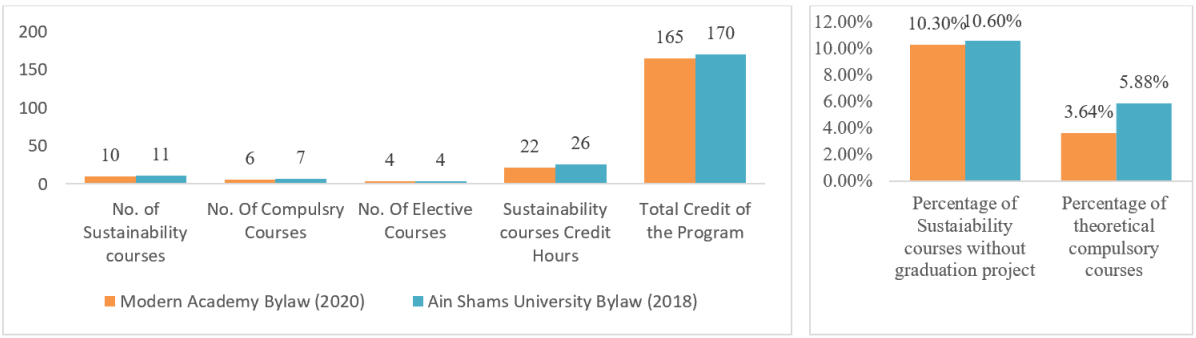

Figure 4 The comparative analysis of the sustainability courses in the two institutions for their building technology program

5. The Study Proposed Framework for Implementing Sustainability

The pursuit of a sustainable built environment necessitates the expertise of qualified professionals, particularly architects. Consequently, as a result, an architecture curriculum is crucial for guiding professional choices in architectural practice [10]. Therefore, the research now will provide its proposed framework for a curriculum design with balanced sustainability implementation, for all concentrations apart from the environmental/sustainable concentration.

The sustainability courses' design proposed in the curriculum is demonstrated in Table 6, where there must be at least 4 compulsory theoretical courses with a total of 8 CHs and another 4 elective theoretical courses with another total of 8 CHs. The framework suggested 7 different elective courses that are greatly needed in the work field to select from. This means a total of 8 courses with 16 CHs for theoretical courses alone. Their sequence and distribution are relative to the student's level and the course scope as demonstrated in Table 6. Additionally, their goals must create a balance between the three domains of sustainability; physical/ environmental, social, and economic.

As for the design studios, there is a need for at least one sustainable design studio with 3 CHs besides the graduation project with a minimum of 5 CHs, with a total of 8 CHs. Additionally, to increase the students' practical skills in applying sustainability it is advised to follow the courses' main assessment method and contact hours distribution suggested by Table 6.

In conclusion, the framework proposed by the research consists of a minimum total of 24 CHs, for all different architectural concentrations aside from the sustainable concentration with total credit hours between 165 and 170. However, it must be acknowledged that implementing sustainability inside all design studios and theoretical courses with different dosages is a good

alternative for implementing sustainability in the Bylaws and programs with lowered credit hours availability.

Table 6. The framework proposed by the research for a balanced sustainability implementation in the curriculum

Courses required	Scope / Level of the Course	Courses' Main Assessment Method	Credit Hours	Type of Course	Min. Contact Hours Needed
Course (1)	Basic Environmental Principles (Second year of architecture study)	One or Mini Projects	2	Compulsory	2 H Lecture + 1 H Section
Course (2)	Sustainable Architecture (Types and Trends) (Third year of architecture study)	One or Mini Projects	2	Compulsory	2 H Lecture + 1 H Section
Course (3)	Technical Course (1) such as Thermal/ HVAC/ Lighting. (Third year of architecture study)	One or Mini Projects	2	Compulsory	2 H Lecture + 1 H Section
Course (4)	Technical Course (2) such as Acoustics/ Water / Wastes. (Third year of architecture study)	One or Mini Projects	2	Compulsory	2 H Lecture + 1 H Section
Course (5)	Environmental Software & Simulation Programs (Third year of architecture study)	Weekly Assignments & Final Project	2	Elective	1 H Lecture + 2 H Section
Course (6)	Environmental Planning (Third or fourth year of architecture study)	One or Mini Projects	2	Elective	1 H Lecture + 2 H Section
Course (7)	Urban & Environmental Conservation (Third or fourth year of architecture study)	One or Mini Projects	2	Elective	1 H Lecture + 2 H Section
Course (8)	Sustainable Risk Management (Third or fourth year of architecture study)	One or Mini Projects	2	Elective	2 H Lecture
Course (9)	Sustainable Landscape (Third or fourth year of architecture study)	One or Mini Projects	2	Elective	1 H Lecture + 2 H Section
Course (10)	Sustainable Rehabilitation of The Built Environment (Third or fourth year of architecture study)	One or Mini Projects	2	Elective	2 H Lecture
Course (11)	Renewable Energy and Buildings (Third or fourth year of architecture study)	One or Mini Projects	2	Elective	2 H Lecture
Course (12)	Environmental Design Studio (Third year of architecture study)	One project	3	Compulsory	1 H Lecture + 6 H Sections
Course (13)	Graduation Project (Part 1 & 2) (Fourth year of architecture study)	One project	Min. 5	Compulsory	2 H Lecture + 9 H Sections

6. Conclusion

A thorough literature review was conducted in order to comprehend how sustainability implementation was previously studied in the architecture educational system worldwide. The results were used for benchmarking and comparison in this study. The research first analysed case study was MAM an Egyptian private higher institute. Its Bylaw, architecture curriculum, and courses were analyzed to examine its implementation of sustainability.

Based on the available information, it was found that the sustainable courses ranged from 13.3% to 20.18%. It was observed that these percentages represent an intermediate percentage of sustainable courses when compared to the results from the UAE (8%-45%) and the Asian (5%-25%) institutions from past studies. However, in comparison to the results of the other 6 Egyptian institutes in the El-Feki et al study, it was found to be more than adequate. Additionally, the comparative analysis with the second case study, the Ain Shams University architecture program, when excluding graduation projects, MAM had 10.3% and Ain Shams had 10.6%. All these numbers reflect an appropriate sustainable implementation especially since the program under study is with building technology and not sustainable concentration. However, a change to the ratio between compulsory to elective courses is recommended in favour of compulsory courses in MAM's curriculum.

Additionally, when analyzing the distribution of the sustainability-related courses over the academic years (levels), they were found to be concentrated in the third level (semesters seven and eight), which is optimum although different from Santiago et al. study. The sustainability courses in the Asian countries of the study are found in the middle of their curricula, peaking between the fifth and seventh semesters.

Finally, the study presented its proposed framework in Table 6 that may be used when designing the architecture curricula in the future, to have a balanced sustainable implementation. The framework discusses 13 courses that could be added to any program, apart from a sustainability specialization, with a total of 24 CHs. The proposed framework included the suggested courses' scopes, levels, main assessment method, credit hours, types, and the required minimum contact hours with their distribution between lectures and sections.

7. Recommendations

For future study it is recommended to:

- Apply the findings and framework proposed by the research on other institutions, then conduct a comparative analysis with these research findings.
- Studying and analysing the main sustainability course inside the architectural curriculums of the institution under study in detail and evaluating the students' feedback.

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✉Authors Emails

R. M. M. Mohie El-Din: eng_rehammostafa@yahoo.com

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