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OPTIMIZING THE PERFORMANCE OF UNIVERSITIES BUILDINGS IN EGYPT AS A MEANS OF ACCOMPLISHING THE 2030 SUSTAINABLE DEVELOPMENT GOALS

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ABSTRACT

The 2030 Sustainable Development Goals are a pressing worldwide collaboration call to action for all countries. In accordance, Egypt Vision 2030 aims to integrate sustainable development concepts and objectives into all state institutions. The United Nations in Egypt had declared that a number of multiple actions are ongoing through the process of enhancing the fourth sustainable development goal which is quality education by means of several factors. Among most of the important factors is improving higher education institutions' quality. Architecture of Universities can impact student experiences and learning outcomes by providing a significant learning environment, preparing students for the future, and embracing intelligent and efficient design strategies. Enhancing the performance of Universities' buildings could possibly be a step forword to achieve the fourth sustainable development goal. The authors adopted data collection strategy to review the means of accomplishing the sustainable development goals focusing on the fourth development goal locally and globally, as well as assessing the factors of optimizing the performance of Universities' buildings in order to promote quality education. The authors then adopted case studies analysis globally represented in University of Orgeon, United States, and locally represented in the American University in Egypt to analyze the strategies used by the case studies in order to enhance its quality. The authors concluded a set of guidelines in order to optimize the performance of Universities' buildings in Egypt in a trial to enhance achieving the 2030 fourth sustainable development goal.

KEYWORDS: Sustainable development goals, Quality Education, Performance of Universities' buildings, Higher education institutions' quality, Egypt Vision 2030.

تحسين أداء مباني الجامعات في مصر كوسيلة لتحقيق أهداف التنمية المستدامة 2030

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قسم الهندسة المعمارية و تكنولوجيا البناء ، الأكاديمية الحديثة للهندسة و التكنولوجيا ، المقطم ، القاهرة ، مصر.

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الملخص

تمثل أهداف التنمية المستدامة لعام 2030 دعوة ملحة للتعاون العالمي للعمل لجميع البلدان. ومن هذا المنطلق، تهدف رؤية مصر 2030 إلى دمج مفاهيم وأهداف التنمية المستدامة في كافة مؤسسات الدولة. وكانت الأمم المتحدة في مصر قد أعلنت أن عددًا من الإجراءات المتعددة جارية من خلال عملية تعزيز الهدف الرابع للتنمية المستدامة وهو التعليم الجيد من خلال عدة عوامل. ومن بين أهم العوامل تحسين جودة مؤسسات التعليم العالي. يمكن أن تؤثر هندسة الجامعات على تجارب الطلاب ونتائج التعلم من خلال توفير بيئة تعليمية مهمة، وإعداد الطلاب للمستقبل، وتبني استراتيجيات التصميم الذكية والفعالة. قد يكون تحسين أداء مباني

الجامعات خطوة للأمام لتحقيق الهدف الرابع للتنمية المستدامة. واعتمد المؤلفون استراتيجية جمع البيانات لاستعراض سبل تحقيق أهداف التنمية المستدامة مع التركيز على الهدف التنموي الرابع محليا وعالميا. وكذلك تقييم عوامل تحسين أداء مباني الجامعات من أجل تعزيز جودة التعليم. ثم اعتمد المؤلفون تحليل دراسات الحالة ممثلة عالمياً في جامعة أورجيون بالولايات المتحدة، وممثلة محلياً في الجامعة الأمريكية في مصر لتحليل الاستراتيجيات التي تستخدمها دراسات الحالة من أجل تعزيز جودتها. وتوصل المؤلفون إلى مجموعة من المبادئ التوجيهية لتحسين أداء مباني الجامعات في مصر في محاولة لتعزيز تحقيق الهدف الرابع للتنمية المستدامة 2030.

الكلمات المفتاحية : أهداف التنمية المستدامة، جودة التعليم، أداء مباني الجامعات، جودة مؤسسات التعليم العالي، رؤية مصر 2030

1. INTRODUCTION

The United Nations approved the Sustainable Development Goals (SDGs), sometimes referred to as the Global Goals, in 2015 as a global call to action to end poverty, safeguard the environment, and guarantee that by 2030 all people live in peace and prosperity. The 17 SDGs are interconnected; they acknowledge that decisions made in one area will have an impact on other areas and that development must strike a balance between environmental, social, and economic sustainability.

The research problem can be summarized in the lack of research based solutions that promote the improvement of higher education institutions' quality as a main strategy in Egypt Vision 2030 for accomplishing the Sustainable development goal (SDG4) quality education.

Nations have made commitments to give developing nations' improvement the highest priority. The sustainable development goals must be accomplished in every setting with the help of all societal members' creative thinking, expertise, technology, and financial resources.

Accordingly, the research main objectives are:

- Discuss and review the sustainable development goals of 2030, focusing on the Fourth Sustainable Development Goal (SDG4) which is Provide Quality Education, Egypt Vision 2030 focusing on fourth sustainable development goal.
- Analyzing the optimization of the performance of each space inside the Universities' buildings as well as the switching into green uvinersities and case studies represented in the University of Orgeon, United States, and the American University in Egypt and its used strategies in order to enhance their performance and consequently their quality.
- Conducting a set of guidelines in order to optimize the performance of Universities' buildings in Egypt in a trial to enhance achieving the 2030 fourth sustainable development goal.

2. RESEARCH METHODOLOGY

The research has been structured into three distinct approaches, each focusing on a different stage of the inquiry process. The first approach involves gathering information and doing a literature review on the following points:

- The sustainable development goals of 2030.
- The Fourth Sustainable Development Goal (SDG4) which is Provide Quality Education.
- The accomplishment of the sustainable development goals in Egypt through Egypt Vision 2030 focusing on fourth sustainable development goal.

- The optimization of the performance of Universities' buildings including classrooms, lecture halls, laboratory spaces, hallways, reception areas, and service areas.
- The switching into green uvinersities and its relation ship with maximizing the learning outcomes of students which will consequently improve the quality education.

The second approach involves case studies analysis globally represented in the University of Orgeon, United States, and locally represented in the American University in Egypt to analyze the strategies used by the case studies in order to enhance their performance and consequently their quality.

The authors concluded a set of guidelines in the third approach as a result of studying both the first and second approaches in order to optimize the performance of Universities' buildings in Egypt in a trial to enhance achieving the 2030 fourth sustainable development goal.

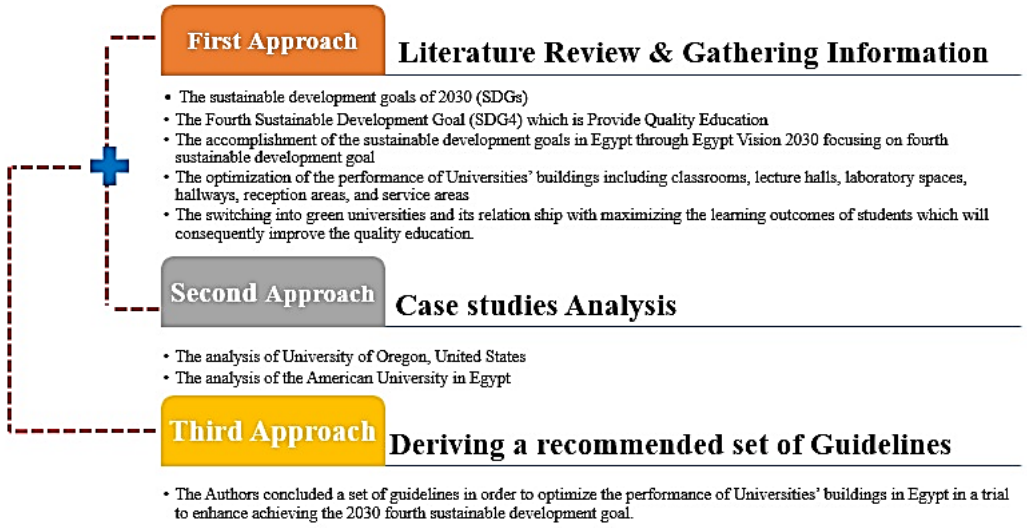

Fig. 1. Research Methodology. Source: (The Authorsauthors)

3. LITREATURE REVIEW

3.1. The Sustainable Development Goals 2030

A common roadmap for peace and prosperity for people and the planet, both now and in the future, is provided by the 2030 Agenda for Sustainable Development, which was accepted by all United Nations Member States in 2015. The 17 Sustainable Development Goals (SDGs), represent an urgent call to action for all nations in an international collaboration [1]. These goals are established for overcoming poverty and other forms of inequality, also for maximizing concerted efforts to fight climate change, protect our seas and forests, enhance health and education, in addition to promoting economic growth [1].

The sustainable development goals will be achieved by uniting the governments, corporations, media, Universities, and regional non-governmental organizations to enhance the quality of life for citizens in all of the countries by 2030. The 17 sustainable development goals are [1, 2]:

(SDG 1): Eliminate Poverty

(SDG 2): Erase Hunger

(SDG 3): Establish Good Health and Well-Being

(SDG 4): Provide Quality Education

(SDG 5): Enforce Gender Equality
(SDG 6): Improve Clean Water and Sanitation
(SDG 7): Grow Affordable and Clean Energy
(SDG 8): Create Decent Work and Economic Growth
(SDG 9): Increase Industry, Innovation, and Infrastructure
(SDG 10): Reduce Inequality
(SDG 11): Mobilize Sustainable Cities and Communities
(SDG 12): Influence Responsible Consumption and Production
(SDG 13): Organize Climate Action
(SDG 14): Develop Life Below Water
(SDG 15): Advance Life On Land
(SDG 16): Guarantee Peace, Justice, and Strong Institutions
(SDG 17): Build Partnerships for the Goal

3.1.1. The Fourth Sustainable Development Goal (SDG4): Provide Quality Education

Noticeable progress has been made towards accomplishing the goal of universal primary education since 2000. The proportion of children not attending school has decreased by nearly half globally, with the overall enrollment rate in developing nations reaching 91% in 2015. In addition, there has been a significant rise in the percentage of girls enrolled in school than ever before and in literacy [3]. The Primary targets for the fourth SGD are summarized in the following [3]:

- It is essential that all boys and girls receive free, equitable, high-quality primary and secondary education by 2030, resulting in learning outcomes that are relevant to and effective for Goal 4.
- Facilitating that all boys and girls have access to high-quality pre-primary education, early childhood development, and care by 2030 so they are prepared for primary education.
- Permitting that all men and women have equal access to reasonably priced, high-quality technical, vocational, and postsecondary education by 2030, including university education.
- Increase the proportion of children and people with the necessary technical for employment, respectable careers, and entrepreneurship by a significant margin by 2030.
- Eliminate gender gaps in education by 2030 and guarantee people with disabilities, and children in risky situations equal access to all educational opportunities.
- It is a priority to ensure that by 2030, every young person and a significant percentage of adults' men and women are literate and able to count.
- Construct and renovate educational facilities that include the needs of children, people with disabilities, and women, and that offer a safe, peaceful, welcoming, and productive learning environment for all.
- Increase the number of certified teachers available by 2030, especially through international collaboration for teacher preparation in developing nations.

3.1.2. The accomplishment of the sustainable development goals in Egypt: Egypt Vision 2030

Egypt Vision 2030 is a national agenda that was introduced in February 2016 and represents the nation's long-term strategic strategy to mainstream sustainable development ideas and goals throughout all state institutions. "Comprehensive sustainable development" and "balanced regional

development" are the fundamental principles of Egypt Vision 2030. Egypt Vision 2030 includes the three aspects of sustainable development: the environmental, social, and economic components. Egypt made the decision to revise its sustainable development plan in the beginning of 2018 in order to stay up with changes in the local, regional, and international context, with the assistance of development partners. Egypt Vision 2030, in its second edition, aims to inspire by outlining how Egypt's contribution would benefit the international agenda and the larger global context. The updated vision places a strong emphasis on approaching every problem from the perspective of the environmental, economic, and social components of sustainable development. It is a comprehensive and well-organized vision made up of the sector-specific plans of the government ministries [4].

Egypt Vision 2030 emphasizes on raising the standard of living and quality of life for Egyptian residents in every aspect of life through the promotion of social integration, justice, and citizen participation in politics and society together. This is in addition to achieving high, inclusive, and sustainable economic growth, increasing investment in people, and developing their creativity through greater knowledge, innovation, and scientific research in all disciplines. Egypt Vision 2030 prioritizes creating an integrated and sustainable ecosystem that increases resilience and capacity to withstand natural disasters in order to mitigate the consequences of climate change. The vision also emphasizes how state and local institutions are governed through improvements in administrative transparency, the establishment of monitoring and evaluation systems and the empowerment of Local administrations ministries [4].

Egypt Vision 2030, is a step towards promoting equitable growth through applying the Sustainable Development Strategy (SDS). The Sustainable development strategy was established using a participatory strategic planning methodology, in which leaders of the national and international development community, government organizations, and representatives of civil society worked collaboratively to establish broad goals for every area and pillar of the economy [5]. The Egypt Vision 2030 through applying the (SDS) is shown in **Table 1.**

Table 1. Comparison between the Sustainable development goals (SDGs) & the sustainable development strategy (SDS)in Egypt Vision 2030 that is set to achieve the SDGs. Source: (Arab Development portal, 2023)

The Sustainable Development Goals according to the United Nations (SDGs)	**The Sustainable Development Strategy (SDS) : Egypt Vision 2030**
Sustainable Goals	**Sustainable Strategy to achieve the goals**
(SDG1): Eliminate Poverty (SDG2): Erase Hunger (SDG3): Establish Good Health and Well-Being (SDG4): Provide Quality Education (SDG5): Enforce Gender Equality (SDG6): Improve Clean Water and Sanitation (SDG7): Grow Affordable and Clean Energy (SDG8): Create Decent Work and Economic Growth (SDG9): Increase Industry, Innovation, and Infrastructure (SDG10): Reduce Inequality (SDG11): Mobilize Sustainable Cities and Communities (SDG12): Influence Responsible Consumption and Production (SDG13): Organize Climate Action (SDG14): Develop Life Below Water (SDG15): Advance Life On Land	Enable Egypt to be an Active global Player Meet the Ambitions of Egyptians to improve the efficiency of Basic services Enable the Civil Society organizations ans parliament members to monitor the implementation of the strategy. Its Objectives, Targets, programs, and projects implemented according to a specific timeline. Align SDS objectives with the sustainable development goals, and the sustainable development strategy for Africa 2063. Develop a long term unified political, economic, and social vision as the base for short and medium term development plans at the national, local sectorial levels.

(SDG16): Guarantee Peace, Justice, and Strong Institutions (SDG17): Build Partnerships for the Goal	

3.1.3. The accomplishment of the fourth sustainable development goal (SDG4) in Egypt

Aiming to address the main development difficulties that people in Egypt and around the world come across, the UN and its partners in Egypt continue to attempt to achieve the 17 Sustainable Development Goals. During the current program cycle in Egypt, the number of activities in order to reach the fourth development goal (SDG4: Quality Education) for each place is shown on the map below in **Fig.2** [6].

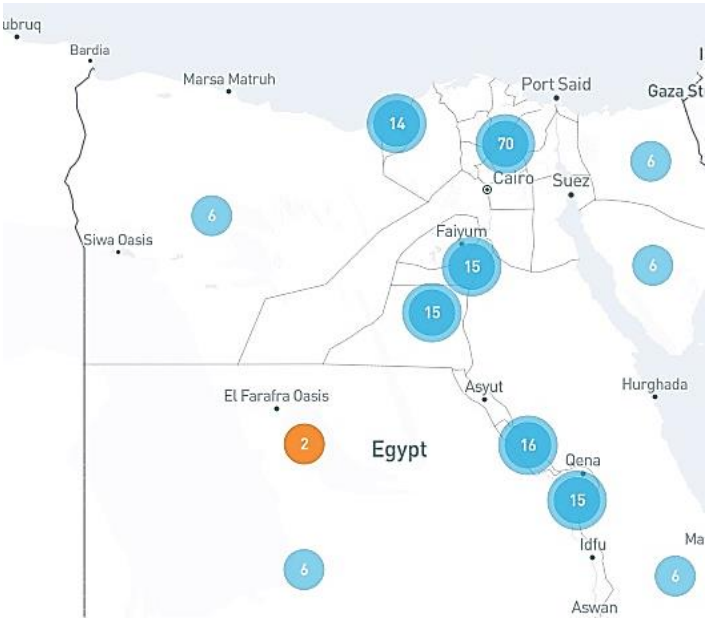

Fig. 2. The number of activities distributed all over Egypt for achieving the SDG4. Source: (United Nations Egypt, n.d)

For Achieving the fourth sustainable development goal which is quality education, the United nations in Egypt had declared that a noticeable number of ongoing activities had been processed with detailed locations of total number of activities 163 in the whole education process for all levels, in addition to two activities at a country level marked around El Farafra Oasis [6] as shown in **Fig.2.** In terms of enhancing the higher education specifically and training programs in Egypt, multiple actions are ongoing through the process of enhancing the fourth sustainable development goal (SDG4) which are : [5]

-Establishing institutions of higher education in collaboration with the private and civil sectors.
-Development of the teaching staff's human capital.
-Enhancing the roles and responsibilities of research centres in universities.
-Establishing interactions at the local, regional, and global levels between graduates and employment institutions.
-Launching the "Egyptian Diplomas Equivalency System" and accepting credentials from higher education.
-Developing curriculum using the "National Qualifications Framework" as a guide.

-Improving higher education institutions' quality.
-Updating the process of university admissions.

3.2. Optimizing the performance of universities

The design of universities is a critical aspect of creating a space that not only supports students academically but also supports them socially. There are multiple important factors need to be considered in the process of designing universities. The urban planning strategies is one of the most important factors. Designing the university campus is like planning a mini city. It is imperative to visualize the scale of the urban public space project and the design on one axis [7]. Considering the essential facilities, which is an essential component of university design. A comprehensive experience integrating important facilities like social and cultural settings and academic buildings (labs, lecture halls, and studios) should be made accessible by the design. The design must also be visually appealing and represent the university's identity. It is the role of designers to create an environment that gets students ready for the future [7]. On a larger scale, the most influence on students' sense of belonging to the campus culture comes from well-designed university campuses [8]. Campuses that are intended to make students feel at home are valued by modern students [8]. However, relationships with the surrounding community must be considered when planning the campus. This could include forming partnerships with adjacent businesses and groups to give students access to opportunities and experiences in the real world [9].

3.2.1 Optimizing the performance of buildings: Classrooms and Lecture Halls

Recently, after the panademic, most universities had turned from huge lecture halls to smaller classrooms, as well as having multiple zones to be suitable for modest group work [10]. These solutions should enhance social distancing and led discussions, as well as supporting these spaces with light movable furniture to be reorganized as needed. Through a wider perspective, the percentage of the classroom spaces in the majority of universities was less than 5% which is definitely an authentic nominal percentage [10]. Several small classrooms or conference rooms are recently recommended with a noticeable percentage so as it permits more flexibility and multi-usage functions.
The classrooms' design should enhance social distancing as well as un-affecting the student's communication as shown in **Fig.3.** Moreover, integrated technology became a must inside lecture halls and classrooms in order to enhance remote communication between students and to assure a successful hybrid educational system. Technology is used in modern learning for note-taking, homework, presentations, and other class activities. Charging stations and plenty of outlets are required to ensure that online course materials and assignments are easily accessible. Large, interactive touchscreens that display essential building or program information can also be used to embed technology throughout a building. Virtual teaching and videoconferencing are very important in today's classrooms**.**
In addition to the natural ventilation, natural lighting, individual movable furniture with wider paths if possible, and entry door sensors with sanitization spaces were also recommended [10]. Also, requiring both institutional and sanitizing surfaces have become an extremely considerable parameter in designing learning environments. Self and easily cleaning surfaces with colourful texture was and still an advisable solution [11].

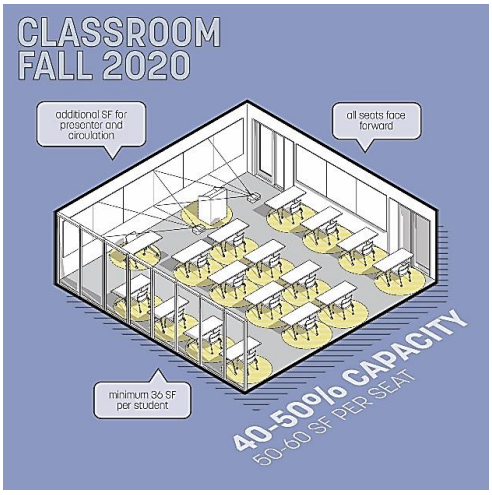

Fig.3 A model for the design of classrooms after the pandemic. Source: (Sasaki, 2020)

3.2.2 Laboratory spaces

Laboratory spaces should also promote social distancing as well as guaranteeing the optimal exploration of sciences as shown in **Fig.4**. Numerous colleges had invested in some featured lab facilities that could help students in both exploring and keeping the social distancing [12]. Digitalized interdisciplinary laboratories were extremely necessary. Careful collaboration was highly recommended depending on the field of study, and discipline. However, many fields of study require human engagement more than online courses. It is usually recommended a hybrid educational attributes for undergraduate students, however with post graduate students and professionals it is strongly preferable using more online platforms and virtual laboratories [11]. Internet connectivity has become an extremely critical requirement inside all educational spaces of universities. Sanitization of Laboratories with a constant rate considering all the required precautions for protecting equipment as well as guaranteeing the best disinfection cleaning methods had and still been importantly increasing [13].

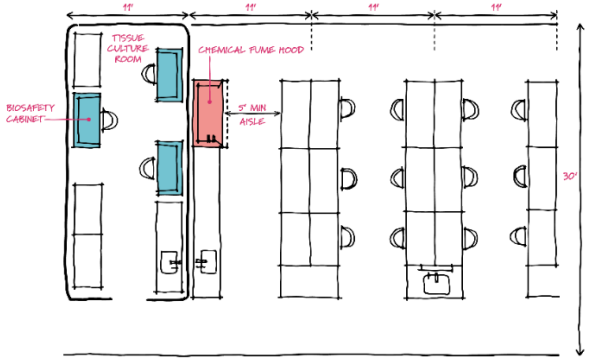

Fig.4 A model for the design of Laboratory space. Source: (Lab Manager, 2021)

3.2.3 Hallways, and Reception areas

Establishing zones where people could communicate through designing the campus, hallways and reception areas. Built in furniture was one of the practical options in hallways and office receptions. After the pandemic, replacing the long benches with multiple shorter ones so that students cannot gather in a closer proximity might be a relevant option [10]. In addition to, university campus and hallways should also have an internet access. There is no need for such massive technological facilities in spaces without a strong access for internet. Educational institutions must require such

significant connectivity resources which students might not have at the present time [11]. Also the routine cleaning and sanitizing for the reception areas and hallways multiple times a day had been required so as to guarantee the best healthy environment for students and co-workers [14].

3.2.4 Service areas

Installing sensor bathroom's devices so as to enhance the un-spreading of germs through the multiple touching was a practical and saving solution during the pandemic and still a good hygienic option for healthier bathrooms [15]. Moreover, the usage of durable, easy cleaning, or even self-cleaning surfaces were highly recommended for hygienic reasons, as well as silver and copper hardware for their natural anti-microbial properties [15].
In general, scientists, engineers, and governments have recognized all disease-prevention solutions and recommended cautious measures to promote healthy universities and reduce disease transmission through the following sustainable applied techniques: [16]

- Installing Bipolar ionization HVAC systems (in current and prospective buildings), which improve indoor air quality and limit the transmission of pathogens.
- Increased contactless routes, such as smartphone control lifts, touchless door and window locks, and automatic door opening with face ID.
- The use of antimicrobial paint and particles in existing and future buildings to minimize disease transmission.
- Use of antimicrobial copper coated contact surfaces (for example, door and window knobs, walls, etc.)

3.2.5 Switching into Green Universities

Green universities are defined as "Educational institutions that meet their needs of natural resources; energy, water, and materials without compromising the ability of current and future generations to meet their own needs" and "universities that work to achieve sustainability in the curricula of teaching and scientific research through the provision of specialised courses" [17]. Based on the information previously provided, green universities are academic establishments that strive for sustainability across a range of operations, purposes, and objectives.

The University of Indonesia's Green Metric World University Ranking is used to categorise green universities. It serves as a forum for academics globally to exchange best practices and information about achieving sustainability on campus and gives each university the chance to assess its own capabilities and deficiencies in advancing green university and sustainable development. The basis for this classification is based on several factors. Among the most important factors in terms of promoting the performance of universities' buildings is Energy and climate change which acquired a percentage (21%). This criterion is getting the greatest attention on the global green scale. Achieving this factor is expressed in terms of applying the following strategies: [18].

- Usage of campus-based energy-saving equipment.
- Develop environmentally conscious and intelligent building strategies on campus.
- Enhancing the quantity of renewable energy sources on campus
- Managing the overall electricity consumption in relation to the total number of campus employees.
- Handling the percentage of renewable energy generated
- Applying the components of green building implementation as specified in all building and renovation policies

- Usage of the greenhouse gas emissions reduction program

3.3. The relationship between optimizing universities' buildings and the sustainable development goal (SDG4) Quality Education

In terms of enhancing the higher education specifically and training programs in Egypt, multiple actions are ongoing through the process of enhancing the fourth sustainable development goal (SDG4), one of them that is clearly declared by the Egyptian governance which is Improving higher education institutions' quality. Enhancing the architecture of universities could possibly be a step forword the fourth sustainable development goal (SDG4) which is Quality Education as shown in **Fig.5.**

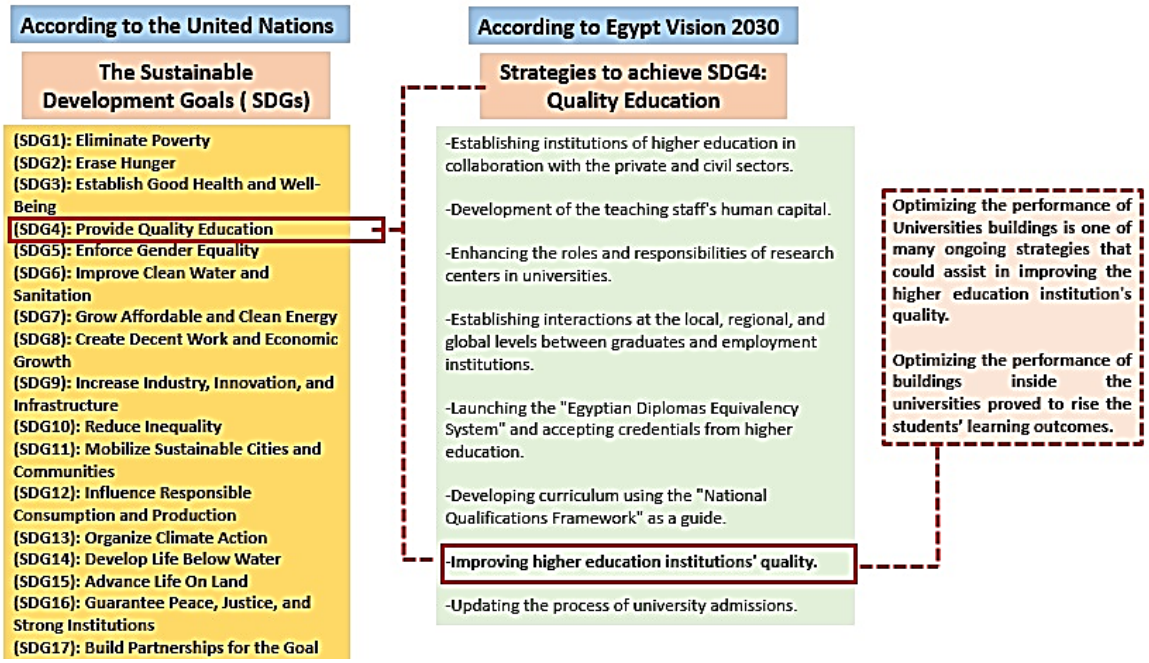

Fig.5 The relation ship between optimizing universities' buildings & the SDG4 Quality Education. Source: (The authors)

3.3.1 Impact of universities' buildings on the learning outcomes of Students

The design of universities can impact student experiences and learning outcomes by providing a significant learning environment, preparing students for the future, and embracing intelligent and efficient design strategies. Student satisfaction with the learning environment is highly dependent on their perception of the aesthetics and spatial organization of the facility and whether a space is suitable to learning [19]. On the other side, universities'design must prepare students for the future by providing them with the necessary skills and resources. Universities must have a supportive environment to develop highly skilled professionals in established fields [20].

Several unique design aspects can enhance student learning in a university context. Some of these design aspects, according to a study, include movement and furniture, perception of space, and the use of active learning classrooms [9]. Furthermore, good university campus design should include students' social and psychological requirements, designing areas that help them feel at ease and connected to the university culture [9]. It is common knowledge that students learn better when they work together. Collaborative learning has been shown to improve students' high-level thinking skills while also increasing their confidence and self-esteem. These strategies enable students to

gain mastery of the content while also improving their social, interpersonal, and leadership abilities. Students are drawn to communal places with pleasant furniture and dining options that are strategically placed near them. Students can alter the level of transparency in collaborative rooms by using movable partitions and whiteboard walls or windows.

4. CASE STUDY ANALYSIS

In this section, the authors adopted case studies analysis globally represented in university of Orgeon, United States, and locally represented in the American University in Egypt to analyze the strategies used by the case studies in order to enhance its quality.

4.1. University of Orgeon, United States

The University of Oregon is one of just two schools in the Pacific Northwest chosen for membership in the highly selective Association of American Universities, a group of more than 70 premier public and private academic institutions in the United States and Canada [21]. In its efforts to become a green university, the University of Oregon meets the following globally green standard criteria: [22]

- The campus buildings have green roofs that lower temperatures by absorbing sunlight.
- Special tiles are used to regulate heating and cooling.
- Reducing the need for central heating systems through using windows with sensors that notify users when to open them and automatically adjust the heating or air conditioning.
- Utilising solar energy to generate electricity and energy across the campus, and taking advantage of natural lighting.
- A number of recently constructed buildings in the university are officially "green," achieving gold and platinum certification from the Leadership in Energy and Environmental Design (LEED) programme of the U.S. Green Building Council. [23]
- The Lillis Business Complex, that holds the Lundquist College of Business and has a silver level accreditation, was the first LEED certified building on campus. The five photovoltaic arrays, which produce electricity and power for Lillis and other campus buildings, are its most significant feature. Lillis was also the first building on campus to have a green roof, featuring plants and soil that absorb sunlight, reduce heat gain, and slow down the rate at which stormwater runs off. In addition, it has an additional floor slab that controls temperature, reducing the need for central heating systems. [23]

Fig.6 The Lillis Business Complex. Source: (SRG Partnership, 2024)

Fig.7 The Lillis Business Complex's plan. Source: (University of Orgeon, n.d).

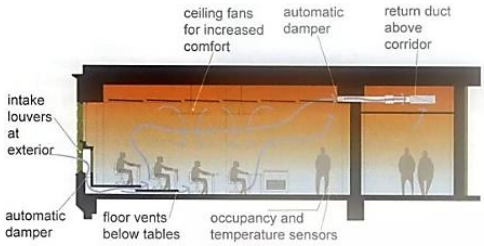

Fig.8 Hybrid Ventilation for Lillis Business Complex. Source: (Green Studio, 2024).

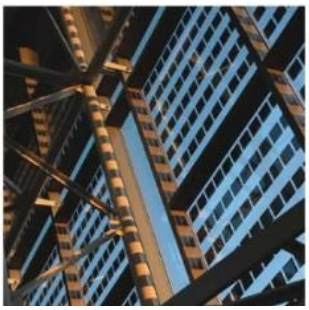

Fig.9 Glass curtain wall with integrated photovolatic. Source: (Green Studio, 2024).

- The Robert and Beverly Lewis Integrative Science Building is the first laboratory in the state of Oregon to receive the LEED Platinum certification. Additionally, it is one of the few research labs worldwide to hold the LEED Platinum certification. The building's sustainable features include a heat recovery unit that recycles heat from the utility tunnel system and heating and cooling exhaust; 28 solar panels that heat water; windows that automatically adjust the temperature when opened and have sensors that notify users of the best times of day to open them; bathrooms that use recycled water; and bamboo-based wood finishing. Comparing the building to comparable structures built to fulfil code requirements, it uses about 58% less energy. [23]

Fig.10 The Robert and Beverly Lewis Integrative Science Building. Source: (Arch week people and places, 2012).

Fig.11 The Robert and Beverly Lewis Building's skylight. Source: (Arch week people and places, 2012).

- The Cheryl Ramberg Ford and Allyn Ford Alumni Centre, which houses the UOAA, gained gold certification when it opened in 2011. To avoid heat buildup, window shades are automatically

raised and lowered according on the sun's angle, natural lighting is used wherever practical, and a rain garden cleans and slows stormwater runoff before it enters the Willamette River. [23]

Fig.12 The Cheryl Ramberg Ford and Allyn Ford Alumni Centre. Source: (UO Alumni, n.d).

4.2. The American University in Cairo, Egypt

The American University in Cairo is located in the heart of the Middle East. It is a leading English-language, American-accredited higher education university as well as a centre of Arab intellectual, social, and cultural life. [26]

The American University in Cairo's leadership in the field of sustainability has resulted in its strategies and practices being included in the United Nations Environment Program's Green Universities Toolkit as a global example of a green educational institution to be emulated globally. The university achieved its position by focusing on the following strategies: [27]

- In order to develop a plan targeted at lowering energy consumption by at least a third over a three-year period, the university assembled an internal work team dedicated to energy, which included architects, engineers, facilities directors, budget officials, and representatives of the Faculty of Science and Engineering.

- Additionally, it produced a dual strategy that aims to ensure that lighting, heating, and cooling systems are installed and operated appropriately, as well as to prevent their excessive usage. As a consequence, the annual energy consumption of the institution was reduced by 35%, or roughly $2 to 2.5 million.

- The AUC only employs LED lighting in all of its external lighting fixtures to save energy waste. TL5 tubes with excellent efficiency are used to light the corridors. Every classroom and meeting space on campus has occupancy sensors installed to control the temperature and make sure the lights go out when a space is not in use. [26]

- The computer-based control system known as a Building Management System (BMS) is used to monitor and manage the mechanical and electrical systems of buildings, including the power supply, ventilation, fire, and security systems. [26]

- The AUC joined the global Race to Zero Campaign for Universities and Colleges in 2022, which is supported by the UN. AUC staff members, and students organised a task force to

develop the university's Net-Zero Plan. As a signatory, AUC commits to make progress towards a nearly net-zero campus by 2050 as its ultimate aim and reducing its carbon emissions as a transitional objective by 2035. For this reason, AUC established a strategy that outlines certain actions aimed at reducing emissions in the future. [26]

Fig.13 Solar cells used in AUC. Source: (The American University in Cairo, n.d)

Fig.14 The American University in Cairo. Source: (Archidatum, 2024)

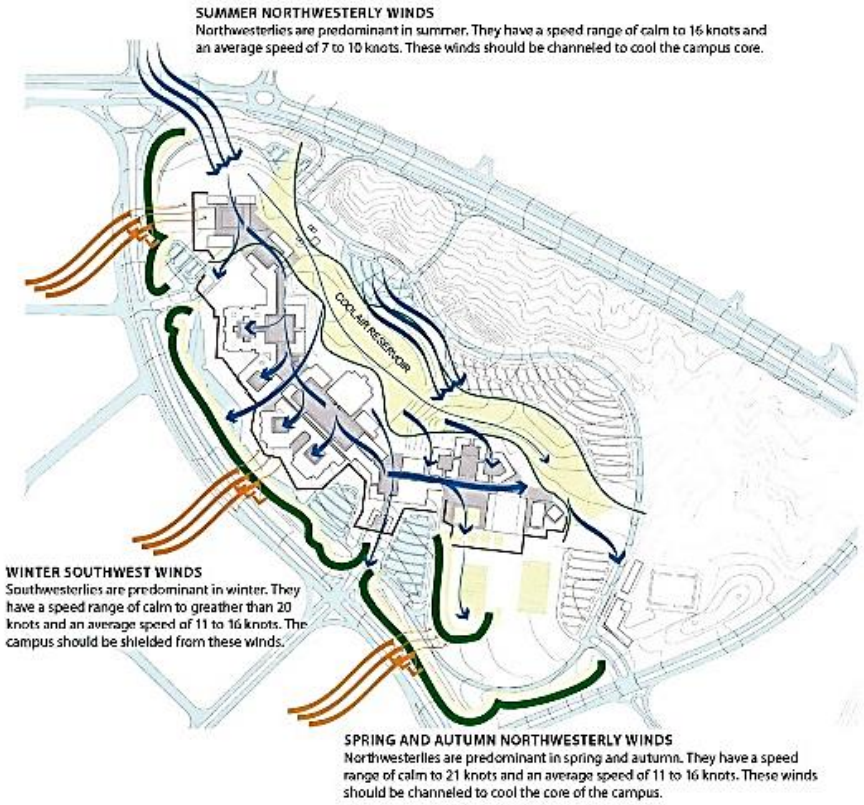

Fig.15 Wind circulation studies through the University. Source: (Archidatum, 2024)

5. DISCUSSION & RESULTS

Optimization of universities' buildings can impact student experiences and learning outcomes by providing a significant learning environment, preparing students for the future, and embracing intelligent and efficient design strategies. Based on the literature review and case study analysis, the authors conclude a set of guidelines to be followed in order to optimize the performance of

universities' buildings in Egypt in a trial to enhance achieving the 2030 fourth sustainable development goal which is Quality Education.

The set of Guidelines includes two major levels. The first level is on the scale of spaces inside Universisties' buildings. The second level is on the the whole universities' buildings scale.
In the scale of spaces inside universities' buildings, there ought to be multiple installments in order to optimize the spaces'performance. Classrooms & Lecture halls should follow a set of guidelines such as Having multiple zones to be suitable for modest group work, Using light movable furniture , Permitting more flexibility and multi-usage functions, Enhancing the internet access, Integrating Technological features such as large, and interactive touchscreens & advanced technology applications for virtual teaching and videoconferencing, Enhancing natural ventilation & lightings and others as shown in **Table 2**. Laboratory spaces should follow a set of guidelines such as Promoting digitalized interdisciplinary laboratories, Enhancing the internet access, Integrating Technological applications for more online platforms and virtual laboratories, and Requiring both institutional and sanitizing surfaces. Hallways & Reception areas should follow also a set of guidelines such as Applying Built in Furniture as a practical solution, Enhancing the internet access, Requiring sanitizing surfaces, and Increased contactless routes, such as smartphone control lifts, touchless door and window locks, and automatic door opening with face ID. Also, Service areas require a set of guidelines such as Installing sensor bathroom's devices, Usage of durable, easy cleaning, or even self-cleaning surfaces.
As for the whole scale of universities' buildings, a set of guidelines should be followed in order to optimize the performance of buildings as shown in **Table 2** such as the usage of green roofs that lower temperatures by absorbing sunlight, usage of special tiles are used to regulate heating and cooling, using windows with sensors that notify users when to open them and automatically adjust the heating or air conditioning, utilizing solar energy to generate electricity and energy across the building, employing LED lighting in all of its external lighting fixtures to save energy waste, and Usage of the computer-based control system known as a Building Management System (BMS) to monitor and manage the mechanical and electrical systems of buildings, including the power supply, ventilation, fire, and security systems.

Table 2 Set of guidelines to optimize the performance of universities' buildings. Source: (The authors)

Aspects of Applying Guidelines	**Set of guidelines to be followed in order to optimize the performance of universities' buildings**
On the scale of spaces inside universities' buildings	
Classrooms & Lecture Halls	Having multiple zones to be suitable for modest group work
	Using light movable furniture
	Permitting more flexibility and multi-usage functions.
	Enhancing the internet access
	Integrating Technological features such as large, and interactive touchscreens & advanced technology applications for virtual teaching and videoconferencing
	Charging stations and plenty of outlets to enhance online courses
	Enhancing natural ventilation
	Enhancing Natural Lighting

	Applying entry door sensors with sanitization spaces as well as requiring both institutional and sanitizing surfaces
Laboratory spaces	Promoting digitalized interdisciplinary laboratories
	Enhancing the internet access
	Integrating technological applications for more online platforms and virtual laboratories
	Requiring both institutional and sanitizing surfaces
Hallways, and Reception areas	Applying built in furniture as a practical solution
	Enhancing the internet access
	Requiring sanitizing surfaces
	Increased contactless routes, such as smartphone control lifts, touchless door and window locks, and automatic door opening with face ID.
Service areas	Installing sensor bathroom's devices
	Usage of durable, easy cleaning, or even self-cleaning surfaces
On the whole scale of universities' buildings	
Usage of green roofs that lower temperatures by absorbing sunlight.	
Usage of special tiles are used to regulate heating and cooling.	
Using windows with sensors that notify users when to open them and automatically adjust the heating or air conditioning.	
Utilizing solar energy to generate electricity and energy across the building.	
Employing LED lighting in all of its external lighting fixtures to save energy waste.	
Usage of the computer-based control system known as a Building Management System (BMS) to monitor and manage the mechanical and electrical systems of buildings, including the power supply, ventilation, fire, and security systems	

Conclusions

For Achieving the fourth sustainable development goal which is quality education, the United nations in Egypt had declared multiple actions are ongoing through the process of enhancing the fourth sustainable development goal (SDG4), one of them that is clearly declared by the Egyptian governance which is Improving higher education institutions' quality. Enhancing the architecture of universities could possibly be a step forword the fourth sustainable development goal (SDG4) which is Quality Education. Optimization the performance of universities' buildings can impact student experiences and learning outcomes by providing a significant learning environment. Based on the literature review and case study analysis, the authors conclude a set of guidelines to be followed in order to optimize the performance of universities' buildings in Egypt. The set of guidelines includes two major levels. The first level is on the scale of spaces inside Universisties' buildings. The second level is on the the whole universities' buildings scale. In the scale of spaces inside universities' buildings, there ought to be multiple installments in order to optimize the spaces'performance. Classrooms & Lecture halls should follow a set of guidelines such as having multiple zones to be suitable for modest group work, using light movable furniture. Laboratory spaces should follow a set of guidelines such as promoting digitalized interdisciplinary laboratories, enhancing the internet access. Hallways & reception areas should follow also a set of guidelines such as applying built in furniture as a practical solution, enhancing the internet access.

Also, service areas require a set of guidelines such as installing sensor bathroom's devices, usage of durable, easy cleaning, or even self-cleaning surfaces. As for the whole scale of universities' buildings, a set of guidelines should be followed in order to optimize the performance of buildings such as the usage of green roofs that lower temperatures by absorbing sunlight, usage of special tiles are used to regulate heating and cooling, and using windows with sensors that notify users when to open them and automatically adjust the heating or air conditioning.

The authors recommend implementing the previously resulted set of action in order to enhance the performance of universities' buildings all over Egypt in order to promote the quality of the higher education which is one of the main objectives of the fourth sustainable development goal (Quality Education). It is also recommended the Evaluation for these set of actions after implementing in order to check the effectiveness of these actions on the performance of buildings , and to determine if any technical actions are preferred to be reset.

In a whole context, the authors recommend further actions in the scope of governmental decisions for enhancing the construction of new green universities in Egypt for the future generations in order to cope with climate change and to guarantee the full achievement of applying the sustainable development goals. It is also recommended that universities must designate "spaces" on campus where interdisciplinary and transformative learning are welcomed and promoted. In addition to the physical location, this transformative space also offers time for introspection, discussion, and action. universities must set aside specific time and areas for critical thinking and team work. These areas might facilitate the transformation of learners, classrooms, and persons.

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