ISSN: 2663-5798 || Arab Journal for Scientific Publishing

الإصدار الثامن – العدد الواحد والثمانون
تاريخ الإصدار: 2 – تموز – 2025م
www.ajsp.net

"The Impact of Technology on Educational Sustainability in University Buildings: A Review"

Researchers:

Asmaa Zein alabdeen Alfakhry[1], Omar Hazim Kharoofa[2]

[1]University of Mosul, College of Engineering, Architecture Department, Mosul, Iraq
[2]University of Mosul, College of Engineering, Architecture Department, Mosul, Iraq

ISSN: 2663-5798 || Arab Journal for Scientific Publishing

الإصدار الثامن – العدد الواحد والثمانون
تاريخ الإصدار: 2 – تموز – 2025م

www.ajsp.net

ABSTRACT:

The rapid advancement across various life sectors has driven the integration of technology to achieve numerous objectives, notably the Sustainable Development Goals (SDGs), which have become a global priority. In higher education, universities act as innovation hubs, making the design of their buildings vital for achieving educational sustainability. This research examines the impact of technology integration in university building design on educational sustainability through an analytical review of prior studies. It highlights key technological elements, including interior design, smart facades, intelligent systems, and campus space planning, and their role in enhancing educational outcomes. The study emphasizes how technology fosters functional efficiency, improves user experience, and reduces environmental impact, presenting it as a critical factor in aligning university buildings with future sustainability demands.

Through the review of a wide range of studies related to technology integration in educational buildings, the study identified several variables that influence the educational process. These include the function of space, the intended sustainability goal within the design, and the scope of technology use. Together, these factors create an environment that promotes innovation, positioning it as a key element in achieving technological sustainability objectives.

Keywords: Technology, Education, Sustainability, University Buildings, Sustainable Engineering.

1. Introduction

Sustainable technology is a framework of digital solutions that drive environmental, social and governance (ESG) outcomes. Here's how to make the most of it (gartner, 2024)

The concept of a smart building revolves around describing the latest automation technologies, communication, security, and control systems. The goal of a smart building is to ensure comfort and safety for users while achieving effective integration with the building system by controlling energy consumption and managing other systems with maximum efficiency (Abdullah, Ismail, & Yurievich, 2023). Technological innovation and sustainable technologies represent effective solutions to current problems, making them fundamental to sustainable development strategies (Rainey, 2009). Sustainability is a key driver of innovation, and only companies that achieve sustainability as their goal will achieve a competitive advantage (Huang, 12 july 2021) . The survival of companies and society depends on their ability to find new uses for available resources and reintegrate them in innovative ways. The economic and social change in the Western world, especially after the Industrial Revolution, is largely attributed to technological innovations Sustainability is a primary driver of innovation, and only companies that make sustainability their core goal will gain a competitive advantage. (Rizova, 2007). In recent times, smart buildings have become essential, with their success criteria extending beyond functional flexibility, workspaces, and automated monitoring systems. They now significantly emphasize meeting user needs. Hence, user satisfaction is a fundamental factor in the success of smart university buildings. Achieving this requires designing spaces that align with users' behaviors and diverse needs. When user requirements are effectively met, their satisfaction levels increase, positively impacting their enthusiasm and productivity [1]. Meeting needs also requires achieving the principle of adaptation, which is to achieve an environment that is more flexible in modification and change and thus accommodates changes and renewed spatial and functional needs and adapts to them over time. Adaptation is associated with a set of economic, social, and environmental benefits, as it is one of the features of sustainable architecture (Abdullah, Ismail, & Yurievich, 2023). One of the main factors in achieving sustainable development is technology, which is an integral part of the structure of societies. Although some people question this concept, sustainable development requires sustainable solutions that integrate with the continuous development of technology, which requires fundamental changes in institutions and systems. Technological progress in achieving social goals stimulates technological innovation (Mulder, Balas, & Lente, 2012). In addition to technology, science, and innovation constitute the pillars for achieving sustainable development goals by enhancing the comprehensive understanding of the challenges related to each goal and increasing the ability to make decisions through the production and dissemination of knowledge, thus providing solutions to address the complexities resulting from the interconnectedness of sustainability goals. These three pillars are closely intertwined, with science focusing on the acquisition of knowledge through the systematic study of the physical, natural, and social world, while technology focuses on the application of this knowledge to meet specific needs (Santiago & Taborda, 2022). The impact of technology on learning is primarily due to the influence of innovation or teaching strategies, rather than technology itself (Valverde-Berrocoso, Borrega, & Pizarro, 2022). Innovation is the development of new ways of producing or using goods and services. This relationship is nonlinear in nature; some innovations may fundamentally change social or natural systems, raising new scientific questions and stimulating the production of additional knowledge, opening up new avenues for sustainable development (Santiago & Taborda, 2022). Instruction, technology, and the design of learning spaces all influence each other reciprocally. The instruction required determines how a space is organized and used, and the choice of technology can support or constrain certain learning environments. In addition, some spaces limit the use of certain types of technology or provide opportunities for its integration. Technology also influences how teachers and students use the space, taking into account the

educational content and the students themselves (Jannah, Yaumi, & Herdah, 2023). This great impact of technology and its integration into various aspects of life led us to the research question: How does technology affect the sustainability of education in the university environment? How can technology be integrated into the design of the university building to achieve sustainability that improves educational levels? To answer these questions, this research aims to provide an accurate and detailed analysis of the literature on the impact of the type of educational technology used in higher education to achieve sustainable development goals related to technology and education.

2. Methodology

In recent years, several international reports have highlighted the impact of technology. These studies provide a comparative global perspective that helps in understanding the factors and processes that contribute to supporting or hindering these technologies' full integration within educational systems (Valverde-Berrocoso, Borrega, & Pizarro, 2022).

This review adopts a systematic approach to measure the impact of technology on the sustainability of education in university buildings; this was done within technology-focused educational settings. The search process began by identifying key terms through a primary literature review, consultation with the supervisor, and using keywords such as “sustainable technology”, “sustainable education”, “university buildings”, “smart buildings”, etc. Inclusion criteria were useful in identifying studies conducted in the last two decades. Data were extracted by identifying important details such as the study objectives, procedures followed during the search, and outcomes. Thematic analyses were used to find patterns and themes related to the study.

The studies presented in this research provide a systematic and sequential review of the impact of educational technology on learning outcomes in higher education through improving the internal environment or by integrating smart systems into education, as the section explained, including design methods for university buildings and smart building materials, reaching the sustainability of technology in education, in addition to methods of sustainability of the university campus and its impact on active learning processes, as the interactive design is one of the modern design approaches that has gained clear interest in the field of outdoor spaces, as it depends primarily on increasing the element of excitement, enjoyment, learning, changing behavior, and enriching the sensory experience of users to improve their interaction by involving the five senses (Aldobouni & Al-Omary, 2021). Some studies also examined the building management system and evaluated the performance of educational facilities designed sustainably to conclude the mutual influence between technology and function in university buildings.Since the evaluation of post-occupancy studies is an essential part of planning and assessment processes, it helps analyze the impacts of the built environment design and identify its strengths and associated challenges. This contributes to improving methods for creating future environments by leveraging the findings (Alfakhry, 2011) .The detailed review of the literature resulted in extracting the common variables between the studies and then concluding through their analysis how technology affects the sustainability of education in university buildings, to come out of it with a set of axes that link technology to the functions of the educational building for the sake of sustainability and good levels of education.

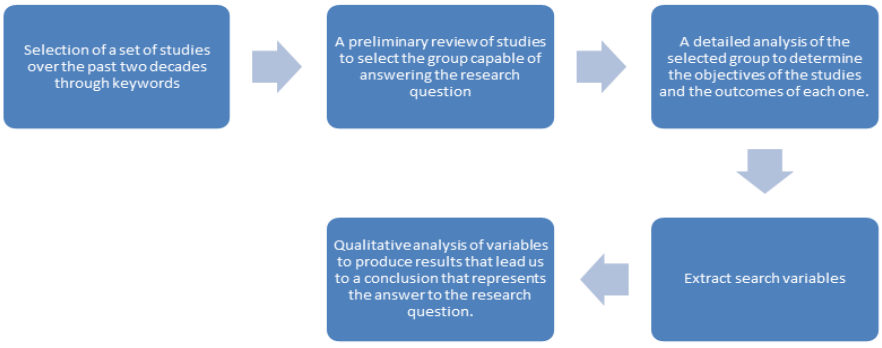

Fig.1. Research methodology

3. Literature review

Designing a suitable classroom will prevent students from feeling bored or physically exhausted and will provide them with motivation and comfort during the learning process, whether this place is indoors, outdoors, or virtual. It also contributes to creating a supportive educational environment and encourages the development of an innovative learning system (Jannah & Others 2023), This study concluded that four main ideas are forming the foundation for developing future learning spaces: learning through practice, context-based learning, interaction, and learning sites. To achieve this design, a concept was developed that integrates space, technology, and knowledge, blending aspects of knowledge, dimensions of space or learning

environment, and the use of technology as one of the future smart learning designs. Thus, the study emphasized the correlation between pedagogy, technology, and learning space, as illustrated within the TPACK framework (Technological Pedagogical Content Knowledge) (Jannah, Yaumi, & Herdah, 2023). This relationship was confirmed by (Moreno & Palau, 2023) which provided a guide for designing smart classrooms based on environmental conditions, providing technology-based educational solutions for good education, and supporting sustainability with its environmental and technological goals. It revealed that the characteristics of these spaces greatly affect the entire educational process and are reflected in the performance of teachers and students (Moreno-Moreno & Palau, 2023)**.** Controlling and managing the factors that make these classrooms unique directs attention toward smart learning spaces (Smart classrooms) where the use of technology becomes particularly important. The study by (Mogas Recalde 2021) indicated that smart classrooms are built on three main pillars: technology, sustainability, and inclusivity. In addition, the characteristics that can be available in a smart classroom are classified into three dimensions: the technological dimension, educational processes, and environmental conditions (Mogas-Recalde, 2021). Accordingly, the study by (Chao & Pena 2021) focused on understanding students' needs to achieve the design of educational buildings that ensure satisfaction and comfort by aligning functionality and understanding the smart systems required in the design to achieve the intended goal of the design, considering the function as the basis for sustainable buildings through analyzing a case study of higher education classrooms (Chao & Pena, 2021) While the study (Chiesa 2017) briefly described an approach that integrates functional, technological, and environmental aspects in the architectural planning of educational facilities based on the analysis of activities and user needs, considering this stage of building planning as a necessary basis for the next stage of initial architectural formation (Chiesa, 2017). And the study by (Madkour 2020) highlighted the multiple types of educational spaces, stating each one, its design characteristics, and its requirements for technical sustainability to achieve the best scientific output through integrating good design and technology (Madkour, 2020)**.** (Akintayo, Eden, Ayeni & Onyebuchi 2024) highlight the importance of strategic integration of technology into education to achieve educational goals. It concluded that the technical sustainability of education depends on how this technology is used to create comprehensive and effective learning environments for all students and provide an infrastructure suitable for the type of technology used (Akintayo, Eden, Ayeni, & Onyebuchi, 2024). The study by (Valverde-Berrocoso, Borrega, & Pizarro 2022) reached a similar conclusion, as its results demonstrated that educational technology is a concept that includes the use of devices, applications, and methodological approaches that are applied in specific contexts. Therefore, educational technology can be effective to a certain degree, depending on how it is used [8]. A study by (Nyakongo Mokaya Clinton & Ronoh, 2024) showed that emerging technologies could radically transform the teaching and learning processes by providing personalized education and enhancing interaction (Nyakongo Mokaya Clinton & Ronoh, 2024), while a study by (Johnson, Jacovina, Russell, & Soto, 2024) showed the impact of the use and advancement of technology on our society and revealed the challenges facing the integration of technology in the educational space and the opportunities it offers, emphasizing the importance of the thoughtful integration of technology in education (Johnson, Jacovina, Russell, & Soto, 2024) .The study by (Raja & Nagasubramani 2018) highlighted the advantages and disadvantages of using technology in education. It first explained the methods of utilizing technology in learning through the internet, display devices, digital fingerprinting, and its application in receiving lessons, electronic certificates, and more. The study's findings confirmed that the use of technology, along with modern tools and equipment, enhances students' ability to learn and interact. When technology supports the educational process, the transfer of knowledge becomes easy and highly convenient, in addition to being more effective. This indicates that technology plays a significant role in improving the learning experience (Raja & Nagasubramani, 2018).Similarly, the study by (Ince-Muslu & Erduran 2021)examined the factors influencing the integration of technology in education and found that teachers played a highly effective role in this process. The study identified several factors affecting teachers, including their perception and awareness of technology, self-confidence, planning, and access to technological materials, alongside other external factors unrelated to teachers, such as physical conditions, administrative support, student readiness, economic status, and the structure of the mathematics curriculum (Ince-Muslu & Erduran, 2021).As a result of these studies, numerous research efforts have proposed modern teaching methods that integrate technology. For instance, the study by (Rieh, et al., 2017) presented an analysis of educational programs to reach how to integrate sustainability into architectural education programs (Rieh, et al., 2017).The study by (Al-Kazzaz 2014) explored the strengths and weaknesses of using computer-aided drawing techniques during the conceptual design phase. The study concluded that computer drawing techniques play a significant role in activating the complex engineering language of drawings that are difficult to represent manually. However, these techniques lack the ability to foster innovative, imaginative, reflective, and retrospective thinking skills. Additionally, the computer environment serves as an ideal medium for transferring pre-prepared ideas from the designer to the design team or the general public. It facilitates the exchange of information either in real-time or at different times, even across geographically distant locations, unlike manual drawings, which cannot achieve this (Al-kazzaz, 2014). In the same context, the study (Passe, 2020) focused on using a new educational approach using an important educational tool represented by a sustainable design studio that can allow for the exploration and integration of complex social, cultural, environmental, and technical considerations)Passe(2020 ،.In the study by (Faludi

2015) a method for sustainable design was developed in an attempt to transform sustainability from a burden into an innovative tool with inherent commercial value. The method combines creative thinking for holistic systems with quantitative sustainability metrics (Faludi, 2015). While the study (Shi, Fang, Chen, Phillips, & Fukuda, 2020) presented a curriculum that aims to create a global platform that enables students to critically explore and apply modern technology to advance the boundaries of sustainability in the professional and educational field. The curriculum seeks to provide the multidimensional knowledge needed to use robots in automated construction while providing evidence of economic, social, and environmental improvements in the built environment. It also highlights insights into new and complex construction processes that will redefine the concept of architecture in the near future (Shi, Fang , Chen , Phillips, & Fukuda, 2020) . Accordingly, the study (Gallo, 2024) emphasized the role of universities and university laboratories designed with the latest technological techniques in increasing innovation and development for international industrial competition (Gallo, 2024)**.** The study (Kim, 2021) also highlights the importance of classrooms based on the STEAM concept that contributes to integrating logical thinking, discovery-based learning, practical learning, and problem-solving-based learning. It also supports planned activities in laboratories and contributes to the development of educational programs (Kim, 2021) . After this amount of research that proved the importance of integrating technology into education, a study (Azadkhani, 2022) showed the extent of the impact of technology on the quality of the internal environment and the quality of materials by finding the relationship between technology and architecture variables (educational buildings in particular) (Azadkhani, 2022) .The study (Hassan, Senousy, & Goda, 2023) also showed that smart technologies are integration between the building system and technology, as the integration of these technologies into buildings was found to serve the user and make his life easier. Therefore, smart technologies have recently become closely linked to the concepts of sustainability and have a significant impact on the main aspects of the building such as function, construction, and form. Hence, it is important to adapt interior design technology to the requirements and needs of society, adapt interior design to be compatible with future design thinking, and take into account the surrounding environment. The term sustainable technology emerged (Hassan, Senousy, & goda, 2023). This was also confirmed by the study by (Talee 2019)) talee (2019 ‹. The study (Zhicheng Dai, 2021) provided a reference and inspiration for building and evaluating smart educational environments, by rethinking the structure of the smart educational environment (physical space, resource space, and social space) by applying information and communication technology (ICT) in higher educational institutions, which led to the transformation of the environment from digital to smart (Zhicheng Dai, 2021) .During the study (Malek & Osama, 2018) the most important smart systems used in the internal environment for the comfort of occupants were reviewed. Models of smart architectural elements and other types of smart furniture used in different functions were also presented, as the research focused on the integration of technology with architecture for sustainable buildings (malek & osama, 2018)**.** The study (Hassanain, 2022) worked after reviewing the most important smart systems needed in university buildings to present the challenges that hinder these systems from working on comfortable and attractive buildings in order to avoid them in future designs and provide smart-university buildings with more control over the internal environment to achieve sustainable goals technically and environmentally for a better scientific product (Hassanain, 2022). The study (Barnes, 2012) provided an example of how space can be an educational tool for sustainability with all its economic, social, and environmental goals through the latest smart systems and technology used (Barnes, 2012). While the study (Romano, Baratta, & Piferi, 2016) focused on achieving technical sustainability by using advanced technology in the envelopes and facades of university buildings and thus achieving internal comfort through the design of external facades (Romano, Baratta, & Piferi, 2016), as the study (Ahmed, 2021) confirmed that university and educational buildings are among the functional patterns that consume energy, and sought to achieve its goal of finding a clear mechanism for rehabilitating existing university buildings to ensure energy saving and achieving thermal comfort for users by identifying the appropriate design methods and technologies for university buildings (ahmed, 2021) . For the same purpose, the study by (Hasim, Jalil, Safiee, Khalid, & Jie 2020) provided insights into how facility management processes in universities can be leveraged to enhance sustainability across its various objectives (Hasim, Jalil, Safiee, Khalid, & Jie, 2020).The study by (Ahmed, Mateo-Garcia, Arewa, & Caratella, 2021) focused on evaluating the role of technology, processes, and individuals in achieving social, economic, and environmental benefits resulting from low-energy renovation techniques and processes (Ahmed, Mateo-Garcia, Arewa, & Caratella, 2021). Similarly, (Hossain, 2020) aimed to improve environmental performance and enhance the learning experience regarding energy and sustainability. Experimental workshops were organized for students in their classrooms, utilizing smart systems and technologies to raise awareness of the impact of environmental and behavioral changes on energy savings through real-time visualization (Hossain, 2020) .The study (Tariq, 2024) emphasizes the importance of sustainable educational buildings not only as physical learning spaces but also as dynamic environments that contribute to informal education processes. Sustainable buildings can be real-world examples of environmental conservation, teaching students about energy efficiency and sustainability through their design and operation. By incorporating advanced AI-driven tools to optimize energy consumption, educational facilities can become interactive learning centers that encourage students to engage with sustainability concepts in their daily lives (Tariq, 2024).The study (Gibau & Kissel 2019) indicated the importance of following different active learning methods, focusing on the impact of

the design of the learning space, whether a classroom or a university campus (external study), in addition to the importance of using modern technological means in education and how they can lead to better educational results (Gibau & Kissel, 2019). Accordingly, the studies by (Yaqoub & Abbas 2019) (Yaqoub & Abbas, 2019) and (Oktay & Küçükyağcı 2015) (Oktay & Küçükyağcı, 2015) aimed to analyze the sustainable campus design process, set objectives, and establish priorities related to sustainable campus design and its use in active learning processes. Additionally, the study by (MATLOOB 2016) provided a clear understanding of campus sustainability in terms of physical design, demonstrating a clear relationship between the physical form of the campus and sustainability aspects (MATLOOB, 2016). Historical evidence in the study (Best & Purdey 2012) indicates that not all green buildings perform well. Improving occupant satisfaction and performance may be less related to the green design structure and more related to the extent to which occupants know how to deal with the environmental constraints imposed by this new type of building to achieve the desired results (Best & Purdey, 2012) As a result, studies were searched that focused on evaluating the performance of buildings after occupancy to enhance the main research objective of knowing the effect of function on the technical sustainability of educational buildings, so the study (Ibrahim, Elsayed & Moustafa 2022) indicated the technological systems that can be used in the design of smart university buildings and the importance of using the building management system to ensure the operation of the building and systems and bridge the gap between design and actual performance, thus achieving the highest level of sustainability (Ibrahim, Elsayed, & Moustaf, 2022). The study (Chao & Pena 2021) focused on understanding the needs of students to reach the design of educational buildings characterized by satisfaction and comfort through the suitability of the function, thus achieving high sustainability values, and understanding the smart systems necessary in the design to achieve the desired goal of the design, considering the function as the basis for sustainable buildings (Chao & Pena, 2021). Also, the study (BOUDJADJA, BENAYOUNE, MAHIMOUD, & Rafik 2019) stressed the importance of designing buildings according to the function required of them and relying on the requirements of users to ensure the use of appropriate technical equipment that leads to more sustainable buildings in the future. It also stressed the importance of this approach in designing educational buildings, especially since it has an impact on the productive educational process (BOUDJADJA, BENAYOUNE , MAHIMOUD, & Rafik, 2019). The study (MANAHASA & ÖZSOY 2016) provided new insights into the design considerations of educational buildings in universities, aiming to suggest changes to improve students' quality of life. The research results show that optimal building performance is related to both design and effective management (MANAHASA & ÖZSOY, 2016). The study (Abisuga, Wang, & Sunindijo 2019) contributed to enriching knowledge in the field of space management and identified 36 performance characteristics that can be classified into four categories: surrounding environment, space, technology, and support and service requirements. The research indicates that meeting users' needs is essential to achieving their satisfaction, emphasizing that these needs differ between different learning spaces, which calls for customizing the evaluation for each space separately (Abisuga, Wang, & Sunindijo, 2019) The study (Lawrence, Keime, & Elsayed, 2019) showed that university educational buildings contain a variety of administrative spaces, classrooms, libraries, and studios, reflecting their complex and multi-use nature. The key characteristics of each environmental strategy (including passive systems, hybrid systems, or active systems) are described, in the context of the building occupants, the spaces they serve, and the level of interaction they provide. The energy performance and thermal comfort of users are analyzed and the study investigates the relationship between comfort and its contributing factors. The research also explores which type of personal control significantly affects the overall comfort of building occupants (Lawrence, Keime, & Elsayed , 2019).

4. Reults and discussions

By presenting the studies, we find that there are many design aspects in which technology is integrated to achieve the various sustainable development goals, all of which aim to enhance the educational process in universities.

Table 1 is showing the identification of the basic variables in the research (the type of function of the space to be studied and the scope of technology used to achieve the sustainability goal of the study) in order to extract the relationship between function, technology, and sustainability in university buildings and their impact on education.

N	Variables / The Studies	Function			Sustainability goal				Technology Classification			
		Educational buildings			Econo-mic		Social					
		Classroom	University Campus	Others	Innovation and Technology	Others	Good education	Others	Environmental	Interior design	Smart system	Elevation	Integration in design

ISSN: 2663-5798 || Arab Journal for Scientific Publishing
الإصدار الثامن – العدد الواحد والثمانون
تاريخ الإصدار: 2 – تموز – 2025م
www.ajsp.net

1	(Jannah & others 2023)	O	O		O		O				O		
2	(Moreno & Palau 2023)	O	O		O		O		O		O		O
3	(mogasrecalde, 2021)	O			O		O		O		O		O
4	(Chao & Pena, 2021)	O				O	O		O				O
5	(Chiesa 2017)	O							O				O
6	(Madkour 2020)	O	O		O		O				O		O
7	(Akintay & others 2024)	O			O		O				O		
8	(Nyakongo & others 2024)	O			O		O				O		O
9	(Valverde& others 2022)	O			O		O				O		
10	Johnson & others 2024)	O			O		O				O		
11	(Raja & Nagasubramani) 2018	O			O		O				O		
12	(Ince-Muslu & Erduran, 2021)	O			O		O				O		O
13	(Rieh, et al., 2017)	O			O	O	O	O	O				O
14	(Al-kazzaz, 2014)	O			O		O				O		
15	(Passe 2020)	O			O		O					O	O
16	(Faludi, 2015)	O			O		O				O		
17	(Shi & others, 2020)	O			O	O	O	O	O		O		
18	(Gallo 2024)	O			O				O			O	
19	(Kim 2021)	O	O		O		O				O		O
20	(Azadkhani 2022)	O					O		O	O	O		O
21	(Hassan & others 2023)	O			O		O			O	O		
22	(talee2019 ،)	O			O		O			O	O		
23	(Zhicheng Dai 2021)	O					O						O
24	(Malek & Osama 2018)	O	O	O	O	O		O	O		O		
25	(Hassanain 2022)	O			O				O	O	O		
26	(Barnes 2012)	O			O		O				O		
27	(Romano & others 2016)	O		O	O				O			O	
28	(Ahmed 2021)	O		O		O	O		O		O		O
29	(Hasim, Jalil, Safiee, Khalid, & Jie, 2020)	O	O	O		O	O	O	O		O		O
30	(Ahmed & others 2021)	O			O		O		O	O	O	O	O
31	(Hossain 2020)	O	O				O		O		O		
32	(Tariq 2024)		O		O	O	O				O		
33	(Gibau & Kissel 2019)	O	O		O		O				O		
34	(Yaqoub & Abbas 2019)		O		O		O		O				O
35	(Oktay & Küçükyağcı, 2015)		O				O						O
36	(MATLOOB, 2016)		O						O				O
37	(Best & Purdey 2012)	O					O		O				O
38	(Ibrahim & others 2022)	O		O	O	O			O		O		
39	(BOUDJADJA & OTHERS 2019)	O		O		O	O				O		O
40	(MANAHASA & ÖZSOY 2016)	O	O				O			O		O	O
41	(Abisuga & others 2019)	O			O		O		O		O		O
42	(Lawrence & others 2019)	O		O	O	O			O		O		
The total		38	12	7	33	11	34	4	21	6	31	5	21

Table 1. variables in the research

ISSN: 2663-5798 || Arab Journal for Scientific Publishing
الإصدار الثامن – العدد الواحد والثمانون
تاريخ الإصدار: 2 – تموز – 2025م
www.ajsp.net

The results indicate an increasing trend towards integrating technology in educational buildings to achieve sustainability goals. Smart systems and modern technologies are considered essential for achieving economic and environmental objectives, while the focus on improving the quality of education remains a key aspect of social goals. The importance of innovation in the use of technology is also highlighted, particularly in areas such as interior design and façade integration, to support future sustainability requirements.

Results

The analysis of previous studies reached the following points:

4.1. According to studies that addressed the relationship between technology and the function of university buildings with the aim of improving education, there are a several variables that determine how technology affects education through the design of the building, namely

a) The function of space within the educational building (classroom - laboratories or practical studios - the university campus - other functions such as libraries or corridors used for active education or administrative spaces)

b) The sustainability goal achieved or intended to be achieved in the building or educational space (environmental goals - social goals, including the fourth goal of improving education as a primary goal in educational buildings - economic goals, including the ninth goal of supporting innovation and technology as a primary goal of the current research)

c) The scope of using technology within the design of the building (within the interior design of spaces - the use of smart systems - the design of smart facades - integration in design from the design stage to implementation and then maintenance later)

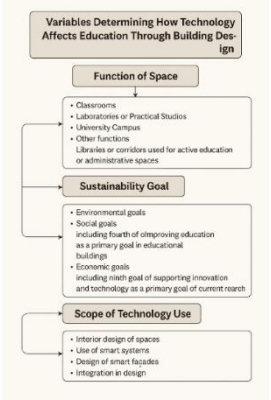

Fig. 2. a several variables that determine how technology affects education through the design of the building. (researcher's work)

4.2.The variables are linked together as shown in the figure 2 , which shows the following:

a) The inner ring: represents the functions of the educational space (to the top right represents the internal educational spaces - the upper left represents the other internal spaces - the lower part represents the external spaces)

b) The middle ring: represents the scope of using technology in the design (the upper part to the right represents the integration in the design and the upper left part represents the internal design, while the lower part represents the smart systems and finally the lower part from the right represents the smart interfaces)

c) The outer ring: represents the sustainability goals to be achieved in the educational building (the red part represents the economic goals - the blue part indicates the social goals - while the green color expresses the environmental goals

4.3. Analysis of studies indicates how the scope of technology use in design is related to the quality of educational space to enhance the educational process as shown in the figure 3 :

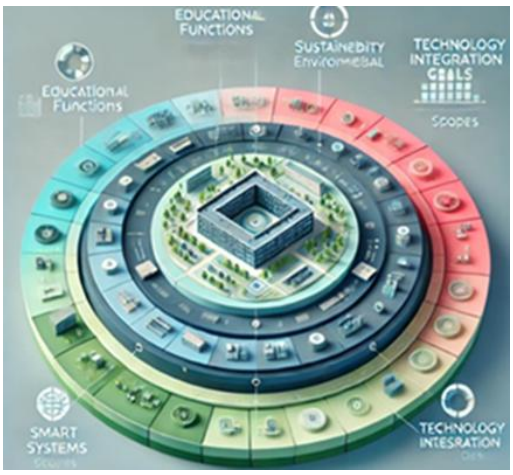

Fig. 3.The relationship between sustainability goals, types of technology, and building functions (researcher's work)

a) Interior design: Only 6 studies out of 42 addressed the adoption of interior design with smart technologies. These studies targeted interior spaces, especially classrooms, and were often linked to the use of smart systems as well.

b) Smart systems: represent the highest percentage of studies, with 31 studies that varied between different educational spaces, indicating a high tendency to use smart systems within the university environment.

c) Smart facades: As with interior design, a small percentage of 5 studies achieved the sustainability of the educational building through the design of smart facades. These studies took into account the scope of active education and benefiting from the sustainability of the university campus.

d) Integration in design: A large percentage of studies (21 studies) that reflect real experiences tend to integrate the design process from the planning stages to implementation and post-occupancy, which achieves the highest rates of sustainability for its various objectives

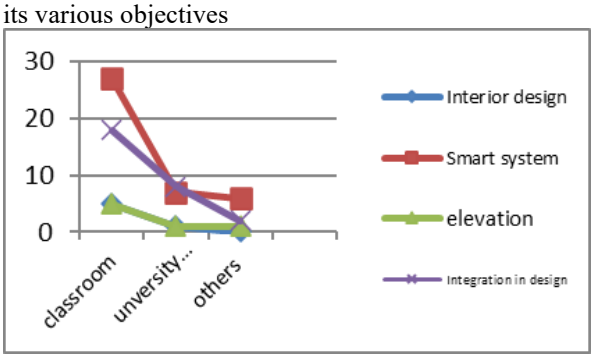

Fig. 4.Distribution of Technology Types across Educational Building Functions (researcher's work)

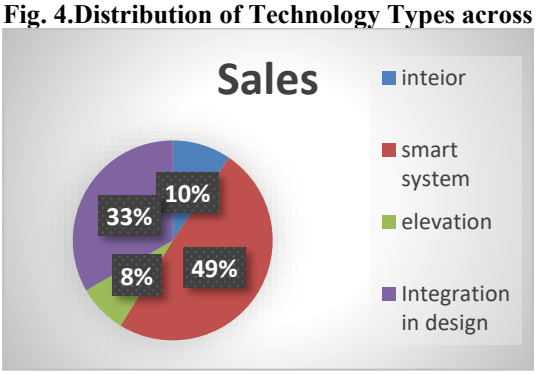

Fig. 5. Distribution of studies by areas of technology use in educational design (researcher's work)

5. Conclution

By presenting several studies that addressed various aspects of the impact of using technology in university buildings on the sustainability of education, some axes were concluded that represent the impact of using technology in the design of university buildings on the educational process:

a) Diversity of Educational Building Functions
Each function (such as lecture halls, laboratories, university campus spaces, and administrative areas) requires a different technological approach to achieve sustainability, which necessitates understanding the specific needs of each function.

b) Diversity of Sustainability Objectives

- Economic: Focus on supporting technology to improve economic efficiency.
- Social: Emphasis on enhancing the quality of education as a primary objective.
- Environmental: Clear interest in energy efficiency, reducing environmental impact, and using sustainable materials.

c) Broad Scope of Technology Use
Technology is employed in interior design, smart systems, facades, and integrated design from planning to implementation and maintenance with the aim of improving the quality of the educational environment and promoting sustainability.

Innovation as a Core of Sustainability
The reliance on smart technology and integrated design drives innovation and the development of effective solutions that contribute to sustainability. This requires that the infrastructure be compatible with the specific educational function to ensure efficiency and effectiveness.

References

Oktay, S. Ö., & Küçükyağcı, P. Ö. (2015, 5 28-30). ÜNİVERSİTE KAMPÜSLERİNDE SÜRDÜRÜLEBİLİR TASARIM SÜRECİNİN İRDELENMESİ. *Uluslararası Sürdürülebilir Yapılar Sempozyumu*.

/ISNYFo9. (n.d.).

Abdullah, F. H., Ismail, K. J., & Yurievich, S. M. (2023, march 1). Consistency Relationship between Fractal Geometry and Adaptation as a Principle for Achieving Sustainable Architectural Design. *Al-Rafidain Engineering Journal (AREJ), Vol.28, No.1*, pp. pp. 1-13.

Abisuga, O., Wang, C. C., & Sunindijo, R. Y. (2019, september). A holistic framework with user-centred facilities performance attributes for evaluating higher education buildings. *Facilities*.

Ahmed, A., Mateo-Garcia, M., Arewa, A., & Caratella, K. (2021, march 8). Integrated Performance Optimization of Higher Education Buildings Using Low-Energy Renovation Process and User Engagement. *energies*.

ahmed, r. a. (2021). *Mechanisms for the rehabilitation of the internal energy-efficient environment in the educational buildings of the University of Mosul.* mosul: university of mosul / collage of engineering.

Akintayo, O. T., Eden, C. A., Ayeni, O. O., & Onyebuchi, N. C. (2024, may). Evaluating the impact of educational technology on learning outcomes in the higher education sector: a systematic review. *International Journal of Management & Entrepreneurship Research*, pp. Volume 6, Issue 5, P.No.1395-1422.

Aldobouni, S. I., & Al-Omary, A. Y. (2021, october). Interactive Design in Urban Outdoor Spaces A Comparative Study of the Employment of Digital and Traditional Technologies. *Al-Rafidain Engineering Journal (AREJ) Vol.26, No.2*, pp. pp.18-31.

Alfakhry, A. A. (2011). Post Occupancy Evaluation of Daylighting in Lecture Halls at the New Buildings in the University Of Mosul. *Al-Rafidain Engineering (AREJ), 19*(5), 28.

Al-kazzaz, D. A. (2014). Freehand Drawings versus CAD Drawings in the Conceptual Architectural Design Phase. *Al-Rafidain Engineering (AREJ)*, 1-76.

Azadkhani, P. (2022, 11 27). The impact of modern construction technology in improving the quality of the architectural environment of sustainable educational buildings. *Journal of Urban Management and Energy Sustainability (JUMES)*.

Barnes, L. L. (2012, AUGUST). Green buildings as sustainability education tools. *Library Hi Tech*.

Best, R., & Purdey, B. (2012). Assessing Occupant Comfort in an Iconic Sustainable Education Building. *Australasian Journal of Construction Economics and Building*, pp. 55-65.

BOUDJADJA, BENAYOUNE , H., MAHIMOUD, A., & Rafik. (2019, 12 17). Evaluation de la performance d'un bâtiment à travers la méthode d'évaluation post-occupationnelle. Cas d'un équipement universitaire situé à l'université d'Oum Bouaghi, Algérie. *Conférence Internationale , Villes Durables Et Développement Local*.

brook, k. (2018). *he role of institutional excellence in keeping pace with environmental developments.* American Journal of Environmental Excellence.

Chao, V. L., & Pena, V. L. (2021, October 11). Purpose Adequacy as a Basis for Sustainable Building Design: A Post-Occupancy Evaluation of Higher Education Classrooms. *MDPI*.

Chiesa, G. (2017, jan). An Environmental Technological Approach to Architectural Programming for School Facilities. *scispace*.

Faludi, J. (2015). A Sustainable Design Method Actingas an Innovation Tool. *Design Across Boundaries Volume 2*, 1-16.

Gallo, d. P. (2024, 8 2). Innovazione e sviluppo. L'università per la competitività industriale. *Repository istituzionale dell'Università degli Studi*, pp. 506-515.

gartner. (2024). *What Is Sustainable Technology and Why It's Important*. Retrieved 3 8, 2025, from https://www.gartner.com/en/chief-information-officer/topics/sustainable-technology

Gibau, G. S., & Kissel, F. (2019). Starting With the Space: Integrating Learning Spaces and Technologies. *Journal of Teaching and Learning with Technology*, pp. 17-32.

Hasim, M. S., Jalil, M., Safiee, L., Khalid, E., & Jie, K. (2020). Factors influencing the adoption of sustainability into university facilities management practices: a case study of universities in South Australia. *International Journal of Environment and Sustainable Development*.

Hassan, M. H., Senousy, A., & goda, D. (2023). The effect of using nanotechnology applications on construction materials to raise the efficiency of the smart building. *journal of architecture , art ,and humanistic sciences*.

Hassanain, M. A. (2022, may). An assessment of users' satisfaction with a smart building on university campus through post-occupancy evaluation. *Journal of Engineering Design and Technology*.

Hossain, M. (2020, Aug 3). Application of IoT and BEMS to Visualise the Environmental Performance of an Educational Building. *scispace*.

Huang, Y. (12 july 2021). Technology innovation and sustainability: challenges and research needs. In *Springer Nature 2021* (p. 1663). Germany: Published online.

Ibrahim, H., Elsayed, M. S., & Moustaf, W. S. (2022, july 16). Functional analysis as a method on sustainable building design: A case study in educational buildings implementing the triple bottom line. *Alexandria Engineering Journal*.

Ince-Muslu, B., & Erduran, A. (2021). A Suggestion of a Framework: Conceptualization of the Factors That Affect Technology Integration in Mathematics Education. *International Electronic Journal of Mathematics Education*.

Jannah, R., Yaumi, M., & Herdah. (2023). Utilization of Learning Space as a Learning Resource Center. *Journal of Islamic Studies and Society*, pp. 63-77.

Johnson, A. M., Jacovina, M., Russell, D., & Soto, C. (2024, APRIL 22). Challenges and solutions when using technologies in the classroom. *DOI*.

Kim, S. (2021, 9 7). Design Principles for Learning Environment based on STEAM Education. *International Journal of Advanced Culture Technology*, pp. 55-61.

Lawrence, R., Keime, C., & Elsayed , M. (2019, 8 16). Evaluation of environmental design strategies for university buildings. *Building Research & Information*.

Madkour, H. G. (2020). A study of interactive learning spaces within educational facilities. *INTERNATIONAL JOURNAL OF ARCHITECTURAL ENGINEERING AND URBAN RESEARCH*, pp. 16-26.

malek, m., & osama, m. (2018, april 30). The Impact of Novel Enviromental Trends and Intelligent systems in creating sustainable interior architecture. *International Design Journal*.

MANAHASA, O., & ÖZSOY, A. (2016, novomber). Do architects' and users' reality coincide? A post occupancy evaluation in a university lecture hall. *ITU A|Z*, pp. 119-133.

MATLOOB, F. A. (2016). *SUSTAINABLE CAMPUS DESIGN IN BAGHDAD UNIVERSITY, IRAQ.* baghdad: Universiti Teknologi Malaysia.

Mogas-Recalde, J. (2021, 1 25). l'adveniment de la Quarta Revolució Industrial: anàlisi dels factors clau per al disseny d'aules intel·ligents. *UTE. Revista de Ciències de l'Educació*, pp. 61-72.

Moreno-Moreno, P., & Palau, R. (2023, 6 1). Design Guide for Smart Classrooms based on environmental conditions. *RiiTE*.

Mulder, K. F., Balas, D., & Lente, H. V. (2012). *What is Sustainable Technology? Perceptions, Paradoxes, and Possibilities.*

Nyakongo Mokaya Clinton, & Ronoh, R. (2024, july). Assessing the Impact of Emerging Technologies on Teaching and Learning: A Review of Technology-Based Learning Environments. *INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)*, pp. No. 2454-6186.

Paquette, D. (. (2020)). . *How early decisions on coronavirus testing helped shape a pandemic.:.* USA - washington: https://www.washingtonpost.com/.

Passe, U. (2020). A design workflow for integrating performance into architectural education. *Buildings and Cities*, pp. 565–578.

Rainey, D. L. (2009). Sustainable technology management and development. In D. L. Rainey, *Sustainable Business Development: Inventing the Future Through Strategy, Innovation, and Leadership* (pp. pp. 385 - 443). Cambridge University Press.

Raja, R., & Nagasubramani, P. (2018). Impact of modern technology in education. *Journal of Applied and Advanced Research*, S33–S35.

Rieh, S.-Y., Lee , B.-Y., Oh, J.-G., Álvarez , P. P., Lee, K., Park, J., & Schuetze, T. (2017, JUNE 27). Integration of Sustainability into Architectural Education at Accredited Korean Universities. *MDPI*.

Rizova, P. S. (2007). The Blackwell Encyclopedia of Sociology. *wiley*.

Romano, R., Baratta, A. F., & Piferi, C. (2016). INVOLUCRI ADATTIVI PER LA RIDUZIONE DEI CONSUMI ENERGETICI DEGLI EDIFICI UNIVERSITARI. *Residenze e servizi per studenti universitari*.

Santiago, F., & Taborda, J. (2022). United Nations Capacity-building Programme on Technology Facilitation for Achieving Sustainable Development Sustainable Development Goals. In T. a. United Nations Inter-Agency Task Team on Science, *Science, Technology and Innovation to Achieve Sustainable Development Goals:Guidelines for Policy Formulation.*

Shi, X., Fang , X., Chen , Z., Phillips, T. K., & Fukuda, H. (2020, FEB 27). A Didactic Pedagogical Approach toward Sustainable Architectural Education through Robotic Tectonics. *MDPI*.

talee, S. M. (2019). Using Intelligent Techniquesin Sustainable Buildings- Buildings' External Form of Arabian Gulf Region as a Case Study –. *Al-Rafidain Engineering Journal (AREJ)*, 1.

Tariq, R. (2024, JULY 1). Complex artificial intelligence models for energy sustainability in educational buildings. *DOI*.

Valverde-Berrocoso, J., Borrega, J., & Pizarro, M. (2022). Educational Technology and Student Performance: A Systematic Review. *Frontiers in Education*, 1,2,10.

ISSN: 2663-5798 || Arab Journal for Scientific Publishing

الإصدار الثامن – العدد الواحد والثمانون
تاريخ الإصدار: 2 – تموز – 2025م
www.ajsp.net

Yaqoub, I. I., & Abbas, Z. K. (2019). Sustainable University Roadmap for Achieving Sustainable Development: An Analytical Study of the Opinions of a Sample of University Professors in the Iraqi Context. *Journal of Baghdad College of Economics University*, p. Issue of the 8th International Scientific Conference.

Zhicheng Dai. (2021). Assessment of Smart Learning Environments in Higher Educational Institutions: A Study Using AHP-FCE and GA-BP Methods.

"أثر التكنولوجيا على استدامة التعليم في الأبنية الجامعية – بحث مراجعة"

إعداد الباحثين:

أسماء زين العابدين الفخري[1]، عمر حازم خروفة[2]

الملخص:

التقدم السريع والمتزايد في مختلف مجالات الحياة صاحبه اندماج التكنولوجيا مع كل تلك المجالات لتحقيق العديد من الاهداف أبرزها اهداف التنمية المستدامة التي اصبحت في العقود الاخيرة محور اهتمام عالمي في العصر الحديث بمختلف محاورها (الاقتصادية والاجتماعية والبيئية والتقنية وغيرها).

يستعرض البحث أثر استخدام التكنولوجيا في تصميم المباني الجامعية على تحقيق الاستدامة التعليمية من خلال منهج تحليلي لمجموعة من الدراسات السابقة لتوفير نظرة شاملة عن كيفية تاثير التكنولوجيا على نتائج التعليم في الابنية الجامعية. يسلّط البحث الضوء على أهمية الابتكار التكنولوجي، من التصميم الداخلي إلى الواجهات الذكية وتصميم الفضاءات الخارجية في الحرم الجامعي، مما يعزز من قدرة المباني التعليمية على تلبية متطلبات الاستدامة المستقبلية. ومن هنا، يُظهر البحث أن توظيف التكنولوجيا بشكل فعّال في المباني التعليمية يُعد خطوة أساسية لدعم الاستدامة في قطاع التعليم العالي.

الكلمات المفتاحية: التكنولوجيا المستدامة، استدامة التعليم، ابنية جامعية، الهندسة المستدامة.