



Research Articles

Integrating sustainable development goals into the architecture curriculum: Experiences and perspectives

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ABSTRACT

The Sustainable Development Goals (SDGs) play a crucial role in architectural education, as buildings contribute 39% of global energy-related carbon emissions and 40% of extracted materials are used in construction. This research investigates the current status of SDG integration in architecture education, its challenges, and potential future advancements. A qualitative survey was conducted among architecture educators from 22 institutions across nine countries, focusing on four key aspects: (i) general knowledge and understanding of the SDGs; (ii) qualification and experience regarding the SDGs; (iii) integration of the SDGs in architecture education; and (iv) implementation of the SDGs in architectural practises. The findings revealed that most educators did not receive formal education focused on the SDGs, relying on self-exposure and self-learning. SDG 11 was the most adopted, focusing on improving slum areas, providing safe housing, and promoting sustainable urban settlements while preserving cultural heritage.

Introduction

Sustainability, introduced in 1987, emphasizes meeting present needs without compromising future generations' ability to meet their own needs [1]. The term 'sustainable architecture' emerged a little earlier in the 1970s and gained significant popularity during the 1990s, which is attributed to the construction of the headquarters of the United Nations in New York, USA [2]. Sustainable architecture is about constructing a healthy built environment with ecological and resource-efficiency principles [3]. Aligned with similar goals, the United Nations formulated 17 Sustainable Development Goals (SDGs), wholeheartedly embraced by 193 countries, whereas SDG 11 focuses directly on Sustainable Cities and Communities [4]. According to several scholars, sustainable architecture aligns directly with several SDGs, such as Goals 4, 7, 9, and 11 [5].

Despite the long-standing concept of sustainable architecture, 40 % of global extracted materials are used in construction [6]. Buildings still account for a significant 39 % of global energy-related carbon emissions, with 28 % influenced by building envelope quality and design [7]. These indicators reveal that contemporary social development patterns lead to environmentally unsustainable cities [8,9]. Nevertheless, architecture

plays a crucial role in approaching environmental concerns holistically [10]. Therefore, architects bear the responsibility of envisioning and designing cities that improve the overall quality of life, sustainability, social equity, health, and resilience of communities [10]. The Royal Institute of British Architects (RIBA) emphasizes that architects hold a unique position due to their ability to address the majority of the SDG goals [11]. Thus, the need for incorporating sustainable architecture education is currently a global call to enable current students and future architects to practice architecture more sustainably [12,13].

The role of education in society is a topic of debate, with some viewing it as a transformational mechanism [14], while others see it as a reflection of society [15]. Universities encourage interdisciplinary education to enable students to make informed decisions and advocacy [16]. In the context of architecture education, the United Nations announced the "Decade of Education for Sustainable Development" which emphasised the crucial role of educators in transforming societies to be more sustainable [17] and reinforcing the significance of architecture education to enable future architects for making well-informed decisions for future generations and overall planet sustainability.

Many architecture schools have integrated sustainable architecture into their curricula and design studios [16,18]. To comprehensively

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embed sustainable development in architectural education, the curriculum must emphasize environmental, social, and economic sustainability approaches, preparing students to contribute positively to their communities [19,20]. This educational approach teaches students to design buildings that interact with their surroundings, respect the natural environment, and cater to various intellectual, cultural, and social needs [21]. Hence, considering the diverse dimensions of sustainability targeted by the SDGs, integrating them into architectural pedagogy is crucial [22]. Incorporating SDGs into architecture education allows for assessing the sustainability of cities and creating healthier environments, communities, and societies [10]. In this context, architects would be perceived as “ambassadors” of the SDGs and be responsible for translating their impacts to communities through everyday practices [10].

Several recent studies have investigated the incorporation of sustainability concepts into architecture education and design studios. However, limited research focuses on the extent to which SDGs are integrated into architecture curricula worldwide. Akgun et al. [23] analysed the architecture guide to the SDGs by UIA in order to provide different approaches to incorporate the SDGs in the architectural studio courses. Ramadan and Abowardah [21] proposed an efficient framework to integrate sustainability pedagogics within the architectural design studio. They have collected the students’ perspectives on this approach and assessed their sustainability performance among the students’ projects. The results of the study revealed that integrating sustainability concepts at the project’s early stages would encourage students to achieve a higher sustainable performance. Erkarlan and Akgün [24] presented an educational approach for integrating SDGs into the architectural studios to increase awareness and achieve SDG targets. By analysing student graduation projects, the results reveal the success of instructors in orienting the students about urban change and the future in a responsible way. Hoskara et al. [25] also proposed a framework to integrate SDGs within architecture education in Turkey by analysing the current status of architecture schools in dealing with SDGs within their curricula and systems. Results demonstrated an overall lack of understanding of SDGs and the architecture’s potential to realise SDGs. El-Kholei and Yassein [22] investigated the architectural students’ awareness and knowledge of sustainability. The findings highlighted that students are not fully aware that influencing their practices, which requires a reforming of architectural education to achieve the SDGs. This reformation would require qualified instructors and facilities to deliver knowledge and prepare students for the labour markets.

Although SDGs are considered recently in the literature, since they were introduced in 2015 [24,26], they have attracted significant interest from various research disciplines. Many studies have been conducted about the learning outcome of students with knowledge about SDGs [22]. However, there is not enough data to indicate how prepared the educators are to integrate SDGs into architecture curricula since architects and educators who graduated before then might not have received formal SDG-based education during their architecture studies [27]. Therefore, understanding the role of SDGs in architectural education is vital for equipping architects to tackle sustainability challenges effectively. This research aims to address this gap by exploring the perspectives and experiences of architecture educators globally on integrating SDGs into the curriculum. Through implementing qualitative survey approaches, the research delves into the current status of SDG integration in architecture education, its challenges, and the potential for future advancements. The study focuses on examining the qualifications and competencies of current architecture educational systems for extending SDG integration into current curricula. The findings aim to support architecture educators and institutions in preparing SDG-aware architects and enhancing sustainable design education for the well-being of future generations and the environment.

The rest of the article proceeds by discussing the research methodology and data collection approach. In Section 3, the research findings are classified into (i) general knowledge and understanding of the SDGs;

(ii) qualification and experience regarding SDGs; (iii) integration of SDGs in architecture education; and (iv) implementations of SDGs in architectural practices. Afterwards, Section 4 discusses how architecture relates to all SDGs and the necessity to emphasize them in architectural curricula through recommendations provided in Section 5.

Methodology

Aligned with research objectives, a questionnaire survey was developed by the researchers to investigate the status quo of integrating SDGs into architecture education, explore the implementation of SDGs into architecture curricula, and identify enhancement potential. An online questionnaire conducted between May 2023 and June 2023 was distributed by electronic mail to 55 diverse worldwide architecture educators with/without field experience. The response rate was moderate (60 %), where 33 educators completed the whole questionnaire. Some questions have been applied closed-ended and open-ended methods, where the participants had to choose among fixed answers to provide a uniform basis for comparison of responses. The authors used data analysis methods to analyse responses. The main aim of the questionnaire was to investigate the level of awareness and preparations for the UN’s 2030 agenda for SDGs by collecting information among four key aspects:

- (i) General knowledge and understanding of the SDGs, which examines the participants’ comprehension of SDGs.
- (ii) Qualification and experience regarding SDGs, which examines the exposure of educators to SDGs during their architecture studies.
- (iii) Integration of SDGs in architecture education, which focuses on the current incorporation of SDGs into architecture curricula and opportunities for further enhancements.
- (iv) Implementations of SDGs in architectural practices, which discusses the practical application of SDGs within architectural practices.

The questionnaire consisted of three parts, as illustrated in Fig. 1. The first part collected demographic information regarding the gender, age, profession and qualification of educators. In the second part, participants were asked to indicate their level of exposure and qualification to SDGs. Finally, participants needed to demonstrate their experiences of SDG integration in architecture education and practices.

Demographic analysis

Understanding the demographic information of respondents is crucial for contextualizing their knowledge and experiences around the SDGs. A total of 33 experts have participated in the survey, with almost gender-balanced engagement, and diverse age groups, as shown in Fig. 2. Notably, 56 % were aged between 30 and 45, while 16 % fell into the 25–30 and 45–50 age brackets. An additional 8 % were over 50.

Survey participants originated from 22 different architectural institutions across nine countries as illustrated in Fig. 3, including Pakistan (21), Egypt (6), the USA (2), Austria (1), the UK (1), Brazil (1), South Africa (1), Switzerland (1), and Australia (1). More than a third are academic professors, while others are lecturers and instructors. While most participants hold a master’s or PhD degree, two respondents did not specify their level of education. More than three-quarters (82 %) are active educators and academic members. Others are retired faculty or have previous educational experiences.

Results

In this section, a concise summary is provided of the survey results for the four key research aspects.

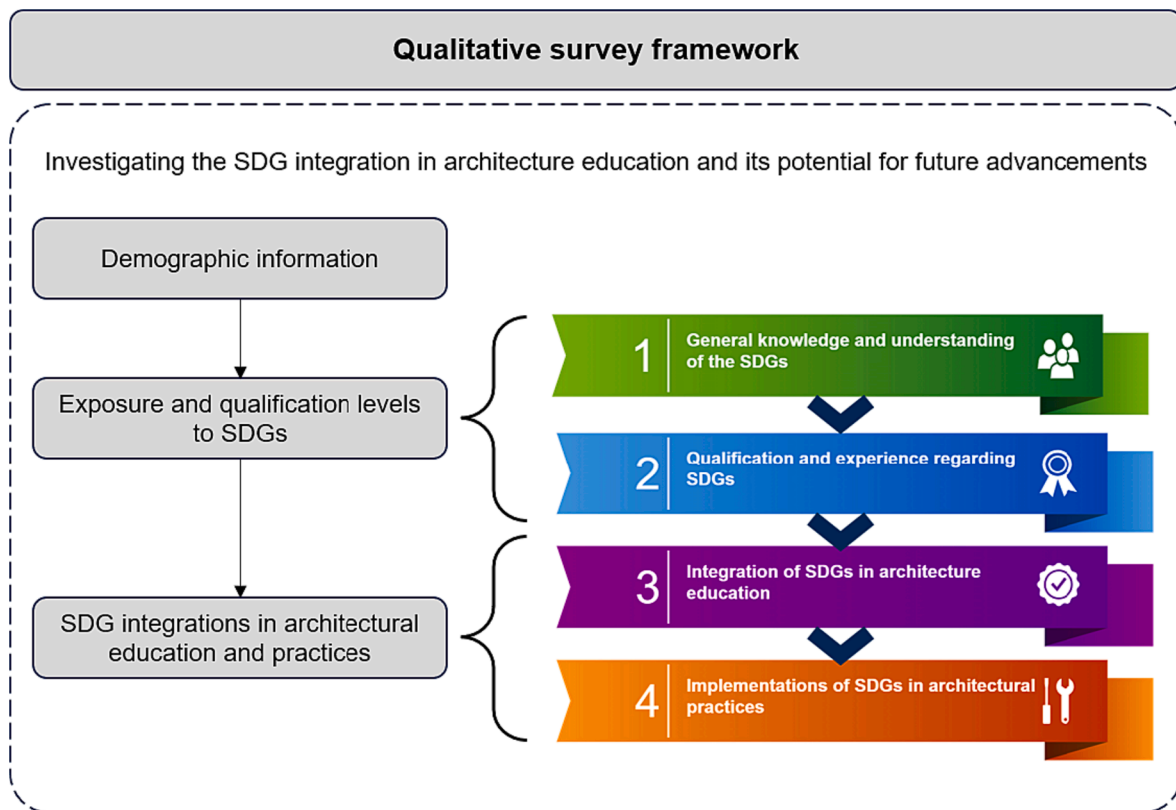


Fig. 1. A schematic diagram for the structure of the qualitative survey conducted in this research (source: authors).

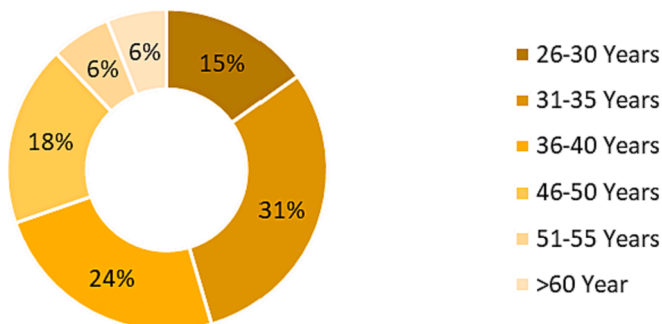


Fig. 2. Age distribution shares of the participants in the survey (source: authors based on the survey).

General knowledge and understanding of the SDGs

Examining participant age groups, it's evident that a significant majority exceed the age of 30. Consequently, many are likely to have considerable work experience or advanced education beyond a basic bachelor's degree. Data indicates that nearly 58 % of participants hold master's degrees, 21 % have PhDs, and only 15 % have a bachelor's degree. The participant breakdown also reveals that 39 % are professors, 52 % are lecturers and only 9 % work as teaching assistants, as shown in Fig. 4. Notably, some higher education teaching criteria, such as in Pakistan and Egypt, mandate lecturers to hold at least a master's degree in their respective disciplines [28]. This indicates a predominantly well-qualified teaching staff for architecture education.

Along with understanding participant ages, assessing their knowledge of the SDGs is also vital. Considering that the SDGs were introduced in 2015 [24,26], participants who graduated before then might not have received formal SDG-based education during their architecture studies [27]. However, those who pursued higher degrees after 2015 may have

been exposed to the SDGs. The majority of participants indicated varied levels of awareness about the SDGs. 49 % reported learning about the SDGs around 2015. Only 9 % mentioned encountering the SDGs for the first time, while others became aware more recently. Fig. 5 illustrates the understanding levels of participants of the SDGs. Approximately 30 % feel extensively informed, 45 % consider themselves well-informed, and 15 % feel moderately informed. Meanwhile, 6 % lack a sense of SDG awareness, with the remainder perceiving limited awareness.

These findings reveal that although most participants lacked direct formal SDG education, around 72.5 % indicated self-informed awareness other than formal education. The survey doesn't point to a specific age group lacking awareness of the SDGs. Since learning about the SDGs was not obligatory, It's apparent that 6 % of participants chose not to pursue self-learning about the SDGs. This observation suggests that the global efforts to promote the SDGs might not have been entirely effective in reaching all segments.

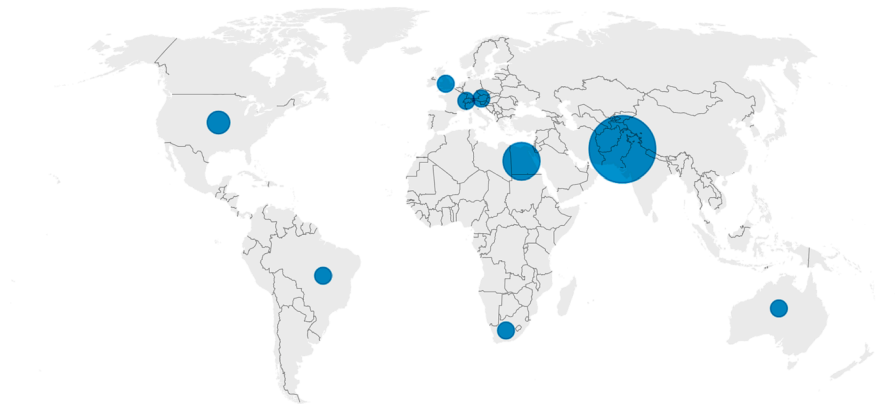
Qualification and experience regarding SDGs

Fig. 6 offers valuable insights into the exposure of participants to SDGs during their architecture studies, both directly and indirectly. The figure highlights that at least one participant below the age of 30 did not encounter SDGs either directly or indirectly during their education. This raises the possibility that integrating SDGs or sustainable architecture education may still be reluctant at some institutions. As shown in Fig. 6, about two-thirds of participants have either direct or indirect knowledge of SDGs or sustainable development within the field of architecture, where one-third reported having direct exposure to SDGs during their formal education, while an additional one-third asserted indirect exposure. Notably, only 18 % were directly instructed on SDGs within architecture and design studios.

As a significant portion of teaching staff lacks direct formal education about the SDGs, it's unsurprising that participants hold varying opinions on the significance of each SDG. These findings raise concerns

Geographical distribution of survey participants

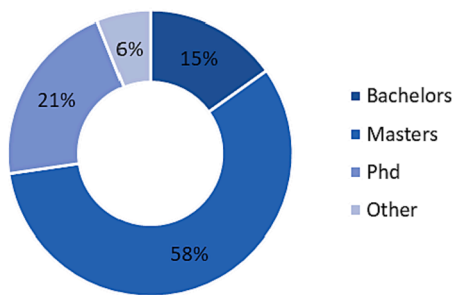
The number of participants across different countries



Thirty-five participants originated from nine countries; Pakistan (21), Egypt (6), the USA (2), Austria (1), the UK (1) Brazil (1), South Africa (1), Switzerland (1), and Australia (1).

Fig. 3. Geographical distribution of participants in the survey (source: authors based on the survey).

Educational qualification



Profession distribution

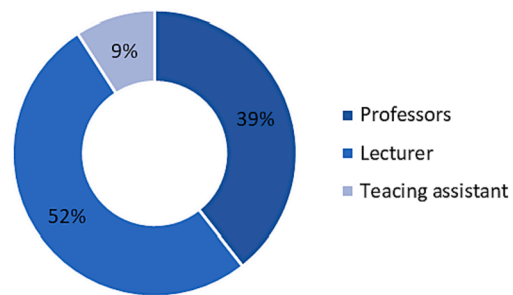


Fig. 4. Educational qualification and profession distributions of participants in the survey (source: authors based on the survey).

How participant informed about SDGs

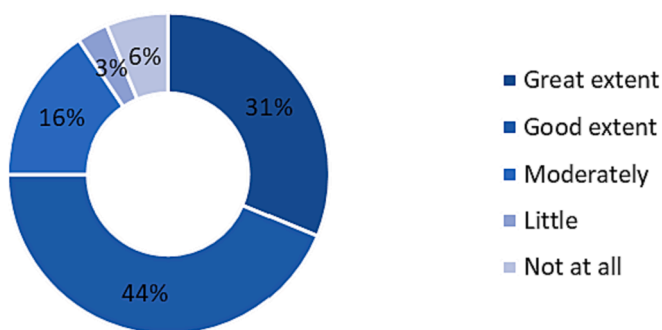


Fig. 5. Understanding SDG levels according to survey participants (source: authors based on the survey).

about the active role of institutions in educating their faculty members about SDGs to be more qualified for these subjects.

Integration of SDGs in architecture education

According to the survey, 18 % of participants are retired faculty

members or do not teach architecture-related courses. Others (82 %) are active academic members. Participants were questioned about their teaching experience. The survey indicated that 88 % of participants have teaching experience. Among those participants, all have teaching experience in architecture bachelor's courses. Furthermore, 33 % have instructed postgraduate students, and 9 % have even engaged with doctoral students. Regarding educational subjects within architecture institutions, 64 % are engaged in teaching architecture or design studios. Another 18 % teach subjects linked to the architecture curriculum, such as materials, urban planning, drawing, and structure. Otherwise, 18 % indicated that this doesn't apply to them, which may be due to current engagement in fieldwork or retirement from academia. Participants were further asked about the level of SDG incorporation in their teaching practices, as illustrated in Fig. 7. The survey revealed that 9 % integrate SDGs to a very great extent, 21 % to a great extent, 42 % to a moderate extent, 21 % to a small extent, and the remaining do not integrate SDGs in their teaching practices. Around 93 % of participants are engaging with the SDGs in varying capacities.

Within this context, participants were then requested to identify the key SDGs addressed in their courses, as shown in Fig. 8, which indicates the number of participants incorporating SDGs into their teaching. As expected, Goals 11 and 13 emerged as the most adopted SDGs because the concept of sustainable building design is not a new one in architecture and the built environment[3]. The findings demonstrate that SDGs are being addressed across participants' subjects in various

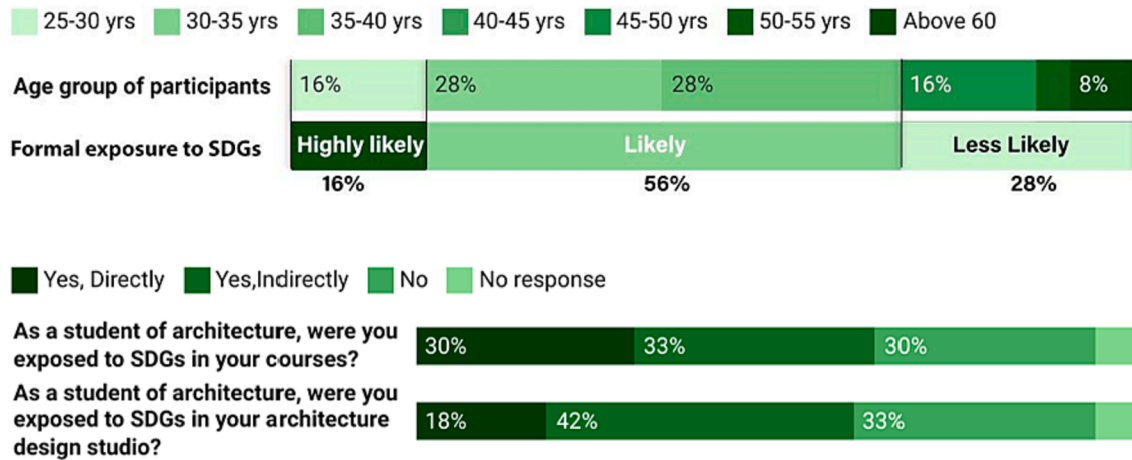


Fig. 6. The exposure levels to SDGs according to the age of participants and the integration within the architecture studio course and other courses (source: authors based on the survey).

Participants incorporating SDGs in teaching

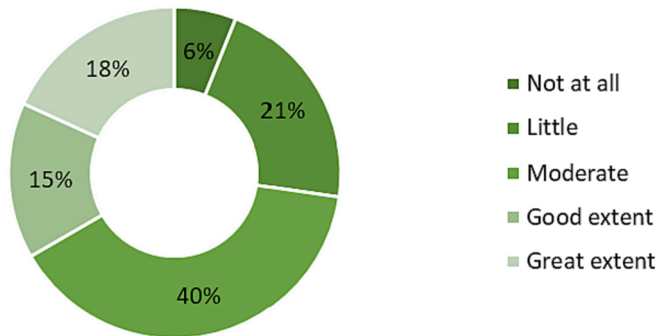


Fig. 7. SDG integration into participant curricula (source: authors based on the survey).

capacities. This leads to consideration of the integration of specific SDGs within architectural design studios. Fig. 8 reveals that architectural studios incorporate more SDGs than individual teaching practices. Nevertheless, SDG 11 remains the most integrated, followed by SDGs 6, 7, and 13.

According to participants' opinions. 70 % agreed that all SDGs have to be integrated into architectural design studios. However, participants' perspectives differ on the level of importance attributed to each SDG, which could be attributed to participants' diverse exposure to SDGs during their education. Notably, Goals 7, 9, and 11 gained the highest importance among participants, as shown in Fig. 9. The participants were asked to further elaborate on their SDG teaching experiences. Participants do not consider themselves to be SDG teaching experts.

Yet, as seen in Fig. 10, many are undertaking various efforts to enhance their skills. Only 12 % of participants have significantly revised their courses to incorporate SDGs, while 18 % have strong intentions to include SDG-related content. Otherwise, 24 % indicated that their coordinators or seniors had directed them to address SDGs directly in their courses. Only 9 % of respondents strongly agreed that their institutions have updated their curricula to include the SDGs. None of the interviewees firmly agreed that students requested additional course material relating to SDGs. This demonstrates that some students also have some ignorance. Another 12 % strongly agree that their institutions' educational plans and initiatives include SDGs. About 21 % incorporate sustainability-related case studies into their courses.

Besides, 36 % firmly encourage students to participate in community-based, social, or environmental activities. As SDGs are planned to enable every individual to contribute towards a sustainable environment, participants teach SDGs across a range of architecture subjects, including materials, structure, urban design, and sustainable building design-related courses.

The SDGs, known as Agenda 2030, are targeted for accomplishment by 2030. This framework is designed to engage the current generation in contributing to the preservation of our planet. Therefore, understanding the participants' perceptions of the integration of SDGs in education is critical. Approximately 75 % of participants anticipate an increasing emphasis on teaching SDGs until 2030, with no participants expecting a decrease in focus over time.

Regarding educational institutions' efforts to integrate SDGs, participants were asked whether SDGs were directly mentioned in their architectural design studio courses. 39 % indicated that their institutions do not directly incorporate SDGs into the architecture curriculum, while 61 % affirmed that SDGs are formally included. This observation aligns with participants' responses to whether they were exposed to SDGs during their architectural studies, of which only 24 % affirmed direct exposure within educational institutions. The findings lead to the conclusion that architecture educators in institutions face challenges beyond their formal preparation.

Most participants indicate that SDGs are not taught as an independent subject at their institutions, suggesting that the UN's 2030 agenda for SDGs is still out of reach for many. This lack of independent subject teaching indicates that institutions are not generally committed to incorporating SDGs, which reflects a certain level of ignorance of the urgent global concern of climate change. Fig. 11 provides a detailed insight into the integration approach of SDGs into architecture curricula among institutions. It reveals that approximately 18 % of participants find that their institutions comprehensively cover this topic, 39 % mention the topic sufficiently covered, 24 % believe it's not adequately covered as they expected, and 4 participants note poor coverage. One participant believes the topic is entirely missing, while another is unsure about the current situation at their institution. These observations indicate that although SDGs aren't yet taught as an independent subject in most institutions, around 58 % of participants perceive that they are being incorporated at a satisfactory level. Most of the participants say that SDGs are not taught as an independent subject at their institutions, as shown in Fig. 12.

Participants further discussed the extent of emphasis on SDGs within the architecture curriculum. Around 54 % believe there is sufficient emphasis on SDG-related matters in architecture courses at their institutions. Additionally, only 24 % of participants view SDGs as a

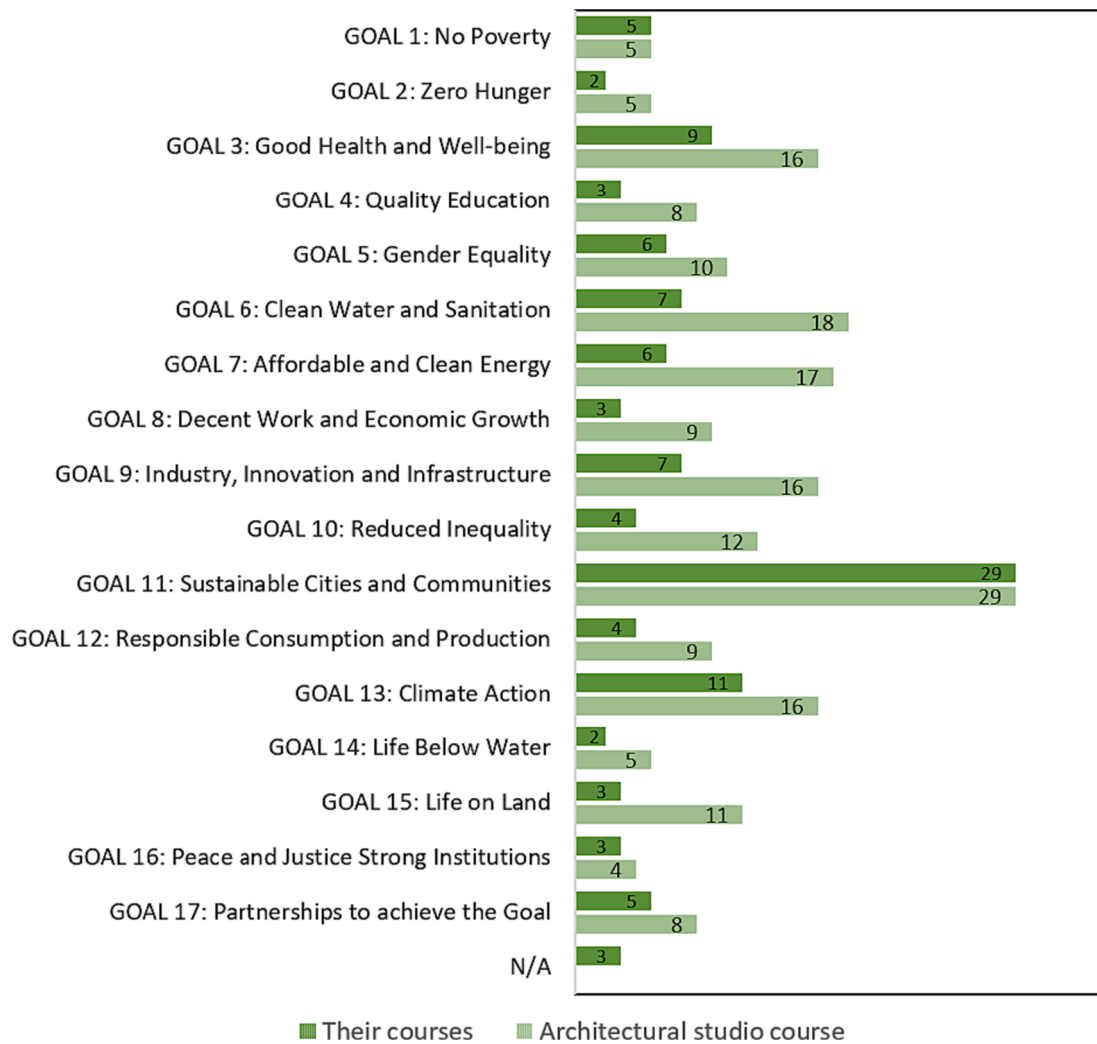


Fig. 8. SDG goals incorporated in teaching by participants and in Architecture design studios in the institutions (source: authors based on the survey).

standalone subject in their institution’s curriculum. These findings underline the considerable work required to align with Agenda 2030 and indicate the room for enhancing the architecture curriculum.

Furthermore, evaluating the adequacy of current architecture curricula in equipping students with basic SDG knowledge, 55 % of participants found the existing curriculum lacking in this regard. Despite this issue, there’s a divided perspective on how the SDGs should be integrated into the curriculum, as revealed in Fig. 12. Approximately 42 % suggest integrating SDGs across various modules and courses, 12 % advocate for a standalone subject, 19 % lean toward discussing SDGs through academic debates, and 27 % prefer to see SDGs reflected in research, projects, and exhibitions. These variations in the extent of SDG incorporation reflect its diverse importance among participants. The findings indicate that SDGs are not yet a top priority for most participants.

Overall, the findings reflect participants’ aspirations for SDGs to be seamlessly integrated into the architecture curriculum. They admit the vital role of architects in conserving the environment and natural resources. Although most participants believed that fully integrated SDG courses were a future matter, they currently teach some SDGs directly or indirectly. Institutions seem less obligated to emphasize the SDGs, and students may also demonstrate fewer concerns, as SDGs will require time for integration and gain popularity.

Implementations of SDGs in architectural practices

The survey revealed that 64 % of participants are active architecture practitioners, 24 % engage in the profession occasionally, and the other participants are not classified as field practitioners. Further questions were asked of those who consider themselves practitioners regarding the importance of SDG implementation and to what extent they integrate SDGs into their architectural practices.

70 % of practitioners incorporate SDGs into their practices at different levels, as shown in Fig. 13. 17 % of participants are significantly incorporating SDGs into their practices, whereas 10 % claim to integrate SDGs to a very great extent and 7 % to a great extent. 33 % indicate that they are moderately incorporating SDGs into their practices, 20 % incorporate SDGs to a limited extent, and 30 % don’t implement SDGs into their architecture practices.

The survey demonstrates that most of the participants believe SDGs are crucial for practising architecture, although 48 % of participants do not integrate SDGs into their practices to a satisfactory level, as shown in Fig. 13. Overall, 84 % of participants believe the SDGs are critical, while 15 % are unsure or believe the SDGs are less significant in the context of architectural practice.

The survey findings suggest that most participants haven’t fully embraced SDGs in their architectural practice, indicating that SDGs are not the primary objective in the field. However, most participants acknowledge the importance of SDGs in architecture practice. This

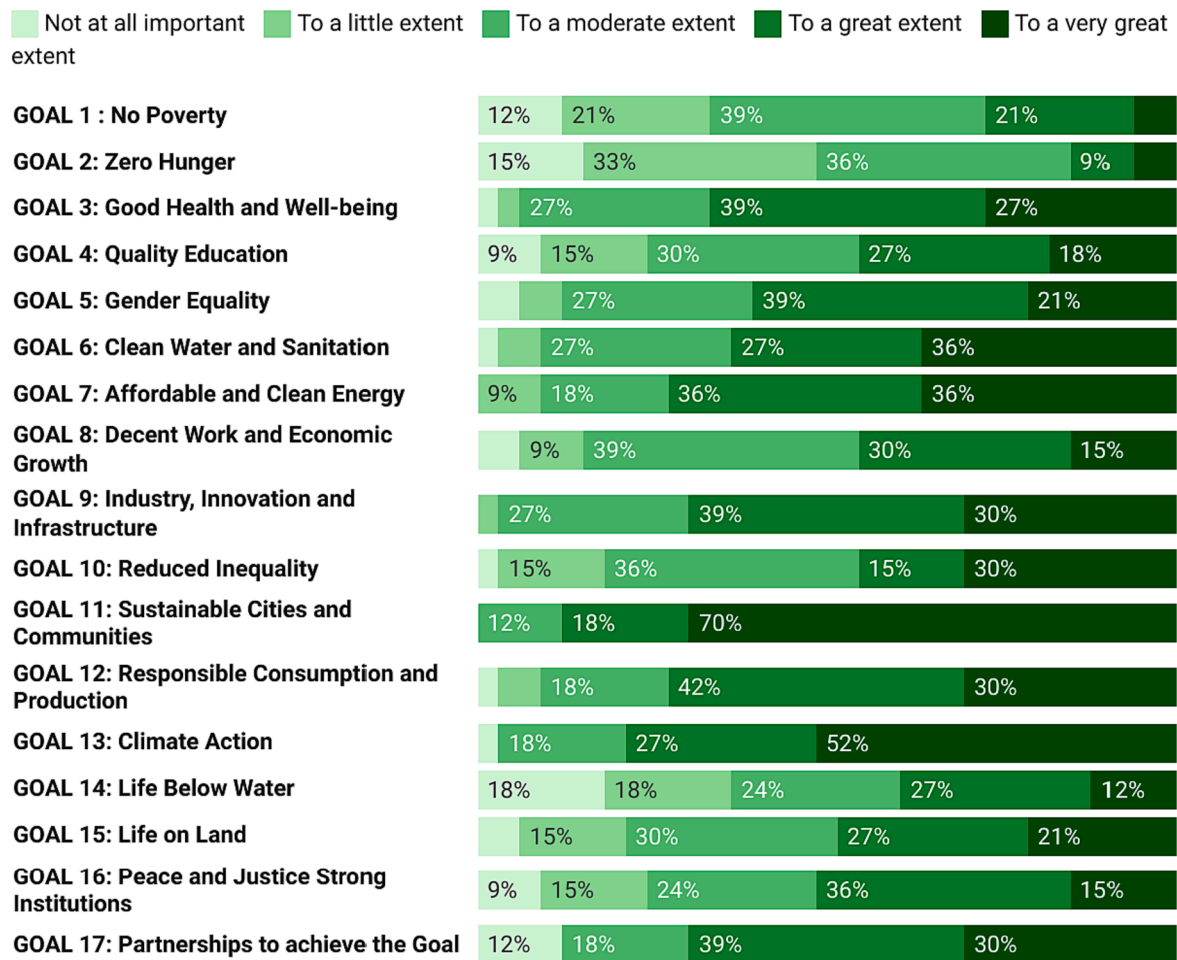


Fig. 9. SDG goals important for Architecture design studio according to participants (source: authors based on the survey).

emphasizes the critical role of well-educated and informed architects, who understand the impact of architectural design, in driving the global sustainable change needed.

Discussion

In this study, some notable indicators have been revealed regarding the current status of SDG integration in architecture education. Most architecture educators did not receive formal education specifically focused on the SDGs. However, an increase in the integration of SDGs into architectural education in the future is highly anticipated [12,13]. Most participants relied on self-exposure and self-learning to enhance their understanding and knowledge of the SDGs, which led to variations in their perceptions of the importance of each SDG goal within the context of architectural education. Consequently, there is a lack of understanding among participants regarding the significance of the UN’s 2030 agenda and the correlations between the SDGs and the architecture and design fields.

The educational sector has a vital role in addressing this issue of incorporating SDGs in its architectural institutions and schools [13]. Institutions should formally educate their staff and ensure that every SDG goal is given equal priority while integrating SDGs into the curriculum, as the SDGs are interconnected and progress in one goal often relies on advancements in others. Besides, courses need to be devised to educate both faculty and students about the SDGs, which will ensure a widespread and comprehensive understanding of the SDGs among architecture educators [21,22,24].

The study highlighted that SDG 11, which focuses on improving slum areas, providing safe and affordable housing, and promoting sustainable urban settlements while preserving cultural heritage [29], was the most familiar SDG among the survey participants. Although SDGs are not equally incorporated into different architecture courses, architectural design studios have significant potential to cover all the SDGs. However, architecture educators do not firmly agree on the importance of teaching all SDGs, which may be due to lack of awareness of the potential of the architecture industry to contribute to sustainable development. SDG 11 is not the only indicator related to the architecture of cities and urban settlements, but it’s linked to the other SDGs. Therefore, it is crucial to highlight these interconnected relationships and shed light on how architecture and urban planning can contribute to and be impacted by the various SDGs;

- SDG 1 aims to “End poverty in all its forms everywhere”, where architecture can lessen the impact of poverty on individuals and communities by designing and providing sustainable and affordable housing solutions. Architectural interventions can also develop educational and training environments that empower people with skills and opportunities to overcome poverty [30].
- SDG 2 aims to “End hunger, achieve food security and improve nutrition and promote sustainable agriculture”. As the availability of fertile agricultural lands decreases with the increase in urban density, initiatives, such as utilising rooftops for food production (aquaponics), can alleviate the burden on agricultural land and ensure more efficient use of resources [31]. Additionally, this

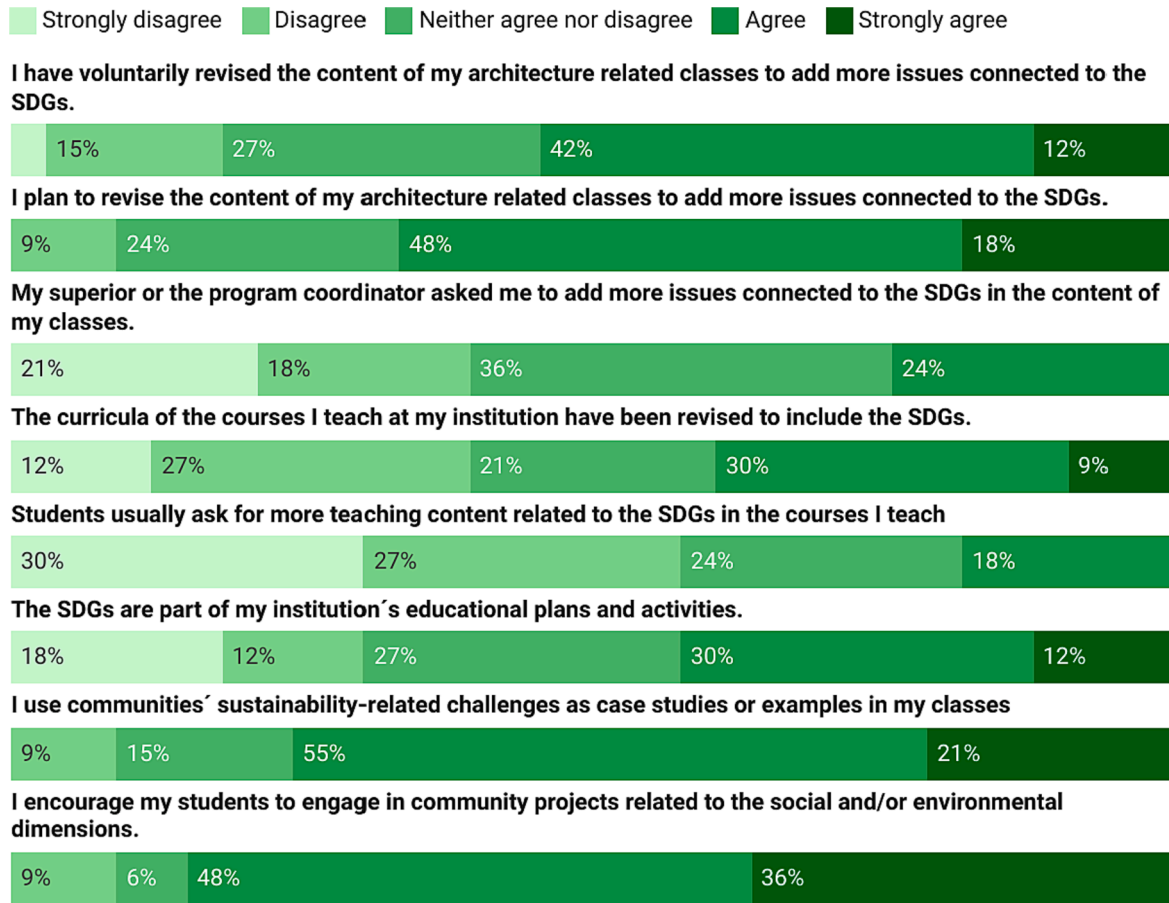


Fig. 10. Efforts of participants for teaching SDGs (source: authors based on the survey).

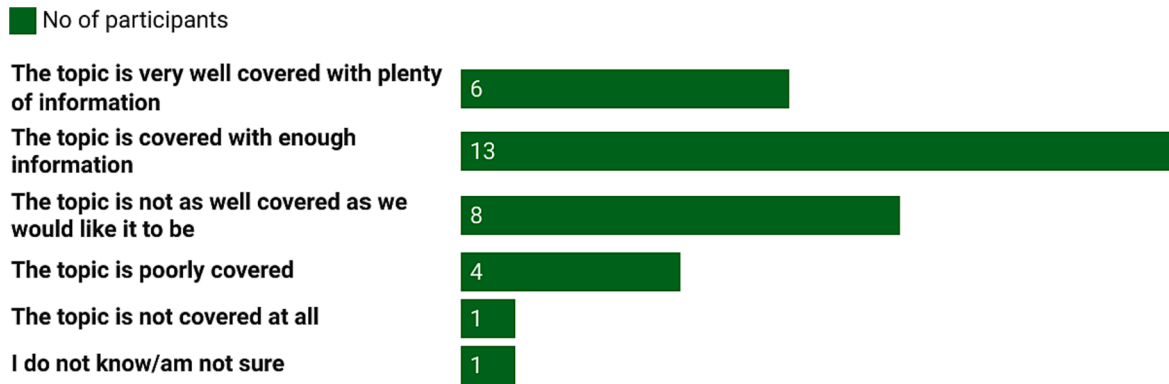


Fig. 11. Emphasis on matters related to SDGs in architecture courses by institutions (source: authors based on the survey).

approach can contribute to mitigating climate change and urban heat island effects [32].

- SDG 3 calls for “ensuring healthy lives and promoting well-being for all at all ages”. The built environment plays a significant role in improving health outcomes and enhancing the quality of life for all individuals by enhancing and creating spaces with high indoor environmental quality, including air quality, acoustic conditions, and thermal and visual conditions. Along with promoting physical activity and encouraging social interaction [33,34]
- SDG 4 is about ensuring an equitable quality of education. In this respect, architecture has a critical role in providing more comfortable and cost-effective educational buildings to maximise learning outcomes [35,36].

- To achieve gender equality and empowerment of women (SDG 5), architecture can play a vital role in improving women’s living conditions and socialisation opportunities [37]. For instance, incorporating safe and inclusive spaces to provide support and resources for women experiencing domestic violence or seeking empowerment. In addition, prioritise accessibility to public spaces and amenities and promote their participation in social, economic, and political activities.
- SDG 6 (clean water and sanitation) can be related to architecture through the design of buildings and urban infrastructure that incorporate innovative water conservation and efficient wastewater treatment technologies, which reduce the strain on existing water

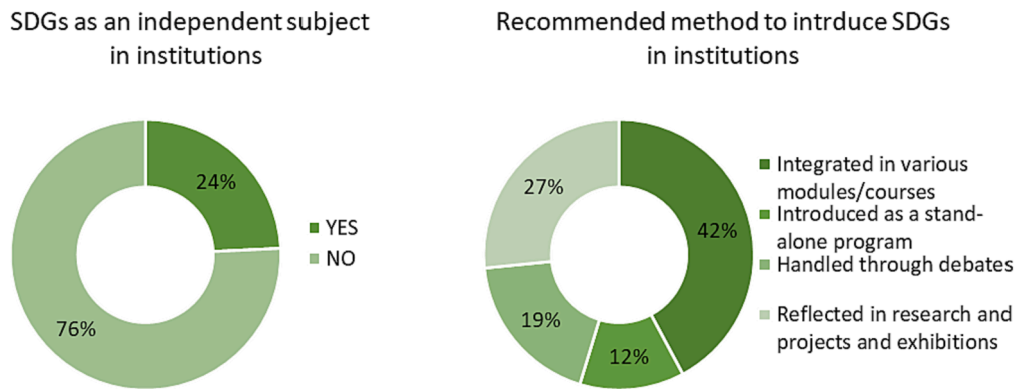


Fig. 12. SDGs as an independent subject at the institutions of the participants and the recommended approach of integration (source: authors based on the survey).

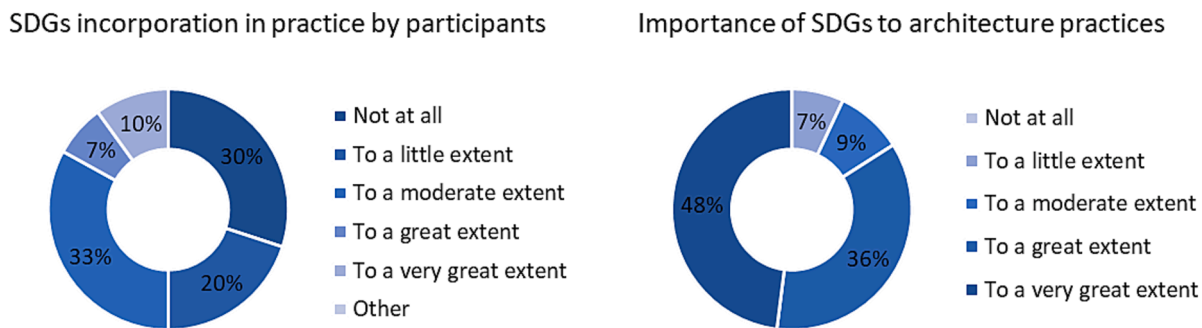


Fig. 13. The integration of SDGs in architecture practising and significance of SDGs in practice according to the survey participants (source: authors based on the survey).

resources and ensure sustainable access to clean water for future generations [38].

- SDG 7 (affordable, reliable, and sustainable energy); Buildings are responsible for around 40 % of global energy consumption as well as being potential energy producers [7]. Architects and urban planners play a crucial role in designing energy-efficient buildings by integrating sustainable design principles and renewable energy technologies, such as passive solar techniques and efficient insulation, to minimise energy consumption and maximise renewable energy generation, contributing to a more sustainable and resilient energy future [39,40].
- SDG 8 (decent work and economic growth); Architectural design plays a crucial role in creating a conducive and efficient work environment, which in turn promotes productivity and job satisfaction [41]. Additionally, incorporating sustainable design principles into the planning and development of buildings can contribute to long-term economic growth by reducing energy consumption and operating costs [37].
- SDG 9 (industry, innovation, and infrastructure); Smart architectural solutions are a prime example of how industry, innovation, and infrastructure intersect with architecture by integrating advanced technologies to optimise energy efficiency, enhance occupant comfort, and improve overall building performance, which not only ensure the needs of their occupants and businesses but also pave the way for sustainable and future-proof urban development [39,42].
- SDG 10 (reduce inequality); Architecture has a key role in promoting inclusivity and addressing inequalities within communities and societies. Architects can advocate for policies and regulations that prioritise affordable housing, public spaces, and infrastructure in underserved areas, further addressing societal disparities [43,44].
- SDG 11 is about sustainable cities and communities. Architecture contributes to developing communities and cities that are safe, resilient, sustainable, and robust [29]. Architects are accountable for

providing an affordable and healthy built environment and infrastructure, aiming to minimize the carbon footprint of buildings and promote renewable energy sources. Buildings and communities must be designed to increase their resiliency in the face of climate change and incorporate green spaces to mitigate the loss of vegetation and biodiversity resulting from urbanization [29,45].

- SDG 12 is responsible for consumption and production. The building industry consumes significant resources and results in waste over the whole building life cycle, from construction and operation to demolition [37]. Efforts to minimize waste and promote recycling in the construction industry are crucial for driving positive change towards a more sustainable future and achieving SDG 12. Implementing sustainable construction practices, such as using recycled materials and adopting circular economy principles, can significantly reduce the environmental impact of building activities [46].
- SDG 13 is about responding to climate change. Architecture significantly contributes to climate action. The built environment generates 40 % of annual global CO2 emissions. Implementing sustainable design and construction practices, including reducing energy demand, using energy-efficient materials, and incorporating renewable energy sources, contributes to significant reductions in greenhouse gas emissions and mitigating climate change impacts [45,47,48].
- SDG 14 is about conserving marine life and resources. Construction and demolition waste may end up in water and oceans, leading to polluting marine life and having negative impacts on aquatic biodiversity. Architects have a key role in conserving marine resources for sustainable development. Implementing sustainable design practices and proper waste management systems is crucial to minimising waste, promoting the use of eco-friendly materials, and mitigating the negative impact on marine ecosystems caused by construction and demolition activities [49].
- SDG 15 is about biodiversity loss, deforestation, and degradation. Architects should consider the impact of the built environment on

the surrounding environment and ecosystem, such as conserving on-site trees and vegetation. These efforts not only support preserving biodiversity but also contribute to mitigating climate change by reducing carbon emissions and promoting a sustainable and harmonious interaction between the built environment and nature [50,51].

- SDG 16 is about peace, justice, and inclusive institutions. Architecture has a role in promoting justice and equality in communities. Governmental and public buildings such as parliaments, courthouses, and public libraries should be designed to facilitate and preach peace and justice in societies [37]. By incorporating elements of transparency, accessibility, and inclusivity in their design, these buildings can serve as symbols of democratic values and promote public trust in the justice system.
- SDG 17 aims to “Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development”. Architects have an active role in cooperation and coordination between different disciplines, stakeholders, and authorities for developing an energy-efficient and sustainable built environment. Furthermore, collaborating and engaging with communities, particularly in developing countries, contributes to raising awareness about the importance of sustainable development and encourages local participation in achieving the SDGs. This collaborative approach is essential for ensuring the financing and technologies needed to accelerate SDG implementation [37].

Overall, while there is a growing awareness of SDGs among architectural educators, there is still much work to be done to ensure that all educators are well-informed and that SDGs are fully integrated into architectural education. The research findings aim to improve the curricula by including the concept of sustainability in the curricula through an interdisciplinary approach, partnerships with institutions and communities, scientific research, practice, improving teachers’ competence levels, and enhancing the course accreditation process. This is crucial to maximising the potential of the architecture industry to advance sustainable development goals on a global scale.

However, several limitations have been experienced. The study captures the opinions of academic staff but does not include student perspectives. The research does not focus on the adaptation approaches of the SDGs in architectural education or propose specific curriculum modules. Instead, it offers detailed insights into how SDGs should be taught in architecture schools, the training required for academic members, and the importance of educating architecture students about SDGs to influence their future practices positively.

Conclusion and recommendation

This research investigated the current status of SDG integration in architecture education, its challenges, and potential future advancements through a qualitative survey conducted among educators from different countries. The survey aimed to investigate to which extent are institutions and educators qualified to integrate SDGs into their architecture curricula by focusing on four key aspects: (i) general knowledge and understanding of the SDGs; (ii) qualification and experience regarding the SDGs; (iii) integration of the SDGs in architecture education; and (iv) implementation of the SDGs in architectural practises.

The integration of SDGs into architectural curricula lacks a prescribed global framework. The UN did not explicitly mandate the incorporation of SDGs into education across disciplines, leaving institutions and educators with varying levels of discretion. Consequently, there is a wide range of arguments on how SDGs should be integrated into the architecture curriculum, whether they should be addressed directly or indirectly, and whether the emphasis should be on all SDGs or individuals, particularly SDG 11. Given this complexity, a comprehensive restructuring of architecture curricula is crucial to align with current needs and concerns. The following strategies can facilitate the

seamless integration of the SDGs into architecture curricula:

- The integration of SDGs should be spanned across multiple academic years, rather than a single subject or year to ensure a comprehensive understanding and application of different sustainable development principles. This allows for the reinforcement of knowledge as students revisit and build upon their understanding of SDGs throughout their academic journey.
- The incorporation of interdisciplinary courses over different semesters that explore the combination of architecture and sustainable development can provide students with a holistic understanding of the SDGs and their relevance to architectural practices, ensuring a dynamic and varied exposure to different goals over time.
- The architectural curriculum should integrate all of the SDGs instead of focusing on individual SDGs (e.g. SDG 11). This comprehensive approach will enable students to understand the broader context and connection between different goals, developing a holistic understanding of sustainable development in the field of architecture, which will equip them with a well-rounded knowledge and skillset to address complex challenges.
- The incorporation of at least one SDG-related design project during architectural studies is crucial to enabling students’ practical engagement with sustainability challenges, which not only enhances their understanding of sustainable design principles but also equips them with the necessary skills to contribute meaningfully to the achievement of the SDGs in their future careers.
- Collaboration initiatives between universities should include SDG-focused seminars, lectures, and speeches, which would raise awareness of the crucial elements of sustainable development among both educators and students. Additionally, universities could establish partnerships with local communities and organisations to create practical projects that allow students to actively engage in sustainable development efforts.

Since the SDGs are broadly applicable, they should be inherent in architectural subjects, ensuring that students recognize their potential to effect positive change. To ascertain a comprehensive understanding of SDG recognition in architectural institutions, further studies covering different regions are required. The UN should take a proactive role in promoting the integration of SDGs as fundamental components of architectural educational frameworks. Despite the UN’s Agenda 2030, achieving widespread SDG integration may require a long time span—decades rather than years—similar to the development of sustainable architecture. Otherwise, institutions should consistently strive to enhance their educators’ knowledge about recent developments and technologies in architectural education paradigms. While access to quality education remains unequal, well-educated architects should be more responsible for tackling these challenges and issues.

CRedit authorship contribution statement

Mennatullah Hendawy: Leadership, Conceptualization, Data curation, Methodology, Supervision, Validation, Revising Visualization, Writing – review & editing. **Mahreen Junaid:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft. **Amin Amin:** Methodology, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

- [1] World Commission on Environment and Development (1987). Our Common Future. [online] World Commission on Environment and Development, pp.1–300. Available at: <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf> [Accessed 4 Jul. 2023].
- [2] AA-architects (2022), “What is sustainable architecture?”, available at: <https://aa-architects.org/sustainable-architecture/#:~:text=The%20term%20E2%80%9C%20Sustainable%20Architecture%20has%20been%20around%20since,the%20United%20Nations%20headquarters%20in%20New%20York%20City.> (Accessed: October 23, 2022).
- [3] Kunszt G. Sustainable architecture. *Periodica Polytechnica Civil Engineering* 2003; 47(1):5–10.
- [4] Pedersen CS. The UN sustainable development goals (SDGs) are a great gift to business! *Procedia Cirp* 2018;69:21–4.
- [5] Boarin P, Martinez-Molina A. Integration of environmental sustainability considerations within architectural programmes in higher education: A review of teaching and implementation approaches. *Journal of Cleaner Production* 2022; 342:130989.
- [6] Ramnani V. (2021). “39% of global carbon emissions generated by buildings, construction”, available at: <https://www.moneycontrol.com/news/business/real-estate/39-of-global-carbon-emissions-generated-by-buildings-construction-7707561.html> (Accessed: October 26, 2022).
- [7] World Green Building Council. (2022). Causes of Air Pollution from the Built Environment | World Green Building Council, available at: <https://worldgbc.org/clean-air-buildings/causes>, (Accessed 18 October 2022).
- [8] Bithas KP, Christofakis M. Environmentally sustainable cities. *Critical review and operational conditions. Sustain Dev* 2006;14(3):177–89.
- [9] Blowers A, Pain K. The unsustainable city. *Unruly Cities? Order/Disorder* 1999: 247–98.
- [10] Thorne M., and Duran P. (2016). “The role that architecture can play in the development agenda.” available at: <https://www.devex.com/news/the-role-that-architecture-can-play-in-the-development-agenda-88124> (Accessed 10 September 2022).
- [11] Donovan, E., (2020). “Explaining sustainable architecture”, in IOP Conference Series: Earth and Environmental Science (Vol. 588, No. 3, p. 032086). IOP Publishing.
- [12] Patterson J, Wyborn C, Westman L, Brisbois MC, Milkoreit M, Jayaram D. The political effects of emergency frames in sustainability. *Nat Sustainability* 2021;4(10):841–50.
- [13] Mohamed KE, Elias-Ozkan ST. Incorporating sustainability principles into architectural design education: Results of an experimental design studio. *Journal of Green Building* 2019;14(3):143–58.
- [14] Simsek H. Transformational leadership in educational context: education scholars’ fantasy. *Eurasian J Educ Res* 2013. in print.
- [15] Durkheim E. *Suicide: A study in sociology*. Routledge; 2005.
- [16] Yeretizian A. (2020). Pedagogical methodologies to achieve SDGs in developing economies.
- [17] UNESCO. Decade of education for sustainable development: 2005-2014. *Draft International Implementation Scheme*. 2005.
- [18] Sonetti G, Brown M, Naboni E. About the Triggering of UN Sustainable Development Goals and Regenerative Sustainability in Higher Education. *Sustainability* 2019;11(1):254. <https://doi.org/10.3390/su11010254>.
- [19] Sonetti G, Lombardi P, Chelleri L. True green and sustainable university campuses? Toward a clusters approach *Sustainability* 2016;8(1):83.
- [20] Lozano R, Lukman R, Lozano FJ, Huisingh D, Lambrechts W. Declarations for sustainability in higher education: becoming better leaders, through addressing the university system. *J Clean Prod* 2013;48:10–9.
- [21] Ramadan MG, Abowardah ES. Incorporating a sustainability approach in Teaching Architectural Design Studio. *The International Journal of Design Education* 2022; 17(1):37–64.
- [22] El-Kholei AO, Yassein GA. Embedding sustainability and SDGs in architectural and planning education: reflections from a KAP survey, Egypt. *Archnet-IJAR: International Journal of Architectural Research* 2023.
- [23] Akgun Y, Erdoğan Erkarlan Ö, Neşeliler P. A guide for a guide: using UIA publications for an SDG-focused studio. *Archnet-IJAR: International Journal of Architectural Research* 2023.
- [24] Erkarlan ÖE, Akgün Y. Incorporating United Nations 2030 sustainable future agenda into the architectural studio: a graduation studio case. *International Journal of Art and Design Education* 2022;41(4):603–20.
- [25] Hoskara S, Akgun Y, Erkarlan O, Koc O. July. Integration of the UN 2030 Sustainable Development Goals into Architectural Education in Turkey. In: *World Congress of Architects*. Cham: Springer International Publishing; 2023. p. 815–33.
- [26] Alcamo J, Thompson J, Alexander A, Antoniadis A, Delabre I, Dolley J, et al. Analysing interactions among the sustainable development goals: findings and emerging issues from local and global studies. *Sustain Sci* 2020;15:1561–72.
- [27] Walter Leal Filho, Portela, R., Paula Varandas Ferreira, Madalena, M., Berenguer, A., Nadjaclcia Vilar Almeida, Fritzen, B., João Morais Júnior, Ciliana Regina Colombo, Walleci Gabeu Lira and Lira, T. (2023). Perceptions of the academic community on the performance of sustainable development initiatives in higher education. doi:<https://doi.org/10.1002/sd.2633>.
- [28] Karakus M. *Overview of Higher Education (Egypt)*. Bloomsbury Education and Childhood Studies: Higher Education 2019.
- [29] Chidimma NOR, Ogochukwu OF, Chinwe SA. The 2030 agenda for sustainable development in Nigeria: The role of the architect. *Science, Technology & Public Policy* 2020;4(1):15–21.
- [30] Zollinger, S. (2008). One piece at a time: Building community in a south Texas Colonia.
- [31] Wiegand, M. (2019). *Aquaponics Development in the Netherlands The Role of the Emerging Aquaponics Technology and the Transition towards Sustainable Agriculture (Master’s thesis)*.
- [32] Ju P, Anser MK, Osabohien R, Ochuba O, Ahuru RR, Ashraf J. Trade openness, foreign direct investment and sustainable agriculture in Africa. *Problemy Ekonomii* 2022;17(1).
- [33] Fischer F, Carow F. Impact of Public Health and Sustainability of Global Health Action for Achieving SDG 3. Good Health and Well-Being. 2022. p. 111.
- [34] Zhang Y, Tzortzopoulos P, Kagioglou M. Healing built-environment effects on health outcomes: Environment–occupant–health framework. *Build Res Inf* 2019;47(6):747–66.
- [35] Taylor N, Quinn F, Jenkins K, Miller-Brown H, Rizk N, Prodromou T, et al. Education for sustainability in the Secondary Sector—A review. *Journal of Education for Sustainable Development* 2019;13(1):102–22.
- [36] Cheryan S, Ziegler SA, Plaut VC, Meltzoff AN. Designing classrooms to maximize student achievement. *Policy Insights from the Behavioral and Brain Sciences* 2014;1(1):4–12.
- [37] Mossin, N., Stilling, S., Bøjstrup, T.C., Larsen, V.G., Blegvad, A., Lotz, M. and Rose, L., 2018. *An architecture guide to the UN 17 Sustainable Development Goals*. KADK.
- [38] Berkebile B, McLennan J. The living building: biomimicry in architecture, integrating technology with nature. *BioInspire Magazine* 2004:18.
- [39] Amin A, Kem O, Gallegos P, Chervet P, Ksontini F, Mourshed M. Demand response in buildings: Unlocking energy flexibility through district-level electro-thermal simulation. *Appl Energy* 2022;305:117836.
- [40] PE PGPD. Sustainable energy systems engineering: the complete green building design resource. McGraw-Hill Education; 2007.
- [41] Salama AM, Courtney L. The impact of the spatial qualities of the workplace on architects’ job satisfaction. *ArchNet-IJAR: International Journal of Architectural Research* 2013;7(1):52–64.
- [42] Clements-Croome D, editor. *Intelligent buildings: design, management and operation*. Thomas Telford; 2004.
- [43] Glass LM, Newig J, Ruf S. MSPs for the SDGs—Assessing the collaborative governance architecture of multi-stakeholder partnerships for implementing the Sustainable Development Goals. *Earth System Governance* 2023;17:100182.
- [44] Bieri S., and Bader C. (2023). *Transitioning to Reduced Inequalities* (p. 246).
- [45] Amin A, Mourshed M. Weather and climate data for energy applications. *Renewable and Sustainable Energy Reviews* 2024;192:114247.
- [46] Norouzi M, Chafer M, Cabeza LF, Jiménez L, Boer D. Circular economy in the building and construction sector: A scientific evolution analysis. *Journal of Building Engineering* 2021;44:102704.
- [47] Brown MA, Southworth F. Mitigating climate change through green buildings and smart growth. *Environment and Planning A* 2008;40(3):653–75.
- [48] Amin A, Mourshed M. Community stochastic domestic electricity forecasting. *Applied Energy* 2024;355:122342.
- [49] Siddiqua A, Hahladakis JN, Al-Attia WAK. An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. *Environmental Science and Pollution Research* 2022;29(39):58514–36.
- [50] Ferrer-Balas D, Buckland H, de Mingo M. Explorations on the University’s role in society for sustainable development through a systems transition approach. Case-study of the Technical University of Catalonia (UPC). *J Clean Prod* 2009;17(12): 1075–85. <https://doi.org/10.1016/j.jclepro.2008.11.006>.
- [51] Ferrer-Balas D, Buckland H, de Mingo M. Explorations on the University’s role in society for sustainable development through a systems transition approach. Case-study of the Technical University of Catalonia (UPC). *J Clean Prod* 2009;17(12): 1075–85.