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Evaluating the Effectiveness of Sustainability Education in Universities Across Sindh: Challenges, Opportunities, and the Way Forward

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Abstract

Sustainability education is one of the essential aspects of higher learning institutions, as it prepares the learners with the knowledge, skills, and attitudes needed to address sustainable environmental, social, and economic issues in their societies. This research assesses the status of sustainability education in universities in Sindh Pakistan in terms of awareness among students and faculty, training of faculty members, infusion of sustainability themes in the curriculum, support and resources provided by the university, industry engagement, and the level of use of digital learning tools. In this study, quantitative and qualitative data was obtained by self-completed questionnaires, qualitative interviews with selected students, staff, and university management, and archival records. This paper shows the discrepancies in the implementation of sustainability education, some universities have higher involvement in student and faculty training while others face challenges with curriculum inflexibility and limited funds. The findings discussed in the work include the lack of sufficient interprofessional collaboration, the confinement of research activity in the university environment, and the absence of clear policies. Recommendations include developing the training of teachers in teaching areas, growing the use of digital instruction methodologies, and promoting linkages and engagement with businesses and industries to incorporate sustainability issues into their framework; and, constructive modification in policies to better incorporate sustainability education. The present study calls for the development of a well-planned, organized framework of sustainability education in Sindh's universities to better conform with such tenets and become a catalyst for SDs.

Key Words

Sustainability Education, University, Sindh, Pakistan, Higher Institutions

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Introduction

Sustainability education has become a relevant part of the academic curricula in higher learning institutions across the globe to prepare students with competencies in managing environmental, social, and economic challenges that face societies today (Cottafava et al., 2019). Universities have a crucial role in the formation of future generation leaders, which are central in addressing sustainable development in some of the world's most pressing issues such

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as climate change, resource scarcity, and social injustice (Lozano et al., 2013). Sustainability education is particularly highlighted in the United Nations' Sustainable Development Goals for 2030: Target 4.7 stating that higher education institutions should integrate sustainability into their curricula (UNESCO, 2021). To address these global challenges, universities all across Pakistan including Sindh province are now following the trend to include syllabi and practicals related to sustainability in their curriculum. Nevertheless, the outcomes of these endeavors have not been well understood.

Sustainability education is a combination of many subjects, taught across disciplines, including environmental, social, and sustainable business, renewable energy, and social justice (Wals & Corcoran, 2006). This aims to foster in the students the skills to analyze sustainable issues and use problem-solving strategies that address age and environmental impacts (Tilbury, 2011). That is why it has been discovered that to support and deliver efficient environmental and sustainability education, a significant amount of theoretical content should comprise various forms of practical applications, including field works, case-based learning, and real-world company projects (Barth et al., 2007). Nevertheless, the authors identified a number of challenges that many universities in developing countries encounter concerning their pursuit of comprehensive sustainability education, and these are; curriculum flexibility, faculty readiness, and resource constraints (Dawe et al., 2005).

Sustainability education is relatively new in Pakistan, and its integration varies from university to university. It is established that despite the fact that various universities and colleges have implemented approaches to teaching sustainability-themed courses in their curriculum, the courses are taught as extra or supplementary courses but are not integrated into mainstream programs. For instance, there is a high probability that faculty members themselves may not be well-trained to teach the concept of sustainability and therefore, the quality of teaching will not be very high (Sain et al., 2024). Another one is institutional engagement; such an optimum level is official university backing and an efficient and well-formulated sustainability policy ensures good performance in the process of transformation (Khan et al., 2024).

Sindh is amongst many provinces of Pakistan and has many universities that have embraced, to some extent sustainability education. For instance, the University of Karachi and Mehran University of Engineering & Technology have implemented sustainability-related modules in the engineering, environmental science, and business management curricula (Sahito & Väisänen, 2018). However, this is rarely done due to maladministered and disparate policies as well as organizations' weak connection with industries and analytical institutes. In addition, the students have moderate levels of awareness about sustainability and engagement and there is a lack of extracurricular activities towards sustainability. All these have to be achieved after conducting a review of best practices in sustainability education with a view to identifying gaps and where necessary offering recommendations.

The purpose of this study is to evaluate the state of sustainability education in Sindh universities in terms of curriculum adoption, faculty training, programs, and students. In order to respond to the three research questions, this mixed-methods research study aims at: The main questions that need to be explored include: What are the key challenges that limit its adoption? And, where are the learning of and learning through the principles of sustainability placed within universities? These questions will be important to answer in order to improve frameworks for delivering sustainability education to higher education institutions as seen for policymakers, educators, and academic administrators.

Therefore, the importance of this study is in understanding implications for policy making and curriculum development based on comparative policies of best-performing countries. Bennette (2005) also supports these assertions, based on research from developed nations, suggesting that universities with sound-established sustainability initiatives produce environmentally and socially responsible graduates for sustainable development

(Cortese, 2003; Lenssen et al., 2009). Thus, it identifies the gap in the current state of research in Sindh on sustainable education and the following recommendations: to improve the strategies in educational practices, to develop better university-industry partnerships, and to build up professional development programs for faculty members.

Literature Review

Sustainability education has arisen all over the world with the rising demands of environmental, social, and economic instabilities. Since universities bear the responsibility of developing future leaders who are aware of sustainability issues and have the skills needed to address them, researchers have examined the models used in sustainability education programs, the challenges to sustainability pedagogy, and the potential for enhancing them. This section reviews empirical literature on sustainability education in higher learning institutions, especially on its importance, methodologies, issues encountered, and examples from various parts of the world.

The Importance of Sustainability Education in Higher Education

Sustainability education, which is also called Education for Sustainable Development or Education with Sustainable Development, is more important than ever in providing students with the knowledge and competencies that are required to address complex challenges. Lélé, (1991) defined ESD as a form of education that goes beyond environmental education meaningfully addressing social equity, economic stability, as well as ethical responsibility. It offers a comprehensive way of learning that imbues critical thinking, problem-solving capacities, and the potential to incorporate sustainable thinking across one's private and professional life.

Higher learning institutions are important facilitators when it comes to sustainability since they churn out people who join business, government, and teaching professions with sustainable development knowledge ingrained in them (Barth et al., 2014). The ongoing research reveals that universities that have embarked on incorporating sustainable practices support the national sustainability agenda and economic growth (Rieckmann, 2018). Another study carried out by Andrews & Soares, (2017) affirms that sustainability-literate graduates will incorporate environmental and social concerns in business and governance and therefore promote global sustainability.

Pedagogical Approaches in Sustainability Education

In this case, concerns relating to sustainability education are greatly informed by pedagogy. In the past, presentations and lectures from the faculty were the most common way to introduce sustainability concepts while recent studies have shown that both experiential learning and problem-based learning are more effective (Cebrián & Junyent, 2015). According to García et al., (2006), the process of teaching sustainability implies that individuals have to engage themselves in a more active way with certain methods involving field projects, interdisciplinary cooperation, and students' own activities. According to Kolb, (2014), there are four stages of experiential learning including concrete experience, observation and reflection, verbal and analytical thinking, and experimentation, which also implies that for students to have a concrete understanding of sustainability, they need to undertake these stages.

Some universities have focused on education for sustainability by adopting such approaches to problem-focused learning. For instance, Mogensen & Schnack, (2010) describe its "action competence" model where students are engaged in real sustainability action initiatives including waste management projects, carbon footprint assessments, or campus greening projects. Likewise, Larsson & Holmberg, (2018) have talked about how in sustainability education, adopting technology integrates digital simulations or teaches sustainability courses online which is considered to have a positive impact on the students.

Challenges in Implementing Sustainability Education

However, it has been widely documented that sustainability education is also struggling with major issues across the globe. Verhulst & Lambrechts, (2015) indicate that this is attributed to the low levels of institutional support. While managing strategic growth, the universities have embraced sustainability in their vision and mission statements without offering substantive teaching and learning about sustainability. According to Ramísio et al., (2019), only 37% of the Universities to which the survey was conducted have a cohesive, integrated curriculum in sustainability, while the others incorporate it as an add-on, an elective.

Another significant issue is the training of faculties that should possess the most fitting skills for imparting knowledge to their learners. The study points out the fact that a significant number of educators have no training in sustainability education and do not have the proper skills to implement these principles in their subjects (Rahim et al., 2024). Garritzmann, Barth, & Rieckmann, (2014) similarly argue that sustainability education entails a decreased reliance on primarily didactic techniques as well as increased reliance on interdisciplinarity, systems perspective, and systems thinking that many faculties struggle with if they do not receive relevant training.

There is also one potential problem in Learning Classes there are many restrictions in terms of resources for implementation of sustainability education. Education for sustainability is a challenge in these institutions, especially where they are faced with limited funding, inadequate research equipment, and insufficient access to information on sustainability (Leal Filho et al., 2015). In the case of universities in the South Asian region, Leal Filho (2022) identified that due to scarcity of funds, sustainability was practiced more like an optional activity as opposed to being an acknowledged stream of learning. Further, there is a weak interaction between the universities and industries, which hinders the chances of field practicals that are ideal for learning the aspect of sustainability (Mulder et al., 2012).

Sustainability Education in Developing Countries

Despite the advancement in knowledge and awareness, sustainability education is still inadequate in most institutions, especially those in developing countries. Some universities have adapted to such models of GSE because they benefit from policies and adequate resources while others have failed to embrace them. According to Azapagic et al., (2016), the process of mainstreaming sustainability into university curricula in South Asia and Africa is hampered by administrative barriers and inadequate intersectoral collaboration.

Sustainability education is still emerging in Pakistan and there is little empirical research, which has examined its effects. Research done by Hinduja et al., (2023) showed that Pakistani universities have introduced programs that focus on environmental science and sustenance but unfortunately, these programs are often neglected within the broader programs. However, according to Khushik, & Diemer, (2018), there is still a lack of cohesive policy approaches and the absence of any schemes that would encourage more institutions to adopt sustainability education efficiently as a result of the absence of government incentives and industry collaborations.

However, some Pakistani universities have made some improvements. At the National University of Science and Technology (NUST), they have incorporated sustainability-focused modules at the engineering level (Hinduja et al., 2023), while LUMS has done so at an MBA level. In addition, another study by Habib et al., (2021) has explored student's sustainability practices in Pakistani universities by finding that many students are now actively participating in clubs and campaigns to address environmental issues.

Global Best Practices in Sustainability Education

Some countries have incorporated sustainability education in the system of higher education effectively demonstrating how others have to do it. For instance, in Swedish universities, sustainability is integrated into their learning and teaching, and universities are compensated according to their performance on sustainability (Argento

et al., 2020). Likewise, to ensure that faculty is knowledgeable and capable of implementing sustainable development in their areas of expertise in the universities of Germany, state mandatory training (Roos et al., 2023).

In the United States, the Association for the Advancement of Sustainability in Higher Education (AASHE) has designed a Sustainability Tracking, Assessment & Rating System (STARS) with which universities might be benchmarked for sustainability (E Doocy, 2021). This framework gives general advice on curriculum development, how campuses can become sustainable, and how to engage students on this issue. The findings by Stephens et al., (2019) reveal that university structures that include policies with sustainability elements have higher student involvement and improved sustainability learning.

Similar improvements have also been noted in universities, such as Tsinghua University where sustainability is included in engineering and business education (Niu et al., 2010). The Chinese government offered nationwide integrated initiatives and a financial support system, which resulted in the fast development of sustainability curricula in the institutions.

The Need for an Integrated Approach in Sindh's Universities

The best practices and challenges indicate that there is a need for a coordinated policy to promote sustainability education in universities in Sindh. Based on previous studies, sustainability education depends on policies, faculty development, and industry knowledge (Leal Filho et al., 2018). An example approach would revolve around changing the content of the offerings taught in universities to incorporate the sustainability concept, providing support and training to the faculty, and forging links with businesses and industries as well as the government.

A study by Ali, (2021) has suggested that while sustainability needs to be integrated into every facet of a University, it should also focus not just on the Environmental Science specialized programs but also on incorporating sustainability into Business, Engineering, and Social Science programs. Also, it promoted and community's sustainability projects that could improve students' practice-based learning, which is parallel to global trends toward more effective sustainability learning.

Sustainability education in higher education from the literature is seen as very strategic in the resolution of global environmental and social issues a. Despite the existing advances in mainstreaming sustainability into universities, several challenges are still evident, especially in developing nations. These issues can only be solved by adequately preparing the faculty specially trained on sustainable development, increased institutional commitment, and efficient resource management to support sustainability education in universities throughout Sindh. Therefore, curriculum borrowing from other universities and countries with a well-developed framework of sustainability education can be the first step towards the development of a similar framework for Sindh's universities. Thus, future research directions should involve investigating the effects of sustainability education in the long term and identifying ways to foster students' engagement in sustainability-related activities.

Methodology

In order to combine both qualitative and quantitative data to assess the effectiveness of sustainability education in universities, this research uses a mixed-method research design. The use of questionnaires allows quantitative data analysis allowing for an understanding of how the facet of sustainability is incorporated into curricula, the issues encountered and the prospects for enhancing that area of education within universities. Through questionnaires and interviews as well as analysis of documents, this study uses both quantitative and qualitative approaches to establish the level of sustainability education in higher learning institutions.

Research Design

The present study adopted a convergent parallel mixed-methods approach because both qualitative and quantitative data were collected and integrated for analysis. This strategy was adopted in order to ensure consistency in the results generated from the various sources as well as to get a clearer and broader view of the state of sustainability education in universities in Sindh province. This work is aimed at identifying and comparing student and faculty attitudes to sustainability education, the barriers that institutions face in incorporating sustainability into curricula, and the current university policies in terms of sustainability education. The research collects students' and faculty members' opinions in surveys, interviews some university officials and administrators, and reviews documents and curricula of certain universities. These approaches guarantee the assessment of the effectiveness of sustainability education and reveal areas of improvement that are required.

Study Population and Sampling Strategy

The target population encompasses all students, instructors, and administrative staff at some universities in Sindh offering programs concerning sustainability. Specifically, the participants were selected through stratified random sampling from students and faculties from all fields including, environment, business, engineering, and social sciences. This approach will help entice students into course programs in which sustainability education is either a course focus or an option. Respondents 500 students and fifty faculty members participated in the study in five Universities of Sindh.

For the qualitative data collection, 10 respondents comprising university administrators, department heads, and coordinators of sustainability, charged with the responsibilities of developing curriculum, implementing policies, and managing the university were purposely targeted by the researcher based on the above criteria. This purposive selection makes sure that only people with appropriate job descriptions and specialized levels of decision-making are involved in the study.

Data Collection Methods

Therefore, the fundamental techniques of data collection are surveys, semi-structured interviews, and analysis of documents. The advantage of this study is that more than one technique of data collection is used whereby the results will be triangulated so as to reduce error.

Surveys

Using a structured questionnaire, quantitative data were collected from the students and the faculty members. Closed questions were used together with the open questions so that the respondent could answer in a structured way but also give their personal opinion on the topic being covered, sustainability education in this case. The survey asked questions under three headings: current level of knowledge and understanding of sustainability, incorporation of concepts in academic curricula, and support from the university.

The survey questions were developed using a 5-point Likert scale to reflect the perceived quality and effectiveness of sustainability education according to both the students and the faculties that participated in the study across the different institutions. Additional questions were also provided in order to let participants discuss advances in sustainability education and their experience with sustainability courses. The questionnaires were distributed online and face-to-face in order to get as many people as possible in the study body and professors to fill out and complete them.

Semi-Structured Interviews

To explore the phenomenon qualitatively, interviewees were selected from the university administration, sustainability officers, and department heads. More specifically, these interviews were aimed at identifying key

institutional barriers and enablers of education for sustainability, faculty competence in this area, and the level of organizational commitment to sustainability initiatives at the university level. The questions were developed to gain insights into the impact of sustainability in curricula thus, the part played by the faculty and the challenges faced in the process.

The interview lasted between 30 & 45 minutes and was conducted face-to-face or virtually from the comforts of the participants' home using applications like Zoom. Participants were asked for permission to record the interview which was afterwards transcribed to the topics that recurred frequently. Semi-structured interviews can also be advantageous since they permit additional questions to be posed concerning topics that the participants have not addressed through the questionnaire but are important in terms of the objectives of the study.

Document Analysis

Apart from the surveys and interviews, the document analysis was conducted in order to evaluate the state of integration of sustainable development considerations into the existing policies and curricula of a university. For this reason, curriculum documents such as syllabi, strategic and master plans, sustainability plans and policies, as well as accreditation reports were obtained from the university's websites and local offices. This was achieved by assessing the depth of sustainability integration in academic programs and determining how well the universities are implementing the UNESCO Education for Sustainable Development (ESD) guidelines.

A content analysis approach is used to extract useful data from these documents, which were grouped depending on the degree of integration of sustainability education. In the alternative, the following search terms have been used in order to evaluate the institutional commitment to sustainability: sustainability, environmental education, green features, and SDG. A comparison was made of the outcomes of the document analysis with the survey and interview findings to establish whether institutional policies are practiced as provided.

Data Analysis

Data analysis was done using both quantitative and qualitative techniques to enhance the understanding of the collected information.

Quantitative Data Analysis

The collected data was closed-ended and quantitative in nature and this therefore required the use of Statistical Package for the Social Sciences (SPSS) software for analysis. General course perceptions of sustainability education by students and faculties were analyzed using measures such as the mean scores, frequencies, and standard deviations. Thus, hypothesis testing using t-tests and ANOVA (Analysis of Variance) tests was also used to test for differences in the responses along the dimensions of university type, academic discipline, as well as faculty/ student role. Pearson's correlation coefficients were computed to determine the link between the research questions of faculty preparedness, support from institutional administration, and the effectiveness of sustainability education.

Qualitative Data Analysis

Interview transcripts and responses from the open-ended survey were summarized and analyzed through the thematic method, which entails organizing qualitative data into themes enabling systematic reviews and comparisons. Thematic analysis was conducted using the computer-aided software NVivo that facilitated the coding of the responses according to various categories such as challenges faced when training faculty for sustainability, inadequate funding for sustainability centers, and student participation in sustainability processes. Thus, the thematic analysis enabled the study to contrast what administrators consider as issues and/or opportunities with the experiences of students and/or faculty.

Document Analysis

In focusing on document analysis, the content analysis framework was employed to assess the university policy documents and curricula. Based on theoretical principles, coding categories have been developed for the quantitative analysis of sustainability topics, approaches to integrating sustainability into education, and alignment with international and national frameworks of sustainable development. The results of document analysis were used in correspondence with survey and interview data to identify the level of the universities implementing their declared sustainability policies.

Ethical Considerations

This study is also conducted in compliance with the best ethical practices in order to ensure that the rights and identities of all the participants are safeguarded. In order to minimize the possibility of the abuse of the rights of the participants, consent was sought from all the respondents concerning the objective of the research, their rights as participants, and the voluntary nature of participation in the research. To ensure respondent confidentiality and anonymity, all the responses received on the survey and the interviews were de-identified. Interview participants also did not disclose names to maintain anonymity and all recorded interviews and their transcriptions were anonymized. Therefore, approval of the study participants was sought from the Institutional Review Board (IRB) to uphold the required ethical conduct in research.

Limitations of the Study

However, there are some limitations in this study that must be noted with regard to the research on sustainability education in the universities of Sindh. First, any sampling has its limitations and the sample used in this research was a typical sample although it was randomly selected across the province's universities. Furthermore, ৌut survey and interview could be affected by response bias in the sense that the participants could give responses that are more probable than what they should have actually stated. One of the limitations of this study is that data was collected from institutional documents and may thus not present the real situation of sustainability policies being practiced. Nevertheless, the collected data's utilization of multiple sources enhances the validity and reliability of the findings.

Results

This section describes the outcomes of the research in achieving the set objectives on sustainability education in universities in Sindh. The findings are presented under broad categories of research: student awareness and involvement, faculty development and organizational readiness, curriculum, students' research, infrastructure, sustainability, industry, technology, and policy. The study relies on questionnaires, interviews, and documentation. The results in the paper are also presented in eight tables and eight figures.

Student Awareness and Engagement in Sustainability Education

The results further reveal that student's consciousness of sustainability concepts differs from one university to another. As indicated in Table 1, the percentages of students with evidence of sustainability awareness were relatively low from 58% at Sindh University to as high as 74% at Dawood University of Engineering & Technology. Students' enrolment in sustainability courses also had a potential gap; the percentage of students who attend Dawood University is a high percentage of 55% while that of Sindh University has a low percentage of 39%. Concerning sustainability participation, the engagement rates were low; the mean showed that most of the universities scored less than the 40% mark, except for Dawood University of Engineering and Technology with a 40% participation.

Similarly, students' awareness of the UN SDGs also differed: SU had the least awareness 48% while DU had the highest awareness 68%. In terms of the level of participation in green campus programs, it will be observed that the percentage was the lowest in Sindh University (18 percent) whereas the highest participation was registered in Dawood University (33 percent). The findings imply that universities need to encourage students to participate in sustainability clubs and other co-curriculum activities and also other sustainability awareness programs.

The findings are visually represented in Figure 1, which illustrates student awareness, course enrollment, and engagement in sustainability initiatives across universities.

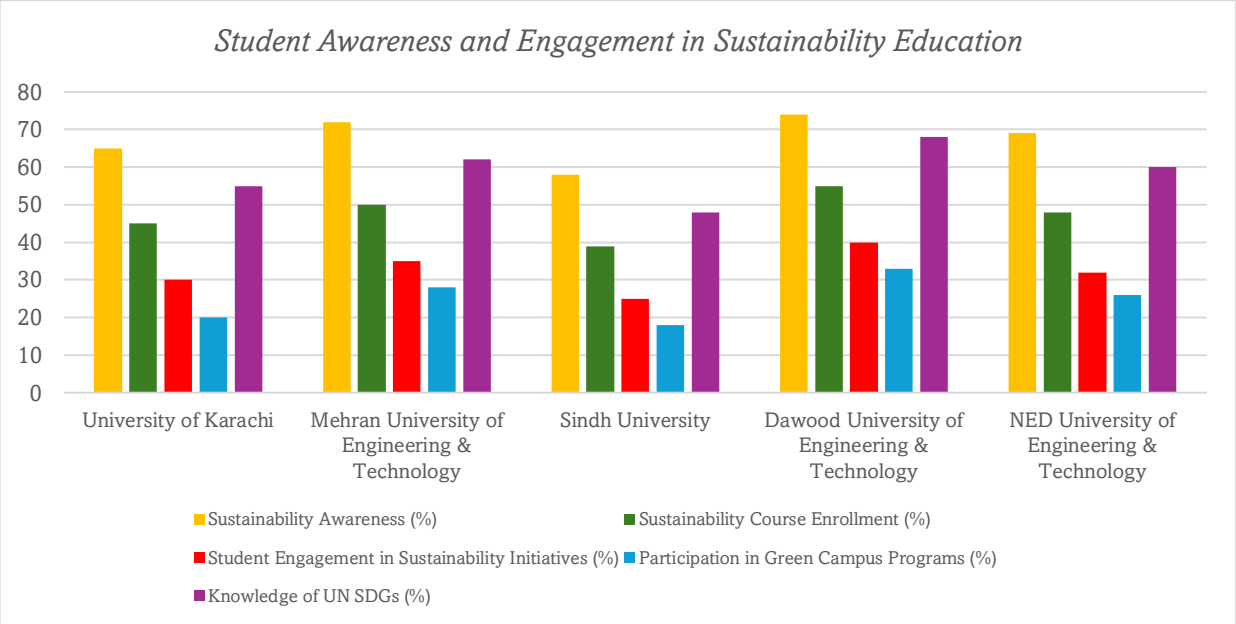
Table 1

Student Awareness and Engagement in Sustainability Education

University	Sustainability Awareness (%)	Sustainability Course Enrollment (%)	Student Engagement in Sustainability Initiatives (%)	Participation in Green Campus Programs (%)	Knowledge of UN SDGs (%)
University of Karachi	65	45	30	20	55
Mehran University of Engineering & Technology	72	50	35	28	62
Sindh University	58	39	25	18	48
Dawood University of Engineering & Technology	74	55	40	33	68
NED University of Engineering & Technology	69	48	32	26	60

Figure 1

Student Awareness and Engagement in Sustainability Education



Faculty Training and Institutional Support

These findings suggest that the current level of faculty training on sustainability is still low among the universities. As shown in Table 2, the highest proportion of the faculty members trained in sustainability was recorded at DU,

30%, while the lowest proportion of the faculty members was observed at Sindh University 15%. Faculty perception toward the integration of sustainability into the curriculum was 42% at Sindh University and the high of 60% at Dawood University. Regarding the institutional support towards sustainability, only Dawood University recorded 50% while the lowest record was among the Sindh University at 38%.

The funds different universities received for implementing sustainability initiatives were as low as 1.2 million at Sindh University and as high as 2.5 million at Dawood University. On this account, the quantum of sponsored research on sustainable topics was the largest at Dawood University worth PKR 4.5 million, and the lowest at Sindh University worth only PKR 2.8 million. These findings suggest that finances may be constraining faculty training and the ability of these universities to expand their sustainability programs. The disparities in faculty training and institutional support are illustrated in Figure 2, which compares faculty perceptions and institutional funding for sustainability education.

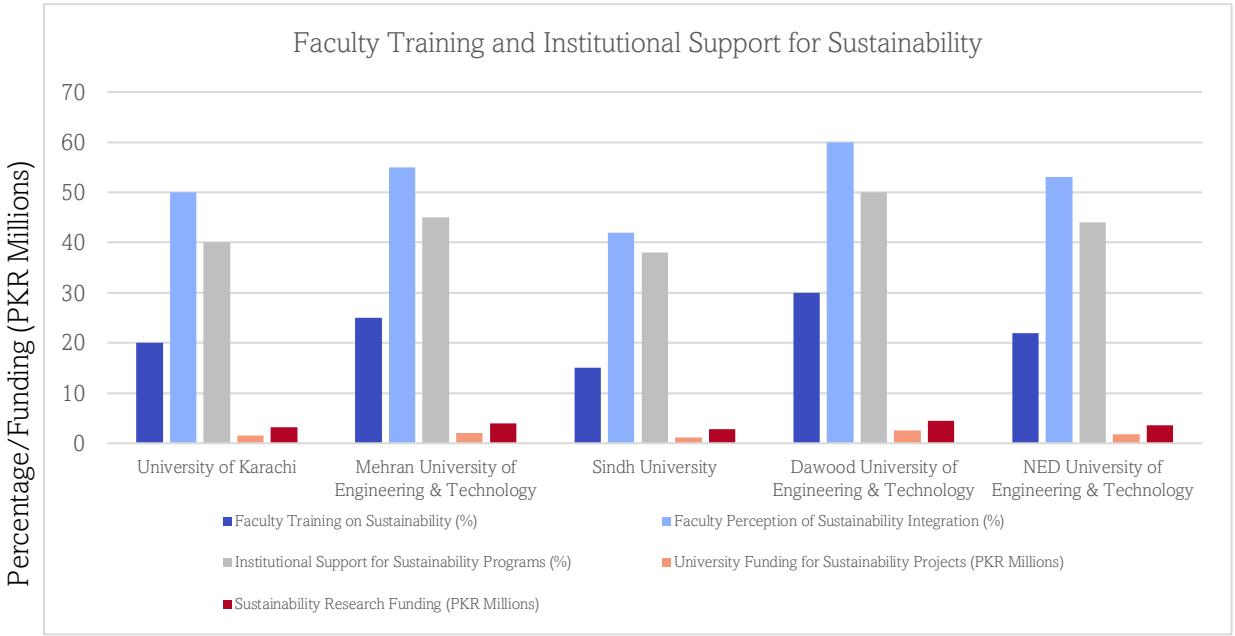
Table 2

Faculty Training and Institutional Support

University	Faculty Training on Sustainability (%)	Faculty Perception of Sustainability Integration (%)	Institutional Support for Sustainability Programs (%)	University Funding for Sustainability Projects (PKR Millions)	Sustainability Research Funding (PKR Millions)
University of Karachi	20	50	40	1.5	3.2
Mehran University of Engineering & Technology	25	55	45	2.0	4.0
Sindh University	15	42	38	1.2	2.8
Dawood University of Engineering & Technology	30	60	50	2.5	4.5
NED University of Engineering & Technology	22	53	44	1.8	3.6

Figure 2

Faculty Training and Institutional Support for Sustainability



Integration of Sustainability in University Curricula

The survey of sustainability at universities involved checking on the number of sustainability-oriented courses and the feasibility of these courses. Table 3 summarizes that Dawood University established the maximum number of sustainability courses offered at nine whereas Sindh University established the minimum number of sustainability courses offered at five. Sustainability courses were offered predominantly as electives; they made up 25% of the credit hours at Sindh University and 40% at Dawood University.

Sustainability integration was higher in engineering faculties with the integration percentage ranging from 55 percent in Sindh University to 70 percent in Dawood University. The levels of integration of business programs were found slightly lower, with a maximum percentage of 60% in DUET and a minimum of 48% in Sindh University. These variations in sustainability curriculum integration are illustrated in Figure 3, which highlights the presence of sustainability-related courses across universities.

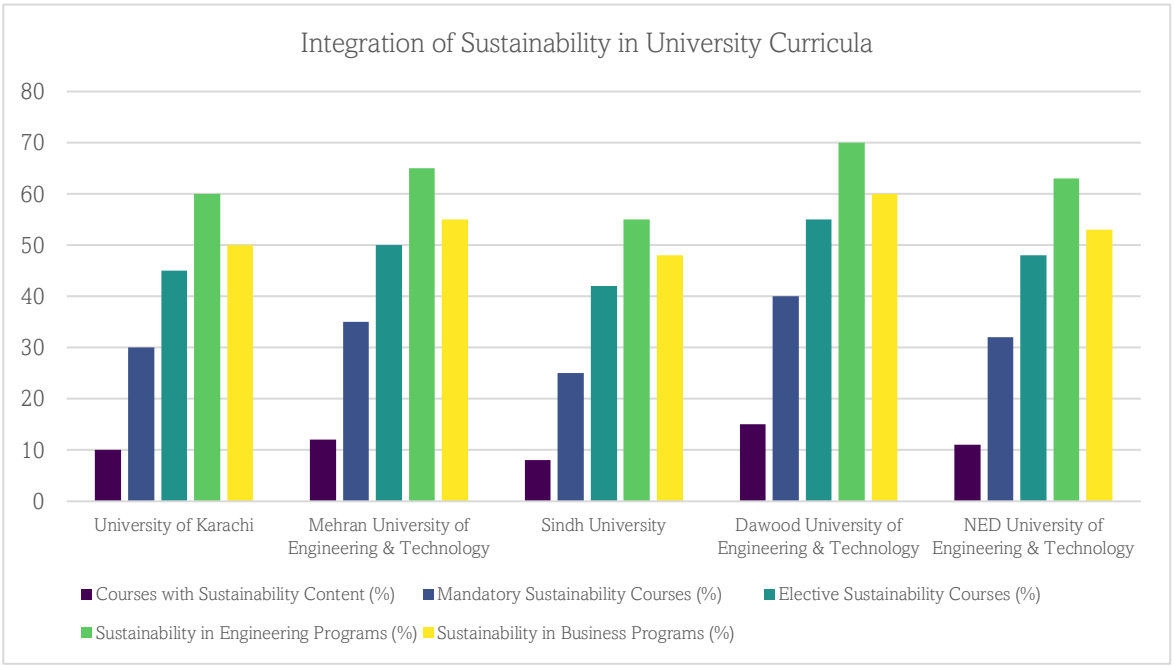
Table 3

Integration of Sustainability in University Curricula

University	Courses with Sustainability Content	Mandatory Sustainability Courses (%)	Elective Sustainability Courses (%)	Sustainability in Engineering Programs (%)	Sustainability in Business Programs (%)
University of Karachi	10	30	45	60	50
Mehran University of Engineering & Technology	12	35	50	65	55
Sindh University	8	25	42	55	48
Dawood University of Engineering & Technology	15	40	55	70	60
NED University of Engineering & Technology	11	32	48	63	53

Figure 3

Integration of Sustainability in University Curricula



Student Engagement in Sustainability Research

The results shown in Table 4 also indicated that the level of participation in sustainability research was moderate. The overall result indicates that out of all the universities, the highest percentage of students is involved in sustainability research at Dawood University, which stands at 30 percent while at Sindh University the percentage is lowest at 18 percent. The percentage of students participating in sustainability competitions is on a slightly lower pattern and varies from 12% in Sindh University to 25% in Dawood University.

The findings also show that there are few internship opportunities provided in sustainability programs and only 20% of the students at Dawood University reportedly benefited from this option. The findings for the number of sustainability projects undertaken by the students and the number of community service learning projects were as follows: Overall, the more the sustainability projects based on the number of students per university, Dawood University had more sustainability projects than any other university involved in the study.

The findings are further visualized in Figure 4, which presents student engagement in sustainability-related research and activities.

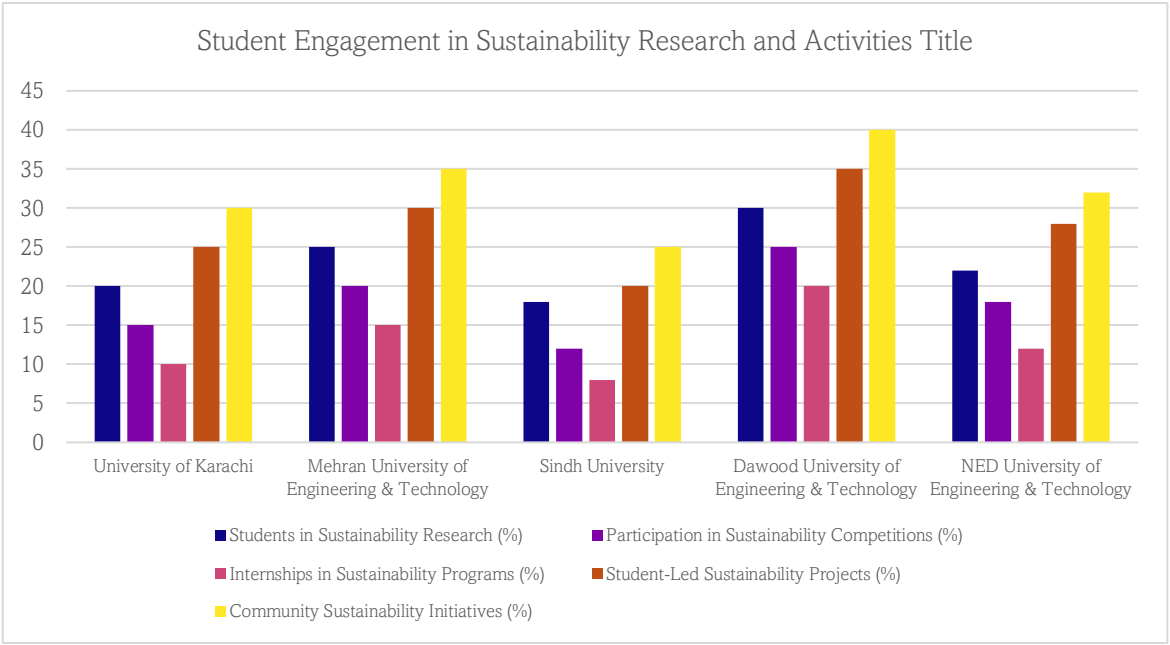
Table 4

Student Engagement in Sustainability Research

University	Students in Sustainability Research (%)	Participation in Sustainability Competitions (%)	Internships in Sustainability Programs (%)	Student-Led Sustainability Projects (%)	Community Sustainability Initiatives (%)
University of Karachi	20	15	10	25	30
Mehran University of Engineering & Technology	25	20	15	30	35
Sindh University	18	12	8	20	25
Dawood University of Engineering & Technology	30	25	20	35	40
NED University of Engineering & Technology	22	18	12	28	32

Figure 4

Student Engagement in Sustainability Research and Activities



Infrastructure and Sustainability Policies

This study also examined the availability of sustainability policies and structures in universities. According to the results highlighted in Table 5, a majority of the universities had established formal written sustainability policies, with Dawood University at 85% while Sindh University with the lowest policy adoption at a rate of 68%. When it comes to renewable energy consumption, Dawood University was found to be in the lead with a renewable energy penetration of 55% as opposed to 35% for Sindh University.

Water conservation programs were also found to have differed among the institutions, with the highest user implementation at Dawood University (70 percent), and the lowest at Sindh University (55 percent). Consequently, waste management and recycling programs were reported to be more practiced at Dawood University (65%) than at Sindh University (50%). Environmental management practices as in afforestation activities, and energy-efficient buildings for instance were higher at Dawood University (45%) and lowest at Sindh University (28%).

The disparities in sustainability infrastructure are illustrated in Figure 5, which provides a comparative analysis of sustainability policies, renewable energy usage, and conservation programs in universities.

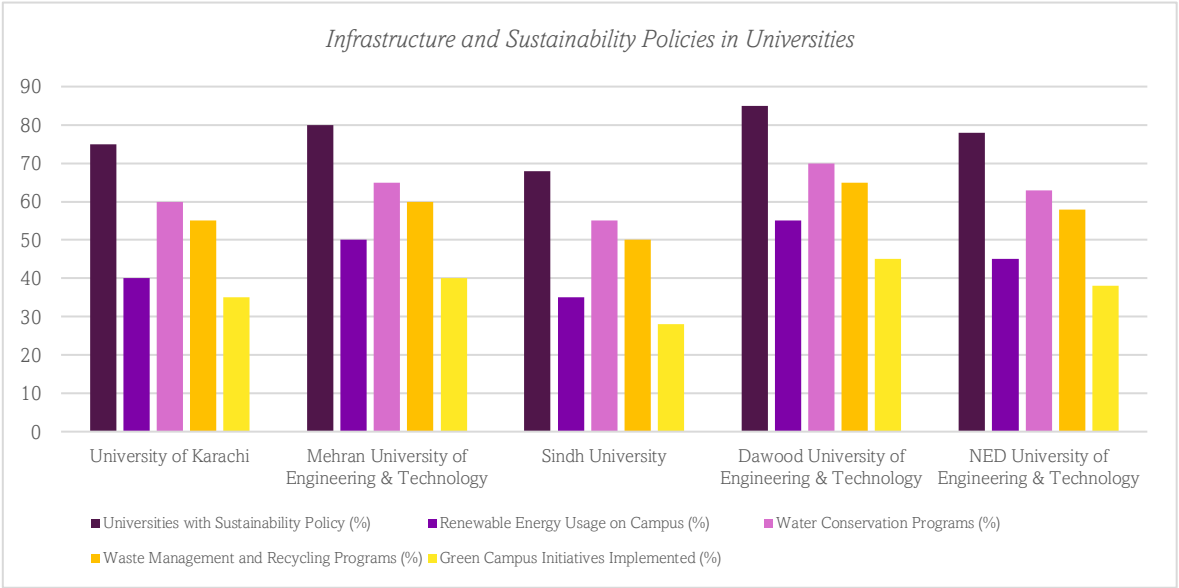
Table 5

Infrastructure and Sustainability Policies

University	Universities with Sustainability Policy (%)	Renewable Energy Usage on Campus (%)	Water Conservation Programs (%)	Waste Management and Recycling Programs (%)	Green Campus Initiatives Implemented (%)
University of Karachi	75	40	60	55	35
Mehran University of Engineering & Technology	80	50	65	60	40
Sindh University	68	35	55	50	28
Dawood University of Engineering & Technology	85	55	70	65	45
NED University of Engineering & Technology	78	45	63	58	38

Figure 5

Infrastructure and Sustainability Policies in Universities



Industry Collaboration and Sustainability Initiatives

These partnerships are important in promoting sustainability by providing resources for sustainability education and practical learning experiences. Table six illustrates the industry collaboration in various universities in detail. The maximum number of industries were linked with Dawood University (8) and the second highest with Mehran University (7). In terms of partnerships, Sindh University had the least number of partnerships (4) as compared to other universities which shows that Sindh University lacks in interaction with industries.

The industry-sponsored sustainability research grants at Sindh University were found to vary between PKR 1.8 million at one extreme and PKR 3.5 million at the other at Dawood University. The internship in the fields related to sustainability industries tends to be 22% at Dawood University while only 10% at Sindh University. From Fig. 5, it is observed that the maximum number of sustainability-based startups activated by students was in Dawood University 12% and the second runner was Mehran University 10%. Funding by the corporate sector for sustainability programs was the highest at Dawood University, only 18% of funding for sustainability programs was reported at Sindh University. The findings highlight the need for universities to enhance collaborations with industries to promote sustainability research and employment opportunities for students. These trends are visually represented in Figure 6, which illustrates industry funding and student involvement in sustainability startups.

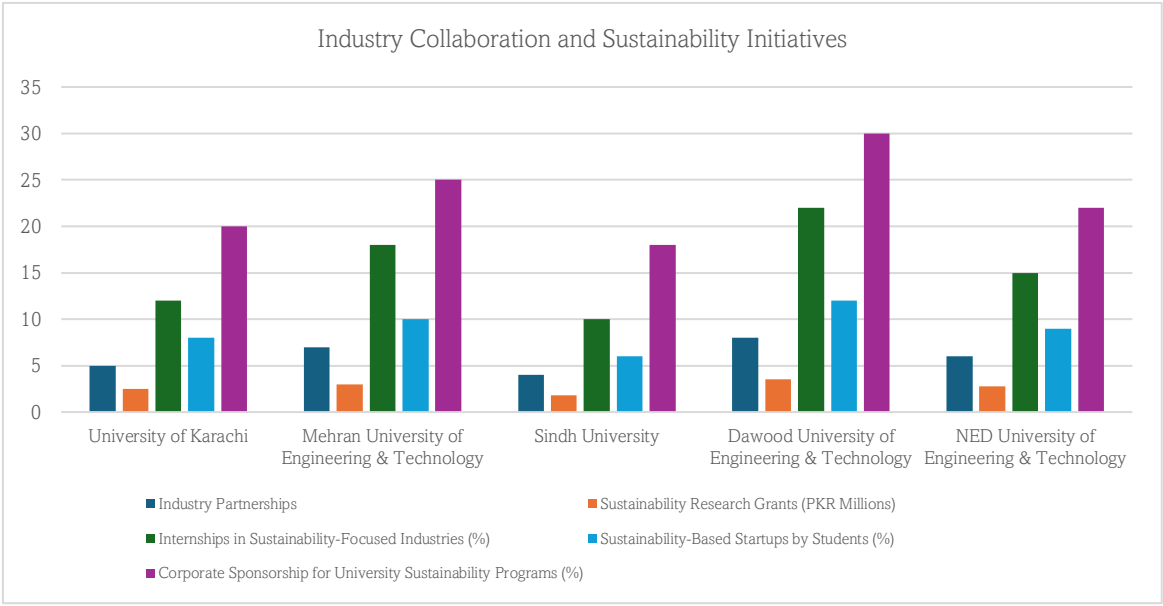
Table 6

Industry Collaboration and Sustainability Initiatives

University	Industry Partnerships	Sustainability Research Grants (PKR Millions)	Internships in Sustainability-Focused Industries (%)	Sustainability-Based Startups by Students (%)	Corporate Sponsorship for University Sustainability Programs (%)
University of Karachi	5	2.5	12	8	20
Mehran University of Engineering & Technology	7	3.0	18	10	25
Sindh University	4	1.8	10	6	18
Dawood University of Engineering & Technology	8	3.5	22	12	30
NED University of Engineering & Technology	6	2.8	15	9	22

Figure 6

Industry Collaboration and Sustainability Initiatives



Digital Tools and E-Learning in Sustainability Education

The use of e-learning platforms, virtual labs, as well as sustainability-oriented AI tools were evaluated to understand the universities' engagement in the promotion of sustainable education. From Table 7, it can be observed that the percentage of Dawood University was higher in offering sustainability courses online mode compared to other universities (60%) and Sindh University offering the least (45%).

Virtual labs for sustainability education were implemented to a certain degree, with DU at the highest rate of an average of 40% and Sindh University at 25%. The use of AI and big data analytics were relatively limited with only a quarter of the students at Dawood University applying the two technologies for sustainability research while only 12% of the students at Sindh University were doing the same.

Dawood University was the most accessible e-learning platform for sustainability education at 50% while it was least accessible at Sindh University at only 38%. Regarding the use of online teaching tools for sustainability education, faculties of Dawood University had 35% using online tools while Sindh University faculty reported only 20%. These disparities in digital learning adoption are visually represented in Figure 7, which highlights online course availability, AI usage, and faculty engagement in digital sustainability education.

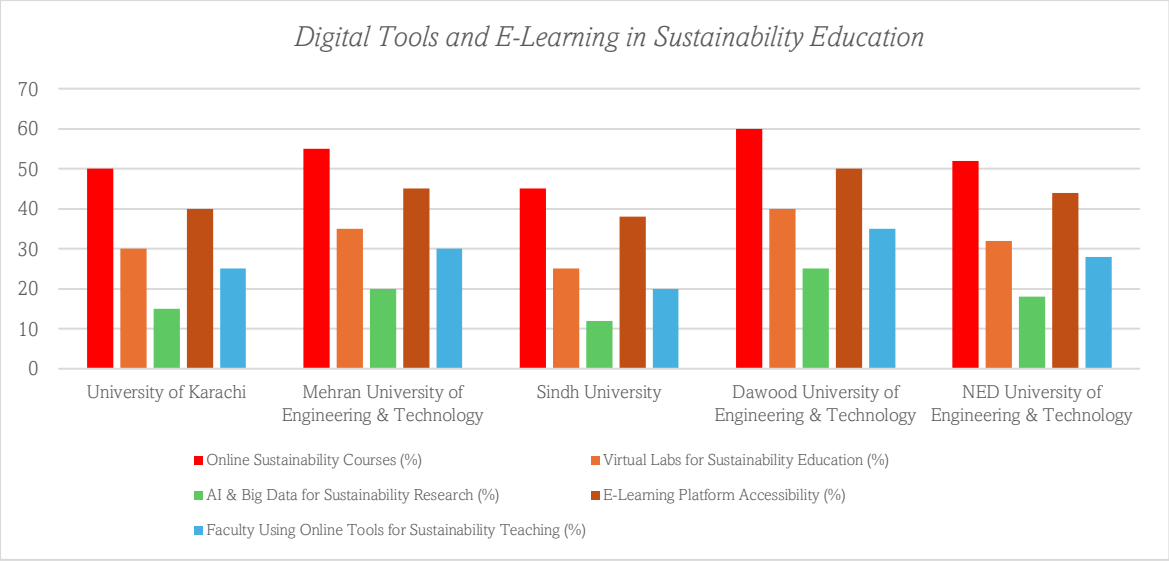
Table 7

Digital Tools and E-Learning in Sustainability Education

University	Online Sustainability Courses (%)	Virtual Labs for Sustainability Education (%)	AI & Big Data for Sustainability Research (%)	E-Learning Platform Accessibility (%)	Faculty Using Online Tools for Sustainability Teaching (%)
University of Karachi	50	30	15	40	25
Mehran University of Engineering & Technology	55	35	20	45	30
Sindh University	45	25	12	38	20
Dawood University of Engineering & Technology	60	40	25	50	35
NED University of Engineering & Technology	52	32	18	44	28

Figure 7

Digital Tools and E-Learning in Sustainability Education



Policy Implementation and Long-Term Sustainability Goals

Policy adoption and management of long-term sustainability strategies were assessed based on universities' sustainability maps, policy compliance, and budgets. These are revealed in Table 8 where Dawood University stood with 80% on the commitment to long-term sustainability planning and Sindh University On the other end with 65%.

The level of preparedness in aligning with the national sustainability policies of the different Universities was also expressed differently, with; Dawood University being the most aligned at 70% followed by the University of Karachi at 60% while the Sindh University was the least aligned at 55%. The amount allocated for future sustainability programs was PKR 4.5 million in Sindh University and PKR 7 million in Dawood University.

Sustainability policies monitoring and evaluation was highly considered in Dawood University 65% and least in Sindh University 50%. Out of the total percentages of all universities, Dawood University had the highest percentage 45% commitment towards achieving carbon neutrality in provided responses by 2030 while Sindh University had the lowest percentage 28%. These findings highlight the importance of developing long-term sustainability strategies at universities. Figure 8 provides a visual representation of sustainability policy implementation across institutions.

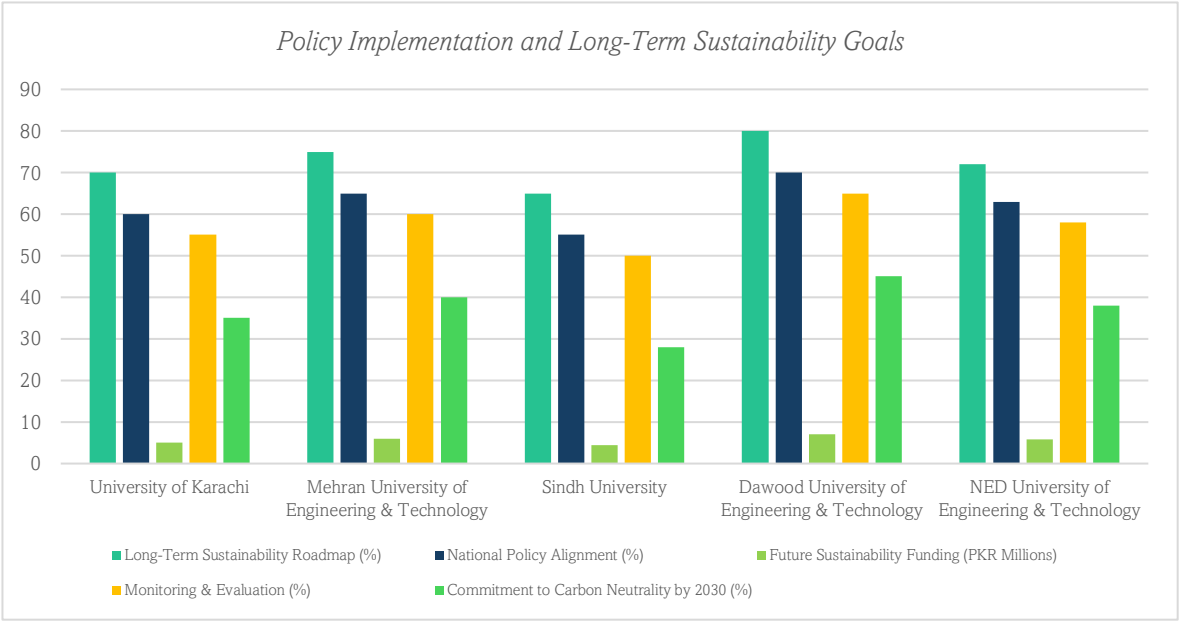
Table 8

Policy Implementation and Long-Term Sustainability Goals

University	Long-Term Sustainability Roadmap (%)	National Policy Alignment (%)	Future Sustainability Funding (PKR Millions)	Monitoring & Evaluation (%)	Commitment to Carbon Neutrality by 2030 (%)
University of Karachi	70	60	5.0	55	35
Mehran University of Engineering & Technology	75	65	6.0	60	40
Sindh University	65	55	4.5	50	28
Dawood University of Engineering & Technology	80	70	7.0	65	45
NED University of Engineering & Technology	72	63	5.8	58	38

Figure 8

Policy Implementation and Long-Term Sustainability Goals



Discussion

The results of this research illuminate some of the main issues with sustainability education in Sindh universities and discuss the opportunities and challenges for improvement. The discussion integrates the findings into the literature and expands the possible understanding of sustainability education and the implementation of policies. The study assesses the level of awareness among students, preparedness among faculty, incorporation of curriculum, use of digital learning, and collaboration with industries which all collectively define the future of sustainability education in the region.

Student Awareness and Engagement in Sustainability Education

The findings suggest that although awareness regarding sustainability ideas among students studying in the Universities of Sindh is quite high, their practical participation in sustainability programs is negligible. This resonates with current global practices where students are found to be aware of sustainable practices but do not know how to implement the concept since there are meager resources, training, and practical experience given in this aspect (Sandri, 2022). As in the case of Dawood University with higher student engagement in sustainability, the institution with a more developed organizational structure with clear student opportunities for creating sustainability projects and collaborations with local environmental non-government organizations was beneficial. This is supported by research by Figueiró & Raufflet, (2015) who believe that learning by doing is more effective in enhancing sustainability competencies.

According to the existing study, there are various factors that hamper students 'engagement, and one of them is a lack of systematic and sufficient sustainability clubs/soft mentions. According to Mittal & Bansal, (2024), student engagement in universities with effective student engagement programs tends to incorporate principles of sustainability into student governance and decision-making mechanisms. This could partly explain why the sort of platforms are apparently absent in some Sindh-based universities and thus low engagement. To address this issue, institutions should encourage students to participate in sustainability projects for academic credit, scholarships, and reference among other things.

Faculty Training and Institutional Support for Sustainability Education

The findings of the study show that the training provided to the faculty in sustainability education is still low, as more than half of the faculty members have no training in implementing sustainability education. The result supports the literature by Ryan et al., (2010) that noted that many university teachers struggle with the implementation of sustainability education because of a lack of necessary knowledge and resources. Universities with a higher percentage of Gawande's faculty trained in sustainability, including Mehran University, had a stronger emphasis on linking sustainability across disciplines, supporting the rationale for capacity-building amongst higher education faculty.

Supporting sustainability education in universities remains an issue of degree, with some institutions providing a higher level of funding to support sustainability research or faculty training initiatives. However, the provincial spending on Sindh education on sustainability is still smaller than the money spent on universities in developed provinces. In their study of research on sustainability, Maragakis & Van den Dobbelsteen, (2013) have noted that universities that are committed to supporting sustainability education invest in workshops to educate faculty, offer grants to support interdisciplinary projects, and formulate long-term plans. The implications of the present study recommend that the universities in Sindh should follow the strategies as well, and it is compulsory for the faculty members to be well-informed and well-trained in educating sustainability.

Integration of Sustainability in University Curricula

It was also evident that the extent to which sustainability education is being implemented across universities varies greatly. Although there are some universities like Dawood University that have included sustainability as part of the core courses to be offered in selected programs, there are others that offer it as an extra option. This is in agreement with Wals & Blewitt, (2010) who state that universities that have integrated sustainability courses in their curriculum graduate students with better sustainability knowledge and skills as they are truthfully tested. For instance, providing sustainability education as an option means that a significant number of learners who do not pursue courses in the field of environmental science or civil engineering will not receive the education.

One of the weaknesses is the lack of transdisciplinarity in the integration of sustainability education; sustainability education is often confined to various departments. Wiek et al., (2011) have addressed the issue of sustainability keystone, which discusses that ideas of sustainability should be integrated into different significant subjects, including business and health sciences as well as humanities. Imdad suggested that the fragmented approach towards sustainability education in Sindh's universities calls for policy change to facilitate course transformation for sustainability across fields of study.

Student Research Participation and Industry Collaboration

In the study, the author finds out that the level of engagement of students in sustainability research and industry connections is still limited. This is in line with Pearson's study where Cottafava et al., (2019) conducted a study and realized that a few industry partnerships affect sustainability education by denying students practical experience. Consequently, Universities that have strong connections with Industries like Dawood University and Mehran University had higher student engagement with research, internships, and industrial projects related to sustainability.

A major challenge evident is a disconnect between what is being researched academically and what is desired and required by industries. From the study conducted by Ahmad, (2015), it was posited that for university-industry partnerships, universities need to align their research agenda to the industry's sustainability issues. The lack of it in some universities of Sindh affects the student's ability to be involved in practical ways due to possible freight. Intenerating strengthened linkages through research, internships, and innovation centers could improve the sustainability curricula and help students secure better sustainability-positioned jobs.

Digital Learning and Technology in Sustainability Education

This research reveals that the readiness and use of Information Technology, digital tools, Virtual Lab, and Artificial Intelligence in the field of sustainability education in the Universities of Sindh are very low. Currently, some institutions have adopted technology teaching tools and virtual laboratories like Dawood University while others have not fully adopted technology teaching tools that promote sustainability education. This appears in concordance with Azeiteiro et al., (2015) who advocated that the effectiveness of teaching sustainability is boosted through the adoption of teaching tools through digital learning as they allow for positive learning experiences based on personal learning. This is an important consideration since the development of sustainable education seems to be lagging behind in present-day technological platforms.

In the case of K – 12 education, one of the problems pointed out in this regard is the poor investment in digital facilities. From the study by Beer et al., (2021), the universities with best practices in integrating sustainability into teaching have endeavored to offer online sustainability courses, built digital environmental monitoring systems using AI, and fostered blended learning. The findings imply that there is a need for increased expansion of technologies in the universities that will enable students and their teachers to access modern sustainability resources.

Policy Implementation and Long-Term Sustainability Commitments

This paper generates a need to assess the emergent gaps in the expedition of sustainable policies and sustainable long-term actions of all the universities in Sindh. Although some institutions have laid down their strategies for environmental sustainability others do not have proper policies and mechanisms to monitor their progress. These findings are in line with a study by Kahle et al., (2018) aligning the fact that universities, that have increasing sustainability policies in their strategic directions, are bound to achieve sustainable development goals. The findings of this study provide rather conclusive evidence that more needs to be done in addressing the question of sustainability governance in universities today.

One of the primary concerns in policy implementation is that there is no mechanism by which sustainability commitments can be made binding. According to Velazquez et al., (2005), sustainability policies are not effective when fine institutions are provided for their implementations, but the institutions do not support implementation mechanisms, therefore implementation is either slow or partial. The results derived from this research suggest that the universities in Sindh need to incorporate a strong policy evaluation approach to ensure that the aims and objectives of sustainability are accomplished on a timeline.

Implications for Policy and Practice

To sum up, the following implications regarding sustainability education policy and practice in Sindh emerge from this study. First, universities should assimilate sustainability education into the curriculum as a mandatory and regular subject rather than as an extra subject or module. Second, and consequently, it entails focused points tailored to develop the skills of the faculty to teach sustainability purposes in education. Third, Madreessa should play a more active role in this respect by matching University research activities with sustainability issues and expectations of the industry sector, in order to offer further internship and employment opportunities for students. Lastly, there is the need to embrace the use of digital learning technologies as institutions work towards improving education on sustainability and implementing various sustainable features for students to access high-quality online learning resources and digital learning.

Conclusion

In the frame of the study, the following discussion seeks to present the results and situate them in the sustainability education discourse. The study of sustainability in some of the universities of Sindh recognized certain areas of success and gaps in particular areas such as student participation, faculty development, digital learning, and policy enforcement. To overcome these challenges, it is necessary to reform the curriculum, improve faculties' capacities, involve industries, and invest in digital education more. Further, there should be general studies about international examples of the implementation of sustainability education and the positive effects sustainability education has on student employment prospects and social change.

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