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Composite sustainability index for online and distance education

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Abstract

The surge in internet usage and the influence of the COVID-19 pandemic have emphasized the significance of online and distance education. However, there is a scarcity of scholarly research on the sustainability of initiatives implemented through these modalities, and the existing measurement methodologies for sustainability are not well suited to this particular context. This study aims to elucidate the relationship between sustainability and the performance of online and distance education and proposes a composite sustainability index to assess these programmes. The methodology for constructing this index follows the stages outlined by the Organization for Economic Co-operation and Development (OECD) and employs both qualitative and quantitative approaches. The qualitative techniques involve interviews conducted with a group of field experts in order to ascertain the prioritization of indicators. Data from these interviews is used to identify key indicators for further prioritization. The application of quantitative analysis involves the characterization of participants and the execution of calculations for finalizing, weighting, normalizing, and aggregating indicators, resulting in the creation of the composite sustainability index. This mixed-method approach is consistently applied throughout the index development process. The study yields a comprehensive sustainability index that assesses online and remote education programmes. It identifies 15 sustainability criteria corresponding to key sustainability dimensions and quality deployment pillars. The practical implications of these indices hold great significance, as they can provide valuable guidance to strategic decision-makers in enhancing current offers and shaping future policies and resource allocations for programmes delivered through online and distance education methods.

Keywords: Composite index, Distance education, Higher education quality, online education, Open and distance learning, Performance quality, Sustainability.

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1. Introduction

The COVID-19 outbreak in 2020 highlighted the significance of online-based lesson delivery and instructor–learner interactions within the remote education context. Online and distance learning are avenue through which the courses offered by Malaysian higher education institutions can expand their course offerings and cater to a wider range of learners. This mode of instruction facilitates accessibility for individuals from various segments of society. From the perspective of the educational institution, there is potential for a substantial reduction in the traditional cost of reaching each individual learner who enrolls in an educational programme. Similarly, on the learner's side, the cost incurred by acquiring academic credentials that transcend temporal and spatial boundaries can be significantly diminished. In light of these endeavors, there has been a notable increase in the enrolment of courses, whereby learners have expressed greater involvement and enthusiasm for online learning [1]. Online and distance education plays an integral role in attaining the United Nations Sustainable Development Goals, specifically Goal 4 (quality education), Goal 8 (decent work and economic growth), Goal 9 (industry, innovation, and infrastructure), Goal 10 (reduced inequalities), and Goal 13 (climate action). This is further facilitated by the fourth industrial revolution and driven by the imperative to ensure the continuity of teaching and learning amidst the ongoing pandemic. However, previous studies may have failed to adequately consider the importance of online and distance education in relation to sustainability. Thus, this paper aims to advance this line of inquiry.

2. Background of Study

According to recent data from January 2023, the global number of individuals utilizing the internet has reached a milestone of 5.16 billion, or approximately 64.4% of the global population [2]. This surge in internet usage has been paralleled by a growing reliance on digital technology for education, ushering in the era of the 'digital native' generation. This generation comprises young individuals who have grown up in a digital-centric environment where engagement with digital gadgets is considered typical.

The integration of technology in the field of education has facilitated the emergence of online and remote learning, a phenomenon that has been commended for its potential to promote environmental sustainability [3-6]. The notion of sustainability is widely seen as crucial in addressing multifaceted environmental and societal challenges and is considered essential for the well-being of both current and future generations [7]. Despite these notions, there remains a limited body of research exploring how sustainability can be quantified within online and distance education programmes [8-10]. Consequently, evaluating the sustainability of these programmes remains a complex endeavor [10].

Traditionally, the concept of sustainability in the realm of education has been largely interpreted from an environmental perspective, focusing on the survival of educational institutions [5, 6, 11]. However, it is crucial to acknowledge the significance of online and distance education programmes in fulfilling the fundamental principles of sustainability. The graduates of these programmes hold substantial economic importance and are expected to wield considerable social and environmental influence.

Nonetheless, there is a lack of research investigating the extent of sustainability in certain courses or programmes delivered through online and distance education modalities. Bacelar-Nicolau, et al. [9] examined the effectiveness of a master's programme, that incorporated elements of environmental and social sciences, in enhancing students' awareness and comprehension of sustainability through the use of e-learning. Similarly, Azeiteiro, et al. [8] conducted a descriptive analysis using a case study approach to assess the effectiveness of e-learning in imparting education related to sustainable development. The assessment of the sustainability of online and remote education programmes is a multifaceted and unsolved matter that necessitates further investigation, given their unique characteristics that differentiate them from typical classroom or in-person programmes.

Various tools and methodologies have been developed to construct composite indicators for measuring the sustainable attainment of higher educational institutions [12]. However, the key performance indicators are widely considered applicable to the assessment of campus sustainability rather than being tailored to the specific needs and requirements of remote education. This leaves a gap in which precise criteria and indicators need to be established for online and remote education in order to evaluate performance quality, specifically from the standpoint of sustainability. Therefore, this study attempts to elucidate the relationship between the sustainability of online and distance education performance and to propose a composite index for measuring the sustainability of online and distance education programmes.

3. Literature Review

In this section, we will examine previous research in the following areas: online and distance education, sustainability assessment in higher educational institutions, the evaluation of the performance and quality of service providers who are offering online and distance education, and the analysis of online and distance education from a sustainability standpoint.

3.1. Online and Distance Education

Distance education entails the practice of instructing and acquiring knowledge in a manner that temporarily separates the teacher and learner in terms of time or physical location. It employs a diverse range of media for instructional delivery, encourages two-way communication, and may occasionally incorporate in-person meetings for tutorials and learners and instructors' interaction [13]. This form of education encompasses an extensive range of educational programmes designed to cater to diverse audiences through a wide variety of media channels [14]. It offers different modes of study for students at various levels of education, and students are not continuously and immediately supervised by instructors who are not

physically present in lecture rooms or on the premises to monitor pupils. However, the students still benefit from the guidance, planning, and educational support provided by a learning institution [15].

The concept of distance education, originating in the 19th century, has undergone significant transformations in terms of the organization and communication of the process of learning [16]. This evolution is primarily attributed to the ongoing advancements in information and communication technology (ICT), which have brought about rapid changes in the delivery of lessons and the learning experience. Formerly, the term 'distance education' was well known for its representations of two generations – correspondence education and multimedia education – which was emerged in 1728 in Boston, USA, without the inclusion of digital communication technology [17]. The evolution of remote education in recent times has been closely intertwined with the advancements in information and communication technology (ICT). This progress can be traced back to the advent of the internet, which marked the beginning of the third generation of distance education, commonly referred to as online education. However, the underlying meaning and overall concept of online education have been identified as somewhat fragmented throughout the extensive and disparate body of literature [18]. This is due to the fact that online education can be perceived as both a substitute for traditional on-campus instruction and a form of distance education. Online education has become an increasingly important and emerging field that lies at the junction of distance education, human–computer interaction, instructional technology, and cognitive science [18]. It is crucial to understand its potential in elucidating the concept of modern distance education. Therefore, drawing upon the definitions proposed by Filipovska, et al. [14], Holmberg [15], and Larreamendy-Joerns and Leinhardt [18], the concept of online and distance education encompasses a tremendous range of programmes catering to numerous audiences through a multitude of media. These programmes operate independently without the immediate supervision of instructors who are physically present with their students in lecture rooms or on the same premises, and they include instructional alternatives for on-campus learning and teaching.

3.2. Sustainability Assessment of Higher Educational Institutions

Several tools have been thoroughly evaluated and utilized to assess and compare the integration of the Education for Sustainable Development agenda within specific higher education institutions. Nevertheless, these tools have revealed the need for further refinement, particularly in terms of their capacity to gauge the external influence of higher education institutions on sustainability, their inclusivity in the assessment process, and their ability to evaluate unconventional sustainability aspects [19]. One of the techniques available is the Green Metrics University Ranking, which utilizes a comprehensive set of 33 indicators categorized into six domains. These domains include several areas like infrastructure, energy, climate change, waste, water, transit, and education and research. However, community involvement is notably absent from its considerations [20]. Another method, known as Higher Education 21, uses a set of 12 key indicators and eight strategic management indicators that primarily concentrate on organizational management changes, with relatively less emphasis on social indicators [21]. The Times Higher Education Impact University Ranking (TIMES) centres on the evaluation of higher education institutions' adherence to the Sustainable Development Goals [22]. Nonetheless, there is currently a notable absence of a comprehensive sustainability assessment instrument specifically designed to address the distinctive settings and characteristics of online and distance education.

3.3. Performance and Quality Assessment of Online and Distance Education Providers

In order to evaluate the sustainability of online and distance education, it is important to closely examine elements related to performance and quality. Comparatively, traditional education metrics often prove inadequate when they are applied to distance education providers [23]. Prior scholarly investigations have sought to create methodologies and benchmarks for assessing the calibre of online colleges and providers of distance education. For instance, Open and Distance Learning Performance (ODLPERF) is an instrument that measures service quality for open and distance learning (ODL) institutions [24]. The ODLPERF scale comprises 29 items that assess performance and service quality in ODL institutions, where 'open' signifies a commitment to reducing barriers to the learning process [24]. Another example is Malaysia's National e-Learning Policy (DePAN), which encompasses five dimensions – infrastructure, organizational structure, professional development, curriculum, and e-content – along with the enculturation of e-learning [25]. Additionally, the Creating an Online Dimension for University Rankings (CODUR) framework considers various dimensions, including student support, teacher support, technological infrastructure, research and organization, sustainability, and reputation [12], While Capacho, et al. [26] have devised a comprehensive set of 153 operational indicators specifically tailored for evaluating virtual education. Despite these advancements, it is noteworthy that sustainability performance has not been adequately integrated into the formulation of indicators for assessing the quality and effectiveness of distance education programmes or online education. Hence, it is imperative to incorporate sustainability metrics in the assessment of online and distance education's performance.

3.4. Assessment of Online and Distance Education from a Sustainability Perspective

Online and distance education programmes have certain features or attributes that distinguish them from traditional classrooms. The existing key performance indicators are nevertheless generally applicable to an overall campus sustainability assessment rather than being 'customized' to the specific needs and requirements for distance education itself. As previously discussed, there has been a dearth of studies assessing the quality of online and distance education based on sustainability perspectives. Although there has been an initial development of a sustainability framework for online and remote education comprising economic, environmental, and social dimensions [1], further examinations are required to enhance the applicability of the framework in a quantitative manner using an empirical approach. This motivated the aim of the present study, which is to establish a composite sustainability index for online and distance education.

4. Methodology

The methodology for constructing a comprehensive sustainability index for online and distance education programmes is rooted in the framework proposed by the Organisation for Economic Co-operation and Development [27]. This method involves a series of stages, which comprise:

1. Initial identification of criteria and indicators
2. Grouping of initial indicators into social, environmental, and economic categories
3. First round of prioritization for indicators
4. Finalization of key indicators via the application of predetermined cut-off values
5. Second round of prioritization for indicators
6. Assignment of weights to indicators
7. Normalization of indicators
8. Aggregation of indicators
9. Generation of a composite sustainability index for a given programme.

The development of this composite index involved a combination of qualitative and quantitative techniques. Qualitative methods were utilized during Stages 3 and 5, wherein interviews were conducted with a carefully selected group of experts in the field. These interviews were conducted to carry out both the initial and secondary prioritization of indicators. The data collected from the initial interviews was systematically structured and examined in order to determine the final set of important indicators that would be prioritized in the future round of interviews. Quantitative analysis played a crucial role in the profiling of the participants and the execution of the computational steps required for finalizing, weighting, normalizing, and aggregating the indicators. This quantitative approach was maintained throughout the process until the composite sustainability index was produced.

The initial characteristics of online and distance education programmes were derived from the framework for enhancing the quality of e-learning implementation in Malaysian higher learning institutions, as proposed by DePAN. This framework encompasses elements such as infrastructure, organizational structure, curriculum and content, professional development, and the integration of e-learning into higher learning institutions. Additionally, this study incorporated attributes identified by Azeiteiro, et al. [8], which were subsequently empirically examined by Harizan and Hilmi [10]. These attributes encompassed aspects such as the quality of instructors, collaborative work, learning materials and activities, and the use of pedagogical skills.

After conducting an extensive literature analysis, the researcher identified and chose pertinent sustainability criteria and indicators that are connected with each aspect of online and distance education. The next phase involved organizing these identified criteria and indicators into categories based on their alignment with the social, environmental, and economic dimensions of sustainability. Subsequently, the aforementioned categories were transformed into a set of questions designed for dissemination among a meticulously selected cohort of field specialists specialized in the domain of online and distance education.

The criteria used to select these field experts encompassed their academic standing, association with or employment in the designated centres or schools specializing in online and distance education, and demonstrated achievements in teaching, publication, or leadership within the realm of online and distance education.

In order to identify the essential criteria, the experts were assigned the responsibility of evaluating the significance of each item using a Likert scale with five points, ranging from 1 (representing low importance) to 5 (representing high importance). Subsequently, the survey responses were collected and analyzed, leading to the computation of the average value for each criterion.

The sustainability criteria were then organized in ascending order based on their mean values. In order to identify the primary sustainability criterion, a significant threshold with a predetermined cut-off point of 3.00 was utilized, as suggested by Shale and Gomes [23] and Dobrovolskienė and Tamošiūnienė [28]. Sustainability criteria with mean values surpassing 3.00 were deemed significant and advanced to the next stage of selection. The subsequent round of prioritization for the criteria encompassed two distinct groups, each consisting of five field specialists who had already engaged in the survey. The assigned experts were responsible for evaluating and assigning a hierarchical order to the significance of each criterion during this particular stage of the assessment process.

5. Results and Findings

After obtaining the responses from the second prioritization, Kendall's coefficient of concordance (W) was used to indicate the degree of association of ordinal assessments made by multiple experts while assessing the same samples. The Kendall's coefficient values have a range of 0 to 1, with larger values indicating a stronger correlation. In the current investigation, the values of Kendall's W fell within the range of 0.2 to 0.4, indicating a moderate level of concordance among the experts in their assessment and ranking of the criteria and indicators. The results of the criteria rankings are shown in Table 1.

Table 1.
Criteria and indicators.

Dimension	Code	Pillar	Criteria	Indicator	Points	Rank
Economic	Eco1	Infrastructure	Reasonable and efficient operating costs	Proportion of direct education costs as of total operating cost (%)	31	4
	Eco2	Organizational structure	Integration of e-learning into organizational vision	Availability of an e-learning team, guidelines, or unit (Yes/No)	41	2
	Eco3	Professional development	Training in online and distance learning	Number of hours of training per year devoted to teaching staff about online learning (#)	29	5
	Eco4	Curriculum & e-content	Institutional support for learning design	Direct instructional cost per course hour equivalent (RM/hour)	39	3
	Eco5	Enculturation	Funding for online learning	Percentage of total institutional expenditure dedicated to online learning (%)	61	1
Environmental	Env1	Infrastructure	Measures of interoperability	Number of interoperability measures within and between e-learning system and external open sites, including access control (#)	26	5
	Env2	Organizational structure	Environmental conservation policies	Percentage of non-print materials (%) for each course	35	4
	Env3	Professional development	Sustainability-related capacity building	Number of hours of sustainability-related training per year devoted to staff (#)	48	1
	Env4	Curriculum & e-content	Content or courses related to sustainability	Percentage of sustainability-related content or courses in the programme (%)	44	3
	Env5	Enculturation	Impact of operations on the environment	Percentage of carbon footprint generated by e-learning operations (%)	45	2
Social	Soc1	Infrastructure	Bandwidth speed capacity, bandwidth access, e-learning platform utilization, and related support	Percentage of student complaints or appeals resolved or closed (%)	27	5
	Soc2	Organizational structure	Institutional strategic plan for online learning (i.e., online vision statement, online mission statement, online learning goals, and action steps)	Student satisfaction with overall organization (*)	35	4
	Soc3	Professional development	Impactful e-learning activities for students	Student satisfaction with the overall learning experience (*)	36	3
	Soc4	Curriculum & e-content	Utilization of blended/online approach, availability of original e-content, and e-assessment deployment	Instructors' or tutors' satisfaction with feedback on their courses derived from student surveys (*)	49	2
	Soc5	Enculturation	E-learning enculturation and recognition mechanism	Stakeholders' satisfaction with e-learning activities and events held within and outside the organization (*)	63	1

Note: * 1 = "Most disagree"; 5 = "Most agree".

Due to the divergent perspectives regarding the prioritization of the criteria, it became imperative to evaluate the level of consensus among these viewpoints. The International Business Machines Corporation (IBM) developed IBM SPSS® Statistics, a statistical software suite for data management, advanced analytics, multivariate analysis, business intelligence, and criminal investigation, to quantitatively evaluate the agreement between two experts. This agreement was achieved by running Kendall's W test. Kendall's W indicates the degree of association of the ordinal assessments made by multiple experts when assessing the same samples (*see* Table 2).

Table 2.
Weighting factors of criteria and their groups.

Code	Criteria by group	Weighting factors by group	Total weighting factor
Economic		0.238	0.119
Eco5	Funding for online learning	0.504	0.060
Eco2	Integration of e-learning into organizational vision	0.255	0.030
Eco4	Institutional support for learning design	0.135	0.016
Eco1	Reasonable and efficient operating costs	0.066	0.008
Eco3	Training in online and distance learning	0.040	0.005
Environmental		0.137	0.068
Env3	Sustainability-related capacity building	0.499	0.034
Env5	Impact of operations on the environment	0.261	0.018
Env4	Content or courses related to sustainability	0.138	0.009
Env2	Environmental conservation policies	0.066	0.005
Env1	Measures of interoperability	0.035	0.002
Social		0.625	0.313
Soc5	E-learning enculturation and recognition mechanisms	0.513	0.160
Soc4	Utilization of blended/online approach, availability of original e-content, and e-assessment deployment	0.262	0.082
Soc3	Impactful e-learning activities for students	0.129	0.040
Soc2	Institutional strategic plan for online learning (i.e., online vision statement, online mission statement, online learning goals, and action steps)	0.063	0.020
Soc1	Bandwidth speed capacity, bandwidth access, e-learning platform utilization, and related support	0.033	0.010

The subsequent phase was the quantification of the indicators, accomplished through the utilization of mathematical and statistical techniques. The most important indicator has the greatest weight. Understanding the importance of indicators or their weights is crucial. This is because each indicator that describes the topic that is being studied affects the final result in its own unique way.

The Super Decisions V3 software [29] was used to calculate the relative weights of the indicators and perspectives based on the judgments of the field experts. To compare the indicators properly, it is important to make sure that they are in the same format. This was done by using a method called minimum-maximum normalization, which helped to put all the indicators on the same level, even if they originally had different units [30]. After normalization, the indicators had no dimension and ranged between 0 and 1 (0 is the worst and 1 is the best) (*see* Table 3).

Table 3.
Types of indicators.

Code	Criteria	Indicator	Type
Eco1	Reasonable and efficient operating costs	Proportion of direct education costs as of total operating cost (%)	Min
Eco2	Integration of e-learning into organizational vision	Availability of an e-learning team, guidelines, or unit (Yes/No)	Max
Eco3	Training in online and distance learning	Number of hours of training per year devoted to teaching staff about online learning (#)	Max
Eco4	Institutional support for learning design	Direct instructional cost per course hour equivalent (RM/hour)	Min
Eco5	Funding for online learning	Percentage of total institutional expenditure dedicated to online learning (%)	Max
Env1	Measures of interoperability	Number of interoperability measures within and between e-learning systems and external open sites, including access control (#)	Max
Env2	Environmental conservation policies	Percentage of non-print materials (%) for each course	Max
Env3	Sustainability-related capacity building	Number of hours of sustainability-related training per year devoted to staff (#)	Max
Env4	Content or courses related to sustainability	Percentage of sustainability-related content or courses in the programme (%)	Max
Env5	Impact of operations on the environment	Percentage of carbon footprint generated by e-learning operations (%)	Min

Code	Criteria	Indicator	Type
Soc1	Bandwidth speed capacity, bandwidth access, e-learning platform utilization, and related support	Percentage of student complaints or appeals resolved or closed (%)	Max
Soc2	Institutional strategic plan for online learning (i.e., online vision statement, online mission statement, online learning goals, and action steps)	Student satisfaction with overall organization (*)	Max
Soc3	Impactful e-learning activities for students	Student satisfaction with the overall learning experience (*)	Max
Soc4	Utilization of blended/online approach, availability of original e-content, and e-assessment deployment	Instructors' or tutors' satisfaction with feedback on their courses derived from student surveys (*)	Max
Soc5	E-learning enculturation and recognition mechanism	Stakeholders' satisfaction with e-learning activities and events held within and outside the organization (*)	Max

Note: * 1 = "Most disagree"; 5 = "Most agree".

Subsequently, the process of aggregation began, in which a comprehensive composite sustainability index was established specifically for online and distance education programmes. The aforementioned result was derived by aggregating the weighted and normalized individual indicators.

Finally, a composite sustainability index was generated, and it is given a name, i.e., Composite Sustainability Index for Online and Distance Education (COSIODE). COSIODE is shown as an equation that combines the weight of the sustainability indicator with its adjusted value. The outcome value will always fall between 0 and 1. Here is the equation:

$$COSIODE = 0.008eco1 + 0.030eco2 + 0.005eco3 + 0.016eco4 + 0.060eco5 + 0.002env1 + 0.005env2 + 0.034env3 + 0.009env4 + 0.018env5 + 0.010soc1 + 0.020soc2 + 0.040soc3 + 0.082soc4 + 0.160soc5 \quad (1)$$

Equation 1 presents a comprehensive assessment of sustainability in online and distance education, taking into account economic (eco), environmental (env), and social (soc) factors, each with its respective weight. The equation serves as a valuable tool for evaluating and comparing the sustainability performance of different educational programmes or institutions in the online and distance education sectors.

6. Discussion and Implications

Despite the existence of numerous techniques and procedures that are designed to create indicators for assessing the achievement of sustainability in higher education institutions, these approaches have proven inadequate in addressing the unique characteristics associated with online and distance education.

Thus, it is important to highlight the relationship between sustainability and online and distance education performance and to propose a composite sustainability index for measuring the sustainability of online and distance education programmes. The findings of the present study have captured the unique relationship between quality performance and the sustainability attainment of programmes delivered via online and distance education. The recent discoveries signify a notable progression, expanding upon the previous work by Harizan and Shah [1], which established the foundation for integrating sustainability factors into the evaluation of performance criteria. These calculated indices serve as a valuable resource for decision-makers, enabling them to compare online and distance education programmes effectively.

They enable continuous improvements in multiple areas, culminating in a more accurate assessment of sustainability progress throughout the entire campus. Furthermore, these indices provide strategic guidance to decision-makers when they are assessing programmes and making decisions regarding improvements within higher education institutions. The process of making such judgments frequently entails the development of prospective policies and the distribution of resources towards these projects.

The goal of this study is to provide thorough support for the monitoring policies and their implementation in the context of higher education, as set forth by the Malaysian Ministry of Higher Education. Additionally, the findings align with initiatives aimed at addressing climate change and achieving Sustainable Development Goal 13 by quantifying the degree to which online and distance education programmes contribute to environmental sustainability. Furthermore, these aims align with the goals set forth in the National Higher Education Strategic Plan 2007–2020 and the Blueprint on the Enculturation of Lifelong Learning for Malaysia 2011–2020. These plans aim to enhance learners' ability to engage in lifetime learning. Moreover, the results can bolster the National e-Learning Policy (DePAN 2.0) in its endeavors to emphasize educational quality and innovation, promote Malaysian education globally, reduce delivery costs, elevate Malaysia's expertise on the global stage, and foster lifelong learning. The aforementioned findings can be regarded as substantial evidence supporting Malaysia's efforts in implementing indices that aid in assessing institutional advancements in attaining Sustainable Development Goal 4. This goal specifically focuses on enhancing accessibility to lifelong learning opportunities for all individuals. It is important to note that the newly developed index offers only an initial understanding of how to effectively address sustainability aspects within online and distance education programmes. Additional validation and examination are essential in order to enhance the comprehensiveness and validity of each sustainability criterion within the realm of online and distance education.

7. Conclusions

Although there are numerous methods and indices for evaluating the sustainability of educational institutions, there is a lack of research that has specifically developed indicators, criteria, or indices that meet the distinctive requirements of online-based distance education programmes.

This research produced a composite sustainability index for the assessment of online and distance education programmes by identifying fifteen sustainability criteria, five for each economic, environmental, and social dimension, which are categorised into five pillars of an e-learning quality deployment framework.

The analysis of their significance revealed that for institutions, the social dimension is the most important, followed by the economic and environmental facets.

The findings indicate the effectiveness of an assessment tool designed to evaluate the sustainability of programmes delivered by an educational institution through online and distant learning methods using certain performance criteria. This approach represents a novel and hitherto unexplored endeavour.

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