

FROM SUSTAINABILITY VALUES TO PROGRAM IMPACT: A CURRICULUM-CENTERED FRAMEWORK FOR TVET REFORM

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ABSTRACT

This study investigates how sustainability values influence program effectiveness within Technical and Vocational Education and Training (TVET) institutions in Pakistan, with a specific focus on the mediating role of sustainability-oriented curriculum design and the moderating effect of contextual barriers. Grounded in Human Capital Theory, Education for Sustainable Development (ESD), and Institutional Theory, the research employed a quantitative, cross-sectional design and surveyed 120 TVET institutions across four major provinces. Structural equation modeling and moderated mediation analysis were used to test the hypothesized relationships. Findings reveal that institutional sustainability values are positively associated with TVET program effectiveness, particularly when mediated by curriculum reforms that integrate sustainability competencies. However, this relationship is significantly weakened by contextual challenges such as limited infrastructure, governance constraints, and resource disparities. Interestingly, the effects of sustainability-driven curriculum design on program outcomes were found to be relatively robust across varied institutional contexts. The study offers a nuanced understanding of how sustainability reforms in vocational education unfold through complex interactions between institutional commitment, pedagogical innovation, and environmental constraints. By empirically validating a mediated and moderated model, the research contributes to expanding theoretical frameworks for ESD and TVET in resource-constrained settings.

Keywords: Sustainability in TVET; Curriculum Design, Education for Sustainable Development (ESD), Contextual Barriers, TVET program Effectiveness

1. Introduction

Technical and Vocational Education and Training (TVET) institutes in Pakistan are well known to be a pivotal instrument towards economic growth, human resource development, and social empowerment, but they have continued to have structural gaps that hinder their direction towards sustainability policies and modern labour market demands. TVET is the key process through which education is converted to employable skills, not to

mention that it should close the gap between theoretical knowledge and practical skills. The historical development of TVET in Pakistan is connected with the attempts by the government to improve the institutional coverage and enroll new participants, but the quality and topicality of training is a controversial issue. It has been shown that although there are developments in policy and the creation of coordinating agencies, TVET institutions face issues with the governance,

including lack of infrastructure, and gender inequality (Ashraf, Xu, & Xiang, 2024). These difficulties undermine the prospects of TVET to play a significant part in the sustainable development by compromising its ability to prepare young Pakistanis with skills, which can enhance their economic, environmental, and social sustainability platforms.

Empirical studies identify a number of both long-term issues in the Pakistani system of TVET such as the unresponsiveness of the curriculum to industry demands, the lack of connections between higher education and industry, and the ineffective training of teachers (Ali, Rahman, and Karsidi, 2024). Such systemic obstacles do not only undermine the potential of the TVET programs in facilitating employment to the graduates, but also dilute the ability of Pakistan to generate a workforce that could generate sustainability innovations. The skills gap is enhanced by the lack of an infrastructure and the lack of finances which absorb the quality of provided training (Bano, Yang, and Alam, 2022). Also, gender inequalities and socio-cultural limitations limit access to women, and this results in unequal access to skill development opportunities which are known to be a source of inclusive growth (Ali, Rahman, and Karsidi, 2024). Although national policies such as the Skilling Pakistan reforms and National Skills Strategy (NSS) are meant to modernize the sector and harmonize the curricula with the labor market demands, their implementation has been varied across regions and institutional situations (Ansari, 2013; Ali, Rahman, and Karsidi, 2024).

Simultaneously, sustainability is discussed globally as the incorporation of the so-called green or sustainability competencies into technical education that would foster the adoption of environmental friendliness and adaptations to more sustainable economies. Studies on vocational education have indicated that these skills would not only cover technical competencies in the context of renewable energy and environmental management but also general life skills that would make learners volunteer in environmental stewardship and sustainable practices (Pirzada, Naz, and Jamil, 2023). Green

competencies are also not integrated into formal TVET curricula in most of the settings, such as in Pakistan, as a result of the lack of teacher training, institutional preparedness, and competing priorities (Pirzada et al., 2023). This is a big gap considering that in Pakistan, there are environmental issues such as climate change and scarcity of resources that highlight the importance of sustainability literacy and green job competencies in the future competitiveness of the workforce.

Although the issues of TVET in Pakistan have gained growing academic interest, a research gap is still noticeable in the relation to the interaction of sustainability orientation in curriculum design with institutional barriers and the overall effectiveness of the program. The bulk of the current research provides either descriptive details of TVET constraints or case studies analysis of the relevance of the curriculum, which lacks a careful analysis of the multifaceted interplay between sustainability integration, environment-specific obstacles, including industry involvement and governance, and quantifiable results in terms of employability or adaptability. In addition, the available literature tends to give precedence to general description of policy rather than to the effective empirical research that would reflect institutional differences and the real-life experiences of teachers, administrators and learners within TVET institutions. This gap constrains our knowledge of how sustainability-based curriculum reforms can be implemented in order to improve program responsiveness and graduate outcomes in Pakistan, especially in provinces under-researched or in marginalized groups.

The unmet gaps motivate this study to describe and empirically research the connections presented in the conceptual framework in terms of the role of sustainability on designing the curriculum, the factors that impede adaptation, and the effect of their interplay on the effectiveness of TVET programs. The study aims to address how TVET institutes can incorporate sustainability ideas in the pedagogical material, evaluation methods, and industry connections in a systematic manner, by making sustainability an

inherent aspect of the curriculum planning process, as opposed to assuming it as an added feature. Through this method, it is possible to study internal institutional potentials and external systemic restrictions in a subtle way, and learn the role played by the barriers of fragmentation of governance, resource deficiency and lack of engagement with the industry in the adaptation processes.

This study aims at assessing the level of course sustainability currently being embedded in TVET curriculums, determining and classifying barriers that inhibit or distort adaptation activities in various institutional settings, and the consequences of these variables on important variables of program performance including graduate employability and employer satisfaction. With evidence on these issues created, the study will not only serve the research community but also actionable interventions that may be used to inform a policy adjustment, institutional practice, and interventions. The meaning of this study is especially relevant because of the demographic characteristics of Pakistan, whereby a considerable number of youth population relies on TVET channels to get livelihood opportunities, as well as, the ability to increase sustainability competencies to maintain economic resilience and even equitable development.

Besides, explaining the impediments to adaptation and plotting their impact on curriculum design and program outcomes, the study aims at providing useful recommendations to stakeholders such as policymakers, TVET managers, educators, and industry partners. These contributions would be critical in helping to rebrand TVET as an instrument of sustainable development, which can address the new trends in the labor market, environmental needs, and inclusive development agendas. Finally, the proposed research will fill the existing gaps in knowledge and help to make evidence-based decisions that will enhance the contribution of TVET to the sustainable development agenda in Pakistan.

2. Literature Review

2.1. Sustainability in TVET

The sustainability in Technical and Vocational Education and Training (TVET) literature indicates a developing but under-researched area of investigation, with the increased awareness of how TVET can contribute to the realization of sustainable development objectives. In TVET, sustainability means instilling the environmental, economic, and social aspects of sustainability in the curricula, pedagogical methods, institutional policies, and training of workforce such that graduates would not only possess technical skills but also a potential to serve vibrant societies and sustainable economies. A recent literature review of studies on vocational and technical education in Pakistan highlights the fact that TVET is seen as a key to socio-economic change, but the existing curricula do not carry heavy sustainability competencies, which has led to the continued disconnect between education and the requirements of the green economy and labour market (Ali, Rahman, and Karsidi, 2024). Such barriers are identified in this body of work, including archaic curricula, ineffective partnership with industry partners, and governance inefficiencies, which disproportionately impact rural and marginalized groups, and provide TVET a poor response to sustainability goals and inclusive workforce development (Ali et al., 2024). These findings are consistent with other discourses that highlight the need to shift the TVET systems to become more sustainable in support of a just access to quality education and enlightening employment opportunities.

The literature on TVET and sustainability places the discipline in the broader context of Education for Sustainable Development (ESD) that promotes not only the impartation of skills in a technical manner but the development of knowledge, attitudes and values that can be applied to resolve more complex environmental and social issues. Sustainability has been defined by the United Nations Educational, scientific and cultural organization (UNESCO) as overall goal of TVET system where educational programs can enable learners to make informed choices that enhance environmentally friendly practices and socially

responsible behaviors (UNESCO-UNEVOC, 2002). This approach considers TVET to be more than a vocational training: it is a strategic tool that can be used to improve economic productivity, resilience of the community, and environmental care at the same time. Making sustainability a part of the TVET curriculum therefore relates to a reconceptualization of conventional pedagogies, interdisciplinary and experiential conceptualizations of learning, and the consistency of education outcomes with Sustainable Development Goals (SDGs), especially SDG 4 on quality education and SDG 8 on decent work and economic growth. According to research, the ability of TVET institutions to promote sustainable development becomes stronger when they take the form of comprehensive approaches, namely the process of greening campus operations, integration of environmental awareness, and the opportunity to enhance community engagement, which in turn ensures the emergence of graduates able to meet the requirements of the changing green labor markets and become the agents of ecological innovation (Ye, He, Bai, and Wu, 2024; UNESCO-UNEVOC, 2002).

Although there is conceptual agreement on the relevance of sustainability in TVET, empirical research indicates that there are serious issues to be overcome. When TVET systems reform is being undertaken, as it is the case in Pakistan or other developing nations, the incorporation of sustainability is often unbalanced, and often superficial, which is a factor of the constraint of institutional resources, preparedness of teachers, and policy alignment. The comparative studies provided by other national settings such as the research conducted in Europe and Africa indicate that innovative solutions to this problem such as competency-based education, industry partnership and curriculum co-creation with stakeholders have the potential to make TVET programs more relevant and sustainability-oriented, however such interventions are important only with robust policy settings and long-term investments (Albertz, 2025; Aluthge, 2022). In addition, the recent research pursuing nature-based solutions to TVET curricula suggests that transdisciplinary

cooperation and applied learning would be necessary to bring the theoretical concept of sustainability to a practical meaning in the work of vocational experts, which is a new trend in research that no longer follows the traditional approach of technical learning (Keryan, Uhlhorn, Wals, et al., 2025).

In general, the literature is clear that sustainability in TVET is an essential and a complicated task. The institutional capacity, the process of curricular design, teacher competencies and industry engagement are systemic conditions that have a major influence on the level of operationalization of sustainability in TVET institutions. Further studies are required to produce empirical data regarding the effective models of sustaining the introduction of sustainability in various TVET settings, evaluating the outcomes to graduates in relation to employability and acquisition of green skills, and identifying the policy instruments to help to scale up the reforms. This kind of work is imperative in aligning TVET with national development priorities and international sustainability requirements and thus makes vocational education systems have a significant role in economic sustainability, environmental protection, and social equity.

2.2. Sustainability-oriented Curriculum Design

The idea of the sustainability-oriented design of the curriculum has been acquiring more and more relevance in the field of educational research when the institutions aim to align the learning outcomes with the requirements of the sustainable development. In Technical and Vocational Education and Training (TVET), sustainability-oriented curriculum design denotes the deliberate incorporation of environmental, economic, and social sustainability into curriculum goals, material, pedagogy, and evaluation in such a manner that it increases the level of contribution made by learners towards sustainable practice at the workplace and in society. Literature has repeatedly pointed to the fact that the design of the curriculum is a key mechanism by which the intention of sustainability is transformed into the practice of education, especially in the context of

vocation when education is closely linked to production systems, technological aspects, and labor markets (Lozano, Barreiro-Gen, Lozano, and Sammalisto, 2019). Instead of viewing sustainability as a supplementary curriculum topic, sustainability-driven curriculum design should involve reorganizing the curriculum on an integrated basis to incorporate sustainability skills in technical subject areas and training programs. Empirical research has indicated that the sound sustainability-based curriculum design in TVET focuses on competence-based methodologies that transform technical skills to transversal ones e.g. systems thinking, problem solving, ethical reasoning, and environmental awareness. The works of the Journal of Cleaner Production prove that the introduction of sustainability learning outcomes into vocational curricula improves the capacity of learners to implement sustainable practices in the occupational environment, especially in the case of the correspondence between curriculum design and industry standards and green innovation agendas (Brundiers, Barth, Cebrián, Cohen, Diaz, Doucette, Dripps, Habron, Harré, Jarchow, Losch, Michel, Mochizuki, Rieckmann, Parnell, Walker, and Zint, 2021). The results here show that the curriculum design is an intermediate variable that mediates between sustainability objectives and educational performance and influences the operationalization of sustainability knowledge in TVET programs.

The literature also emphasizes on the fact that institutional capacity and educator competence play a critical role towards the sustainability-oriented curriculum design. The literature on curriculum reform in vocational and higher education points to the fact that the knowledge related to sustainability in instructors and their pedagogical self-confidence have a major influence on the introduction of sustainability in the curriculum (Cebrián, Segalàs, and Hernandez, 2019). In places where curriculum design procedures are centrally based or independent of the teaching practice, the aspect of sustainability integration remains merely shallow. On the other hand, the models of curriculum design that are based on participation of teachers, industry

stakeholders as well as policymakers are linked to more coherent and context-based sustainability integration especially in vocational education systems that are undergoing reform (Barth, Godemann, Rieckmann, and Stoltenberg, 2007). This research literature highlights the middle ground of curriculum design in the interpretation of abstract sustainability principles into significant learning experiences.

Sustainability-based curriculum design in the context of developing nations has other problems to address which are resource limitation, fragmentation of policy and development priorities. The studies covering TVET systems in Asia and the Global South show that the concept of sustainability is mentioned more frequently in policy documents, but when it comes to curriculum development, there is no apparent guidance on what learning outcomes and assessment strategies to implement and how the curriculum should relate to sustainability (Pavlova, 2018). Consequently, the distribution of sustainability competencies is lopsided in the programs and institutions. However, there is some evidence that, where a clear connection between sustainability goals and employability and labor market relevance is made in the curriculum design, TVET programs are better placed to help to ensure economic resilience and responsibility towards the environment (McGrath, Mulder, Papier, and Suart, 2019).

In general, the literature represents sustainability-oriented curriculum design as a pivotal intermediary between sustainability ambitions and TVET programs performance. Curriculum design determines whether sustainability will become a practical competency or a rhetorical aspiration, by influencing what is taught, the manner in which teaching and learning is understood and evaluated. Nevertheless, in spite of the increasing academic interest, there is a still scanty body of empirical study that explores the role of sustainability-oriented curriculum design as a mediating factor in particular national TVET settings. This is a significant gap especially in Pakistan where research has not been done in a systematic way to examine the relationship between the sustainability goals and program

outcomes as dependent on the curriculum design processes. This gap should be addressed to develop theory and practice associated with sustainable TVET reform.

2.3. TVET Program Effectiveness

The effectiveness of TVET programs is usually discussed as a multidimensional phenomenon instead of a single score, as vocational programmes are likely to transform the training inputs into labour-market returns as well as to assure quality of learning, accomplishment, and equity of access. Operationalisation of the term effectiveness in rigorous evidence in low- and middle-income countries is most commonly done by using employability and employment outcomes, including paid employment, formal employment and earnings, but the size of the impacts on average and variance by programme design is often small (Tripney and Hombrados, 2013). To assess the effectiveness in the TVET scene in Pakistan, this heterogeneity has two implications. First, the selection of outcomes should be appropriate to labour-market realities; in the face of high levels of informality and underemployment, any kind of employment can fail to capture substantial changes in job quality, sectoral mobility, and hours worked, as well as in the viability of self-employment. Second, it should be effective within reasonable time frames, as some of the benefits are realized later or wear out over time based on the rate at which skills become outdated and the ability that the programmes link graduates with the demand (Bolli-Kemper et al., 2025). Stated differently, programme effectiveness can best be conceived of as the degree to which TVET enhances the work courses and wellbeing of graduates, which is attributable to the programme rather than simply the result of post-training.

New causal and synthesis studies help to understand what to measure and why. A quasi-experimental analysis of a large Nepalese youth vocational training programme demonstrates why the metrics of effectiveness should go further than wage jobs: the programme boosted non-farm employment and earnings, but women became self-employed, which demonstrates that the approach to programme success may run through

channels not captured by conventional employment metrics (Chakravarty et al., 2019). On the same note, vocational and general track evidence shows that vocational education can increase earnings and employment, though with greater system design-dependent returns, which confirms that close benchmarking is necessary when determining whether a TVET programme is an effective or ineffective programme (Silliman and Virtanen, 2022). The meta-analytic evidence is consistent with this argument: in comparison to general education, average employment effects are small, but comparisons to broader control groups can be more productive, implying that the effectiveness conclusion can strongly depend on what the other education route is among the learners (Bolli-Kemper et al., 2025). In addition to labour outcome, implementation quality and experience of the participants, such as instructional quality, administration, learning environments, and socio-emotional or cultural capital gains that can mediate employability are also effective (qualitative synthesis indicates that these dimensions influence outcomes and equity, particularly in the case of disadvantaged youth, Shi and Bangpan, 2022). Lastly, both completion and retention are part of effectiveness since dropout may cancel desired returns; a meta-synthesis of dropout on vocational training has demonstrated that an early termination is not just a factor but also a training and workplace-related phenomenon, and therefore programme effectiveness in TVET not only needs to consider persistence and completion but also training quality as outcomes of programme effectiveness (Boehn and Deutscher, 2022). In the case of Pakistan these strands all suggest that the measurement of the effectiveness of TVET programmes needs to be a mixture of tracer-type of labour outcomes with counterfactual designs where possible with process and learning-environments measures that elucidate the differences in outcomes amongst institutes, trades, genders and regions (Tripney & Hombrados, 2013; Shi and Bangpan, 2022).

2.4. Contextual Barriers as Moderator

According to the literature on contextual barriers in Technical and Vocational Education and Training (TVET), the institutional, socio-economic and governance contexts within which the training is conducted are very strong determinants of program outcomes. Contextual barriers: These are organizational and situational restrictions that are external to the contents of the curriculum itself and which moderate the relationship between educational inputs and effective output. Such barriers are fragmentation of governance, industry linkages, poor infrastructure, insufficient capacity of the instructors, socio-cultural norms, and distortion of the labor market. The studies always indicate that even effectively designed TVET programs may fail to achieve their goals when the situational conditions do not match the program goals, meaning the need to explore the notion of these barriers as moderating factors instead of marginal obstacles (McGrath et al., 2019).

Weak institutional governance and coordination has been cited as one of the greatest contextual obstacles to TVET systems especially in developing countries. The lack of coordinated control between federal, provincial and sectoral governments is likely to cause overlapping programs, unequal standards and poor resources distribution. Empirical research has shown that inefficiencies in governance lower accountability and restrict the responsiveness of TVET institutions to the demands of labor markets and hence moderates the effectiveness of programs (Tripney and Hombrados, 2013). In places like South Asia, governance problems are worsened with poor monitoring and evaluation tools which stipulate that there are poor feedback loops between employers and training providers (Bolli-Kemper et al., 2025). These organizational constraints define the institution behavior and limit scalability and sustainability of the productive TVET interventions.

Another important contextual factor, which mediates TVET outcomes, is industry engagement. The literature reveals that the lack of cooperation with employers tapers the significance of training content, the employment learning

prospects, and graduate employability. Research indicates that high rates of formal training completion do not mean that graduates will attain market relevant skills in the event that employers have weak connection to the curriculum development or evaluation processes (Silliman & Virtanen, 2022). This is especially the case in economies that have extensively high informal sectors in which employers have little motivation to hook up with formal training systems. Consequently, TVET programs can be generating credits in the absence of the labor market value, which lowers their perceived efficacy (Maiga et al., 2020).

Other contextual barriers are human and physical resource limitations. One of the common themes of the literature is that there are not enough instructors who are well trained, their training equipment is old and that there is lack of funding to run modern workshops and laboratories. These limitations directly influence the quality of instructions and the acquisition of skills by learners, mediating the curriculum design/outcomes association. The qualitative synthesis study reveals that low training quality, overcrowded learning centers, and poor learning materials are perceived by the participants as disappointment factors leading to dropout and poor post-training results (Shi and Bangpan, 2022). These results imply that the contextual barriers not only hinder effectiveness but also confer with the characteristics of learners and increase inequities of disadvantaged groups.

The socio-cultural and gender norms are also effective contextual moderators of TVET effectiveness. The experiences of low- and middle-income countries show that low mobility, work division, and social stigma of vocational education become obstacles to women and marginalized populations, limiting their participation and labor market outcomes (Chakravarty et al., 2019). Such contextual constraints may even conceal the apparent effects of programs, causing underloss of the impact of programs when not under analytical consideration, even though these programs may be technically effective.

The literature in general identifies contextual barriers as critical moderating variables

determining the attainment of desired outcomes by TVET programs or otherwise. Such obstacles affect the institutional capacity, involvement of stakeholders, and learning experiences of learners, and condition the success of sustainability-based curricula and training provision. The empirical agreement proposes that an increase in the effectiveness of TVET necessitates not only the curricular changes but also systemic changes that should include governance issues, industry connections, resources, and socio-cultural issues. An appreciation of contextual barriers as mediators is a more explanatory and realistic approach in interpreting variation in the effectiveness of the TVET programs among different institutions and regions.

3. Theory, Hypotheses and Framework

The theory that supports this study lies in the human capital theory, education and sustainable development, and institutional theory, which form a holistic perspective to explain the difference in the effectiveness of the TVET program. According to the human capital theory, education and training increases the productive skills and capabilities of individuals that leads to an increase in employability, earnings, and economic performance (Becker, 1993). In the context of TVET systems, this view justifies the idea that the successful training programs must be converted into good labor market performance. Nonetheless, empirical studies are increasingly showing that training and outcomes relationship is not automatic and homogenized especially in developing economies where institutional weakness, labor market segmentation, and socio-cultural restraints are defining how skills are applied (McGrath et al., 2019). This weakness calls a need to expand the human capital theory to include sustainability and contextual factors, which determine the returns of investment in training.

The theory of education for sustainable development (ESD) has been complementary to this view and its argument is that education systems are supposed to equip learners not only to immediate work experiences but also to social, economic, and environmental sustainability in the

long term. When applying to the situation of TVET, sustainability means that training goals need to incorporate environmental awareness, social responsibility and economic resilience to enable graduates to meet the technological change, green transitions and changing labor markets (Pavlova, 2018). Sustainability is thus understood as a strategic direction that defines the priorities in institutions and learning experiences. Nonetheless, ESD theory also acknowledges that the sustainability objectives are achieved mainly via curriculum design, which would establish what knowledge and competencies it educates, the way the learning process takes place, and the evaluation of outputs. Even lack of intentional curriculum integration makes sustainability an imaginary promise as opposed to being an operational fact (Lozano et al., 2019).

The institutional theory also displays the reasons why the sustainability-focused reforms usually have unequal outcomes throughout the TVET systems. Organizational behavior and performance are affected by institutions through regulation, normative, and cultural environments (Scott, 2014). Contextual barriers which are related to fragmented governance, limited financial and physical resources, a weak sense of industry engagement, capacity constraints of the instructors, and socio-cultural norms influence implementation of the curricula and translation of the training into employment outcomes in TVET. Such contextual considerations do not just have a direct influence; they determine the magnitude and orientation of the relationships between the inputs and outputs of education. In that regard, the treatment of the contextual barriers is supported by institutional theory as an intervening variable that predisposes the efficiency of interventions aimed at sustainability (Tripney and Hombrados, 2013).

Combining these theoretical insights, the proposed framework brings sustainability as the explanatory factor with respect to the effectiveness of TVET programs. The design of the sustainability-oriented curriculum is set as a mediating variable where the argument is that sustainability influences the outcomes mostly in terms of curriculum designs, methods and

approaches used in the study and assessment practices. Curriculum design transforms intentions to sustainability into practical competencies thus determining the relevance of the skills, the quality of learning and employability of the graduates. A moderating variable is placed to include contextual barriers which affect the strength of relationship between the curriculum design and program effectiveness. In higher contextual barriers environment, the well-crafted sustainability-oriented curricula might result in little results because of the potential constraints of implementation and the challenges of absorption by the labor market. On the other hand, the positive impact of curriculum design on program effectiveness is likely to be greater in case of low contextual barriers.

In this context, effectiveness of TVET programs is viewed as a multidimensional outcome comprising; employability, relevance of the skills, graduate satisfaction, and perceived fit with the requirements of the labor market. The framework hence makes a moderated mediation model where sustainability has indirect effects on program effectiveness via curriculum design with contextual barriers moderate the intensity of indirect effect. This method goes beyond the linear explanations of TVET performance and presents a theoretically justified ground on which the reasons behind the success of sustainability initiatives in certain contexts are investigated but fail in others.

The hypotheses derived from this framework are stated explicitly as follows.

H1: Sustainability has a significant positive effect on TVET program effectiveness.

H2: Sustainability has a significant positive effect on sustainability-oriented curriculum design in TVET institutions.

H3: Sustainability-oriented curriculum design has a significant positive effect on TVET program effectiveness.

H4: Sustainability-oriented curriculum design mediates the relationship between sustainability and TVET program effectiveness.

H5: Contextual barriers significantly moderate the relationship between sustainability and TVET program effectiveness, such that the positive effect of sustainability on program effectiveness is weaker when contextual barriers are high.

H6: Contextual barriers significantly moderate the relationship between sustainability and sustainability-oriented curriculum design, such that the positive effect of sustainability on sustainability-oriented curriculum design is weaker when contextual barriers are high.

H7: Contextual barriers significantly moderate the relationship between sustainability-oriented curriculum design and TVET program effectiveness, such that the positive effect of curriculum design on program effectiveness is weaker when contextual barriers are high.

Together, these hypotheses articulate a coherent theoretical model that links sustainability, curriculum design, contextual conditions, and program effectiveness. By empirically testing this model within the context of TVET institutes in Pakistan, the study aims to contribute to theory development by clarifying the mechanisms and boundary conditions through which sustainability influences vocational education outcomes, while also offering practical insights for policy and institutional reform.

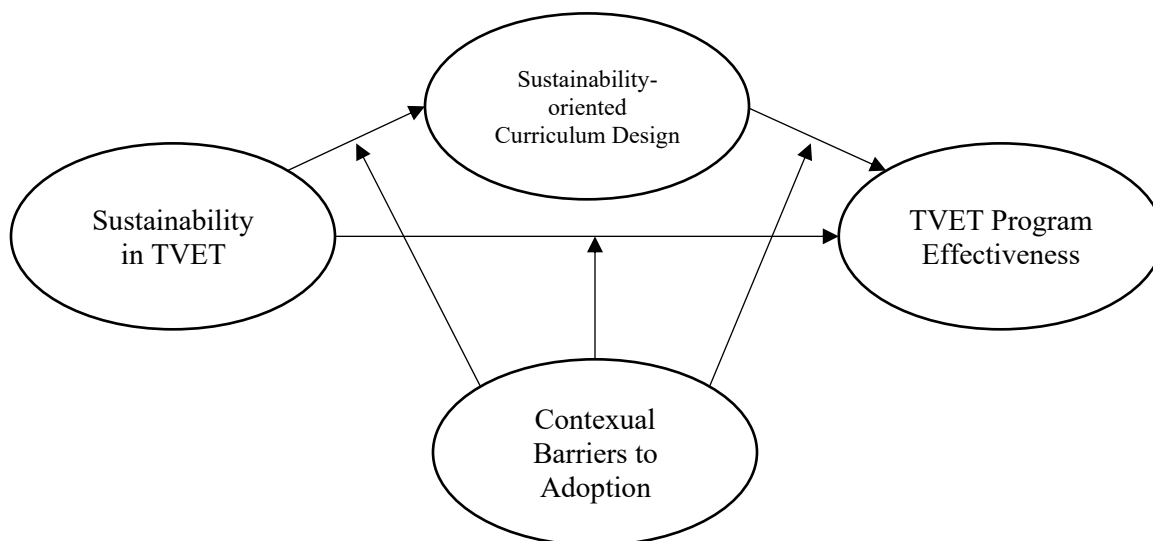


Figure-1: Research Framework

The principles of the Education for Sustainable Development (ESD) underlie the research methodology based on a quantitative research design and deductive approach. This is a method that starts with theory-based hypotheses, which are based on a conceptual framework, which makes the sustainability values the driving change agents in Technical and Vocational Education and Training (TVET) systems. In particular, the model demonstrates that sustainability oriented curriculum design serves as an intermediary variable between the institutional sustainability targets and the effectiveness of the TVET programs, whilst acknowledging the obstacles to adaptation as possible moderating variables. The structure mirrors the transformative aspirations of ESD, which stress systemic thinking, contextual responsiveness and educating sustainable futures. The cross-sectional design was used, and it allowed data gathering on a wide range of TVET institutions during one period. This design is appropriate in exploring the operationalization of sustainability in terms of institutional processes and curriculum structures, as well as in gaining the differences in the problem of adaptation and digital inclusion to the four largest provinces of Pakistan, namely Punjab, Sindh, Khyber Pakhtunkhwa (KPK), and Balochistan. These areas were chosen to represent a variety of institutional capacity, governance systems, digital platforms, and socio-economic settings to enable the study to

find out how contextual obstacles play out in the execution of sustainability-oriented education reforms within the TVET sector.

The study population was all the known institutions of TVET that were public in the above mentioned provinces and systematic random sampling was done to make the selection unbiased and representative geographically. One hundred and twenty institutions were picked and distributed evenly throughout the provinces with both urban and rural setting represented. The type of respondents used was institutional leaders or principals, department heads, and in-charges who were found to possess the strategic insight required to give informed responses regarding the integration of sustainability and decision-making in curricula. This methodology aligns with the current empirical research, which applies leadership lens to assess the educational reform, innovation, and sustainability (Abdullah et al., 2021; Khalid and Noor, 2025).

A designed questionnaire was used to collect data, and it was structured to test four core constructs, (1) Sustainability (independent variable), (2) Sustainability-oriented Curriculum Design (mediator), (3) Barriers to Adaptation (moderator) and (4) TVET Program Effectiveness (dependent variable). Multi-item scales were used to operationalize all constructs based on previous studies and were customized to include ESD principles like equity, critical thinking, and

transformative learning. The answers were taken on a five-point Likert scale, which was strongly disagree to strongly agree. Cronbach alpha values of the instrument were also checked and all were above 0.90 which means that it had a high level of internal consistency (Hair et al., 2019; Fornell and Larcker, 1981).

In testing the direct, mediating, and moderating effects of the data, multiple regression methods were used to analyze the data. To start with, direct correlations between sustainability values and the effectiveness of TVET programs were studied. A mediation analysis was then conducted based on the PROCESS macro Model 4 (Hayes) to find out whether sustainability-oriented curriculum design is a mediating variable. This action was critical in testing the hypothesis that incorporating sustainability in curriculum content positively impacts on the effectiveness of the institutions. Finally, a moderation analysis with Model 1 in PROCESS determined the moderating effect of barriers to adaptation; resource limitations, regulatory challenges and institutional inertia on the relationship between sustainability and program effectiveness.

The ESD-based methodological framework enables a powerful exploration of the interaction of sustainability values, curriculum design, and realities of the context to influence effective and futuristic TVET systems. It builds on the old technology and organizational designs (including TOE) by taking a sustainability prism that recognizes the role of both educational transformation, equity, and resilience in shaping the context of developing countries, such as Pakistan. The study can provide practical implication to policy-makers, educators, and institutional leaders who wish to adopt more sustainable and adaptive practices of vocational education within the resource-constrained environments by empirically testing such relationships.

4. Results

4.1. Reliability and Validity

In order to test the constructs considered in the proposed research model, an exploratory factor analysis (EFA) was carried out based on a Principal

Component Analysis (PCA) with Varimax rotation and Kaiser normalization that is highly recommended to interpret orthogonal factors and create a clear construct separation (Field, 2018). The independent variables included in the analysis consisted of four variables: Sustainability, Sustainability-driven Curriculum Design, Contextual Barriers to Adoption, and TVET Program Effectiveness all of which were operationalized using multi-item measurement scales based upon the Education for Sustainable Development (ESD) framework. Each construct reliability was determined to be rated by Cronbach alpha (α) and all constructs showed high internal consistency. The alpha of the Sustainability measure was 0.897, which validated that SUST1-SUST5 measure was always able to measure institutional values and practices that were congruent with sustainability concepts in TVET situations. Curriculum Design based on Sustainability also possessed a very high reliability (0.895), as an indicator of the effectiveness of a scale in indicating the extent to which the sustainability in Curriculum Design is reflected in Curriculum Planning, Pedagogy, and Curriculum Assessment. On the same note, Contextual Barriers to Adoption had high reliability (0.874), which implies that the items (CTB1-CTB5) chosen to measure institutional and systemic barriers to sustainability in vocational education, including infrastructural barriers, governance fragmentation and socio-cultural barriers, were effective in gauging these challenges. TVET Program Effectiveness had the best internal consistency (0.942), which confirms its status as a measure of programmatic outcomes (i.e. employability, graduate satisfaction, and relevance to labor market demands). All items showed high factor loadings between 0.736 and 0.885, which is above the traditional criterion at 0.70 (Hair et al., 2019), and this is an indicator of high construct validity. The high loadings confirm the fact that every item is a great contributor to its latent construct. As an illustration, the constructs (PREF1-PREF5) of the TVET effectiveness category had particularly high loadings, which means that the intent perceptions are coherent around graduate outcomes, which is a key variable

in TVET evaluation systems (Shi and Bangpan, 2022).

The general sampling adequacy was also checked in Kaiser-Meyer-Olkin (KMO) and Bartlett Test of Sphericity. The KMO value was 0.874, which is far much better than the acceptable value of 0.60, indicating that there is meritorious adequacy on factor analysis (Kaiser, 1974). The Test of Sphericity by Bartlett was significant ($\chi^2 = 1591.475$, $df = 190$, $p < .001$), which proves that the correlation-matrix is not an identity-matrix and hence can be subjected to factor analysis. These statistical indicators support the fact that the data structure used was appropriate in the process of extracting valid and interpretable factors. In addition, the four-factor solution described a total of 73.066 percent of the total variance, which is superior to the 60 percent standard that is generally required in social science

studies (Fornell and Larcker, 1981). The high percentage shows that the items that have been chosen are effective to represent the underlying constructs and explain a significant percentage of the shared variance of the observed variables.

All of these psychometric findings confirm the soundness of the measurement model. They espouse the conceptual framework of the study where sustainability affects the effectiveness of TVET programs in terms of curriculum design with contextual barriers moderating these effects. This confirmation can be also compared with the previous studies that have highlighted the significance of developing empirically based instruments to evaluate the concept of sustainability integration in the vocational educational systems, especially when the context is based in the developing countries (Brundiers et al., 2021; Lozano et al., 2019; Pavlova, 2018).

Table-1: Reliability and Validity Analysis

Variable	Code	Items	Factor Loadings	Reliability
Sustainability	SUST	SUST1	.820	.897
		SUST2	.736	
		SUST3	.823	
		SUST4	.835	
		SUST5	.786	
Sustainability-driven Curriculum Design	SCD	SCD1	.777	.895
		SCD2	.819	
		SCD3	.811	
		SCD4	.805	
		SCD5	.745	
Contextual Barriers to Adoption	CTB	CTB1	.840	.874
		CTB2	.828	
		CTB3	.778	
		CTB4	.815	
		CTB5	.798	
TVET Program Effectiveness	PREF	PREF1	.833	.942
		PREF2	.885	
		PREF3	.883	
		PREF4	.860	
		PREF5	.883	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. KMO = 0.874 Bartlett's Test, Chi-square = 1591.475, df = 190, p < .001 Total Variance Explained = 73.066%				

4.2. Regression Analysis

Table 2 shows the outcomes of the regression model of the direct associations among sustainability (SUST), sustainability-oriented curriculum design (SCD), and TVET program effectiveness (PREF) as postulated in the proposed model. The hypothesis of the direct effects is strongly supported by the empirical data as all the hypothesized paths are statistically significant at $p = .001$. The first one, between Sustainability (SUST) and TVET Program Effectiveness (PREF) produces a standardized regression coefficient (β) of 0.354, with a t -value of 4.096, and an R^2 of 0.125. It means that the values of sustainability in institutions are related to the explanation of 12.5% of the variation in perceived program effectiveness. The outcome confirms Hypothesis H1, which means that institutional sustainability commitments have a positive effect on program outcomes, including employability, relevance, and graduate satisfaction. It is consistent with the previous study that highlights sustainability as a strategic factor of the long-term educational and economic outcomes in TVET conditions (Lozano et al., 2019; Pavlova, 2018). The second direction is the analysis of the impact of Sustainability (SUST) on Sustainability-driven Curriculum Design (SCD) that indicates a bigger regression coefficient of 0.494 with the t -value of 6.154, and R^2 of 0.245. This indicates that institutional sustainability values explain 24.5 percent of the sustainability-oriented curriculum practices. This

statistically significant association confirms Hypothesis H2, which proves that sustainability considerations are a very important antecedent to curriculum reform. The institutions, which are more environmentally and socially sustainable, have a higher chance of incorporating these dimensions into the teaching process, assessment, and course material, which is reflected in the studies by Cebrián, Segalàs, and Hernandez (2019) and Brundiers et al. (2021). The third direct correspondence, between Sustainability-driven Curriculum Design (SCD) and Program Effectiveness (PREF), is also important with $\beta = .454$, $t = 5.507$ and $R^2 = .206$. This is in support of Hypothesis H3, which states that curriculum design is an important process that helps to transform the values of sustainability into program outcomes. According to the model, a sustainability-based curriculum with a well-organized design contributes to the effectiveness of TVET programs to the greatest extent, as it is consistent with the international recommendations on ESD-based pedagogies (Barth et al., 2007; Shi and Bangpan, 2022). All in all, the R -square values represent the significant explanatory power, and the curriculum design becomes an especially powerful variable in the mediating institutional sustainability values and program performance. These results form an initial basis on the mediated model in which sustainability affects the outcomes directly and indirectly through curriculum change.

Table-2: Regression Analysis for Direct Paths

Path	β	t -value	p -value	R^2
SUST $\rightarrow$ PREF	.354	4.096	.000	.125
SUST $\rightarrow$ SCD	.494	6.154	.000	.245
SCD $\rightarrow$ PREF	.454	5.507	.000	.206

The mediation analysis provided in Table 3 evaluated the hypothesis of whether Sustainability-driven Curriculum Design (SCD) is the mediator between Sustainability (SUST) and TVET Program Effectiveness (PREF). It was done with the PROCESS macro of Hayes (Model 4) and bootstrapped at 5,000 samples, the recommended value of bootstrapping when indirect effects are intended to be tested without the use of

assumptions of normal distribution (Hayes, 2018). The results indicate that the sustainability has an important indirect influence on TVET effectiveness based on the curriculum design and the point estimate is 0.2214 and the bootstrapped standard error (SE) is 0.0633. The indirect effect has a 95% confidence interval of 0.1034 to 0.3514 and the lower limit (LLCI) and upper limit (ULCI) are not crossing the 0, indicating that the

mediation effect is also statistically significant. This finding confirms Hypothesis H4, that sustainability-oriented curriculum design is a mediating factor, which elucidates how sustainability values are converted into better outcomes of TVET programs. In practice, this implies that institutions that incorporate the sustainability principles in their curriculum design are more likely to amplify the efficiency of the program, particularly regarding employability, skills and learner satisfaction. The role of this indirect route confirms the thesis that sustainability in itself is not necessarily going to have positive outcomes but needs to be implemented in the form of curriculum design, pedagogy, and learning evaluations (Lozano et al., 2019; Brundi et al., 2021). The given finding conforms to the Education for Sustainable Development (ESD) theory, which underlines the role of reforming the curriculum as the means to

deliver sustainability outcomes in the education systems (UNESCO-UNEVOC, 2002; Cebrián et al., 2019). It also resonates with the findings of the vocational education studies that the sustainability intentions should be embedded in the program content and delivery so as to produce the practical education and labor market outcomes (Pavlova, 2018; Barth et al., 2007). All in all, the powerful mediation attests to the theoretical framework of the model of study: sustainability affects TVET efficacy directly and indirectly, and the design of the curriculum plays a pivotal role on the change process. The implications of this finding to the policy makers and the leaders of the educational institutions are of key importance since the study demonstrates the necessity of a conscious redesign of the curriculum to ensure that institutional commitments to sustainability are translated into meaningful training outcomes.

Table-3: Regression Result for Mediation

Path	Indirect Effect	Boot SE	Boot LLCI	Boot ULCI
SUST → SCD → PREF (Indirect Effect)	.2214	.0633	.1034	.3514

The findings of the moderation analysis carried out to examine the moderating effect of Contextual Barriers to Adoption (CTB) on the correlations between Sustainability (SUST), Sustainability-driven Curriculum Design (SCD), and TVET Program Effectiveness (PREF) are summarized in Table 4. The terms of interaction were utilized as the Hayes PROCESS macro Model 1 that can estimate the moderation effects with the help of regression and bootstrapped standard errors (Hayes, 2018). The interaction term was found to have a significant positive result (CTB * SUST → PREF, $\beta = 0.2581$, $t = -2.898$, $p = .0045$), which demonstrated that the effect of contextual barriers on the direct relationship between sustainability and TVET program effectiveness has a significant negative value. Namely, the negative coefficient of beta indicates that the positive influence of sustainability values on the effectiveness of the programs is less significant in institutional settings with stiffer contextual determinants, including discontinuous

governing structure, resource shortage, lack of infrastructure, or industry connections. The observation supports one of the Hypothesis H5 since it is based on the institutional theory according to which the limitations and opportunities existing in operational contexts determine organizational performances (Scott, 2014; McGrath et al., 2019). On the other hand, the remaining two terms of interaction such as CTB * SUST → SCD ($\beta = .0303$, $t = -.6782$, $p = .8999$) and CTB*SCD → PREF ($\beta = .0110$, $t = -.8999$, $p = .8999$) were not found to be significant. These findings show that contextual barriers do not modify the effect of sustainability on curriculum design or the impact of curriculum design on program effectiveness significantly. This implies that on achieving the status of course embedded sustainability, its role towards TVET effectiveness might not be significantly influenced by other contextual factors, despite institutional constraints. Such inconclusive results are related to the prior literature indicating that

institutionalizing curriculum change may be somehow independent of structural limitations (Cebrián et al., 2019; Brundiens et al., 2021). The substantial moderation of the SUST PREF path supports the fact that specific contextual obstacles need to be taken into account when evaluating the sustainability results of education systems. Although the intentions behind the creation of sustainability-related curricula might be very positive, their effects on efficiency would be diluted in the institutions that are marred with inefficiencies within their systemic framework. This observation is consistent with research on low- and middle-income countries (LMICs), which highlights that TVET redesign initiatives should

extend beyond redesigning content and to institutional, infrastructural, and socio-political change factors (Shi and Bangpan, 2022; Bolli-Kemper et al., 2025). Overall, the moderation analysis reveals that institutional context is an extremely important variable in terms of transforming sustainability strategies into effective outcomes, though it affects the immediate relationship between values and outcomes, rather than the mechanisms used in the curriculum, in between. This highlights the significance of multi-level interventions: on the one hand, curriculum design is the key to success of sustainability measures in TVET, on the other hand, enabling environments play a significant role.

Table-4: Regression Analysis for Moderation

Path	β	t-value	p-value
CTB * SUST $\rightarrow$ PREF	-.2581	-2.898	.0045
CTB * SUST $\rightarrow$ SCD	-.0303	-0.416	.6782
CTB * SCD $\rightarrow$ PREF	-.0110	-0.126	.8999

5. Discussion of Results

The results of the current research are the empirical evidence that sustainability values, at institutional level, are strongly related with the quality of the TVET programs in Pakistan. This supports the theoretical standpoint by Human Capital Theory (Becker, 1993), which posits that an investment on knowledge and skills can provide some payoffs in terms of productivity and performance. Nonetheless, the fact that the strength of this relationship is moderate also indicates that the conceptualized sustainability values as a guiding principle or a policy statement might be insufficient on its own to lead to a notable change in an institution. Such results resonate with the fact that human capital development is the focal point in vocational education rhetoric, but its conversion into result is very dependent on local institutional settings, labor market responsiveness, and social-political underpinning communities (McGrath and Powell, 2016).

More importantly, the research contributes to the literature through the empirical test of the mediating position of sustainability-oriented curriculum design in the correlation between

sustainability values and program effectiveness. The large indirect impact is a strong argument in favor of the Education for Sustainable Development (ESD) model that attaches much importance to curriculum as the key to the operationalization of sustainability in the educational practice (UNESCO, 2017; Lozano et al., 2019). This is in line with the author Cebrián et al. (2019), who says that unless there is curriculum level integration, the sustainability efforts will be symbolic and unrelated to student learning outcomes. This paper demonstrates that the curriculum is not only a receptive channel of institutional interests, but a process that enables the conversion of normative values into practical skills, including systems thinking, ecological literacy, and ethical reasoning, which have been broadly identified to be the core of ESD (Barth et al., 2007; Rieckmann, 2018).

The results of Brundiens et al. (2021) are also consistent with the importance of curriculum design as a mediator because they emphasize that instilling sustainability in curricular goals, content, and assessments result in more robust graduate competencies and more sustainable decision-making in professional life. It also resonates with

the findings of Pavlova (2013) who points at the relevance of competency-oriented and contextualized curriculum models in the vocational education systems that are green transformed. Nonetheless, the focus on curriculum design also brings issues of the reliance on the capabilities of the teachers, institutional assistance to innovation and adaptation to the demands of the labor market - aspects that are not well-developed in the Global South (Wals and Corcoran, 2012; Albertz, 2022).

The results of contextual barriers provide a more restrictive insight. The existence of the significant negative interaction effect of contextual barriers and the sustainability effectiveness relation supports the tenets of Institutional Theory (Scott, 2014) which posits that institutional outcomes depend not just on internal strategies but also on the outside set-up, such as regulatory frameworks, resources availability, and social-cultural norms. This outcome confirms the fears of Shi and Bangpan (2022) that much of the available TVET programs in low- and middle-income nations do not deliver anticipated effects, not owing to poor curriculum design, but owing to poor institutional infrastructures, teacher inadequacy, and industry involvement. It also resonates with the findings of Bolli et al. (2021), who discovered that the absence of harmonized systems of government and reliable funding means that the reform of vocational education, however brilliant, is bound to fail in its implementation.

However, as opposed to that, the moderating effects of the contextual barriers on the sustainability-related curriculum design and the impact of curriculum design on the program effectiveness are not significant, which implies a more complicated situation. These results seem to contradict the conventional institutional theory assumptions, which implies that as soon as the principles of sustainability are institutionalized in curriculum structure, they might be relatively shielded against external contextual constraints in their effect. A similar tendency was found by Lozano and Barreiro-Gen (2021), who documented that curriculum-based sustainability interventions usually have internal integrity and perseverance even under unfavorable conditions,

especially when inspired by dedicated professionals or well-established organizational culture. This resilience needs to be viewed with caution though. It can indicate that curriculum change is going on in a vacuum - isolated -lost-in-institutional-reality, which Meyer and Rowan (1977) note may result in legitimacy and no effect. Such decoupling is also determined through previous research on TVET in South Asia, where the formal introduction of sustainability concepts does not always result in better teaching, learning, and employment results (Chakroun & Kevy, 2018).

This partial moderation also agrees with the study by Maig et al. (2020), who claim that curriculum design can be an adaptive reaction to contextual pressures, but it will not be effective in the end due to systemic influences, including policy coherence, teacher professional development, and industry collaboration. The lack of substantial moderation in both of these pathways can hence imply either an institutional inertness to curriculum changes or the inability of external systems to identify and accommodate the internally triggered pedagogical changes. Silliman and Virtanen (2022) also express this viewpoint and note that it is impossible to separate the effectiveness of TVET with its ecosystem such as employer engagement, recognition systems, and tracking graduates without the danger of overestimating the effectiveness of school-level interventions.

Moreover, the ability of the curriculum design to meet the hindrances posed by the context might be indicative of a more structural problem: many TVET institutions are undertaking curriculum reform because of the pressure of donors or their national curriculum, without the institutional capacity or professional preparation to do so. According to Pavlova (2018), this situation is commonly followed by the superficiality of the curriculum when the topics of sustainability are added to the syllabus but are not converted into project-based, experiential, or community-based pedagogies. In this regard, curriculum can be a world by its own, technically advanced, yet lacking in terms of pedagogy.

On the whole, the research confirms the fact that sustainability integration in TVET is not a linear

process. It is predetermined by mediating variables (e.g., quality of the curriculum) and limited by moderating variables (e.g., contextual barriers), and is a complex system of interactions. This complication frustrates naive policy discourses that believe the presence of sustainability values to be synonymous with systemic reform. Instead, its findings support the discussion of sustainability education as the need to be followed systemically, adaptively, and repeatedly, taking into consideration the institutional asymmetries and regional differences (Wiek et al., 2016). Such a study therefore contributes to the increasing body of literature that considers curriculum as not a predetermined product but a movable contextual process- possibly influenced by power, policy, and practice.

6. Conclusion

This research article aimed to understand how sustainability values affect the program efficacy in Technical and Vocational Education and Training (TVET) institutions in Pakistan. The research was based on the Human Capital Theory (Becker, 1993), Education for Sustainable Development (ESD) (UNESCO, 2017), and the Institutional Theory (Scott, 2014) facing the conceptual framework of sustainability as a predictor of TVET effectiveness mediated by curriculum design and moderated by contextual barriers. Empirical analysis proved that sustainability values at the institution level have a positive correlation with improved employability, learner satisfaction, and alignment to demands of the labor market- observations that have been previously reported in the literature on sustainability and human capital outcomes (Lozano et al., 2019; McGrath and Powell, 2016). Nevertheless, even the moderate strength of this direct correlation tells about the fact that institutional values are not strong enough forces of educational performance unless they are backed by comprehensible implementation mechanisms. The strongest result was associated with the mediating effect of sustainability-oriented curriculum design. Those institutions that operationalized sustainability principles into curricular activities in terms of integrated competencies, pedagogical redesign and context

sensitive content showed much greater effectiveness. This confirms the approach of ESD scholars that consider curriculum as the main channel of sustainability change in the field of education (Cebrián et al., 2019; Brundiers et al., 2021). Conversely, situational obstacles to the sustainability-effectiveness connection were governance fragmentation and resource limitations which had a massive impact in weakening the relationship. This supports an argument that sustainability integration will be dependent on institutional setting (Shi and Bangpan, 2022). Surprisingly, the role of curriculum design in effectiveness did not vary significantly across contexts implying a possible buffering effect. Generally, the results demonstrate that sustainability reformation in TVET is not linear and universal. Instead, it is an interactive process of values, design, and context, which adds to a more systemic and evidence-based conception of sustainability in vocational education.

6.1. Theoretical Implications

This research contributes to theoretical knowledge at the point of convergence of the Human capital theory, Education for Sustainable Development (ESD) with the Institutional Theory in the framework of Technical and Vocational Education and training (TVET). First, it builds upon the Human Capital Theory (Becker, 1993) by empirically showing that institutional sustainability values, in combination with the curriculum reform, can improve the effectiveness of the TVET programs, such as the outcomes such as employability and learner satisfaction. The current results bring to the fore the mediating item of sustainability-oriented curriculum design, unlike classical human capital models that presume direct linear payoffs of educational investments, therefore adding to a more detailed, systems-focused approach to educational returns. Second, the research provides empirical support to fundamental assumptions of the ESD theory, specifically the idea that the curricular integration is the main instrument according to which sustainability values are managed in the learning settings (Lozano et al., 2019; UNESCO, 2017).

The mediation confirmation adds to the ESD theory by not viewing curriculum as a vehicle of content only, but an ongoing organizational process that directs institutional values to program results. Third, the large moderating influence of contextual barriers confirms most of the major assumptions of the Institutional Theory (Scott, 2014), which dictates that institutional performances are anchored and limited by external conditions. Nevertheless, lack of moderation of curriculum-related routes implies that there could be a limit condition in the generality of the institutional pressures -this indicates that inner pedagogical mechanisms might be not entirely dependent on contextual variation. This adds to the emerging research on the differentiated effects of environmental factors on different subsystems in the educational field (Wiek et al., 2016; Chakroun and Keevy, 2018).

6.2. Practical Implications

Practically, the results in the article reiterate the essence of implementing sustainability in the design of core curriculum in TVET institutions. The top priority of educational leaders and curriculum developers should be placed on the incorporation of sustainability-related content besides reorganizing pedagogical approaches, learning outcomes, and assessments to include real-world sustainability skills systems thinking, problem-solving, and ethical decision-making (Barth et al., 2007; Rieckmann, 2018). In addition, the comparative consistency of the influence of curriculum design in diverse institutional settings indicates that the potential of curriculum reform is a high-leverage approach, despite resource constrained settings. This means that the training of teachers must comply with sustainability skills that will equip them to teach reformed courses with confidence. Internal feedback and monitoring mechanisms should also be invested in institutions to make sure that the principles of sustainability are not only declared but also implemented in classroom activity. Also, the results are a warning to institutional leaders that sustainability outcomes are prone to contextual constraints- i.e. inadequate infrastructure or ineffective governance. Although

internal change, such as curriculum change, is needed it should be supported by focusing on external connections, such as employer involvement, community involvement, and alumni loop-feedbacks that can support the efficacy of sustainability-oriented education.

6.3. Policy Implications

On the policy level, the research offers a solid rationale of integrating sustainability as not only an idealized vision, but a procedural, evaluable component of national TVET policies. Policy makers must ensure that sustainability competencies are incorporated in all vocational courses and offer national guidelines/frameworks to assist local institutions to undertake this by drawing on effective examples such as Learning Objectives of ESD by UNESCO (UNESCO, 2017). Notably, the results indicate the vital importance of situational enablers and obstacles. Thus, policy frameworks should not merely cover the curricular requirements but also system-wide preparedness such as investments in infrastructure, teacher capacity, and digital equipment needed to sustainability education to be provided. Equity sensitivity in the process of resource allocation should be applied so that institutions in underdeveloped regions are not left behind in the process of sustainability reforms. Lastly, the high interrelation between sustainability and contextual barriers necessitates cross-sectoral coordination of the ministries of education, labor, industry, and environment to come up with the integrated TVET policies that can integrate the sustainability objectives with employment strategies and industrial demands (McGrath and Powell, 2016; Bolli et al, 2021). It is necessary to solve the existing policy-practice gap with such a coordination to provide that sustainability reform in TVET will not be cosmetic but rather transformative in nature.

6.4. Research Limitations

Although the study has provided an important information on the contribution of sustainability in improving the effectiveness of the TVET program, a number of limitations should be noted. To begin with, the research was cross-

sectional in nature, and this does not allow one to make causal conclusions with regard to the connections between variables. Longitudinal information would be required to monitor changes in time and determine the sustainability of curriculum reforms. Second, institutional leaders and senior administrators were the only respondents surveyed and this may have created bias because such a respondent may offer more positive thoughts on institutional performance and success in reforms. A triangulation of perspectives (through the inclusion of instructors, students, and employers) can be used in future research. Third, the sample represented big provinces in Pakistan, which might not be representative of regional diversity or institutional heterogeneity, especially in the areas with the lack of resources or the problem of conflicts. Finally, the research was more oriented on the internal institutional effects and did not find out the external labour market results (e.g., employment rates, wage patterns) which restricts the evaluation of the effectiveness in the long-run in the practical setting.

6.5. Future Research Directions

Based on the findings and limitations of this study, there are avenues of future research that are offered. To begin with, the researchers ought to think about the longitudinal research that follows the changes in sustainability-focused curriculum reforms and their effects on the outcome of the learners and the development of the institution. This kind of design would give a better causal evidence and capture the dynamic changes as time goes by. Second, the perspectives of multiple actors (students, instructors, and industry partners) should also be introduced to deepen the comprehension of the ways that sustainability values and curriculum are perceived and implemented by various stakeholders of the TVET ecosystem. Third, research in the future may take mixed-method designs that involve quantitative measures and a qualitative case analysis to examine the contextual barriers effects on implementation processes in different institutional settings (e.g., rural vs. urban, public vs. private). Fourth, a more detailed examination of the labor market results,

e.g. employment rates, green job placement and employer satisfaction would be useful in terms of external validity of sustainability education in vocational training. Lastly, comparative research on the low- and middle-income countries on a cross-national level would facilitate the creation of a context-sensitive and yet universally applicable framework of sustainability integration in TVET. Comparative studies of this type may help clarify the role of various policy regimes, economic systems, and cultural backgrounds in mediating outcomes and execution of ESD-related reforms.

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