Influence of Trainer Qualifications on Solar Photovoltaic Systems Integration into TVET Curricula: Evidence from Uasin Gishu County, Kenya.

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ABSTRACT

The Technical and Vocational Education and Training (TVET) institutions are important in the development of skills in renewable energy, but the successful integration of solar PV systems within their curricula relies on the competence and qualifications of trainers. The study employed a sequential explanatory mixed method design to investigate the impact of trainers' competence on the integration of solar PV into the curricula of the TVET institutions in Uasin Gishu County, Kenya. Questionnaires were used to collect quantitative data and analyzed descriptively, and interviews were used to collect qualitative data and analyzed thematically. Results indicated that trainer qualifications significantly affect solar PV curriculum integration, as revealed by the regression model with significant findings of trainer qualifications (($\beta = -0.678$, $p < .01$) trainer and trainees ($\beta = -0.813$, $p < 0.001$). The qualitative results showed that the inadequate specialized training in solar PV, limited continuous professional development, and limited exposure to industry were major constraints in successful integration. From the study findings, the recommendations are, specialized training of trainers, continuous training of trainers and increased industry-institution collaboration, coupled with policy and institutional interventions should be improved to enhance the integration of solar PV in the TVET curriculum.

Keywords: Technical and Vocational Education and Training (TVET), trainer qualifications, solar photovoltaic systems, curriculum integration, renewable energy education, Kenya.

INTRODUCTION

Background information

The world shift towards renewable energy has led to increasing demand for a skilled workforce that is capable of supporting the development, installation, operation and maintenance of evolving energy technologies. Solar photovoltaic (PV) systems is one of the renewable energy technologies that have experienced significant growth due to their costs, scalability, technological advancement and contribution to sustainable energy development. The fastest-growing renewable energy technologies globally is solar PV systems which accounts for a significant proportion of renewable energy capacity additions (International Renewable Energy Agency (IRENA), 2024). The need for technically competent personnel who have the knowledge and skills required to support the solar energy sector has increased due to its rapid expansion (Olabi et al., 2023).

Technical and Vocational Education and Training (TVET) institutions are the main key producers and developers of the human capital required for the renewable energy transition. TVET institutions prepare graduates with the necessary practical competencies required by the emerging labor market and industries through competency-based training and skills-oriented education. TVET systems are expected to adapt their curricula and training approaches to produce technicians capable of responding to the changing technological demand since the renewable energy technologies continue to expand solar PV systems being one of them (Chola & Kiplagat, 2025). However, TVET institutions greatly depend on the capacity of trainers who implement the curricula for its effectiveness in preparing renewable energy technicians.

In curriculum implementation and integration, TVET trainers are key actors because they are being involved in curriculum content that is being translated into practical learning experiences. Solar PV systems is not like other disciplines that are purely theory, it requires trainers who can integrate technical knowledge with practical demonstrations that involves system installation, maintenance, safety procedure, troubleshooting, and emerging industry practices. Therefore, the qualification of the trainer not only depends on theoretical knowledge but also practical experience that include technical expertise, professional certification, and industry exposure. Lack of adequate preparation among the trainers may experience difficulties in delivering competent-based training, which results in graduates who have insufficient practical skills to meet industry expectations.

In technical education, the importance of the qualifications of the trainer has been highlighted in various renewable energy training contexts. In Malaysia, a study by Harun et al. (2021), shows that graduates from electrical-related programs often experience competency gaps in solar PV installation, maintenance, and entrepreneurship due to weakness in practical training and limited alignment between training institutions and industry requirements. Similarly, Hasbolah et al. (2020) among the graduates of solar PV systems many of them lacked adequate knowledge, confidence, creativity and innovation required for participation in the renewable energy sector. Therefore, the effectiveness of solar PV systems education depends significantly on the competence of trainers who are responsible for preparing learners as demonstrated from these findings.

The challenges associated with inadequate trainer capacity in renewable energy education is evident from other developing and developed countries. In Uganda, Aarakit et al. (2022) reported that a limited proportion of TVET trainers have received formal training in solar PV technologies, thus the ability of the institutions to provide quality renewable energy education is affected. The practical competencies required by the solar PV industry is therefore constrained by this insufficient instructor expertise leading to graduate's development constrained. Likewise, in China a research done by Song and Xu (2024); Pan and Filippova (2024), identified weakness in vocational training delivery as barriers affecting the effectiveness of solar PV systems skills development.

Across Africa, human capacity challenges continue to be faced in the development of renewable energy skills. Many TVET institutions experience difficulties in developing sufficient technical expertise among trainers and trainees despite solar PV systems providing opportunities for employment creation and sustainable development. A study by Owusu et al. (2025) in Ghana, identified human capacity and training limitations among the major barriers affecting solar PV systems adoption. As demonstrated from these challenges, strengthening the qualifications of the TVET trainer is essential for ensuring that renewable energy training programs produce graduates with relevant occupational competencies.

The renewable energy sector in Kenya has expanded significantly due to increasing demand for rural electrification, clean energy solutions and green economic development. The need for qualified technicians capable of installing, maintaining and managing solar energy systems has been accelerated by the growth of solar PV systems application. According to the Energy and Petroleum Regulatory Authority (EPRA), the technicians who are licensed in solar PV systems in Kenya have increased from 1080 in 2018/2019 to 1983 in 2023/2024, this reflects the growing demand for skilled workforce in the sector (Kenya News Agency, 2025). TVET institutions therefore have to ensure that their programs produce competent graduates who can meet the labor market requirements due to the growth experience.

Within Uasin Gishu county, Kenya, the need for stronger technical skills development has been created due to the increasing adoption of solar PV technologies. Korir et al. (2023) reported that technical training and human resource development significantly influence the adoption of solar photovoltaic technologies in the county. However, factors constraining effective solar PV systems utilization were identified as limited training opportunities and inadequate technical competencies among personnel. From this literature strengthening the TVET trainers' qualifications and competencies is necessary for improving the quality of renewable energy training.

Despite the growing demand of solar PV systems skills development, limited empirical research has studied how qualifications of trainer influence the integration of solar PV systems into TVET curricula in Kenya. The existing studies have focused on broader issues like infrastructure limitations, institutional preparedness and curriculum challenges, while the contribution of trainers as main curriculum implementers remain unexplored. Therefore, it is important to understand the qualifications of trainers because they are the ones who determine the quality of practical instruction and competency development which gives insight into improving renewable energy education within TVET institutions.

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This study therefore examined the influence of trainer qualifications on the integration of solar photovoltaic systems into TVET curricula in Uasin Gishu County, Kenya. The study contributes to the TVET literature by providing empirical evidence on the role of trainer capacity in implementing renewable energy curricula and preparing graduates with competencies required in the evolving green economy.

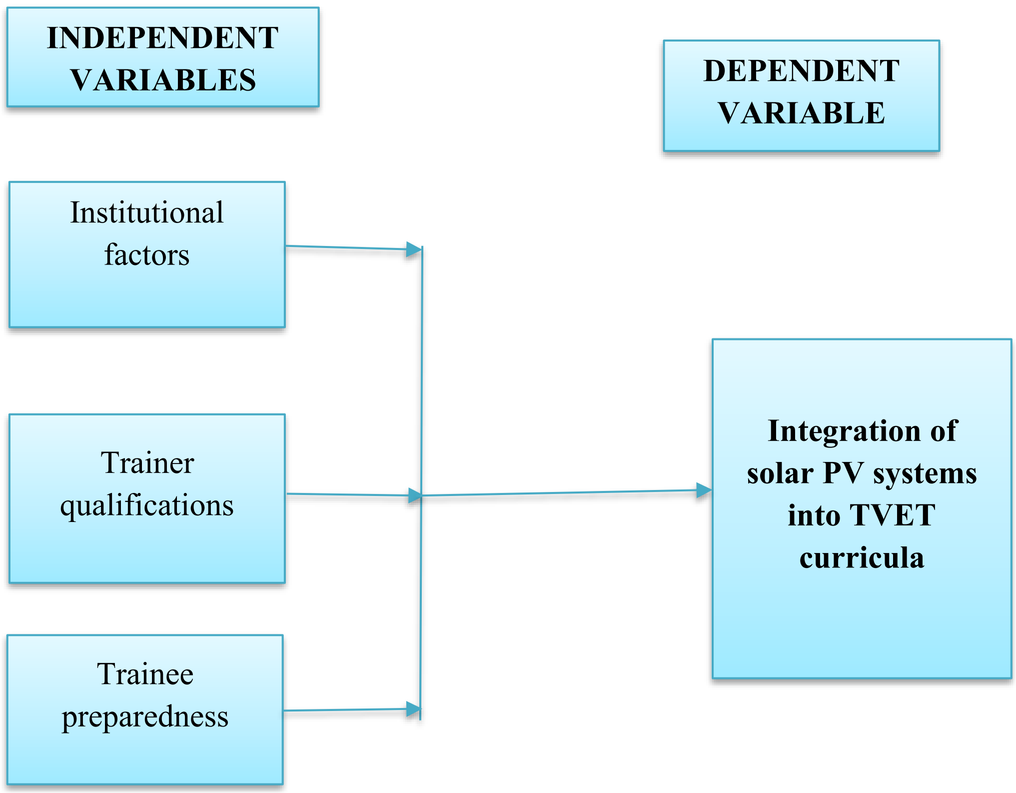
Theoretical Perspective

The primary theories that inform this study are Human Capital Theory (HCT) which treats education, training and skills development as an investment in productive capacity of individuals and the Earnings Function Theory which examines the impact of education, training and skills development on earnings. Trainers' technical knowledge, professional qualifications and ongoing skills development are important aspects of human capital in relation to TVET and can affect their ability to provide relevant and industry responsive training. In this context, investments in the competences of trainers should be seen as expected to reinforce their competences in implementing new technologies like solar PV systems in TVET curricula.

The Communities of Practice (CoP) perspective is also adopted as a complementary lens to draw on. Lave and Wenger (1991) have described learning as a socially situated process in which one participates in shared practices and Wenger (2000) has stressed the importance of interaction and participation in the construction of professional knowledge and competence. Recent work in scholarship has continued to show the relevance of CoP for professional learning, knowledge sharing and building competence in practice ((Wenger-Trayner et al., 2020); (Nicolini et al., 2022)). Vocational teachers have also been studied as a group and the support provided by communities and professional interactions have also been emphasized as factors that facilitate ongoing professional learning and professional development (Smeplass, 2025).

The CoP relevance is especially pertinent to training in solar PV as the technology is constantly changing, necessitating trainers to keep abreast of technical knowledge through professional development, industry interaction and exposure to current workplace practices. This perspective goes beyond HCT, not only by outlining the need to invest in trainer qualifications and skills but also by emphasizing the ongoing development of trainer skills through membership in professional and industry groups. It therefore offers a valuable lens for the interpretation of the results of the current study on specialized solar PV training, continuous professional development, and exposure to industry.

Conceptual Model



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LITERATURE REVIEW

Trainer Qualifications and Solar PV Curriculum Integration

For TVET institutions, trainer qualifications are considered as one of the key players in the successful implementation of Solar Photovoltaic (PV) training programme. Trainers must have both pedagogical skills and technical skills to effectively deliver renewable-energy education. To shift to renewable-energy systems, it is essential to have coordinated skills-development approaches, which can be adapted to meet evolving occupational needs, said Ramsarup et al. (2024). The analysis of their work is pertinent to TVET because trainers play a pivotal role in the process of realizing new occupational competences in the education arena. It did not, however, explore the qualifications of individual trainers or how they may affect the implementation of the Solar PV curriculum, but rather its overall focus was on system-level preparedness, highlighting the significance of the skills-development system. Similarly, Widayati et al. (2021) emphasised that merely imparting technical skills is not enough unless they are implemented in learning process. These studies combined, indicate that the effectiveness of Solar PV training does not solely rely on the trainer's knowledge but on his/her ability to transform this knowledge into competency-based learning; this relationship has not been studied empirically.

From a pedagogical/technical competence perspective, the theme of pedagogical and technical competence is very current in vocational education. With the constant evolution of technology in the renewable-energy sector, some researchers view technical expertise as the most important trainer attribute, while others believe that technical understanding needs to be complemented by good teaching skills. Njenga (2022) added that there is need to keep training trainers with technical knowledge as the technology of solar PV is changing from time to time, which in turn calls for trainers to always keep their technical knowledge up to date to avoid trainings that do not deliver the up to date technical knowledge, hence affecting the training. However, Odondi (2023) said that even a technically competent instructor can have difficulties in achieving meaningful learning when he or she is not pedagogically competent. This contrast suggests that technical and pedagogical competencies are two different aspects of the trainer's qualification and should not be seen as synonyms: technical competence is the ability to possess up-to-date knowledge in a field, pedagogical competence is the ability to make it accessible, doable, and measurable. In spite of that, the two skills are addressed in these studies mostly in conceptual terms and very little empirical data is provided to demonstrate their impact on the actual implementation of integrating Solar PV systems in TVET curriculum, highlighting the need to consider the trainer qualification as a multidimensional phenomenon instead of a mere technical qualification.

Sustaining trainer competence after initial qualification is one way to do it through Continuous Professional Development. Also, the fast rate of growth in the field of renewable energies demands new technology and new teaching methods, and industry experience. In addition, trainers need new technical knowledge and modern teaching methods, as well as industry experience, to meet the rapid growth of new technologies in renewable energies. Kaliappan and Hamid (2021) discovered that continuous professional development will help trainers build technical competencies and enable the use of modern teaching methods, but their study wasn't focused specifically on the trainers of renewable energy or on testing the connection between professional development and making curriculum more modern. This does not provide enough evidence to conclude that the case for continuing professional learning is also valid for Solar PV education. In addition, professional development opportunities are frequently stunted by high teaching loads, a lack of institutional support, financial constraints and low availability of specialized renewable energy training. So, a basic qualification may not necessarily be enough to keep a trainer competent in a rapidly evolving technological area. But the question is not only if trainers are qualified, but if their qualifications are up-to-date in terms of new developments in Solar PV technologies and practices.

This is recently confirmed by scholarship that indicates teachers' capacities as a key determinant of how green-skills are implemented more generally. After systematically analysing literature and networks (314 publications and synthesizing 11 empirical studies from 9 countries), Muhaemanurrohmah and Widiaty (2026) found that teacher capacity was a major constraint in implementation. There was more support for integrative approaches where green skills are part of the programmes that are currently in place rather than an approach that adds green content to existing programmes, suggesting that, rather than a role for changing curriculum content, teacher capacity is a precondition for delivering new competencies. However, the evidence supporting this conclusion is limited: While the systematic synthesis was performed on 11 empirical studies, a much larger bibliometric literature was available, the review covers 'green skills' generally and does not focus on Solar PV education specifically, nor does it measure the effect of trainers' qualification on the incorporation of Solar PV into the curriculum. It thus has a solid basis for suggesting that teacher capability is significant, but does not distinguish between effects of technical qualification, pedagogical expertise, professional development and industry experience on the integration of Solar PV in TVET institutions in Kenya in particular.

Another aspect of successful implementation of the curriculum is the participation of trainers in the development and review of curricula. The close interaction between trainers and learners, training equipment, and workplace technologies make trainers an ideal partner in the detection of new occupational needs. Technology change can create an increasing disconnect between the needs of the workplace and the curriculum of TVET, and therefore, periodic revision of the curriculum is needed to keep it relevant to the needs of the workplace, Wibowo et al. (2022) said. In line with this, Widaningsih et al. (2024) systematic review of TVET educator competencies also revealed that technological transformation has affected the competencies of vocational teachers. In both studies these authors propose that trainers require some additional competence to go beyond content knowledge, but neither of them argues that trainers' involvement in curriculum development leads to increased curriculum integration in practice. Participation can help to increase trainers' awareness of industry trends but this may not lead to a corresponding improvement in teaching practice unless trainers have the required technical knowledge, pedagogical skills, and institutional support. It is therefore important to view curriculum involvement as part of the competence of the trainer rather than as a stand-alone solution to the problems of curriculum implementation.

An associated way that trainers can keep current with relevant technical skills is by industry collaboration, which provides an opportunity to gain exposure to the current industry knowledge, modern technologies and occupational standards. McGrath et al. (2019) noted that the industry education partnership between the classroom and industry enhances vocational training. More recent evidence from Njengele et al. (2024), confirms that TVET-industry partnerships can be used to support workplace-based learning, institutional development, and in some cases, lecturer industry experience, but also indicates that partnership served different purposes and relatively few had a specific focus on lecturer development. It challenges the assumption that having industry collaborations will automatically enhance trainers' competencies: collaboration with industry can be a positive for students without necessarily being a positive for the trainers' competencies. Effectiveness of industry collaboration relies less on the fact of partnerships being in place than on the recognition of the importance of deliberately including trainers within the industrial attachments and the technological updating and professional exchange processes.

Building on this, Chola and Kiplagat (2025) pointed out that through industry partnerships, the gap between the expectations of the vocational training and labour market could be addressed, gaining exposure to emerging technology and evolving job requirements in industries like renewable energy. The directionality of this argument is its emphasis on qualification as a component of a broader employment system instead of a stand-alone (individual) trait. Exposure to industry does not give trainers a comprehensive range of trainer competences, however; industrial attachment can build technical knowledge and understanding of working in the workplace, but not necessarily pedagogical competencies or capability in curriculum development. Industry collaboration should thus accompany and not supersede formal professional preparation and pedagogical development, which are of particular importance for Solar PV training where trainers should be knowledgeable about the current technology but also have the ability to structure the knowledge gained in the workplace into structured learning and assessment activities.

There has been recent evidence from Africa that the implementation of green-competency in vocational education is challenging, even when the importance of green-competency is recognised in the formal setting of the vocational education system. Omego et al. (2026) explored green-competency incorporation in Nigerian TVETs, using the qualitative interview approach with 55 lecturers from six universities, and discovered the incorporation was limited and reliant mainly on the individual lecturers and not on institutional frameworks. The study cited the following as important constraints: outdated curricula, limited lecturer capacity and skills, lack of sufficient instructional resources, weak policy support, and industrial collaboration. It has a qualitative, purposive design and conveys a rich experience of lecturers' geographic zones, but lacks the power to provide an explanation for the curriculum integration in the context of the trainer's qualifications, and no evidence of the statistical size, or direction, of any relationship between qualifications and integration. It also discussed green competencies in different areas of TVET, and not just about Solar PV. The findings thus confirm the general argument of trainer capacity matters, but do not conclude that trainer qualifications are related to the differences in Solar PV curriculum integration, and differences in TVET governance and curriculum arrangements lessen the direct transferability of the Nigerian findings to the Kenyan context.

Mitiku and Ademe (2026) then present more African evidence by discussing the future green-skill needs in an Ethiopian TVET context, and linking the emerging labour-market demand for green skills with preparedness and capacity building needs of institutions. This evidence useful demonstrates that increased demand for competencies in renewable energy puts pressure on TVET institutions to prepare trainers and learners for renewable energy. It was designed specifically for a single institutional context, which reduces its generalizability, however, and does not directly test the impact of trainer qualifications on the implementation of the curriculum, since its focus is on future skills demands. It also leaves the question unanswered, however, whether the competencies of trainers are adequate to respond to the labour-market demand for competencies in renewable energy, because labour-market demand for competencies in renewable energy does not in itself guarantee that TVET trainers have the required competencies.

In Kenya specifically, the need to build the skills and capacities of renewable energy has been reported elsewhere. While there is an increasing awareness of solar PV systems training in TVET, a subsequent study, titled Odondi et al. (2020), from Odondi (2023) work on pedagogical competence, indicated that many of the TVET trainers do not have access to specialized Solar PV systems training. Njenga (2022) also pointed out poor training opportunities that may prevent trainers from adapting to the changing technology. The results of these findings also confirm that capacity needs among trainers in the renewable energy training field have long been a concern in the Kenyan context, with the findings being relatively earlier and therefore, not necessarily to reflect all the subsequent developments in Solar PV technology, green-skills needs and TVET reform. More significantly, they find that trainers' training is an area of constraint and do not quantitatively test if there are differences in trainer training levels that relate to differences in PV curriculum integration; this gap is supported by the need for updated evidence of trainer training in Kenyan TVET institutions.

The literature, examined overall, show convergence and divergence. It is generally agreed that trainers dealing with rapidly evolving technologies must have technical competence, while trainers that want to ensure effective learning from the technologies must have pedagogical competence. There is also increasing awareness that having initial skills and knowledge is not enough and that ongoing training and access to contemporary practice is necessary. The studies do, however, differ in the balance that is placed on these dimensions, some focusing on the technical updating, others on pedagogical competence, others again on alignment of the curriculum, others on collaboration with industry, and others on institutional capacity. The results of a recent systematic evidence show that capacity of teachers is identified as a critical bottleneck in the integration of green skills in education, and that the evidence base underlying this is still limited and heterodox. Empirical evidence from the recent past in Nigeria also demonstrates that the integration of green competency into vocational education can be disembodied from the recognition of the importance of green competency in policy frameworks, while excluding the effect of the competency of vocational trainers.

In general, the literature available to date has three major drawbacks. First, the recent research does not focus on the specific case of Solar PV systems. Secondly, there is a significant amount of evidence from non-Kenyan contexts that reduces the transferability of conclusions. Third, research frequently reports that trainer capacity or professional development or institutional preparedness are factoring that impact curriculum integration, but doesn't actually test if trainers' qualifications affect how much or how little the curriculum is integrated. Therefore, the understanding of the relation between the overall competences required for Solar PV systems integration in Kenyan TVET institutions is still limited due to the lack of evidence on how these competences relate to each other.

To address this gap, the present study has focused on the effect of the trainer's qualifications on the integration of Solar PV systems to the TVET institutions in Uasin Gishu County, Kenya. The study limits the scope of the review on green-skills policy and institutional preparedness to the specific issue of trainers' qualifications and how they relate to the integration of curriculum, thereby advancing the research beyond the general literature on

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the topic and contributing to the empirical evidence regarding the role of trainer qualifications and competencies in implementing the provisions of green-skills curricula in training activities.

Research Gap

Although previous studies have examined competence of the trainer in vocational education, several gaps still remain. To start with, existing studies have examined separately, technical competence, professional development, pedagogical competence, and industry engagement rather than combining their influence on curriculum implementation. Secondly, many studies rely on descriptive approaches in identifying the challenges, thus providing limited evidence on how trainer qualifications influence actual curriculum integration outcomes. Thirdly, in Uasin Gishu county, Kenya, there is limited empirical evidence that exists on the role of trainer qualifications in the integration of solar PV systems into TVET curricula.

Additionally, limited mixed-methods studies have examined both the measurable influence of qualifications of the trainer and the experiences of trainers and institutional stakeholders regarding solar PV curriculum implementation. This study addresses this gap by examining the influence of trainer qualifications on solar PV systems integration into TVET curricula from TVET institutions in Uasin Gishu County, Kenya.

METHODOLOGY

Research Design

A sequential explanatory missed-methods research design was adopted in this study (creswell 2010). The researcher examined the quantitative relationship between qualifications of the trainer and the integration of solar PV systems into TVET curricula and subsequently explored the qualitative experiences that helped in explaining the quantitative findings. This is why the design was more appropriate in the study. Numerical findings require deeper contextual interpretations through participants' experience, thus mixed-methods are best fit for this.

This article presents findings from the second objective of the main study that examined challenges in integrating solar PV systems into TVET curricula in Uasin Gishu County, Kenya. The influence of trainer qualifications on solar PV curriculum integration is the main focus of this article. The quantitative phase examined the relationship between curriculum integration and trainers' qualifications, whereas perspectives from key institutional stakeholder regarding trainer competence, professional development and challenges affecting effective solar PV training was explored in the qualitative phase.

Study Area

The study was carried out in Uasin Gishu County, Kenya. The county was selected because of the increasing demand for solar PV skills development and its growing involvement in renewable energy initiatives. The county has several TVET institutions that offer electrical and electronics related technical programs where renewable energy training, especially solar PV systems, has been incorporated into their training programs. The capacity of TVET institutions to prepare skilled renewable energy technicians provides an appropriate context for its examination. This is due to the increase in the adoption of solar PV technologies in the region.

Target Population and Sampling

TVET stakeholders involved in solar PV training and curriculum implementation are the main target population. These included trainers, trainees, deputy principals, and technicians from selected TVET institutions in Uasin Gishu County. The respondents from the broader study population consisted of **311 respondents**, including 4 deputy principals, 6 technicians, 25 trainers, and 276 trainees. Yamane's formula for finite population was used to determine the sample, which resulted to a sample size of 175 respondents. In order to ensure representation of the different respondent categories stratified sampling was applied. Institutional administrators and technical personnel who possessed relevant knowledge regarding solar PV training implementation were selected using purposive sampling.

For this article, the primary focus of quantitative analysis was on trainers and trainees because they directly provided information regarding qualifications of the trainer and their influence on solar PV systems integration into curriculum. Qualitative data were obtained from technicians and deputy principals to provide additional explanations regarding trainer capacity and institutional experiences.

Data Collection Instruments

Data were collected using questionnaires, interview schedules, and observation checklists. Quantitative data on trainer qualifications and solar PV systems curriculum integration was collected from trainers and trainees using structured questionnaires. The questionnaire items assessed aspects related to: technical competence in solar PV systems, pedagogical competence, industry exposure, professional development opportunities, and ability to integrate solar PV concepts into teaching and practical training.

Semi-structured interviews were conducted with technicians and deputy principals to obtain deeper insights into trainer preparedness, institutional support mechanisms, and challenges affecting trainer competence development.

The practical aspects related to solar PV systems training environments, including availability of practical learning opportunities and training conditions within institutions were recorded using observation checklists.

Validity and Reliability of Research Instruments

Specialists in technology education, TVET curriculum development and renewable energy training reviewed the research instrument for content validity. The experts assessed the relevance, adequacy and clarity of the research instrument (questionnaire) in measuring the study variables. The reliability and sustainability of the research instruments were done by conducting a pilot study in one of the TVET institution outside the selected study area. Cronbach's alpha coefficient was used to assess the reliability with values meeting the acceptable threshold for internal consistency which was above 0.7.

Data Coding and Measurement of Variables

This study used a five-point Likert scale for assessing the study variables. The answers to the questions were initially assigned to the following categories: 1 = Strongly Agree, 2 = Agree, 3 = Neutral, 4 = Disagree, and 5 = Strongly Disagree. Consistent coding for the relevant items was performed during data processing, and composite scores were created for each of the following: integration of solar PV systems, institutional factors, trainers' qualifications, and trainees' preparedness. The direction of each of the composite measures was considered in interpreting the results. Higher scores on the trainers' qualification measure reflected greater trainers' qualification inadequacies, and higher scores on the integration measure reflected higher trainers' solar PV integration in TVET curricula. The coding direction was retained in analyzing the correlation and the regression.

Data Analysis

Descriptive and inferential statistics were used to analyze quantitative data. Means and standard deviation being the descriptive statistics were used to summarize perceptions and level of agreement regarding trainer qualifications and solar PV systems integration. Non-parametric and robust analytical techniques were applied since the data did not satisfy all assumptions required for parametric statistical procedures. To examine the relationship between qualifications of the trainer and solar PV systems integration, Spearman rank-order correlation was used.

In addition, robust regression analysis was conducted to determine the influence of trainer qualifications while controlling for other factors involved in the broader study model. Since data violated the assumptions associated with ordinary least squares regression, particularly the normality and potential influence of outliers, robust regression was used because it provides reliable estimates. Thematic analysis was used for qualitative data from the interviews. Which involved coding responses, identifying recurring themes and interpreting participants' experience regarding competence of the trainer, professional development and challenges affecting solar PV training.

Power analysis/sample adequacy

To determine the statistical sensitivity of the trainer regression model, a post hoc power analysis was completed. There were 15 observations and a model with three predictors. The observed R^2 value was .853 with an alpha level of .05 and the corresponding effect size was very large ($f^2 = 5.80$). The statistical power of the observed effect was high, but the number of observations is relatively small, which means that the precision and generalizability of the regression estimates are limited. The power analysis was used as a sensitivity analysis instead of concluding that the small sample size was sufficiently large for regression analysis.

Ethical Considerations

Before the collection of data, ethical approval was obtained from the relevant institutional authorities. The respondents were informed of the purpose of the research and their participation in the study was voluntary. All participants involved in the study, informed consent was obtained from them before data collection. Confidentiality and anonymity were upheld by ensuring that individual respondents and institutions were not recognizable in the reporting of findings.

Analytical Framework

Trainer qualification was conceptualized as an important predictor of solar PV systems integration into curriculum. Various dimensions were used to examine trainer qualifications which includes technical competence, professional development, pedagogical competence and industry exposure. The integration of solar PV systems into TVET curricula was the dependent variable, reflected through the extent to which solar PV concepts, training activities and practical skills were incorporated into institutional programs.

RESULTS

Descriptive Findings on Trainer Qualifications

The key factor influencing the integration of solar PV systems into TVET curricula was examined to be trainer qualifications. Trainer qualifications were assessed based on the perceptions of the respondents' regarding trainers' technical competence, professional development, pedagogical capacity and preparedness to deliver solar PV training.

From the findings it showed differences between trainers' self-assessment and trainees' perceptions of the qualifications of trainer. Trainees reported a lower assessment of trainers' qualifications, with a mean of 2.165 (SD = 0.811). However, trainers reported a relatively higher perception of their qualifications with an overall mean score of 2.553 (SD = 0.991). These findings indicate that since trainers perceived themselves to have adequate qualifications to deliver solar PV training, gaps in trainer preparedness and competence were identified by the trainees. This difference suggests a possible variation between trainees' experience and trainers' self-perception concerning the effectiveness of trainer capacity in supporting solar PV systems integration into the curricula.

Relationship Between Trainer Qualifications and Solar PV Curriculum Integration

The relationship between trainer qualifications and solar PV systems curriculum integration was determined using Spearman rank-order correlation analysis. The results are presented separately for trainers and trainees as shown below;

Table 1: Correlation Matrix for Trainer and Trainees

	Integration of Solar PV Systems	Institutional Factors	Trainers Qualification	Trainees Preparedness
	Trainers			
Integration of Solar PV Systems	1.000			
Institutional Factors	-.752***	1.000		

	(.000)	.		
Trainers Qualification	-.548**	.363	1.000	
	(.023)	(.153)	.	
Trainees Preparedness	-.644**	.568**	.461*	1.000
	(.005)	(.017)	(.063)	.
	Trainees			
Integration of Solar PV Systems	1.000			
Institutional Factors	-.179	1.000		
	(.352)			
Trainers Qualification	-.235**	.215**	1.000	
	(.004)	(.008)		
Trainees Preparedness	-.248**	-.160*	.039	1.000
	(.002)	(.050)	(.637)	

Source: Authors own work

In the trainers' model, the findings showed a statistically significant negative relationship between the qualifications of the trainer and solar PV systems integration ($\rho = -0.548$, $p = 0.023$). This indicates that there were differences in the level of solar PV systems curriculum integration among TVET institutions due to the variations observed in trainer qualifications.

Among the trainees, there it showed a statistically significant relationship between perceived trainer qualifications and solar PV systems integration ($\rho = -0.235$, $p = 0.004$). Although there was a weak relationship, the findings illustrate that qualifications of the trainer were associated with perceptions regarding the extent of solar PV systems integration in TVET institutions.

The correlation results reveal that trainer qualifications signify an important aspect affecting the effectiveness of solar PV systems curriculum integration. However, the correlation strength differences observed between the trainers and the trainees indicate variations in how trainer competence is experienced by different stakeholders.

Influence of Trainer Qualifications on Solar PV Curriculum Integration

The influence of trainer qualifications on the integration of solar PV systems on curriculum was determined using the regression analysis while accounting for other explanatory factors included in the broader study model. As shown in the table below;

Table 2:Regression Analysis

Variables	Model 1 (Trainers)	Model 2 (Trainees)
Institutional Factors	-0.893*** (0.103)	-0.390*** (0.118)
Trainers' Qualification	-0.678** (0.383)	-0.815*** (0.050)
Trainees' Preparedness	-0.597*** (0.074)	-0.714*** (0.078)
Constant	8.643*** (0.880)	6.680*** (0.409)
F (3, 11)	21.321	
F (3, 126)		18.073
Prob	0.000	0.000

R-Squared	0.853	0.301
Adjusted R-Squared	0.813	0.284
Observations	15	130

Source: authors own work

The regression results indicated a statistically significant negative association between trainers' qualification inadequacies and the integration of solar PV systems into TVET curricula. In Model 1, which comprised trainers, trainers' qualifications had a negative and statistically significant coefficient ($\beta = -0.678$, $p < .01$). This indicates that greater inadequacies in trainers' qualifications were associated with lower levels of solar PV integration, holding institutional factors and trainees' preparedness constant. The overall regression model was statistically significant, $F(3, 11) = 21.321$, $p < .001$, and explained 85.9% ($R^2 = 0.859$) of the variation in the integration of solar PV systems into TVET curricula. This indicates that institutional factors, trainers' qualifications, and trainees' preparedness collectively provided a strong explanation of variations in the integration of solar PV systems into TVET curricula. Similarly, in Model 2, based on trainees' responses, trainers' qualifications had a negative and statistically significant coefficient ($\beta = -0.815$, $p < .001$). The overall regression model was statistically significant, $F(3, 126) = 18.073$, $p < .001$, and explained 30.1% ($R^2 = .301$) of the variation in solar PV integration. This finding indicates that greater perceived inadequacies in trainers' qualifications were associated with lower levels of solar PV integration. The negative coefficients therefore reflect an inverse relationship between qualification inadequacies and curriculum integration, rather than suggesting that qualified trainers negatively influence the integration of solar PV systems.

The results indicate that the integration of Solar PV systems in the TVET curricula has a statistically significant relationship to the lack of trainer qualifications. The size of the coefficients indicates that there is a difference in the perception of the relationship between the two groups of stakeholders (trainer and trainee). These unique viewpoints provide complementary understandings of the competence of the trainers and implementation of solar PV in the education of TVET.

However, caution must be exercised in using the trainer regression model due to the small number of observations included in the model ($n = 15$). The contribution of the model to the observed variance in the solar PV integration ($R^2 = .853$) was significant, but the small sample size may lead to unstable estimates of the coefficients; and findings may not be generalizable. The results thus need to be interpreted as evidence of an observed association in the sampled trainers and not as a definitive estimate of association at the population level.

Qualitative Findings on Trainer Qualifications and Solar PV Training

Additional explanation from the interview findings of the deputy principal and technicians was provided regarding the role of trainer qualifications in solar PV systems integration. Inadequate specialized solar PV systems training, limited continuous professional development opportunities and weak industry exposure were the three major themes that emerged.

Inadequate Specialized Solar PV Training

Participants indicated that some trainers lacked specialized solar PV systems training but possessed general training backgrounds. This hinders their ability to effectively deliver practical solar PV systems content especially in areas that require advanced technical knowledge like system design, troubleshooting, maintenance and installation procedures.

One of the interviews explained:

“Some trainers have electrical backgrounds, but solar PV technology keeps changing. Without specialized training, it becomes difficult to expose trainees to current industry practices.”

Limited Continuous Professional Development

From the findings, there were limited opportunities for trainers to undertake refresher courses professional in upgrading of solar PV systems technologies. The respondents attributed this to financial constrain, inadequate partnership with the renewable energy organizations and limited institutional support. They noted that continuous professional development was necessary because of the rapid evolvement of solar PV systems technologies and require trainers to regularly update their skills.

Limited Industry Exposure

The interaction between TVET trainers and the solar PV industries as a factor affecting trainer competence was identified to be limited. Exposure to the industry was considered to be significant because it enables trainers to incorporate industry expectations into classroom and practical training and current workplace practices. These qualitative findings support the quantitative results by demonstrating that qualifications of the trainer influence the ability of TVET institutions to effectively integrate solar PV systems into their curricula.

Integration of Quantitative and Qualitative Findings

The quantitative and qualitative results were combined for a holistic interpretation of the effect of trainers' qualifications on the integration of solar PV systems in TVET programs. The quantitative results quantified the association between trainer qualifications and the integration of solar PV, and the qualitative results contextualized the association. The quantitative results appear in a joint display in table 3, which shows areas of convergence and divergence across the various themes and findings of the qualitative results.

Integration of Quantitative and Qualitative Findings

The quantitative and qualitative results are integrated showing that poor trainer skills are linked to low rates of solar PV integration into TVET curricula. The quantitative findings demonstrated statistically significant relationships between the qualifications of trainers and the integration of solar PV for trainers and between trainers and trainees for both trainers and trainees; the qualitative findings explained the mechanisms of these relationships. More specifically, it was found that a lack of specialized training for solar PV, a lack of continuous professional development and a lack of industry exposure were major aspects of the solar PV trainer's inadequacy. Therefore, to encourage greater uptake of solar PV, trainers need to have both a general technical qualification and a more up to date, relevant specialist one, as well as access to opportunities for ongoing training and development, and meaningful experience with industry practice.

Table 3: Joint Display of Quantitative and Qualitative Findings on Trainer Qualifications and Solar PV Integration

Quantitative finding	Qualitative theme	Convergence/ divergence	Integrated interpretation
Trainer qualifications were significantly associated with solar PV integration among trainers ($\beta = -0.678$, $p < .01$). Greater inadequacies in trainer qualifications were associated with lower integration.	**Inadequate specialized solar PV training and technical competence**	**Convergence**	The qualitative findings explain the quantitative relationship by showing that some trainers lacked specialized solar PV training and advanced technical competencies in areas such as system design, installation, troubleshooting and maintenance. These gaps may limit effective delivery of current solar PV content.

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Trainer qualifications were significantly associated with solar PV integration among trainees ($\beta = -0.813$, $p < .001$). Greater perceived inadequacies in trainer qualifications were associated with lower integration.	**Limited continuous professional development**	**Convergence**	The qualitative evidence indicates that limited opportunities for refresher training and professional development constrain trainers' ability to update their knowledge as solar PV technologies evolve. This provides an explanation for the quantitative association between trainer-qualification inadequacies and lower integration.
The significant relationship between trainer qualifications and integration was evident from both trainer and trainee models, although the magnitude of the coefficients differed.	**Limited industry exposure**	**Convergence/Complementarity**	Participants reported limited interaction between trainers and the solar PV industry. The qualitative evidence suggests that inadequate industry exposure limits trainers' familiarity with current workplace practices and industry expectations, thereby complementing the quantitative evidence on trainer qualifications and curriculum integration.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

Discussion

The study involved assessing the effect of the trainer's qualification on implementation of Solar PV in TVET curriculum in Uasin Gishu County, Kenya. The quantitative and qualitative results show that the education level of trainers plays an important role in the implementation of Solar PV training. In particular, trainer competence is not just the result of having formal academic or professional qualifications, but also pedagogical skills, technical knowledge, and experience and ongoing professional development in the industry. These dimensions seem to have an impact on how well trainers are able to adapt the curriculum demands to actual learning activities. However, this does not imply that trainer's qualifications are unlinked from the institutional environment; the extent to which qualified trainers can use their knowledge also depends on the quality of the equipment available, institutional support, opportunities for professional development and exposure to current industry practices. The qualifications of trainers seem, therefore, to be an important building block for the human capital needed for integrating Solar PV, and the institutional conditions partly govern how that human capital can be used.

The significant role of the trainers on Solar PV systems integration implies that the trainers are important agents to bridge curriculum provisions with learning experiences. While curriculum documents define what skills and competencies are expected, and training resources outline how they are to be taught, trainers interpret, demonstrate and assess them in actual practice. In a competency-based education system, this role is especially crucial because students are expected to show proficiency in both knowledge and skills. Ramsarup et al. (2024) also said that people need the right skills to be prepared for the new jobs in renewable energy and that trainers' capacity to convert theory to practice is crucial for technical knowledge, while Widayati et al. (2021) emphasized the need for technical skills alone is not enough if the trainers cannot translate theory to practice. The current results support these claims, as it appears that the value of the trainer's qualifications is more about the application than just the presence of the qualifications. A trainer may have a relevant qualification but lack a degree of

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influence on curriculum integration due to an outdated qualification, limited practical experience or lack of opportunities to utilize the knowledge gained in the workplace by the institution. The relationship between qualifications and curriculum integration thus seems to be the ability of the trainer to translate the knowledge gained into suitable learning and practice activities.

This mechanism may also be illustrated by the differences between trainers' self-perceptions and trainees' perceptions of their trainers' qualifications. Trainers showed relatively more confidence in their competencies while trainees felt more inadequacies in their competencies. This difference may suggest that demonstrated competence and formal qualifications are not synonymous: Trainers might choose to assess demonstrated competence based on academic qualifications, professional experience or subject knowledge, while trainees might base their assessment of competence on what they observe during training, such as to undertake practical demonstrations, explain technical procedures, troubleshoot problems, and provide effective practical guidance. This gap may be due to a difference in the way competence is assessed (e.g., one group may have a different sense of what constitutes competence) instead of disagreement between trainers and trainees, or alternatively, trainers may have a body of knowledge that is not readily accessible to trainees but is only evident in higher-level technical or professional contexts. However, the difference indicates that the focus should not be limited to formal qualifications to measure trainer competency, as it suggests that formal qualifications may not be the only indicator of competency needed to provide effective Solar PV training, and highlights the need to assess competency through observation of the teaching and by observing practical skills, a factor that should be considered by TVET institutions when recruiting and deploying trainers for Solar PV instruction.

In addition, the results of the research on continuous professional development also show that the significance of the trainer qualification may be diminished if the opportunities for acquiring knowledge and skills are not available. Njenga (2022) has argued that continuous updating of technical knowledge is essential in the current era of rapid technological changes in the field of Solar PV, which was also confirmed by the qualitative findings of the present study: trainers indicated limited opportunities for refresher training and for professional upgrading. This could include a knowledge-obsolescence mechanism, where trainers who do not keep up to date with technology changes in the Solar PV sector or the energy-storage sector or installation practices or safety expectations may find that their education or training continues to be out of sync with present market demand. Kaliappan and Hamid (2021) also stressed that professional development is a crucial way to gain new technical knowledge in the field and enhance teaching techniques. The results also indicate, however, that the number of training programs attended is not necessarily the best indicator of successful professional development; the effectiveness of professional development programs may depend on the relevance and applicability of the training received and the quality of the training, as short training programs or training that is more theoretical may be less effective if the trainers do not have the chance to practice the new technologies or apply the knowledge gained in their own institutions.

The results also highlight the need to integrate the technical and pedagogical aspects. The technical competence allows trainers to comprehend the design, installation, maintenance, troubleshooting and safety aspects of Solar PV systems; pedagogical competence helps them articulate knowledge, guide hands-on tasks, evaluate learner progress and ensure competency-based learning. Odondi (2023) also noted that even with being technically competent trainers, they might not be able to obtain effective learning when a suitable teaching methodology is absent. The findings of the present study indicate, however, that this relationship is not linear, with a simple additive effect of technical and pedagogical competence on training quality; rather, the interaction between these two competencies seems to be more significant. Technical competence is important but if the trainer cannot demonstrate and explain procedures effectively, then they will have trouble developing the competence of the learner; on the other hand, a trainer with pedagogical skills but lacking technical knowledge may give very well-organized instruction that does not reflect the current practice in the industry. The effective training of Solar PV requires both types of competence to work together; this is an important point to consider for the development of trainers as programs specializing in technical certification might not lead to the desired increase in curriculum integration if pedagogical competence is not acquired at the same time.

Another aspect of trainers' competence that came to the fore was their level of exposure to industry. The qualitative results showed that there was a lack of interaction between TVET trainers and industry practitioners, influencing the awareness of the industry requirements of the trainers. Njengele et al. (2024) said about industry partnership as a way to support the development of trainers and workplace learning while McGrath et al. (2019) said about industry-education partnership as a method for linking vocational training to workplace practices. The current results indicate that industry exposure can have a role in curriculum integration by a knowledge transfer mechanism; trainers who engage with industry can see how things are done, where they are done, at which standards they are done, of what and new expectations of the workplace and transfer that knowledge into teaching. In Solar PV, in particular, the technology and occupational needs may evolve quicker than the curriculum review cycles. Effective curriculum integration from industry exposure, however, does not necessarily result from this exposure alone, as it seems to be dependent on whether the trainers do participate in industry attachments and whether the industrial exposure is relevant to the trainers' teaching areas, and whether there is an opportunity for the trainers to transfer knowledge gained in their workplaces to classroom and workshop practice.

The latter is important as it refutes the notion that industrial attachment is a panacea for the weak competency of trainers. Having significant work experience does not necessarily equate to pedagogical development, for example, having learned a lot about the industry does not necessarily mean that the person is skilled in interpreting the curriculum or in assessing competence. The development of trainers, therefore, should be multi-dimensional and should involve technical upgrading, pedagogical development, professional certification, curriculum competence and continued industry involvement. The suggestion is that industry partner relationships shouldn't be judged to the extent of the number of agreements forums with industry partners but rather trial relationships to the degree that trainers are involved in industry attachments and develop up-to-date technical skills and then apply the industry knowledge to their training programs.

The results also indicate that there is an interaction between institutional resources and support and the impact of the trainer's qualifications. Even highly qualified trainers could have limited capacity to include the installation of Solar PV system in institutions which do not have functional PV panels, batteries, inverters, testing instruments, safety equipment and suitable practical workshops. The intensity of the teaching load can also impact opportunities for professional learning, curriculum evaluation, and industry involvement. The observed link between trainer qualification and curriculum integration for Solar PV, therefore, may also be due to the extent to which institutions provide opportunities for trainer to apply their skills, as this is an important interpretation, it suggests that the qualification of trainers alone may not be enough to ensure significant PV integration. Human capital investment must be paired with physical and organizational investment in the environment in which the human capital is used.

The results in the Kenyan context point to ongoing issues of preparing for renewable energy education. Limited access to specialized Solar PV training was reported by Odondi et al. (2020) in terms of training skills of TVET trainers in Kenya and inadequate opportunities to maintain competencies due to technological change was reported by (Njenga, 2022) . Based on the current findings, these concerns may have implications for more than just trainer preparation; poor preparation could impact the implementation of the curriculum requirements to actual learning. The findings must also be contextualized in the context of the growing renewable energy sector in Kenya: as more people demand Solar PV skills, it puts a strain on training institutions to provide trainers with skills relevant to the industry. The implication is not just that there should be more qualified trainers, but that the skills and competencies required of trainers must be relevant to the technologies and occupational standards that are likely to be used by learners in the workplace upon their completion of training.

Put together, quantitative and qualitative results indicate that trainers' qualifications should be seen in the context of a larger set of factors that influence the integration of Solar PV curriculum. The quantitative relationship points to the importance of trainer qualification as an explanatory factor; the qualitative evidence helps to explain the way this influence can take place via pedagogical competence, technical knowledge, professional development and industry exposure. Concurrently, the qualitative results indicate other factors, such as having access to equipment, institutional support and opportunities for industrial engagement, that can reinforce or inhibit the use of trainer competence. This convergence suggests that the statistical relationship cannot be interpreted as proof that trainer qualifications are the only factor that leads to curriculum integration; rather, trainer qualifications are part of a continuum of interrelated factors within an institutional system.

The results have implications for the HCT used in the study. The HCT perspective is that on a productive side, investment in knowledge, skills and professional development increases individuals' productive capacities. The current results confirm this claim and demonstrate that trainer competence is related to the ability to conduct specialized Solar PV training. However, they propose a key qualification to this straightforward human-capital view: the productivity of human capital acquired is contingent on the environment in which it is used. However, if the required equipment, institutional support, or opportunities for professional development are not available, a highly-qualified trainer may not be able to develop the same "human capital" to achieve better training results. Complementary investments in training infrastructure, industry partnerships and continuing professional development should be provided in tandem with the investments in trainers' qualifications.

The findings, overall, show that trainer qualifications are indeed a key factor in the integration of the Solar PV curriculum, but have a multi-dimensional context. Technical competence is at the core of accurate and up-to-date instruction for Solar PV, pedagogical competence is needed to transfer the technical knowledge into competency-based training and industry exposure is necessary to remain relevant as technology evolves. These skills are not likely to have the desired impact without the necessary institutional resources, management support and opportunities for implementing new knowledge, however. The application is that the narrow emphasis on the formal qualification of trainers at TVET institutions and the policy makers needs to shift to a broader approach to the training of trainers that covers technical upgrading, pedagogical upgrading, industry exposure, continuous professional development and adequate practical training resources. This will have a greater chance of making Solar PV curriculum content come to life for learners and into a pool of competent labor for Kenya's growing renewable energy sector.

Limitations of the Study

One of the quantitative analysis's drawbacks is the small sample size of the trainers (n = 15) that was entered into the regression model. All available trainer respondents who met the study criterion were included, but because of the small sample size the precision of the regression estimates and the external generalizability are diminished. This relatively high R2 must therefore be taken with a grain of salt as estimates from small samples can be sensitive to the individual observations and not robust across samples. The trainer-level regression results should therefore be considered preliminary and not definitive. A larger sample of TVET trainers in various TVET institutions and counties could yield more reliable estimates of the relationship between the trainer's qualifications and integration of the solar PV curriculum.

CONCLUSION

The study highlights that the successful embedding of solar PV systems into curricula of TVET programmes is dependent on the presence of the curriculum frameworks and training facilities as well as trainers' ability to link the curricula requirements to a learning experience that is practical and industry relevant. The quantitative and qualitative results reveal that the trainer's qualifications, in terms of technical competence, pedagogical skills, experience in the industry, and continuous professional development, play an important role in integrating the solar PV curriculum. Trainers typically have appropriate technical backgrounds, but lack of knowledge of advanced solar PV skills, and insufficient exposure to industry best practices or opportunities for professional upgrading. Variations in trainers' self-perceptions and trainees' perceptions of the trainers' competence also indicate that formal qualifications do not necessarily support trainers' competence in the teaching process.

The study also finds that raising the qualifications of trainers must be done in relation to other factors. The practical application of the knowledge gained through training may be constrained by institutional support, access to suitable practical equipment, opportunities for professional development and networking with the renewable-energy sector. Solar PV curriculum integration therefore needs to be an integrated effort, which

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includes both training and enabling institutional conditions. Improvements of these will be of significance in training the workforce with TVET institutions competencies in Kenya's growing renewable energy sector.

RECOMMENDATION

Based on the findings, the study makes the following recommendations:

1. Improve ongoing training of TVET trainers. There is a need for the introduction of structured and regular professional development programmes for TVET institutions and relevant policymakers with emphasis on the emerging Solar PV technologies, such as system design, installation, energy storage, monitoring, maintenance and safety. Professional development should include hands-on training, not primarily theoretical workshops, for trainers to use newly-learned skills when teaching.

2. Blend pedagogical and technical development. Trainer-upgrading programmes should integrate specialized Solar PV technical training with competency-based teaching, assessment and training for the learner. This is important, as technical expertise is not enough to ensure that knowledge about PV is understood in the context of successful learning experiences.

3. Deepen TVET-industry partnerships. Industrial attachments and workplace-based learning should be more structured to create opportunities for TVET trainers to interact with renewable energy companies and other industry stakeholders to gain exposure to the latest technologies and industry standards. Such a partnership should have trainers' development in addition to the student industrial attachment, and should be clearly defined and not limited to trainers' development.

4. Enhance institutional capability of utilizing trainers' competency. The trainers' access to functional Solar PV equipment, suitable workshops, testing instruments, and other teaching aids at TVET institutions and relevant policies should be strengthened. Opportunities for curriculum review and further professional development and engagement with industry should also be provided by the institution so that trainers can apply and update their competencies.

5. Institute mechanisms for training competency monitoring. Trainers' competence should be measured in several ways, such as formal qualifications, technical skills, pedagogical competencies, skills in practical demonstration and industry experience, as well as participation in professional development within TVET institutions. This would offer a more all-encompassing evaluation than an academic one.

6. Enhance curriculum-industry alignment. Curriculum developers and TVET institutions should engage renewable-energy industry stakeholders in the process of reviewing curricula and developing trainers to ensure that Solar PV competencies taught in TVET institutions are in line with the needs of the workplaces.

Suggestions for future research

1. Comparative research among institutions and regions. Further research is recommended to compare the effect of the qualifications of the trainers on the integration of Solar PV curriculum in various TVET institutions across counties and regions in Kenya to determine the variations in effect across the institutions. These studies might involve institutions with varying infrastructure, renewable-energy offerings, linkages with industry, and professional development opportunities. Comparative studies could also be conducted between public and private TVET institutions to determine the effect of the institutional characteristics on the implementation of the curriculum that is effective.

2. Cross-country comparative research. Further studies could be conducted to compare Kenya with other countries in Africa that are having a surge in demand for skills in renewable energy. Research in this area would help to determine if the factors contributing to the competence of trainers and integration of solar PV in the curriculum are context specific or are common factors across the African TVET system.

3. Employers and industry representatives included. Further research needs to delve deeper into the views of employers, Solar PV companies, industry practitioners and other renewable energy actors. Their perspectives may help to gauge whether the skills of TVET graduates in technical, practical, problem-solving and safety skills are aligned with real-life work needs. Inclusion of these stakeholders would also aid in the identification of new skills that might not be sufficiently covered in TVET curricula or in trainer-development programmes.

4. Training outcomes and post-training career paths. Research is needed to determine whether better trainer-development programmes are associated with better outcomes for graduates in terms of skills in practice, employment and employability in the renewable-energy industry. Long-term studies might be useful for determining the long-term effects of the increased trainer competency and if this can be seen in the graduates' performance in the workplace.

5. Interactions between institutional, trainer and trainee factors. The interactions between trainer qualifications and institutional resources and trainee preparedness on Solar PV curriculum adoption may be explored in further research. This would help to understand how better learning outcomes of the curriculum are obtained when qualified trainers are also assisted by the presence of adequate infrastructure, institutional support and readiness of the learners.

REFERENCES

1. Aarakit, S. M., Ntayi, J. M., Wasswa, F., Buyinza, F., Adaramola, M. S., & Ssennono, V. F. (2022). The role of financial inclusion in adoption of solar photovoltaic systems: A case of Uganda. Renewable Energy, 198, 984-998. https://doi.org/10.1016/j.renene.2022.08.056
2. Chola, R. M., & Kiplagat, H. (2025). Contribution of TVET to sustainable development. https://doi.org/10.69641/afritvet.2025.101178
3. Harun, G., Sarip, S., Fatah, A. A., Kaidi, H., & Abd Rahim, N. (2021). Wind, hydro and solar energy challenges for Technical Vocational and Training (TVET) electrical entrepreneur in Malaysia: A review. Journal of Physics: Conference Series,
4. Hasbolah, H., Mamat, S. A., Abdullah, Z., & Sidek, S. (2020). A review on cyber entrepreneurship in Malaysia: past, present and future. Journal of Critical Reviews. https://doi.org/10.31838/jcr.07.19.513
5. International Renewable Energy Agency (IRENA). (2024). World energy transitions outlook 2024: summary for policymakers. . I. R. E. A. (IRENA).
6. Kaliappan, A., & Hamid, H. (2021). Green technology: A must or a need in TVET education in Malaysia? Journal of Technical Education and Training, 13(1), 86-96. https://doi.org/10.30880/jtet.2021.13.01.009
7. Kenya News Agency. (2025). Huawei accelerates pace to plug Kenya's solar labour deficit. . K. N. Agency.
8. Korir, D. K., Ouma, C. O., & Okech, T. C. (2023). Human Resource Training and Development and Adoption of Solar Photovoltaics in Climate Smart Agriculture in Uasin Gishu County, Kenya. The University Journal, 235-246. https://doi.org/10.59952/tuj.v5i3.273
9. Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge university press.
10. McGrath, S., Mulder, M., Papier, J., & Suart, R. (2019). Handbook of vocational education and training. Handbook of Vocational Education and Training. https://doi.org/10.1007/978-3-319-94532-3
11. Mitiku, D. H., & Ademe, B. (2026). Forecasting Future Green Skill Demands for Green Jobs in Addis Ababa: The Case Study of Dajazmach Geresu Duki Industrial College. International Journal of Vocational Education and Training Research, 12(1), 9-25.
12. Muhaemanurrohmah, H., & Widiaty, I. (2026). Mapping the Research Landscape of Green Skills in Vocational Education: A Systematic Literature and Network Analysis. Journal of Informatics and Vocational Education, 9(1), 1-15.
13. Nicolini, D., Pyrko, I., Omidvar, O., & Spanellis, A. (2022). Understanding communities of practice: Taking stock and moving forward. Academy of Management Annals, 16(2), 680-718.

14. Njenga, M. (2022). Professional competencies and the continuing professional development needs of Technical, Vocational Education and Training (TVET) teachers in Kenya. Hungarian Educational Research Journal, 12(4), 475-492. https://doi.org/10.1556/063.2022.00118
15. Njengele, T., Engel-Hills, P., & Winberg, C. (2024). Technical and vocational education and training (TVET) colleges and industry: Strengthening partnership-building practices. Journal of Vocational, Adult and Continuing Education and Training, 7(2), 52-75. https://doi.org/10.14426/jovacet.v7i2.418
16. Odondi, W. (2023). Empowering youth through green-skills: a study of technical and vocational education and training in Kenya. Namibia Journal of Technical Vocational Education and Training, 1, 35-51. https://doi.org/10.59677/njtvet.v1i.70
17. Odondi, W., Maina, L., & Muhia, N. (2020). The Risk to Achieving Sustainable Development Competencies: A Generated Analysis of Access and Training Outcomes in TVET Institutions in Kenya. Africa Journal of Technical and Vocational Education and Training, 5(1), 18-28. https://doi.org/10.69641/afritvet.2020.51100
18. Olabi, A., Elsaid, K., Obaideen, K., Abdelkareem, M. A., Rezk, H., Wilberforce, T., Maghrabie, H. M., & Sayed, E. T. (2023). Renewable energy systems: Comparisons, challenges and barriers, sustainability indicators, and the contribution to UN sustainable development goals. International Journal of Thermofluids, 20, 100498. https://doi.org/10.1016/j.ijft.2023.100498
19. Omego, G. N., Nwandu, L. O., Nwike, U. N., Anyakoha, C. N., Okafor, N. B., Ekuma, J. E., & Nwakile, T. C. (2026). Embedding green competencies in technical and vocational education as a pathway to sustainable development and climate-resilient workforce formation in Nigeria. Discover Education.
20. Owusu, J. J., Okoroigwe, E. C., Mgbemene, C. A., Takyi, G., & Ekechukwu, O. V. (2025). Technical stakeholders' perspective of solar photovoltaic system failure in Sub-Saharan Africa: The case of Ghana. Sustinere: Journal of Environment and Sustainability, 9(1), 24-40. https://doi.org/10.22515/sustinere.jes.v9i1.431
21. Pan, L., & Filippova, A. (2024). A critical examination on EdTech integration in TVET curriculum: Insights from a Chinese TVET institution. Vocation, Technology & Education, 1(2). https://doi.org/10.54844/vte.2024.0593
22. Ramsarup, P., McGrath, S., & Lotz-Sisitka, H. (2024). A landscape view of emerging sustainability responses within VET. Journal of Vocational Education & Training, 76(2), 259-280. https://doi.org/10.1080/13636820.2024.2320911
23. Smeplass, E. (2025). Nurturing inclusivity and professional growth among vocational teachers through communities of practice. Pedagogy, Culture & Society, 33(3), 785-804.
24. Song, X., & Xu, D. (2024). More graduates, fewer skills? Vocational education expansion and skilled labour shortages in China. The China Quarterly, 260, 970-985. https://doi.org/10.1017/S0305741023001856
25. Wenger-Trayner, E., Wenger, E., & Wenger-Trayner, B. (2020). Learning to make a difference: Value creation in social learning spaces. Cambridge university press.
26. Wenger, E. (2000). Communities of practice and social learning systems. Organization, 7(2), 225-246.
27. Wibowo, R. A., Nyan, M.-L., & Christy, N. N. A. (2022). The challenges for Indonesia to integrate dual vocational education and training system. Journal of Technical Education and Training, 14(2), 79-90. https://doi.org/10.30880/jtet.2022.14.02.008
28. Widaningsih, L., Sari, A., Dwiyanti, V., Maknun, J., & Hayat, J. (2024). How digital competency for Indonesian TVET educators explored in the last decade: a systematic literature review based on the Australian qualification framework. Jurnal Pendidikan Teknologi dan Kejuruan, 30(2), 209-221. https://doi.org/10.21831/jptk.v30i2.71436
29. Widayati, A., MacCallum, J., & Woods-McConney, A. (2021). Teachers' perceptions of continuing professional development: a study of vocational high school teachers in Indonesia. Teacher Development, 25(5), 604-621.