



الجامعة الإسلامية للتكنولوجيا
UNIVERSITE ISLAMIQUE DE TECHNOLOGIE
ISLAMIC UNIVERSITY OF TECHNOLOGY
DHAKA, BANGLADESH
ORGANISATION OF ISLAMIC COOPERATION



AMADOU AK JALLOW

STUDENT'S ID: 221031206

M.SC.TE (Specialization in Electrical and Electronic Engineering)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

THE ORGANIZATION OF ISLAMIC COOPERATION

BOARD BAZAR, GAZIPUR DHAKA, BANGLADESH

A STUDY ON THE CHALLENGES AND OPPORTUNITIES OF USING PROJECT-BASED LEARNING IN RENEWABLE ENERGY TECHNOLOGY AT TVET INSTITUTIONS IN BANGLADESH AND THE GAMBIA.

BY

AMADOU AK JALLOW

STUDENT'S ID: 221031206

M.Sc. T.E. (Specialization in Electrical and Electronic Engineering)

**Submitted in partial fulfillment of the requirements for the Degree of Master of Science in
Technical Education with specialization in Electrical and Electronic Engineering at the
Department of Technical and Vocational Education (TVE)**

Islamic University of Technology (IUT)

Dhaka, Bangladesh.

September 2025

RECOMMENDATION OF THE BOARD OF EXAMINERS

This thesis title is “**A Study on the Challenges and Opportunities of Using Project-Based Learning in Renewable Energy Technology at TVET Institutions in Bangladesh and the Gambia**” submitted by **Amadou AK Jallow, Student ID: 221031206** of the Academic year 2023-2024, has been found satisfactory and accepted as partial fulfillment of the requirement of the degree of Master of Science in Technical Education (MSc.TE) with Specialization in Electrical and Electronic Engineering in October 2025.

MEMBERS OF EXAMINATION BOARD

Chairman (Supervisor)

Associate Prof. Muhammad Rashedul Huq Shamim
Department of Technical and Vocational Education (TVE)
Islamic University of Technology (IUT)

Member
(Ex-Officio)

Prof. Dr. Md Abdallah Al Mamun
Head of TVE Dept, IUT
Department of Technical and Vocational Education (TVE)
Islamic University of Technology (IUT)

Internal Member

Dr. Md. Shahadat Hossain Khan
Professor
Department of Technical and Vocational Education (TVE)
Islamic University of Technology (IUT)

External Member

Dr. Dilruba Sultana
Assistant Professor
BRAC IED, BRAC University

DEDICATION

This thesis is dedicated to the Almighty Allah, whose infinite mercy, guidance, and strength have sustained me throughout this academic journey.

To my beloved Parents and my family wife and kids, whose unwavering love, sacrifice, and prayers have been the foundation of my strength, and to my mentor and teachers, whose wisdom and encouragement have guided every step of my academic journey.

To my colleagues and friends who shared in the challenges and triumphs along the way your companionship turned obstacles into opportunities for growth.

Above all, this thesis is dedicated to every student and educator striving to make learning meaningful, practical, and transformative. May this work inspire others to pursue knowledge not only for personal success but for the advancement of humanity.

May it remind every reader that no challenge is insurmountable when purpose, perseverance, and passion unite.

ACKNOWLEDGEMENT

The journey was lengthy. I express my sincere appreciation and gratitude to Allah (SWA), the most beneficial and merciful, for granting me the strength and capability to accomplish this thesis. Without His divine assistance, this achievement would not have been possible. It is my proud privilege and duty to formally acknowledge and extend my sincere gratitude to my esteemed supervisors, first was Prof. Dr Md Faruque Ahmed Haolader, after his contract finish in IUT then I continue with Associate Prof. Muhammad Rashedul Huq Shamim, for their invaluable support, expert guidance, and insightful contributions that have greatly facilitated the completion of this thesis.

He motivated me to pursue an intriguing and valuable subject matter, which I have found great pleasure in working on. Given the assistance of the Almighty, I would like to acknowledge that the successful completion of this study would not have been possible without the invaluable motivation and support that I received from them. I am immensely grateful to both of them for providing me with exceptional facilities and an environment conducive to creative work. I express my utmost gratitude to my esteemed parents for their unwavering support, motivation, and consistent emphasis on the importance of academic pursuits.

I am also deeply grateful to Mr. Faruq Bashir Ironbaba, who played a key role through his guidance and encouragement in this work, and to my friends, without whom this work would not have been possible.

DECLARATION

I Amadou AK Jallow, hereby declare that this thesis work presented in this document is my original creation, completed under the guidance of Associate Prof. Muhammad Rashedul Huq Shamim. This work has not been previously published or submitted for the fulfillment of any degree program. The information contained within this document has been acquired and presented in accordance with the academic regulations and ethical standards of the hosting institutions. I hereby attest that, in accordance with the regulations and standards in place, I have provided complete citations and references for all non-original content and findings included in this work

Amadou AK Jallow



Student ID: 221031206

MSc. TE (EEE)

Abstract

This study investigates the opportunities and challenges of implementing Project-Based Learning in teaching and learning Renewable Energy Technology at Technical and Vocational Education and Training institutions in Bangladesh and The Gambia. The study was guided by a qualitative research design and employed thematic analysis; data collected from educators through semi-structured interviews. The findings reveal that PjBL is widely perceived in both contexts as a student-centered, practice-oriented approach that effectively bridges theoretical concepts with real-world application, which promotes critical thinking, problem-solving skills, technical competence, and workforce readiness. Opportunities are identified, including enhanced student engagement, innovation, and alignment with industry needs. However, implementation is also hindered by substantial challenges, including inadequate laboratory facilities, limited funding, a lack of modern equipment, and time constraints in balancing theory and practice. Additional barriers include varying levels of student readiness and both countries' insufficient teacher training and weaker policy support to fully leverage PjBL's potential in advancing RET education. These findings contribute to the growing body of literature on PjBL in resource-constrained settings and offer actionable insights for policymakers, educators, and industry stakeholders seeking to improve renewable energy skills in TVET systems.

Table of Contents

RECOMMENDATION OF THE BOARD OF EXAMINERS.....	i
DEDICATION	ii
ACKNOWLEDGEMENT	iii
DECLARATION.....	iv
Abstract.....	v
Table of Contents.....	vi
List of Tables.....	viii
List of Figures	viii
CHAPTER ONE	1
Introduction	1
1.0 Background of Study	1
1.1 Problem statement	5
1.2 Objectives of the Study	6
1.3 Research Questions.....	6
1.4 Significance of Study	6
1.5 The possible outcomes of the study	8
1.6 Acronyms	9
CHAPTER TWO.....	11
Literature Review.....	11
2.0 Introduction	11
2.1 The Genesis of PjBL for both Developing and Developed Countries	12
2.2 The Concept of Project-Based Learning	15
2.3 PJBL in Renewable Energy Education	18
2.4 Adoption of PjBL in TVET Institutions.....	19
2.5 Integration PjBL into the curriculum, assessments and industry partnerships	22
2.6 The Challenges in Implementing PjBL	24
2.7 The Impact of PjBL in TVET Institutions.....	26
CHAPTER THREE	28
Methodology.....	28
3.0 Introduction	28
3.2 Research Design	29

3.2.1 Justification for Choosing the Design	29
3.3 Population and Sampling.....	30
3.3.1 The description of the target population.....	30
3.3.2 Purposive Sampling Technique	33
3.3.3 Sampling Size	35
3.4 Data Collection Procedures	36
3.4.1 Semi-Structured Interview.....	37
3.5 The Instrument development.....	39
3.5.1 The Designing Part.....	39
3.5.2 Validity and Reliability	39
3.6 The Data Analysis Technique	40
3.6.1 Why Thematic analysis	40
3.6.2 Steps in thematic analysis.....	40
3.7 Ethical Considerations.....	44
CHAPTER FOUR.....	46
Analysis	46
4.0 Thematic Analysis	46
4.0.1 Challenges Faced by Instructors in Implementing PjBL in RET	46
4.1 Similarities and Differences in PjBL Implementation: The Gambia vs. Bangladesh	51
4.1.1 Similarities	51
4.1.1 Differences	52
4.2 Answer the Research Questions	54
4.3 Study Findings.....	56
CHAPTER FIVE.....	58
Discussion, Improvement, Implications, Recommendations, and Conclusion of Study	58
5.0 Discussion	58
5.1 Suggestions for improvement.....	60
5.2 Implications	61
5.3 Recommendations	61
5.4 Conclusion	61
5.5 References	64

List of Tables

Table 1: Demographic variation	31
Table 2: The country-wise distribution of research participants	36
Table 3 Example of interview protocol Matrix	38
Table 4: Similarities in PjBL Implementation	51
Table 5: Differences in PjBL Implementation	53

List of Figures

Figure 1: Gender percentage	32
Figure 2: The flowchart representing the data analysis process and it's adapted from Braun and Clarke (2006); Kiger & Varpio (2020).....	38

CHAPTER ONE

Introduction

1.0 Background of Study

Vocational education equips students for employment in various trades, crafts, technical fields, or other professions that support capacity building. Its primary objective is to give students the prerequisite knowledge and competencies related to a specific domain (Insyasiska, Zubaidah, and Susilo 2017). Numerous factors contribute to the government's efficacy in enhancing human resources, particularly concerning the labor force. Among these factors is the execution of vocational education initiatives. TVET focuses should not just gaining theoretical insights but also highlight the essential growth of hands-on abilities (Syauqi, Munadi, and Triyono 2020). The concept of vocational education originated initiated the 19th century, a time when the Industrial Revolution generated the emergence of several specialized industries and trades (Deissinger 1994). Subsequently, individuals completing apprenticeships commenced their formal training in specific crafts (Tyson 2020). The establishment of vocational education at the institutional level and post-secondary levels was early 20th century, at the same time as it was introduced into the public education system, this school culture was officially initiated in 1917 (Smith 1999). These programs were intended to train the students with basic knowledge and the needed skills to be successful person in a different career, and industries in the workforce. The learning framework within vocational education encompasses the methodology and mechanisms to train, assess, and certify individuals regarding the knowledge and skills necessary for specific occupations or careers. Instructional strategies may involve lecture-based learning, experiential learning, on-the-job training, and didactic resources like practical exercises, simulations, and books. The primary goal of vocational learning system to certify that students get the essential knowledge and skills that will help them to excel in their selected career domains, including industry, carpentry, and electrical work (S. T. Ahmad et al. 2023).

The global demand for renewable energy solutions has increased significantly in recent decades as nations try to decrease greenhouse gas emissions, fight climate change, and achieve energy security. The transition calls for a highly skilled workforce with technical knowledge and problem-

solving capabilities in renewable energy technologies. However, there has been a concern that the TVET graduates lack the practical skills needed in their real workplace (Haolader and Nickolaus 2012). TVET institutions are uniquely positioned to address this need by equipping students with the necessary practical, hands-on skills that are relevant to industry requirements. However, traditional methods of teaching and learning in TVET institutions are often insufficient to meet interdisciplinary and rapidly evolving nature of renewable energy technology (RET) (Ossiannilsson 2016). Graduates' competencies (learning outcomes) depend on many factors including teaching methods and strategies, teachers' qualifications, the instruction quality, the cognitive characteristics of the learners, students' complexity level, etc. (Haolader and Nickolaus 2012). This involves presenting theoretical and practical skills that the learners need to solve real-world issues, motivating them to collaborate and find solutions together (Varma and Malik 2023a).

Project-Based Learning is a learner-centered pedagogical approach that integrates both theory and practice through the execution of real-world projects (Markula and Aksela 2022). It has stood broadly recognised for its ability to improve critical thinking, problem-solving, teamwork and innovation, making it particularly suitable for fields like renewable energy that require both technical expertise and creative solutions (Andriyanto and Rahdiyanta 2025). In PjBL, students actively involved in learning by addressing complex and open-ended issues, enabling them to connect academic concepts with practical applications in ways that traditional lecture-based methods often fail to achieve (Lee and Lee 2025). According to the literature, the PjBL process is linked to the following five categories of teaching approaches problem-based learning, activity-based learning, self-directed learning, place-based learning and inquiry-based learning (Nassir et al., 2025; Aisyah & Novita, 2025). Empirical investigations across diverse contexts have demonstrated that PjBL can substantially enhance learner outcomes within vocational environments, encompassing increased engagement, improved knowledge retention, and strengthened problem-solving capabilities (Kokotsaki, Menzies, and Wiggins 2016a).

Even though the documented benefits of PjBL implementation in teaching renewable energy technology at TVET institutions is not without challenges. One significant issue is lack of infrastructure and the resources necessary for effective project-based instruction, especially in underdeveloped and developing countries (Afeti and Adubra 2012). For example, limited access to renewable energy systems like solar panels and wind turbines materials constrain hands-on

learning opportunities. Furthermore, many TVET institutions face a shortage of trained instructors proficient in both renewable energy technologies and project-based pedagogies (Subrahmanyam 2020). Institutional barriers such as rigid curricula, inadequate funding, and limited collaboration with industry partners further hinder the effective adoption of PBL. Additionally, students often face socio-economic challenges, such as the affordability and access to education, that can impact the implementation of resource-intensive teaching methodologies (Graham 2018).

On the other hand, the rising global importance of renewable energy and the United Nations Sustainable Development Goals provide opportunities to address the challenges. (SDGs 7), that is affordable and clean energy and (SDGs 4), that is quality education, explicitly advocate for innovation in education and skill development to support sustainable energy transitions (Bernstein 2017). TVET institutions can leverage partnerships with industries, non-governmental organizations, and governments to acquire resources, develop context-relevant curricula, and train instructors in modern teaching methodologies like PjBL. The availability of open-source educational materials and simulation tools also offers low-cost solutions for expanding practical learning opportunities.

1.0.1 Background study of Bangladesh

Bangladesh is a fast-developing country facing growing energy demands due to industrialization, urbanization, and population growth. With limited fossil fuel reserves, the government has gradually prioritized renewable energy technologies (RETs), particularly solar home systems, wind, and bioenergy, as part of its long-term energy strategy. National targets include generating 30% of total electricity from renewable sources by 2040 (SREDA, 2022).

To attain these goals, skilled human capital is vital. TVET institutions in Bangladesh play a central role in preparing learners with the knowledge and competencies required to sustain renewable energy transitions. However, the TVET sector faces significant challenges, including curricula not align with the goals, limited laboratory facilities, lack of trained instructors, and minimal private-sector engagement (Akhter & Malik, 2021).

In this context, Project-Based Learning has gained growing attention as a pedagogical approach that bridges theory and practice knowledge. By involving students in hands-on, real-world projects, PjBL encourages innovation, critical thinking, and employability, aligning well with the

labor market needs of the renewable energy sector. Yet, its adoption remains uneven due to systemic barriers such as limited funding, policy gaps, and inadequate training support for instructors.

1.0.2 Background study of the Gambia

The Gambia, one of Africa's smallest nations, also grapples with rising energy needs while facing significant infrastructure limitations. The national grid is underdeveloped, with electricity access rates below the regional average, making renewable energy sources especially solar power critical for both urban and rural electrification (UNDP, 2021). Given its vulnerability to climate change, The Gambia has aligned its policies with sustainable energy goals, often relying on international donor support and non-governmental organizations (NGOs) to drive renewable energy projects and training initiatives.

TVET institutions in The Gambia are gradually recognized as crucial platforms for training technicians and entrepreneurs capable of supporting the renewable energy sector. However, similar to Bangladesh, the sector struggles with resource constraints, insufficient teaching aids, and a lack of modernized curricula (Njie et al., 2020). Unlike Bangladesh, however, The Gambia benefits from relatively stronger NGO and donor partnerships, which often provide technical equipment, pilot projects, and mentorship programs that enrich student learning experiences.

Project-Based Learning has shown promise in this context by fostering student engagement, teamwork, problem-solving skills, and workplace readiness. Nevertheless, its effective implementation is limited by time constraints, high equipment costs, and reliance on external funding, raising questions about long-term sustainability.

The study aims to explore the possible challenges and opportunities associated with using PjBL in teaching renewable energy technology at TVET institutions in Bangladesh and the Gambia. By examining the factors, the research seeks to provide actionable recommendations to educators, policymakers and industry stakeholders to improve teaching-learning practices. finally, contributing to the development of skilled and competent workforce for the renewable energy sector.

1.1 Problem statement

The growing global focus on renewable energy technologies (RETs) to fight climate change and achieve sustainable development has created an urgent need for a skilled and competent workforce. TVET institutions are the central for preparing this workforce by offering practical, skill-based education. However, traditional teaching-learning methods in TVET institutions often emphasize rote memorization and theoretical knowledge, which fail to train students with the technique of problem-solving, critical thinking and hands-on skills needed to address the real-world renewable energy challenges (Subrahmanyam 2020)

Project-Based Learning has arisen as the promising instructional method acting for bridging the gap. PjBL emphasizes active, student-centered learning by engaging learners into real-world projects that integrate theory with practice, to foster essential skills like collaboration, creativity and innovation (Andriyanto and Rahdiyanta 2025). Despite its potential, the adoption of PjBL in teaching-learning renewable energy technology at TVET institutions remains limited, particularly in Bangladesh and the Gambia.

Several challenges hindering the effective implementation of PjBL in these settings, including Resource Constraints, Limited accessibility to renewable energy technology like solar panels, wind turbines and supporting infrastructure restricts practical, project-based learning opportunities (Afeti and Adubra 2012). Lack of Skilled Instructors, Many TVET educators lack training in both renewable energy technologies and PjBL methodologies, which are critical for effective instruction (Henrie, Halverson, and Graham 2015). Rigid Curricula and Funding Issues, Outdated curricula, insufficient institutional funding, and a lack of collaboration with industry further impede efforts to integrate PjBL into TVET programs (Ossiannilsson 2016).

On the other hand, the increasing emphasis on renewable energy and global initiatives like the support from United Nations Sustainable Development Goals, such as SDG 4 Quality Education and SDG 7 affordable and clean energy, present opportunities to address these challenges. Partnerships with industry stakeholders, the availability of open-source educational tools, and advancements in digital technologies offer potential pathways to integrate PjBL effectively into TVET institutions to address the workforce in renewable energy (Bexell and Jönsson 2017).

1.2 Objectives of the Study

The research is to explore teaching quality for equipping TVET students with more practical skills by exploring the challenges and opportunities in teaching-learning, particularly the adaptation of PjBL in teaching RET at TVET institutions in Bangladesh and the Gambia.

The Specific Objectives of this Study are:

1. To identify the possible opportunities and challenges instructors face in implementing the PjBL approach in teaching-learning renewable energy technology at TVET institutions in BD and the GB.
2. Comparing the status of using PjBL and the initiatives supporting the PjBL approach in teaching-learning RET between BD and the GB.

1.3 Research Questions

- I. What are the possible opportunities and challenges instructors face in implementing PjBL approach in teaching-learning renewable energy technology at TVET institutions in BD and the GB?
- II. What are the different statuses of using PjBL and the initiative supporting the PjBL approach in teaching-learning RET between BD and the GB?

1.4 Significance of Study

The global shift towards renewable energy technologies (RETs) has created a press need for skilled professionals who are capable of designing, implementing and maintaining renewable energy systems. TVET Institutions are essential in creating this skills gap by offering practical, hands-on education. However, the effectiveness of TVET programs in producing competent graduates often depends on the teaching-learning methods employed. The work focuses on the challenges and opportunities of using PjBL in teaching renewable energy technology at TVET institutions that hold significant value for multiple stakeholders.

The increasing imperative of climate change, energy insecurity, and the global drive toward sustainability has rendered renewable energy education a crucial necessity for both developing and

developed nations. Within this context, the application of PjBL in renewable energy technology training at the TVET institutions has proven to be a vital instructional evolution. This research possesses a high importance that not only addresses but is also at the forefront of the urgent demand for teaching methods, which are relevant, experiential, and contextually appropriate and match the dynamic and interdisciplinary characteristics of the renewable energy sector, especially nations like Bangladesh and the Gambia, where energy-related difficulties are directly related to socio-economic aspects.

In both contexts, TVET institutions are strategically positioned as facilitators of workforce development and economic sustainability. Nevertheless, conventional didactic instructional methodologies have frequently proven inadequate in equipping learners with the practical competencies and problem-solving abilities necessary in the renewable energy field. Project-based learning presents a revolutionary alternative by prioritizing experiential learning, collaborative engagement, and real-world problem resolution. The essence of this study has to do with its potentiality to not only expose the gap existing in educational curricula and practical application but also to fill it, preparing students in quite an exceptional way such that they can understand and participate in the implementation of renewable energy technologies in the rural area such as rural electrification, solar-powered agriculture, and microgrid development.

Moreover, this research is critical in advancing equity and inclusivity within technical education. By concentrating on Bangladesh and The Gambia, two nations that face distinct yet analogous developmental challenges, it enriches the existing body of knowledge regarding how context-sensitive adaptations of PjBL can empower marginalised populations through sustainable energy initiatives. Additionally, it offers a comparative perspective for analysing how institutional, cultural, and economic variables influence the design and execution of PjBL in resource-constrained environments. The outcomes of the study can guide curriculum developers, educators and policymakers in customising PjBL frameworks to local realities while maintaining alignment with global benchmarks for green skills and sustainable development.

The suggestion can also possess significance in contributing to policy dialogue. As international development organisations such as UNESCO, ILO, and GIZ increasingly champion learner-centered, competency-based training paradigms, the necessity for empirical evidence emanating from the Global South becomes increasingly pronounced. This study furnishes grounded insights

into the operationalisation of PjBL within TVET institutions characterised by limited resources, drawing attention to exemplary practices, institutional obstacles, and capacity-building requirements. It accentuates the necessity of aligning educational strategies with national renewable energy frameworks, thereby promoting enhanced coherence between education, industry, and environmental sustainability.

In terms of professional development, the research is consequential for educators and administrators within TVET systems. It emphasizes the significance of teacher training, curriculum innovation, and institutional leadership in facilitating the successful integration of PjBL. By concentrating on instructor experiences and agency, this study elucidates the human aspects of pedagogical reform motivations, resistances, and adaptive strategies, which are frequently neglected in broader policy discourses.

Finally, this investigation will contribute to the academic body by providing a nuanced, empirically grounded and contextually enriched understanding of PjBL in renewable energy education within underrepresented regions.

1.5 The possible outcomes of the study

Project-Based Learning is a pedagogy that can be use in teaching renewable energy technology within TVET institutions in Bangladesh and the Gambia has the potential to generate a surplus of significant outcomes for students, educators, and the overarching educational framework. A primary outcome is the cultivation of practical, experiential competencies directly congruent with the skill sets requisite in the renewable energy industry. Through participation in authentic, real-world projects, students acquire experiential knowledge about solar and wind turbine systems, thereby augmenting their employability and self-assurance in technical domains.

Another outstanding outcome is the enhancement of their critical thinking capacity, problem-solving ability and collaborative skill among learners. PjBL facilitates teamwork, necessitating students collaborate within heterogeneous groups, communicate proficiently, and navigate complex challenges. These competencies are essential not solely for technical vocations but also for leadership positions within the evolving energy sector. Furthermore, students emerge as more self-directed and intrinsically motivated as they assume responsibility for their educational

journey, frequently transcending theoretical constructs to pursue innovative, contextually relevant energy solutions.

For educators, the transition to PjBL incites ongoing professional growth, curricular innovation, and the implementation of more dynamic pedagogical approaches. Educators transition from mere sources of content to facilitators of inquiry and design, thereby enhancing the overall educational interaction. This pedagogical reformation cultivates a more engaging and supportive classroom atmosphere, rendering learning more relevant to the demands of industry and societal challenges.

At the institutional level, the embrace of PjBL can engender deeper connections with local communities, energy sectors, and international development collaborators. Projects may tackle tangible energy accessibility issues, particularly in rural or marginalized areas, which is in alignment with the objectives of national development. Consequently, TVET institutions can fortify their position as catalysts for sustainable development by producing graduates who are not only technically proficient but also socially conscientious.

Moreover, PjBL may result in elevated retention and graduation rates, particularly among students hailing from diverse educational backgrounds. The contextual significance of projects assists in bridging gaps in prior knowledge, linguistic barriers, and disparate academic preparedness, which holds particular importance in multicultural settings such as The Gambia and Bangladesh. Ultimately, PjBL can play a significant role in cultivating more inclusive, skilled and adaptable workforce to enhance renewable energy transition in both nations.

1.6 Acronyms

PjBL: Project-Based Learning

TVET: Technical and Vocational Education and Training

GB: Gambia

BD: Bangladesh

GTTI: Gambia Technical Training Institutions

CIF: Crab Island TVET Foundation

FSTI: Fongam Skill Training Institute

QIT: Quest Institute of Technology

GTSC: Gazipur Technical School and College

MPI: Mymensing Polytechnic Institute

CIMT: Chandpur Institute of Marine Technology

CPI: CPI polytechnic

CBPI: Cox's Bazar Polytechnic Institute

ILO: International Labour Organisation

GIZ: Deutsche Gesellschaft für internationale Zusammenarbeit

UNESCO: United Nations Educational, Scientific and Cultural Organization

CHAPTER TWO

Literature Review

2.0 Introduction

This literature review investigates existing studies on the application of project-based learning within Technical and Vocational Education and Training institutions. PjBL has emerged as a student-centered pedagogical method that connects theoretical knowledge with practical application, thereby enhancing students' critical thinking, collaboration, and problem-solving skills (Bell 2010a; Thomas 2000a). Its origins can be traced to progressive educational philosophies in developed contexts, where it was first promoted as a strategy to foster experiential and inquiry-based learning (Dewey, 1938; Blumenfeld et al., 1991). Has time goes on, PjBL has been increasingly adopted in developing countries, particularly in resource-constrained environments, to bridge the gap between academic training and workforce demands (Hmelo-Silver, 2004; Kokotsaki et al., 2016a).

The review first outlines the conceptual foundations of PjBL, with attention to its pedagogical principles and learning results. It explores the role of PjBL in renewable energy education, a sector where hands-on practice is essential for equipping learners to meet global sustainability and technological challenges (Saavedra and Opfer 2012). This is followed by a discussion of the adoption of PjBL in TVET schools, where the alignment between education and industry standards is critical for producing job-ready graduates (Kolmos, Holgaard, and Clausen 2021).

Major issues of PjBL implementation are also examined, which include resource limitations, varying in students' level of understanding, curriculum design constraints, and institutional support, all of which shape its effectiveness in the TVET setting finally (Hanney and Savin-Baden 2013). finally the review evaluates the impact of PjBL in TVET institutions, and particularly its contributions to skill acquisition, employability, innovation, and learners' capacity to engage with real-world industrial challenges (Lehmann et al. 2008; (Graham 2018; Guo, Saab, Lysanne S. Post, et al. 2020)

2.1 The Genesis of PjBL for both Developing and Developed Countries

PjBL is a pedagogical method that traces back to the early 20th century and originates from a educational philosophy called John Dewey. Dewey advocated for experiential learning, emphasizing learning by doing as a means to connect education to real-world problems (Dewey 1938). Additionally, William Kilpatrick further expanded on this idea with the project method, promoting student engagement through meaningful projects (Kilpatrick 1918). Historical, economic, and educational reforms across various regions have shaped the adoption of PjBL in TVET.

TVET, as a crucial driver of economic development, has emerged on a global scale. PjBL in TVET is a method that integrates real-world projects into technical education, equips learners with practical skills needed and presentations to compete in the job market. Historical, economic, and educational reforms have shaped TVET across various regions.

TVET has roots in ancient apprenticeship systems where craftsmen trained apprentices through hands-on experiences. This model persisted through the middle-ages and the industrial revolution, where vocational training became more structured to meet industrial workforce demands (Maclean and margarita 2013).

The development of formal TVET institutions occurred because of industrialization in 19th and early 20th centuries. Germany pioneered “dual system” of education, which integrates classroom training with industry-specific training. Switzerland and Austria also adopted this system of incorporating work-based learning (Deissinger 2015).

Competency-based training was first developed by united states and Europe in the mid-20th centuries, shifting the focus to tangible skills instead of only theoretical concepts (Guthrie 2009). These changes enabled project-based approaches to emerge, as industries began to require more problem-solving and hands-on skills from employees.

Active learning approaches, including PjBL, became the focus of global education reforms in the late 20th to early 21st centuries. Finland, Singapore and Australia adopted PjBL in TVET to promote critical thinking, collaboration, and innovation (OECD 2019).

Germany's dual system of TVET is characterized by an integration of classroom learning and real-world projects across various industries. Many countries seeking to adopt PBL into vocational training use this model as a benchmark (Euler 2013). In Finland, active problem-solving is promoted through institutes of higher education, like polytechnics and vocational schools.

Through the Skills Future initiative, Singapore has integrated PjBL into its vocational education, centering on industry-driven, competency-based, and project-oriented learning (Chee et al. 2017).

The TVET skill gap is being addressed through the implementation of PjBL in developing countries. For example, Rwanda and Kenya, along with some international organizations, have implemented PjBL-focused TVET programs (Carney 2022). In Bangladesh, the TVET system has also incorporated reforms using an employability-driven PjBL approach (Dhar 2021).

The evolution of PjBL within TVET can be linked back to early days of latter segment of the 20th century, a time recognized for its transformative advancements in industrial processes and educational systems that began to highlight competency-driven training and learner-focused strategies (Blumenfeld et al., 1991; Thomas 2000b). As conventional lecture-based pedagogies struggled to adapt to the swiftly evolving technological setting, educators and policymakers progressively regarded PjBL as an effective strategy to cultivate critical analytical skills, foster collaborative engagement, and facilitate the acquisition of practical competencies (Condliffe 2017). Nations with robust TVET frameworks, notably Germany and South Korea, emerged as pioneering examples for the incorporation of PjBL within educational curricula, frequently through dual systems that emphasized synergistic collaboration between industry stakeholders and academic institutions (Rauner and Maclean 2008).

In The Gambia, the prominence of PjBL began to rise during the late 1990s and early 2000s. This era coincided with a global initiative to modernize TVET, propelled by donor-supported endeavors aimed at enhancing employability and technical proficiency. The advent of renewable energy curricula within TVET institutions signified a pivotal moment, establishing a conducive environment for the implementation of project-based learning pedagogy. Educators commenced integration of practical projects involving solar energy installation, photovoltaic system upkeep, and wind turbine technology as a mechanism to contextualize theoretical knowledge within concrete tasks. This advancement was significantly shaped by international organizations such as GIZ and UNESCO-UNEVOC, which advocated for learner-centered pedagogical approaches and

highlighted the importance of sustainable development objectives (Subrahmanyam, 2020; Edel, 2022).

In a parallel manner, Bangladesh's engagement with PjBL materialized as a response to the escalating demand for skilled technicians to facilitate the country's swift industrial growth and diversification of energy sources. Historically characterized by rote memorization and instructor-centered teaching methodologies, Bangladesh's TVET sector commenced a transition towards experiential learning models in the late 20th century. PjBL was introduced as a component of national reforms endorsed by development partners like World Bank and International Labour Organization (ILO), which promoted competency-based educational frameworks and curricula responsive to labor market needs (Vawda & Sarr, 2013; Mwaura & Glover, 2021). Institutions such as the Bangladesh Technical Education Board (BTEB) and various polytechnic institutes began to incorporate PjBL into renewable energy diploma offerings, thereby enabling students to design, construct, and troubleshoot solar and wind turbine systems.

The adoption of PjBL within these contexts reflects overarching trends in global educational policy. Contemporary TVET frameworks are increasingly influenced by the imperative to equip learners with essential 21st-century competencies, encompassing problem-solving abilities, collaborative skills, and digital literacy (Bell, 2010; Helle et al., 2006). In both Bangladesh and The Gambia, educators have embraced PjBL to foster reliable learning environment that replicate real-world workplace setups. This pedagogical approach not only enhances student engagement and retention of knowledge but also augments employability by simultaneously cultivating technical expertise and essential soft skills (Mergendoller et al., 2006; (Thomas and Brown 2011).

Given the context, the path towards the adoption of PjBL in TVET as a fully-fledged approach faces significant hurdles. Faculty members seem not to be taught PjBL frameworks and related pedagogical structures, and supporting institutional frameworks like the curriculum, evaluation, as well as industry partnerships, seem to be stagnant in several areas (Mohd-Yusof et al., 2011; Darling-Hammond et al., 2015). In case of the Gambia, limited resources such as lack of laboratory tools, erratic electricity, and poor ICT infrastructure stifle the execution of hands-on projects. Similarly, Bangladesh is overwhelmed with overcrowded classrooms and low industrial participation which greatly limits the spread of project-based work despite conducive policies.

The emergence of PjBL in TVET, especially linked to renewable energy education, often lies in the establishment of systemic support for innovative teaching methods. This mainly deals with teacher professional development, policy incentives for industry-academia collaboration, and investment in digital learning infrastructure. PjBL has been widely approved as one of the best ways to not only problem-solve wealth but also provide high-quality labor for the market. As the world's global attention now moves to sustainable development, renewable energy is among the major areas where PjBL can make a difference in workforce readiness. Educational institutions in Bangladesh and The Gambia have to take advantage of this momentum by making their curricula in line with the national energy strategies and integrating PjBL into both primary teaching and extracurricular training programs.

It is a fact that the change from lecture-based to project-based learning at the TVET institutions in Bangladesh and the Gambia signifies a joint effort for adopting a practical, student-centered method to transformation the technical education. Regardless of the existence of some structural and resource-based problems, learners' readiness for change can indeed be a reality because PjBL has the ability to remove the line between theory and practice and prepare them for a sustainable future. As time goes by, it will be necessary to continue financial backing that would enable partners in the community to keep their interventions on developmental frameworks and also make TVET market-based without leaving behind present and future labor market needs. therefore, there is a need to understand the concepts of it in TVET.

2.2 The Concept of Project-Based Learning

The evolving global workforce requires a holistic method for education that goes beyond the practical aspects of cultivating critical thinking skills, collaboration and adaptability. The static teaching methods found in TVET are usually inadequate to equip students for such ever-changing scenarios. A notable alternative is PjBL, a more encompassing approach that rotates around student-led projects targeting real-world challenges (Vasiliene-Vasiliauskiene et al., 2020). By marrying theory with actual practice, PjBL further enhances TVET's objectives of producing graduates who are skillful, competent, and ready for industry.

PjBL, shifting to the pedagogies of the 21st century, which emphasize competencies, requires changes in most approaches. These approaches in PjBL require competencies like collaboration

which allows learners to work in groups to obtain goals. Teamwork is solving issues and achieving set targets together as a group (O'Grady-Jones and Grant 2023).

Learning isn't just confined to solo study sessions students now interact with one another through social broadcasting platforms, chat rooms, message boards, and online gaming environments, taking cognitive and emotional engagement to a new level. They regard themselves as skilled creators of the cognitive experiences in which students participate. The change of viewpoint enables them to better include students in the educational process (Rehman et al. 2023). Schools need to make such programs available for students to learn skills that is useful to care for the gold that we help them in creativity and critical thinking, which are so highly valued in many modern workplaces. Project-based learning is also an effective pedagogical approach in today's world. This approach puts real-life problems on par in the educational sector. Each class begins with students looking at a real-world problem that they then try to develop into something that they can work on in pairs or small groups.

Encouraging learners to turn over real-life problems and issues helps to develop 21st-century skills, which aids PjBL, Education and Information Technologies, helping learners understand the lesson better. As a result of the rapid growth of information technologies, Web 2.0 applications were harnessed to assist instructors and learners engaged in project-based learning (PjBL) (Sabaitytė and Davidavičius 2017). As with other instructional plans, PjBL approach is designed widely to improve learners' motivation and enable them to acquire useful skills, including planning and organising the process of learning through research, and developing their social and creative thinking (Vasiliene-Vasiliauskiene, Vasiliauskas, and Sabaityte 2020b). Bell (2014) notes four main pillars of the student-led-teacher facilitated approach: (1) building knowledge through inquiry; (2) research by students but controlled by teachers; (3) collaboration and communication (4) working with real-life problems. Students engage in PjBL through the use of real-life problems, peer interaction, critical analysis, and product or solution design (Vasilienė-Vasiliauskienė, Butviliene, and Butvilas 2016) Projects should make up a large portion of the curriculum since they facilitate learning and give students the chance to interact with and familiarize themselves with the discipline's key ideas. Students are urged to think creatively and explore environments connected with problems by asking open-ended inquiries. They need to encourage an interdisciplinary approach by creating a variety of activities, both individually and in groups.

Engaging learners in completing a project in a real-world setting allows them to gain project-related information and abilities. This approach is known as PjBL, like Process-oriented, context-related, and learner-centered are the three qualities that the perfect project-based learning environment should have. Project-based learning is a process-oriented that drives learning activities that result in a final product. The process of project development incorporates the knowledge, skills, and attitudes that students have learned. Project-based learning involves giving students context-related assignments that mirror collaborative problem-solving techniques in the real-world. Students must be actively involved in project-based learning, and show initiative by considering alternative approaches to a task (Chu et al. 2017). Teachers, on the other hand, facilitate an environment that allows students to collaborate.

Being skilled in the abilities of living, the capacity to learn new things, the level of creativity that a learner can exhibit, and the ability to work with technology and information are the 21st century learning competencies that are of most importance. The study of science is very critical when it comes to providing the workforce that is skilled and exceptional, especially at the time of 4th industrial revolution and 5th social revolution. In case of PjBL, it was confirmed that it is a great way of addressing these various competencies. People are required not only to know the fundamentals but also to know how to apply critical thinking, knowledge in new situations, data interpretation, awareness of the new unit, communication skill, teamwork, decision-making, and problem-solving these are skills and expertise that they demonstrate (Ratih, Festiyed, and Arsih 2024). Constructivism forms the essential base for the creation of PjBL. Constructivism is a method that opens zone proximal development in the classroom for the learners, where they can construct knowledge. With a PjBL method, the teachers are facilitators. Their role is to guide and support while students are driving their learning journey, carry out the project together, and finally bring forth a piece of work that they can show to others. PjBL is very effective teaching method that enables learners to express their's thoughts on their areas of concentration to enquire about develop theory and use a variety of tools and the approach also encourages learners to use what they learn in real-world contexts. Moreover, learners can use the skills they have to solve certain difficulty and address new and creative questions both in and out of the classroom. There are different steps of the project-based learning that are, (i) defining the expected learning outcomes (ii) understanding the concept of teaching materials (iii) skills training, (iv) designing project

themes (v) making project proposals (vi) carrying out project tasks (vii) presentation of project reports (Jalinus, Nabawi, and Mardin 2017).

PjBL is a student-centered instructional method involves active exploration of real-world problems. Reported by Thomas (2000), PjBL fosters critical thinking, collaboration, and practical skills, making it particularly suitable for technical education (Thomas 2000b). Through PjBL, students engage in projects that required them to applies their theoretical knowledge to solve practical problems in order to bridge the gap between classroom teaching-learning and industry requirements (Blumenfeld et al. 1991).

PjBL also emphasizes interdisciplinary learning, encouraging learners to integrate their knowledge from several subjects to address complex problems. Whereby the approach should align with the needs of renewable energy education, where expertise in engineering, environmental science, and economics are essential.

2.3 PJBL in Renewable Energy Education

The global trend for sustainable energy solutions has led to the need for a change in the teaching methods that TVET educational institutions are applying to prepare professionals. PjBL, characterized by its emphasis on real-world problem-solving and student-centered learning, offers a promising avenue for equipping learners with the necessary competencies. At the global level, PjBL has been advocated for the way it is effectively contributing to the teaching of engineering and renewable energy in the modern world. Instance, in a case study of the electric vehicle EOLO project, the authors pointed out that PjBL was helpful in not only promoting the students' motivation but also bringing the real world to the classroom, and in this way, creating collaboration in different disciplines and practical skills (Ariza and Olatunde-Aiyedun 2023). Such examples worldwide ought to reflect the use of PjBL in our education system of proficient workforce in renewable energy has high expectations to thrive. To underline the seven strategies' importance for the educational sustainability development ESD process, some author of the paper conducted a literary study reviewing an expert examination of the tasks. As a result, they found that, along with the traditional classrooms, smart classrooms, which incorporate these methodologies, shaped the behavior of the students and teacher towards cooperation, knowledge sharing, and interaction that is productive (Block and Haus 2020). The approach was actively solving the problem of low-

achieving students by engaging them in relevant topics of Renewable Energy Sources (RES) through the problem-solving exercises that can address the issues at the field of renewable energy. Another approach was done by some authors have employed is the provision of eight years of experience in training photovoltaic PV modules, which is geared toward sustainability development goals (SDGs), critical and based on the problem-solving learning process (Ulazia and Ibarra-Berastegi 2020).

Renewable energy education requires a hands-on work approach to equip the students with needed skills to design the installation and maintain renewable energy system. Studies suggest that PjBL can be instrumental in teaching renewable energy technology by encouraging innovation and problem-solving (Du and Kolmos 2006). In the context of Bangladesh and The Gambia, where renewable energy adoption is still in its early stages, PjBL can prepare students to address challenges such as energy access, grid integration, and system efficiency. A study by (Hossain et al. 2022) highlights the potential of PjBL in enhancing the competencies of TVET students in renewable energy technology. The study found learners who participated in project-based courses demonstrated higher levels of technical proficiency, and confidence compared to those in traditional lecture-based courses. Furthermore, PjBL projects focusing on local renewable energy challenges, such as solar power solutions for rural areas, have shown that students increase engagement and societal impact for better adaptation.

2.4 Adoption of PjBL in TVET Institutions

PjBL should be the main concentration of the educational process, especially in TVET institutions worldwide, the complexity of the approach's basic principles, such as learning through doing, thinking critically, and solving real-world problems, is associated with TVET objectives, that prepare students with workforce skills competencies for the industries.

Implementation of PjBL in TVET in various countries has been well received; however, the reactions have always had inconsistencies. This is exemplified by studies conducted in Malaysia which show the positive aspects of PjBL, such as a better connection between students and teachers, and increased learning outcomes. Despite the benefits, however, resource inadequacies and classroom management problems have also been raised as major challenges.

A study has exposed how great the learning effect that PjBL has on the students when it is properly conducted, but at the same time, it shows the scarcity of adequate materials, indeed, the complete absence of such, thus overpowering other factors and the need for teacher training should have a positive impact on the learners' learning environment (du Plessis 2023).

Furthermore, Indonesia, trying the integration of PjBL into TVET curricula has proved to be very fruitful as it has significantly enhanced the learning process and the skill set of students. Students who were directly involved in PjBL activities were observed to have improved on their collaborative abilities and problem-solving skills. A good exemplary case here would be Marzuki's (2024) work, where he explained that the application of PjBL practices in Indonesian vocational schools had led to the improvement of students in terms of competencies and also made them suitable for the labor market (Marzuki, Zakaria, and Masruri 2024).

In the same vein, through SEIP, the Bangladesh government's initiative for the betterment of TVET has laid the way for incorporating the PjBL method. The SEIP was a project that ran during the period from 2014 to 2023, and its primary objective was to provide a basic level of training through the competency-based model to the local population and also lift them out of poverty by training them in the job market (Lee 2020). The initiative, though mainly about skills, points to the principles of PjBL in design, thus opening up the possibility of incorporating more project-based practices in TVET in Bangladesh (Lee 2020).

In The Gambia, though the studies that touch on PjBL in TVET are quite scarce, the educational reforms undertaken by the country and the resulting improvement in the vocational training sphere give a hint of favorable ground for the development of innovative teaching methods such as PjBL. The integration of PjBL in the education system with the labor market needs is the idea that the PjBL is the most appropriate teaching method for reading students to confront the actual tasks (Powell 2001).

PjBL's implementation in TVET on a global scale is a result of the impact of institutional readiness, resource availability, and teacher competencies. The significance of educating teachers properly for the better execution of PjBL has been widely confirmed. Research from Uganda, for example, was emphatic on TVET top management's role in handling PjBL projects realistically, thus pointing out that proper organization of activities, resources, and support for trainers and other staff was of significant importance (Turyatumba et al., 2023).

Besides, the rise of PjBL in the educational context has been linked to an increase in 21st century students' skills, the study of (M. Ahmad et al. 2023), a structured literature review pointed out that PjBL was the main contributor to the high level of skills for critical thinking, collaboration and problem-solving needed by current workforce.

To sum up, the utilization of the pedagogical approach in TVET environments around the globe creates an encouraging channel for the upskilling of the local workforce through the modern educational system. Although countries like Malaysia and Indonesia have seen some progress in introducing this method, countries like Bangladesh and The Gambia are still not very far in the process. The continued support for this PjBL shift revolves around acquiring resources, teacher training, and the backing of the institutions. For the successful application of PjBL in TVET institutions globally, extensive research and investment in those areas are equally necessary for the integration.

2.4.1 Adoption of PjBL in TVET Institutions in the Gambia

In The Gambia, the adoption of PjBL in TVET institutions is at a nascent stage, driven largely by international donor agencies and NGOs rather than strong national policy frameworks. The National Development Plan (2018–2021) and the TVET Roadmap acknowledge the need for practical, project-based methods to enhance employability; however, implementation remains fragmented (Jallow & Cham, 2021).

Unlike Bangladesh, where the government plays a central role, The Gambia relies heavily on donor-funded programs (e.g., UNESCO-UNEVOC, World Bank, and GIZ initiatives). These programs have introduced renewable energy training modules that incorporate PjBL approaches, such as community-based solar electrification projects where students gain real-world, hands-on experience (Njie, 2020).

Despite these opportunities, barriers remain, including weak institutionalization of PjBL in curricula, limited funding, and dependency on external support. Additionally, instructors often lack adequate pedagogical training to implement PjBL effectively, which affects its sustainability once donor projects phase out (Bah et al., 2019).

Example: In some Gambian TVET centers, PjBL has been applied in solar PV training, where students collaborate on designing and installing small systems for rural communities. While impactful, such initiatives are not yet fully integrated into the mainstream TVET curriculum.

2.4.2 Adoption of PjBL in TVET Institutions in Bangladesh

The incorporation of Project-Based Learning (PjBL) within Technical and Vocational Education and Training (TVET) institutions in Bangladesh has garnered significant scholarly attention in recent years, primarily due to the nation's aspiration to realize sustainable energy objectives while concurrently addressing the issue of youth unemployment. Despite the acknowledgment of the significance of competency-based training in the National Education Policy (2010) and the TVET reforms instituted under the Skills for Employment Investment Program (SEIP), the systematic implementation of PjBL remains markedly constrained. Most educational establishments continue to lean on classic lecture styles, revealing a marked gap in project-driven and practical learning chances (Rahman et al., 2020).

Engagement from industry stakeholders is progressively increasing through public-private partnerships (PPPs), particularly within renewable energy initiatives where solar and biogas technologies are emphasized (Chowdhury & Alam, 2021). Nonetheless, obstacles such as inadequate teacher training, insufficient infrastructural support, and the lack of well-defined curriculum frameworks impede the comprehensive adoption of PjBL. Consequently, this leads to a disparity in implementation across TVET institutions, with urban locales exhibiting a more effective adoption compared to their rural counterparts (Hoque et al., 2020).

Example: In renewable energy programs, some polytechnic institutes have piloted PjBL modules where students work on solar home system installations or microgrid maintenance projects, but these remain donor-driven initiatives rather than being institutionalized across the sector (Rahman & Khan, 2019).

2.5 Integration PjBL into the curriculum, assessments and industry partnerships

PjBL has helped curriculum developers move away from more theory-centric, traditional methods and towards more experience, student-centered learning. To improve student engagement and employability, for example, PjBL has been used by Malaysian institutions such as Polytechnic

Sultan Idris Shah (PSIS) and Kolej Komuniti Selayang (KKSJ) (Martini et al. 2024). To promote collaborative learning and the application of technical skills, these institutions have updated their curricula to incorporate real-world, authentic projects. This has helped students get a profounder knowledge about the subject matter and its practical significance (Varma and Malik 2023b). It is the same in Indonesia, where vocational schools have applied PjBL to close the disparity between the knowledge gained in school and the actual practices in the industry (Romao et al. 2024). It has been reported that learners who took part in PjBL activities exhibit better teamwork, communication, and relational skills beyond the classroom scope (Martinez, Taut, and Schaaf 2016).

In PjBL frameworks, assessment techniques have been changed to consider the special requirements of project-based work. Peer reviews, reflective journals, and performance-based assessments are increasingly being used in place of or in addition to traditional exams (Steghöfer et al. 2018). This all-encompassing method of evaluation assesses critical thinking skills, problem-solving skills, and teamwork in addition to technical competency.

A key factor in guaranteeing the relevance and application of vocational education incorporation of industry collaborations into PjBL programs. Public-private partnerships PPPs have played a significant role in Bangladesh's curriculum creation, quality control, and availability of opportunities for hands-on training. Stakeholders from the industry take part in training boards and committees, contributing knowledge about the skills and trends of the labour market today (Maurer, Haolader, and Shimu 2023). As a result of these partnerships, TVET institutions now offer apprenticeship programs and employ industry professionals as part-time instructors (Tansen 2012).

The application of PjBL in TVET systems in Nigeria has demonstrated favorable effects on graduate results. The method enables the combination of theory and practice, encourages learning, and enhances employability and graduation competencies. To maximize PjBL adoption, however, targeted interventions are required to address issues, including the hiring of unqualified teachers and inadequate instructional facilities (Okolie et al. 2021).

The implementation of PjBL in TVET institutions is not easy despite the obvious advantages. For instance, insufficient resources and problems with classroom management been identified as major obstacles of the successful implementation of PjBL in Malaysia. According to a study conducted

with undergraduate students in technical and vocational education, there were modest difficulties in keeping the classroom under control during PjBL activities, and there were more serious issues with inadequate supplies and technology (Jamaludin & Sahibuddin, 2012).

Comprehensive teacher training programs are crucial to addressing these issues. Research in Uganda has shown how crucial it is to give TVET trainers the tools they needed for successfully use PjBL in real-world life. This study underlined in order to support trainees' competence growth, trainers must be competent in planning, resource mobilization, and instructional delivery (Turyatamba et al., 2023).

In summary, the quality and applicability of vocational education has been greatly improved by the operation of PjBL in TVET institutions worldwide. TVET colleges are in a better position to prepare students for the intricacies of contemporary workforce incorporating PjBL into their courses, examinations, and industry relationships. However, coordinated efforts are needed to address challenges in the implementation, fund teacher preparation, and create supportive institutional policies to fully realize PjBL's promise.

2.6 The Challenges in Implementing PjBL

A popular pedagogical strategy in TVET institutes across the globe is implementing PjBL. PjBL seeks to close the gap between theoretical knowledge and actual application by put in placing a strong emphasis on student-centered and real world problem-solving. However, there are several obstacles to PjBL application in TVET contexts, including teachers' training and capacity gaps, resource constraints, institutional resistance or lack of policy support, and culture or systemic barriers to learner-centered methods.

There are a lot of issues, but the greatest impact is the lack of teacher training and educator capacity. For example, vocational teachers in China usually do not have proper knowledge, skills or work experience to run PjBL activities effectively. This makes it difficult for them to guide learners through interdisciplinary projects and integrate necessary tasks with modern industry practices (Liu 2019a). Much the same is occurring in Bangladesh, where a lack of trained teachers is seriously hindering the execution of Competency-Based Training (CBT) programs in TVET institutions (Rahman, Haolader, and Khan 2012a). One research study came up with the conclusion

that the majority of TVET institutes do not have sufficiently qualified CBT teachers, and this seriously stops effective program implementation (Rahman et al., 2012).

The implementation of PjBL is further hampered by resource limitations, such as restricted access to infrastructure, materials, and information and communication technology (ICT). For instance, inadequate technology and resources have been noted as major obstacles to using PjBL during teaching practicums in Malaysian vocational colleges. These resource constraints worsen classroom management issues in addition to lowering project execution quality (Jamaludin and Sahibuddin 2012b). Similar problems occur in Bangladesh, where TVET institutes' lack of necessary equipment and poor laboratory space pose serious obstacles to the implementation of the CBT program (Rahman et al., 2012).

Another important factor impeding the deployment of PjBL is institutional resistance or a lack of policy support (Liu 2019b). To avoid the complications of PjBL, including higher noise levels, more costs, and departures from predetermined lesson plans, school administrators in some educational settings favour traditional teaching methods. Teachers trying to use cutting-edge instructional strategies may encounter difficulties as a result of this aversion to change (Bin Adnan and Abdul Rahman 2024a). Furthermore, bureaucratic pressures and inadequate administrative assistance have been noted as obstacles in the implementations of compete-based teaching CBT program in TVET institutions in Bangladesh.

Adopting PjBL is further complicated by systemic and cultural impediments to learner-centered approaches. For instance, a cultural and contextual blockade to adoption of ICT in support of PjBL in education in Bangladesh is the instructors' poor command of the English language and It is also difficult to use learner-centered techniques because the ways cultural norms and institutionalized practices shape professors' attitudes and opinions about pedagogical advances (Islam et al. 2021). Stronger collaboration with industries can give teachers real-world experience and align educational projects with real-world applications (Mativo et al. 2017). Establishing multidisciplinary PjBL teams within institutions can foster collaboration and shared expertise. Providing educators with on-site PjBL training can improve their competencies in managing project-based activities. Additionally, policy reforms that support innovative teaching methods and allocate resources for infrastructure development are crucial for successful implementation of PjBL in TVET institution (Hashim 2024).

In summation, Project-Based Learning (PjBL) cultivates essential practical competencies and fosters active engagement among students, both of which are critical components of vocational education. However, its implementation in TVET institutions around the global is fraught with difficulties. To fully realize the impact of PjBL's promise in improving vocational education outcomes, it is imperative to address deficiencies in teacher training, resource constraints, institutional resistance, and cultural hurdles.

2.7 The Impact of PjBL in TVET Institutions

PjBL has developed a modern teaching-learning method within TVET institutions worldwide. Guide the real-life challenges and the needs of learners, PjBL strives to integrate practice with theory. Implementing PjBL in TVET contexts has shown profound effects on learner outcomes, especially concerning the acquisition of soft skills, motivation and engagement as well as overall employment readiness and job preparedness (Xu and Wahid 2024).

PjBL has played a significant role in helping vocational learners develop their soft skills as well as their technical competencies. By involving students in projects based on regional potentials, PjBL successfully enhanced their 4Cs skills that's critical thinking, communication, collaboration, and creativity and promoted deeper comprehension of the subjects matter and its hands-on relevance, according to a study done in Indonesia and Malaysia (Wulansari et al. 2022). According to studies conducted in Oman, students' communication, planning, and time management skills, all crucial for success in real-world work scenarios, were greatly improved by taking part in external consulting projects through PjBL (Belwal et al. 2020).

PjBL has a good impact on students' involvement and motivation as well. Due to the active participation and real-world experiences that PjBL offers, a quasi-experimental study conducted in Peru showed that students exposed to PjBL had greater motivation scores than those in traditional learning environments (Bermudo 2024). Furthermore, studies conducted in the hospitality education sector in South Africa have shown that PjBL increases student interest and engagement by fostering learner autonomy and a deeper comprehension of the subject content (Green and du Plessis 2023).

PjBL gives students the experiences and skills they need to meet industry demands in terms of employability and job preparedness. According to a study conducted in Nepal, PjBL in TVET colleges improves students' technical skills, general abilities like teamwork and communication, and character traits like optimism and self-assurance, all of which are essential for employment (Thapa 2024). Additionally, PjBL helps students to develop work-related knowledge, abilities, attitudes, and competences, hence equipping them for the difficulties of the hospitality business, according to research in South Africa's TVET hospitality education (Green and du Plessis 2023).

CHAPTER THREE

Methodology

3.0 Introduction

In Chapter Three, the research methodology used during the study is presented. It focuses on philosophical paradigm, research design, population and sampling. Description of the target population, sampling size, purposive sampling technique, data collection procedures, Semi-Structured Interview, Validity and Reliability of the tool, data analysis technique and ethical considerations.

3.1 Philosophical Paradigm of this Research

This study is situated within the interpretivist/constructivist paradigm, complemented by insights from critical theory. The interpretivist stance assumes that reality is socially constructed (Matta 2022). Thus, the meanings attached to Project-Based Learning (PjBL) in renewable energy education are best understood through the voices and experiences of participants (Guo, Saab, Lysanne S Post, et al. 2020a). Constructivism emphasises that these meanings are co-created between the researcher and participants, making qualitative inquiry an appropriate approach for capturing the lived realities of teachers/instructors in Bangladesh and The Gambia. Meanwhile, critical theory offers a lens to examine the impact of broader systemic and structural factors such as policy gaps, limited resources, and donor dependency that shape educational practices and opportunities (Shaw et al. 2022).

The chosen method of **thematic analysis** aligns closely with this philosophical stance. Thematic analysis is not only flexible but also inherently interpretive, allowing the researcher to identify, analyse, and interpret recurring patterns of meaning across participant narratives. From an **interpretivist perspective**, thematic analysis facilitates the exploration of how individuals perceive and experience PjBL in their specific institutional contexts. From a **critical standpoint**, it enables the researcher to uncover deeper systemic issues and power dynamics such as inequities in funding, disparities in teacher training, or reliance on international donors that impact the adoption of PjBL.

By situating thematic analysis within this paradigm, the study ensures coherence between philosophy, methodology, and analysis. The findings are therefore not treated as objective “truths,” but as **contextually grounded insights** that reflect participants’ realities while also critiquing the structural barriers constraining effective implementation of PjBL in renewable energy education at TVET institutions.

3.2 Research Design

this study, employs a qualitative research approach to explore how PjBL is implemented and utilized at the TVET institutions in the Gambia and Bangladesh. Education represents a social discipline, and this methodological approach enables the researcher to summarize viewpoints and experiential realities of participants, alongside the contextual variables that shape the educational phenomena under investigation (Lim 2025). In the domain of TVET, PjBL is recognized as a valuable and effective teaching model that fosters student engagement, critical thinking and practical skill through real-world projects (Beckett et al. 2025). However, the adaptation and application of PjBL within the distinct social and economic landscapes of Bangladesh and The Gambia may pose equal challenges and unique opportunities for each country. The qualitative approach is well-suited to uncover the differences by emphasizing the personal experiences of educators or instructors involved in PjBL programs in these regions.

3.2.1 Justification for Choosing the Design

This study utilized a qualitative focus on the application and experiences of PjBL in Bangladesh and The Gambia. The choice of educational qualitative design stems from the attempt to understand phenomena within their contexts through the voices and accounts of educators or instructors. Alongside the qualitative approaches, which seek to provide an understanding of context-rich phenomena, PjBL was interpreted within various institutional frameworks of the region (Creswell 2009). PjBL arises as a significant focal point to its educational characteristics, which require flexibility, interdisciplinary approaches, and an educational shift towards instruction that prioritizes learner engagement and their active part in shaping the surrounding environment. These parameters cannot be captured by looking at the indicators and numbers. It helps to answer how those within the system are experiencing these shifts, and whether these systemic and pedagogical shifts are being embraced, modified, or resisted (Beckett et al. 2025).

The research has chosen to synchronize with qualitative educational research traditions that can provide multiple perspectives and the prospective construction of a more elaborate submission of PjBL implementation (Mertens and Hesse-Biber 2012).

Really, the qualitative model delivers a comprehensive and appropriate schema that can be used to explore the issues that are relevant to the study. It focuses on the primary meaning construction, interpretation, to sense-making, and stakeholder stories that all matter when trying to develop real, practical insights on how PjBL is adopted and sustained in the TVET systems of both countries.

3.3 Population and Sampling

The population of the research is drawn from the TVET institutions that are in Bangladesh and the Gambia from there researcher draws the sample for the research, focusing only on the TVET institutions. The targeted participants were the instructors with experience in using PjBL in their teaching as a method and they were identified by looking for specific indicators or observing some indicators such as lesson plans or syllabus and also checking the labs where students do their practical or hands-on. For the proper comprehension of the implementation of PjBL, the research applies a purposive sampling strategy. This type is good for qualitative studies, where the participants are chosen depending on criteria, in this case, their history with or exposure to PjBL instructional techniques. The number of participants ties in with the qualitative research practices, allowing them to gain a deep understanding of the topics as well as ensuring the comparison of two socio-educational contexts through the insights.

3.3.1 The description of the target population

The target people for the study comprises instructors engaged at TVET institutions located in both Bangladesh and the Gambia. Demographic features of the participants were considered, include gender, discipline, experience in years, location, length of service and level of influence in English, which differ among them are shown in **Table 1**. But the researcher has criteria for selecting the sample size. TVET instructors serve as pivotal agents in the implementation of PjBL, acting as facilitators of learning who bear the responsibility for designing, managing, and assessing real-world projects within classroom and workshop settings. Their beliefs, experiences, and institutional contexts critically impact the extent to PjBL can be effectively embraced and integrated into technical and vocational programs.

Table 1: Demographic variation

Research Countries	Instructors -Id (1-20)	Gender	Experience (year)	Fluency in English	TVET Institutions (Location)	Department	Private or Public (Institutions)
The Gambia	P1	M	6	ok	GTTI	Electrical	Public
	P2	F	7	ok	GTTI	Electrical	Public
	P3	M	15	ok	GTTI	Electrical	Public
	P4	M	5	ok	CIF	Electrical	Private
	P5	M	13	Ok	CIF	Electrical	Private
	P6	M	10	Ok	FSTI	Electrical	Public
	P7	M	14	Ok	FSTI	Electrical	Public
	P8	M	9	Ok	QIT	Electrical	Public
	P9	M	6	Ok	CIF	Electrical	Private
	P10	M	8	Ok	QIT	Electrical	Public
Bangladesh	P11	F	4	Ok	GTSC	Electrical	Public
	P12	F	8	Ok	GTSC	Electrical	Public
	P13	M	21	Ok	GTSC	Electrical	Public
	P14	M	9	Ok	MP	Electrical	Public
	P15	M	4	Ok	MP	Electrical	Public
	P16	M	7	Ok	CIMT	Electrical	Public
	P17	M	8	Ok	CPI	Electrical	Private

P18	M	11	Ok	CIMT	Electrical	Public
P19	M	30	Ok	CB	Electrical	Public
P20	M	6	Ok	CB	Electrical	Public

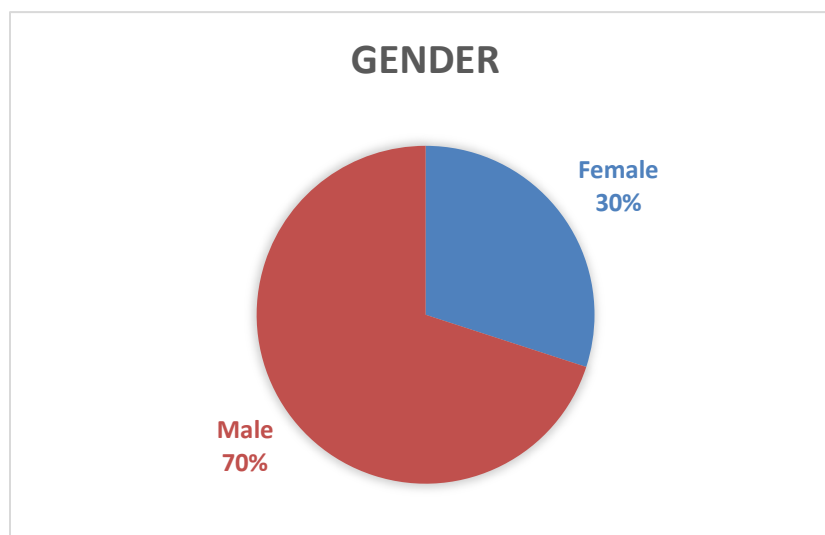


Figure 1: Gender percentage

Some literature reveals that the framework for TVET in Bangladesh includes various institutions that are oversight by the Bangladesh Technical Education Board (BTEB). Instructors within these institutions frequently encounter considerable challenges, including restricted access to ongoing professional development, outdated pedagogical knowledge, and inadequate institutional support for learner-centered methodologies (Haolader, Foysol, and Clement 2017). A significant number of TVET educators in Bangladesh have undergone training rooted in a teacher-focused approach, encountering challenges when shifting towards project-based and competency-oriented teaching models (Rahman, Haolader, and Khan 2012c). Their research revealed a conspicuous absence of capacity-building programs specifically addressing the pedagogical requirements of PjBL, such as collaborative learning, interdisciplinary project design, and authentic assessment strategies (Rahman et al. 2012c).

Similar dynamics are evident in The Gambia, where TVET educators operate under the auspices of the National Accreditation and Quality Assurance Authority (NAQAA). Despite The Gambia's

progress in enhancing vocational education through support from development partners, most notably UNESCO and GIZ systemic deficiencies persist regarding the training of educators to embrace innovative pedagogical models and revealed that while Gambian educators predominantly endorse the concept of practical and participatory learning, their execution is hindered by inadequate resources, insufficient training in experiential pedagogies, and limited autonomy in curriculum development. Consequently, this leads to a fragmented and inconsistent application of PjBL principles within actual classroom environments (Allais 2023).

Therefore, the study's focus on TVET instructors is both strategic and imperative. It acknowledges their critical role as catalysts of pedagogical transformation while recognizing the systemic and institutional constraints that shape their teaching practice. Understanding how these instructors perceive, interpret, and implement PjBL is fundamental to identifying scalable best practices and informing targeted interventions designed that enhancing the quality of vocational education in a low-resource context.

3.3.2 Purposive Sampling Technique

In this study, purposive sampling technique is applied to select the Population of individuals studied consists of instructors working at the technical and vocational education and training institutions in both Bangladesh and Gambia, aiming is explore their insights, viewpoints, and obstacles encountered while implementing project-based learning. To obtain rich and contextually grounded data so, purposive sampling techniques are employed. The reason for selecting participants purposively from those TVET institutions in both countries was to meet the study requirement of the subjects' experience of the phenomenon under study. This strategy of non-probability sampling is regularly used in qualitative analysis to find participants who can provide valuable and thorough insights concerning the phenomenon of studied (Palinkas et al. 2015).

Purposive sampling is particularly appropriate for investigations involving educational innovations such as PjBL, where the objective is not generalizability, but rather profound comprehension. In this framework, instructors who possess experience in implementation, experimentation, or training in PjBL methodologies are intentionally selected. This deliberate selection enables the researcher to access a knowledgeable cohort of educators capable of offering

some perspectives on pedagogical practices, instructional challenges, institutional limitations, and learner outcomes within the TVET frameworks of both nations.

The criteria for participant selection encompass: (i) serving as either a full-time or part-time instructor at an accredited TVET institution by the national or board of authority each country; (ii) possessing at least of three years above instructional educator in technical and vocational education disciplines (Electrical) and use PjBL as teaching method (iii) being a well-established institution and have a good reputation and only two to four instructors will be chosen from one institution based on above criteria's or characteristics in the relevant field. This targeted methodology guarantees that the collected data are relevant and rich in detail, in alignment with the principles of information-rich sampling as advocated by Patton (Patton and Patton 2002).

Furthermore, purposive sampling promotes the inclusion of varied institutional contexts urban versus rural campuses, public versus private institutions, and centers with differing levels of resource availability. Such diversity enhances the data by facilitating comparisons across disparate educational environments, thereby augmenting the analytical depth of the study. As Ravitch and Carl contend, purposive sampling in qualitative educational research is vital for revealing patterns across diverse institutional and cultural contexts, particularly when probing policy-practice discrepancies in pedagogical innovation. (Ravitch and Carl 2019).

This approach is congruent with best practices in qualitative research design, wherein emphasis is placed on "information power" rather than the sample size (Malterud, Siersma, and Guassora 2016a). Given that the objective is to investigate instructor perceptions and institutional processes associated with PjBL, those who possess first-hand, experiential knowledge are deemed more valuable than a large, randomly selected sample with limited exposure to the subject matter (Malterud, Siersma, and Guassora 2016b).

By concentrating on instructors as pivotal agents of change and selecting them purposefully based on relevant experience, the study is poised to generate grounded, actionable insights into how PjBL is interpreted, implemented, and a sustainable solution in the vocational education systems of Bangladesh and the Gambia.

3.3.3 Sampling Size

The demographic focus of the research centers on educators involved in TVET institutions located in Bangladesh and the Gambia, as mentioned in the target population section. From this population, the researcher drew a sample size that depends on the researcher. Therefore, the researcher selected a cohort of twenty (20) educators as participants who are teaching renewable energy, consisting of ten (10) from Bangladesh and ten (10) from the Gambia. These are participants who have been using PjBL as a teaching approach for the past years, according to them and what I saw as the researcher on their lesson plan or syllabus during the interview, it aligns with the PjBL approach. These educators represent critical stakeholders in the facilitation and evolution of vocational pedagogy, particularly in PjBL, which necessitates substantial educator involvement, specialized technical knowledge, and adept facilitation abilities. As primary agents of curricular innovations, the viewpoints of these educators provide invaluable insights into both the opportunities and obstacles related to the integration of PjBL within TVET frameworks.

To investigate these dynamics comprehensively, the study employs a purposive sampling methodology, based on their direct engagement with PjBL or their participation in pedagogical innovations within their respective institutions (Zamir and Zia 2023). This sample size is explained within the setting of qualitative research, where the objective is not to achieve statistical generalizability but rather to collect rich, contextually nuanced data (Patton and Patton 2002).

A sample size of 20 participants (instructors) which aligns with established conventions in qualitative educational research particularly within phenomenological or case study methodologies, where emphasis lies on depth of understanding rather than breadth of coverage. As articulated by Malterud in *Qualitative Educational Research*, qualitative inquiries adhere to the principle of "information power," the notion that the relevance of the sample diminishes the necessity for a larger cohort. Given that the selected educators possess direct experience in the implementation or adaptation of PjBL, they are categorized as "information-rich" cases capable of providing profound, nuanced insights into its practical applications (Malterud, Siersma, and Guassora 2016c). The purposive select 20 participants across two distinct nations also corresponds with the findings of Guest, Bunce, and Johnson, who identified that data saturation in qualitative investigations is frequently achieved between 12 and 20 interviews when participants possess related experiences (Guest, Bunce, and Johnson 2006). Furthermore, Ravitch and Carl underscore that a diverse representation of institutions within small samples enhances thematic integrity and

facilitates cross-case analyses, particularly within cross-national educational research (Ravitch and Carl 2019). As **Table 2**, shows the distribution of the district country-wise to collect data from the identified participants.

Table 2: The country-wise distribution of research participants

Countries	Names of the District	Number of Instructors (one to four from each institution Public or private)
Bangladesh	Dhaka	1
	Cox's Bazar	2
	Gazipur	3
	Chandpur	2
	Mymensingh	2
The Gambia	Kanifing	3
	Banjul	3
	Komba South	2
	Kombo North/Saint Mary	2
Total Participants		20

3.4 Data Collection Procedures

Data will be gathered through semi-structured interviews. the scrutinize deployment, value, and barriers connected with PjBL in TVET environments, the qualitative method is viewed as most suitable. The research will utilize SSI; it's primary method of data collection.

Thus, SSI will be conducted with twenty (20) selected TVET instructors (teachers), ten (10) from Bangladesh, and ten (10) from the Gambia. Each interview is anticipated to last approximately 15–20 minutes. SSIs will conduct face-to-face for the participants in Bangladesh and online (virtual) for participants in the Gambia using Zoom meetings.

3.4.1 Semi-Structured Interview

To obtain a comprehensive insight into the execution and difficulties of PjBL at TVET institutions in Bangladesh and the Gambia, this research employs semi-structured interviews its predominant data collection method. Before commencing the interviews, the consent of each participant was obtained and they were briefed on the interview's purpose, with the acknowledgement that anonymised data might be utilized for study purposes. Each interviewee adhered to a consistent pattern, initiating with an exploration of participants' initial expectations and encouraging them to share insights on their perceptions. Qualitative interviews are more dialogue in nature Felix (2009). To understand another person's interpretation of their experience of a phenomenon, the research approach frequently takes the form of semi-structured interview. Each participant was given the opportunity to elaborate on their knowledge as needed. The interview was conducted with an accommodating attitude, a friendly interview style, and a sincere interest in what the subject had to say to accomplish the purpose of the interview. However, during an interview, there was never any attempt to direct a person's response, conversation, or justification. The interviewer's goal was to encourage an open-ended interview format, a laid-back interpersonal relationship, and a sense of personal freedom by focusing on the phenomenon as it is experienced by the interviewee. The semi-structured interview format is advantageous for qualitative inquiries in educational research, as it strikes an equilibrium between the necessity for comparability among participants and the adaptability to investigate emergent themes (Kallio et al. 2016). The methodological approach that enables the researcher to delve in the educators' narratives, perceptions, and contemplations regarding PjBL, encompassing its challenges, advantages, and integration within institutional frameworks.

The selection of SSI informed by study's objective to summarize the context-dependent realities experienced by educators implementing PjBL in environments characterized by resource limitations. As Mason articulates, interviews are well-suited for investigating “how and why of pedagogical practice,” particularly when the agency and interpretation of participants significantly influence outcomes (Mason 2017).

The interviews will ensure representation across diverse institutional categories (public, private) and geographic settings (urban, peri-urban, rural). Using semi-structured interviews in this setting creates good relationship with the interviewee. It allows the interviewee to express their perspectives in a conversational yet concentrated way, as suggested by Brinkmann and Kvale (2018), this format is optimal for revealing tacit knowledge and context-specific practices within educational settings (Brinkmann and Kvale 2018).

Moreover, the cross-cultural aspect of this research is augmented by semi-structured interviews, as they permit the interviewer to modify phrasing and sequencing to ensure clarity and cultural sensitivity. This adaptability is essential for eliciting rich data within the diverse educational contexts present in Bangladesh and the Gambia (King, Horrocks, and Brooks 2019). Now **Table 3** is developed as the interview question protocol Matrix, how the interview questions answer the research question.

Table 3 Example of interview protocol Matrix

No: and Items	Background information	General Knowledge about PjBL	Research question one	Research question two
Interview Q1	Q			
Interview Q2		Q		
Interview Q3		Q		
Interview Q4			Q	Q
Interview Q5			Q	
Interview Q6			Q	Q
Interview Q7			Q	
Interview Q8				Q

Interview Q9				Q
Interview Q10		Q		

The interview question protocol Matrix is adapted from (Castillo-Montoya 2016a)

3.5 The Instrument development

In qualitative academic inquiries, particularly those examining the experiences of educators and their instructional approaches, it is essential to prioritize reliability and methodological strength the data collection tools employed. An investigation on the application of PjBL at TVET institutions located in Bangladesh and the Gambia, it's carried out with a SSI guide as major means of data collection. The development of the instrument encompasses intentional stages involving design, validation, and the establishment of reliability and validity, all of which are guided by established best practices in qualitative methodology as articulated in esteemed academic journals (Castillo-Montoya 2016b).

3.5.1 The Designing Part

The designing part of the interview protocol/checklist was developed by the researcher based on the best way of answering the research objective and twenty-one items were developed by the researcher in a well-constructed validation and it was distributed through expert judgment in the technical and vocational education (TVE) department. After the expert validation, ten questions that are more relevant and clearer were selected from the twenty-one items that were developed to answer the research objectives.

3.5.2 Validity and Reliability

The **content validity**, the initial draft of the interview instrument undergoes expert judgment by five subject-matter experts specializing in vocational education and qualitative research, inclusive of faculty members from an academic institution in Bangladesh, that is the Islamic university of technology (IUT) in technical and vocational education (TVE) Department. These experts critically evaluate the guide for its clarity, relevance, and alignment with the overarching research objectives. Creswell and Poth emphasize that expert evaluations are indispensable for establishing both face and content validity for qualitative instruments (Creswell and Poth 2016).

The **reliability** researcher employs a uniform interviewing protocol across all participants, adhering to a structured procedure. The principal investigator, trained in qualitative interviewing methodologies, conducts the interviews while maintaining a reflexive awareness of their positionality throughout the data collection process. In qualitative research, reliability transcends statistical measures, instead focusing on procedural and interpretive consistency in the application of the instrument (Morse et al. 2002). By diligently designing, validating and using a semi-structured interview instrument, alongside the implementation of recognized protocols for reliability and validity, this study guarantees that its findings will be robust, credible, and firmly grounded in the contextual realities of PjBL within TVET institutions in both Bangladesh and The Gambia.

3.6 The Data Analysis Technique

The realm of qualitative research, thematic analysis, has emerged as a prominent methodology for the identification, interpretation and understanding meaningful patterns within textual data. In this inquiry examining the application of PjBL in the instruction of renewable energy technology at TVET institutions in Bangladesh and the Gambia, thematic analysis represents a fundamental methodological technique for rigorously assessing participants lived experiences, teaching methods, and institutional hindrances.

3.6.1 Why Thematic analysis

A thematic analysis provides a significant degree of adaptability and understanding, rendering it particularly suitable for research that is grounded in subjective narratives and social contexts of participants. This methodological approach is not contingent upon any specific theoretical framework and is particularly advantageous in domains that are less explored, such as PjBL within TVET environments in developing nations. This strategy facilitates comprehensive and nuanced interpretations that possess the potential to inform both policy and pedagogical advancements (Braun and Clarke 2006)

3.6.2 Steps in thematic analysis

Thematic analysis is composed of six steps that are systematic and recursive. Here is a description based on this particular study.

Step 1: Familiarize yourself with the data

Experts are to be sure that they accurately become a part of qualitative data, which involved transcripts of semi-structured interviews with TVET instructors from Bangladesh and the Gambia. The process involved the researchers reading through the transcripts several times, where they took notes and started to identify potential themes (Braun & Clark, 2006; Kiger & Varpio, 2020). To be familiar with the matter is very important, especially if you want to understand the context and meaning of each participant's answers.

Step 2: Generating initial codes

To begin with the data, it was coded manually. These codes consisted of brief phrases or words describing significant parts of the data. For example, information that comes from the teachers talking about the absence of a practical infrastructure was coded as "resource constraints." (Braun & Clark, 2006; Kiger & Varpio, 2020).

Step 3: Searching for themes

After that, associated codes were assembled into categories of developed orders. A theme is a significant emerging theme that is related to the research questions. Like, instructor adaptation to PjBL challenges to renewable energy project integration, student motivation and soft skill development etc (Braun & Clark, 2006; Kiger & Varpio, 2020). The step transforms raw data into analytically meaningful categories.

Step 4: The Reviewing Themes

Themes were assessed to verify that they portrayed the data accurately and that they had the necessary evidence. It is also necessary that the themes were consistent with one another and that they were all relevant to the research description. Thus, during this revision, some themes were combined into one or were removed. Specifically, the theme "lack of training" has been incorporated into the theme "Instructor Adaptation." (Braun & Clark, 2006; Kiger & Varpio, 2020)..

Step 5: Defining and Naming Themes

Each of the themes received a precise definition to frame the context of each theme. The themes were indeed more than just tags; they were also stories that disclosed the commonalities across the dataset. Let's use, for instance, the theme "Barriers to Renewable Energy Project Integration,"

which had such codes as lack of financing, shortage of lab equipment, and teacher overload that were modeled (Braun & Clark, 2006; Kiger & Varpio, 2020). This enhances clarity and allows consistent interpretation across readers.

Step 6: Producing the Report

In the last step, handcraft the story connecting the overarching themes and the goals of the research needed to be done. Authenticity was incorporated through capturing detailed quotes from participants, which helped explain the reality of instructors' lived experiences (Braun & Clark, 2006; Kiger & Varpio, 2020). The report was more than just an account of findings; it also provided analysis with other literature and the socio-educational situation of Bangladesh and The Gambia.

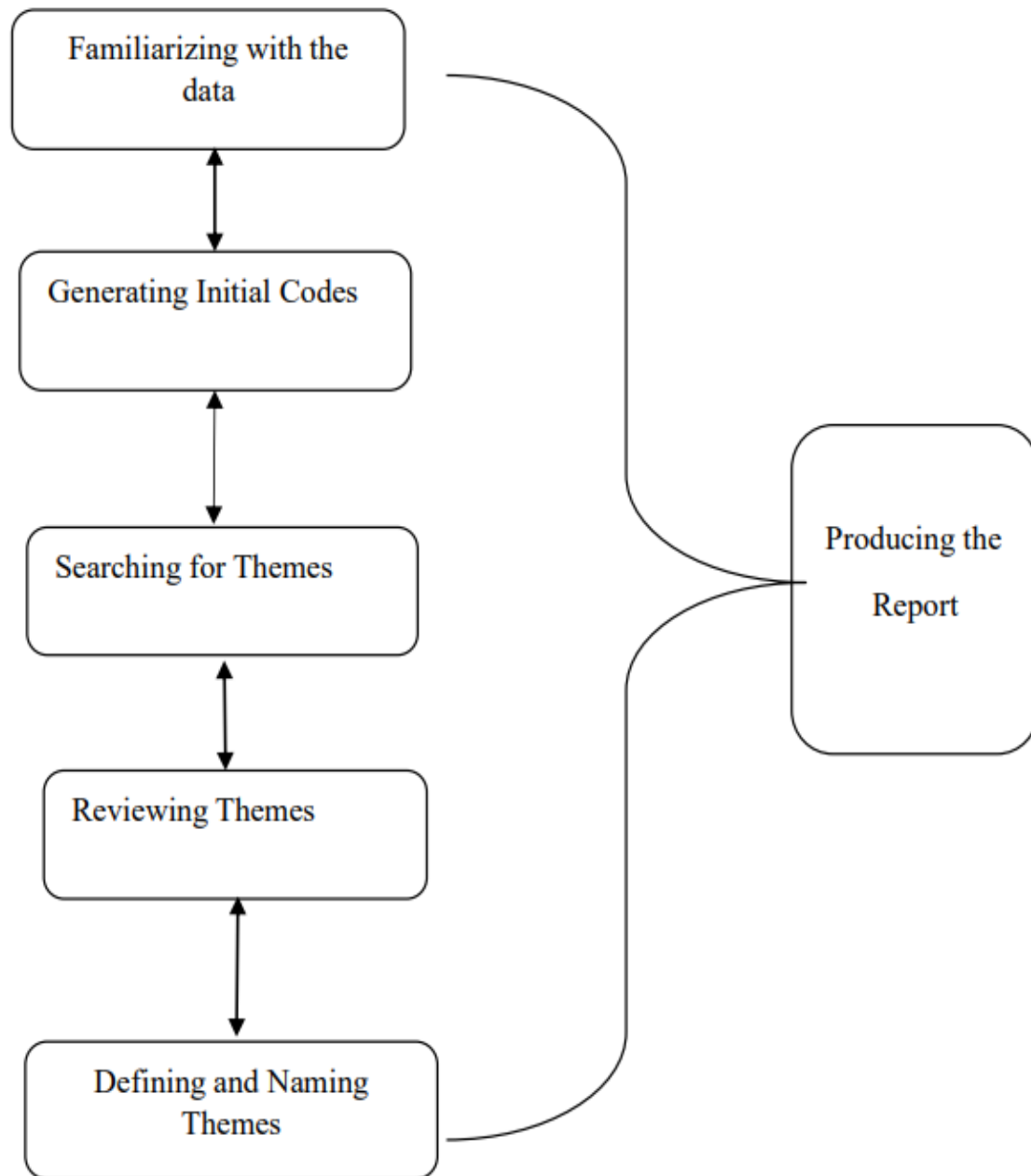


Figure 2: The flowchart representing data analysis process and it's adapted from Braun and Clarke (2006); Kiger & Varpio (2020).

3.7 Ethical Considerations

Before any interview was conducted, the respective TVET institutions and their heads of department were contacted to seek their consent and collaboration for this study. This was achieved by presenting a letter of request to the respective technical and vocational departments (Electrical). All contacted instructors responded positively, and arrangements were made for each interview. Permission to record the interview was required by the participants so that they felt comfortable with it. To ensure interviewees' privacy, all recordings were kept in a confidential and every transcription was identified with pseudonyms to keep the interviewees' identities confidential.

Before their involvement, all educators are presented with a lucid and comprehensive informed consent document, articulated in accessible terminology, which represents the study's objectives, methodologies. This document underscores that participation is entirely voluntary, and that respondents retain the right to withdraw your statement at any point time without incurring penalties. Those participating are kept informed about how the data will be utilized, who will have access to it, and the secure approaches to storage that are applied. This methodology is congruent with the ethical framework articulated by Tracy, who highlighted the imperative of transparency and informed decision-making within qualitative research as a means of honoring participant autonomy (Tracy 2010).

Educators are allowed to pose inquiries regarding the research process to endorsing the consent form, and oral consent is concurrently documented for those who prefer not to execute written declarations due to cultural or contextual considerations a practice endorsed by the scholarly literature when engaging in cross-cultural contexts (Orb, Eisenhauer, and Wynaden 2001). These measures reflect ethical guidance that underscores the necessity for flexibility within the consent process, representing an essential adaptation in varied socio-cultural research environments (Holloway and Galvin 2024).

To safeguard participant anonymity, stringent protocols are enacted. Personal identifiers, including names, institutional affiliations, and geographic locations, are expunged or obscured during the transcription and analytical phases to ensure that no direct associations can be established between the data and individual identities. This approach aligns with ethical standards proposed by Richards and Schwartz, who advocate for anonymization as a fundamental practice in qualitative educational research to mitigate risk and protect reputations(Richards and Schwartz 2002).

Furthermore, confidentiality is rigorously upheld throughout and after the research process. Audio recordings, transcripts, and analytical files are secured within encrypted and password-protected digital repositories, accessible solely to the principal investigator. No raw data will be disseminated publicly or shared with third parties, and results will be presented in aggregate form to further shield participant identities. These protective measures are consistent with the recommendations posited by Wiles et al. (2008), who emphasized that qualitative researchers must implement additional safeguards to avert deductive disclosure in small or closely-knit research communities, such as those inherent in TVET institutions (Wiles et al. 2008).

Primarily, the code of ethics followed in this research in line with acknowledged qualitative research standards which are aimed at free treatment and dignity to the participants. The study hung on informed consent principle of anonymity and confidentiality of all the participants and the acknowledgment of the socio-cultural peculiarities of both countries thus, the deserving name of the research as the research itself indicates it.

Thematic analysis offered a comprehensive and methodical framework for interpretation of the qualitative data collected in the present research. It facilitated the derivation of profound insights regarding the implementation, challenges, and experiences associated with PjBL, the pedagogy of renewable energy technology within TVET institutions across two developing nations. The findings might contribute to the enhancement of educational policy, and instructional design into the environments where innovation is close with resource constraints.

CHAPTER FOUR

Analysis

4.0 Thematic Analysis

This chapter presents a thematic analysis of twenty interviews with TVET instructors from The Gambia and Bangladesh, exploring their perspectives on implementing Project-Based Learning (PjBL) in Renewable Energy Technology (RET) education. The analysis is structured to elucidate the current status, perceived opportunities, and significant challenges of PjBL implementation in both national contexts. The findings are synthesized to provide a comparative understanding, drawing on direct evidence from the participants.

4.0.1 Challenges Faced by Instructors in Implementing PjBL in RET

Despite the recognized opportunities, instructors face a convergent set of formidable challenges that hinder effective implementation.

Main theme: Challenges Faced by Instructors in Implementing PjBL in RET in Bangladesh.

Findings: Systemic Resource and Financial Constraints.

This was the most frequently cited barrier. participants pointed to “*resource limitations and equipment*” (P15, P16) and a critical lack of funding. One instructor stated bluntly, “*We don't have funding for this kind of project,*” relying instead on projects from senior students made for competitions (P14).

Findings: Critical Time Limitations within the Academic Schedule.

The time-intensive nature of PjBL clashes with rigid academic schedules. where “*time constraints within the academic schedule*” were identified as a principal challenge (P19).

Findings: Institutional and Systemic Support.

Beyond physical resources, a need for better structural support was evident. Bangladeshi instructors cited a *“lack of teacher training”* (P13, P15) and *“assessment difficulties”* (P15). The need for top-down initiative was emphasized in Bangladesh, where it was suggested that *“the chairman of the technical education board or DG of technical education”* should be approached to promote PjBL implementation (P11).

Findings: Heterogeneous Student Preparedness.

Instructors in both countries struggle with significant disparities in students' prior knowledge. The same challenge was reported in Bangladesh, where *“students having varying levels of prior knowledge”* complicates effective implementation (P19).

Main theme: Challenges Faced by Instructors in Implementing PjBL in RET in the Gambia.

Findings: Systemic Resource and Financial Constraints.

In The Gambia, instructors highlighted the prohibitive cost of RET components like *“solar panels, the batteries,”* and a lack of basic infrastructure, such as *“projectors or computers” and expensive internet access”* (P2, P3). The core issue was summarized as *“money constraints... You need money to buy the material. So, it’s not always available”* (P5)

Findings: Critical Time Limitations within the Academic Schedule.

A Gambian instructor explained that managing theory, practical work, and a *“good number of students, like forty students”* within a standard timetable is nearly impossible, making the process *“time-consuming”* (P1, P5).

Findings: Need for Enhanced Institutional and Systemic Support.

Instructors called for *“there are no clear guidelines for assessment, industry partnerships, and more resources and training”* (P8).

Discussion 1: The challenges to implementing PjBL in RET for both countries.

The **challenges** to implementing PjBL in RET are **systemic and extremely similar** in both The Gambia and Bangladesh. They form a complex web where financial limitations (the cost of equipment) are exacerbated by logistical constraints (time, large classes) and all point to a need for greater institutional support, funding, and curriculum restructuring.

4.0.2 Main theme: Opportunities of Using PjBL in Teaching-Learning of RET in Bangladesh.

Findings: Enhanced Depth of Understanding and Skill Acquisition:

This is echoed in Bangladesh, where PjBL is seen to help students *"gain a deeper conceptual grasp... because they actively construct knowledge through hands-on experiences rather than passive listening"* (P15).

Findings: Development of Critical Soft Skills and Industry Readiness.

In Bangladesh, participants noted "enhanced teamwork and communication," "encouragement of critical and creative thinking," and *"increased job readiness and confidence in using technology tools"* (19).

Findings: Fostering Innovation and Entrepreneurial Mindset:

In Bangladesh, the opportunity extends to equipping students with *"the knowledge, skills, and mindset necessary to address the complex challenges of transitioning to sustainable energy sources"* (P13), fostering problem-solving abilities crucial for the sector.

Main theme: Opportunities of Using PjBL in Teaching-Learning of RET in the Gambia.

Findings: Enhanced Depth of Understanding and Skill Acquisition.

Participants reported that PjBL leads to a more profound and retained understanding of RET concepts. *"They tend to understand, and they have a deeper understanding of what they are doing"* (P1).

Findings: Development of Critical Soft Skills and Industry Readiness.

A major opportunity highlighted is the cultivation of workplace-ready skills. Gambian instructors cited the development of *"teamwork, project management, and critical thinking"* (P8) and enhanced *"confidence and readiness for industry-based tasks"* (P7).

Findings: Fostering Innovation and Entrepreneurial Mindset:

Instructors in both nations see PjBL as a catalyst for innovation and self-employment. In The Gambia, PjBL was explicitly linked to empowering learners to *"be self-employed"* (P5) and become *"more innovative and creative"* (P6).

Discussion 2: Opportunities for Using PjBL in Teaching-Learning of RET in both countries.

The primary **opportunities** of PjBL, as perceived by instructors in Gambia and Bangladesh, are **transformative**, focusing on creating a more competent, confident, and innovative workforce for the renewable energy sector through enhanced practical understanding, soft skills, and entrepreneurial confidence.

4.0.3 Main theme: Status of Using PjBL in Teaching-Learning of RET in Bangladesh.

Findings: PjBL primarily as a pedagogical approach.

The status is similarly conceptual, with a strong emphasis on PjBL as a student-centered pedagogy. Participants defined it as a method where *"students gain knowledge and skills by working on complex, real-world projects offered over extended periods"* (P11).

The focus is on using projects *“to solve practical problems in RET, thereby increasing the relevance of learning and fostering a deeper conceptual grasp of systems like solar and wind energy”* (P12, P15).

“We have institutional support, but no policies guiding how to teach it.”(P16)

Main theme: Status of Using PjBL and Support in Teaching-Learning of RET in the Gambia.

Findings: PjBL primarily as a pedagogical approach.

PjBL is understood as a hands-on, student-centered method. Instructors perceive “its core function as motivating students by engaging them in meaningful projects that connect classroom learning to real-world application” (P1, P9).

The current implementation “focuses on activities like designing, simulating, and building renewable energy systems, which allows students to see the direct results of their work” (P10).

“Donor-led initiatives, emerging guidelines, but fragile sustainability” (P4).

Discussion 3: Status of Using PjBL and Support in Teaching-Learning of RET in both countries.

The **status** of PjBL in both countries is predominantly **aspirational and conceptual**. Instructors in both countries have a strong, theoretically sound understanding of PjBL's purpose to create meaningful pathways between theory and practice. However, the data suggest that full, resource-supported, and sustainable implementation is often aspirational, constrained by systemic challenges discussed before.

4.1 Similarities and Differences in PjBL Implementation: The Gambia vs. Bangladesh

4.1.1 Similarities

Both The Gambia and Bangladesh emphasise (PjBL) as student-centered, hands-on approach for renewable energy education, with shared attention on bridging theory and practice gap. Educators in both countries highlight PjBL's benefits, including enhanced critical thinking, problem-solving, and technical skill as well as improved workforce readiness through real-world projects. Resource limitations such as outdated lab equipment, insufficient funding, and lack of modern tools are major barriers in both contexts as highlighted in **Table 4**.

Table 4: Similarities in PjBL Implementation

no.	Gambia	Bangladesh
1	PjBL bridges the gap between theoretical and practical knowledge in renewable energy context.	PjBL enables students to apply theoretical ideas to solve real-world renewable energy issues.
2	Motivates students through visible results of practical work.	increases their Motivation when students own their learning and see relevance to industry needs.
3	Identifies challenges such as varied student learning speeds.	Identifies challenges such as varied levels of prior knowledge.
4	Strong emphasis on combining theory with practical engagement to deepen understanding and encourage innovation.	Hands-on activities deepen conceptual grasp of renewable energy systems like solar and wind energy.
5	Promotes self-employment, innovation, and national development through skill acquisition.	Builds technical, troubleshooting, and problem-solving skills, enhancing readiness for the renewable energy workforce.

Additionally, both nations face challenges related to time constraints in balancing theory and practical work, as well as varied student preparedness, which complicates uniform implementation. Strategies like industry collaboration, low-cost solutions, and instructor training are commonly proposed to address these challenges. However, institutional support remains

inconsistent in both countries, with a lack of formal PjBL policies and reliance on external funding (e.g., World Bank, NGOs) for infrastructure and resources.

4.1.1 Differences

While the core principles of PjBL are similar, the context and scale of challenges differ between the two countries as indicated in **Table 5**. Bangladesh has a more structured national vision for renewable energy, with a 30% renewable energy target by 2040, which drives targeted PjBL initiatives like industrial visits to large-scale solar plants. In contrast, The Gambia's efforts are more donor-dependent, with initiatives often tied to external funding (e.g., GIZ, EU) and less integrated into long-term policy frameworks.

Systemic barriers also vary. Bangladesh struggles with a teacher-centered curriculum and minimal institutional policies for PjBL, while The Gambia has begun developing formal guidelines (e.g., Gambia Technical Training Institute's seminars) but lacks sustainable funding. In terms of industry engagement, Bangladesh reports limited private-sector involvement, relying heavily on government-funded labs, whereas The Gambia has stronger NGO and international partnerships for resource sharing and training.

Table 5: Differences in PjBL Implementation

No.	Gambia	Bangladesh
1	Participants focus heavily on hands-on activities, technical skill building, and linking theory to real-world applications in renewable energy (P1, P4, P9, P10)	Participants highlight a more structured approach to blending theoretical understanding with practical application, emphasising conceptual mastery before practice (P12, P15).
2	PjBL is seen as a pathway to make learners self-reliant and contribute to national development (P5).	Focused on preparing students to meet national curriculum standards. (P15)
3	Strong emphasis on material scarcity (P2, P3, P4)	Broader systemic and pedagogical barriers (P13, P15, P16)
4	Time constraints linked to large class sizes and balancing simultaneous learning (P1, P5)	Time constraints tied to fitting PjBL into fixed academic schedules while meeting syllabus requirements (P19).
5	Some students are fast learners, while others slow learners (P1, P6).	Varying levels of subject familiarity before starting PjBL (P12, P19).
6	Improvement suggestions focus on acquiring modern equipment, better resources, and industry partnerships (P8, P10).	Improvement suggestions include setting clear learning goals that support critical inquiry, designing open-ended projects, and securing policy-level support from decision-makers (P11, P15).

Instructor readiness is another key difference. In Bangladesh, educators often lack training in PjBL methods, whereas The Gambia has more structured (though underfunded) teacher training programs. Finally, while both countries advocate for modernised labs, Bangladesh's challenges are exacerbated by larger systemic gaps in technical education, while The Gambia's are more tied to resource scarcity and sustainability of donor-driven projects.

4.2 Answer the Research Questions

- I. What are the possible opportunities and challenges instructors face in implementing the Project-based learning (PjBL) approach in teaching-learning renewable energy technology at TVET institutions in Bangladesh and The Gambia?

Participants highlighted several key opportunities associated with implementing (PjBL) in renewable energy education. First, PjBL effectively bridges the gap between theory and practice by enabling students to apply their theoretical knowledge in real-world scenarios, such as designing and simulating renewable energy systems such as solar and wind power, which enhances their understanding of complex concepts, as mentioned by (P1, P9, P11, P15). Second, the student-centered nature of PjBL fosters active engagement, collaboration, and problem-solving skills, while the tangible outcomes of projects boost students' confidence and motivation (P10, P11, P12, P13, P20). Third, PjBL prepares learners for the labor force by developing industry-relevant competencies like teamwork, project management, and critical thinking, though it also encouraging innovation and self-employment (P6, P8, P15, P19). Finally, hands-on experiences in PjBL enhances deeper conceptual understanding and an a better maintaining of renewable energy technologies, as the learners actively construct knowledge through practical applications (P1, P4, P15). These advantages demonstrate PjBL's potential to transform renewable energy education by making learning more enjoyable, relevant, engaging, and aligned with industry needs.

Despite its benefits, implementing Project-Based Learning (PjBL) in renewable energy education there are several significant challenges. One of the major obstacle is that, varied preparedness among students, where differences in prior knowledge and learning speeds create disparities in their performance, which making it difficult to maintain a uniform pace of instruction (P1, P6, P9, P19). Time constraints also pose critical challenge, as PjBL's extended project timelines often conflict with rigid academic schedules, which is sometime unpredictable and leaving insufficient time for thorough execution (P1, P5, P8, P10, P12). Additionally, resource limitations hinder practical implementation, with high costs for essential materials like solar panels and batteries, coupled with inadequate lab equipments in many institutions (P2, P3, P6, P7, P15). Compounding this issue as lack of reliable internet access and outdated technology in some settings, further restricting effective learning (P3, P10). Finally, insufficient funding and institutional support present systemic barriers, limiting access to modern tools and infrastructure (P5, P11, P12, P14).

In Bangladesh, these challenges are exacerbated by an outdated education system that lacks the necessary framework to support PjBL adoption (P11). Addressing these obstacles will require targeted solutions, including improved funding, resource allocation, and curriculum flexibility, to fully realize PjBL's potential in renewable energy education.

- ii) What are the different statuses of using Project-based learning and the initiative supporting the Project-based learning approach in teaching and learning Renewable energy between Bangladesh and The Gambia?

The current status of PjBL implementation varies significantly between The Gambia and Bangladesh. In The Gambia, some progress has been made through donor support from organizations like the World Bank, EU, and GIZ, which have provided essential tools and materials for PjBL initiatives (P2, P8). However, challenges remain due to the lack of formalized policies and structured support systems, hindering more widespread adoption (P5, P8). In contrast, Bangladesh faces more systemic barriers to PjBL implementation, including outdated curricula and severe funding limitations (P11, P14). Despite these obstacles, there is potential for improvement through targeted advocacy efforts aimed at engaging technical education boards to drive policy changes (P11).

Several key initiatives and improvement strategies have been proposed to address these challenges. External support plays a crucial role, with The Gambia benefiting from donor-funded equipment provisions (P2), while Bangladesh currently relies on temporary solutions like student-made projects for competitions due to resource constraints (P14). At the institutional level, three critical actions are needed: comprehensive teacher training programs to enhance PjBL facilitation skills (P13, P15); investment in modern laboratory facilities and stronger industry partnerships to ensure relevance and resource availability (P1, P8, P10); and the development of clear policy guidelines and assessment frameworks to standardize implementation (P8, P15). Curriculum design also requires attention, with participants emphasising the significant of aligning projects to the relevant industry requirements with incorporating open-ended issues that promote critical thinking, and innovation (P15). These combined efforts could significantly strengthen PjBL adoption and effectiveness in both countries' renewable energy education programs.

4.3 Study Findings

Key findings demonstrate that while PjBL is universally valued for enhancing practical skills, innovation, and employability, common challenges persist. These include severe resource limitations, time constraints, difficulties in balancing theory and practice, and varying student readiness levels that complicate implementation, related to these findings (Bin Adnan and Abdul Rahman 2024b; Ishayati et al., 2025).

Resource constraints represent the most important barrier. In both Bangladesh and the Gambia, inadequate laboratory facilities, scarcity of modern renewable energy equipment, and insufficient funding undermine PjBL execution. Similar challenges are well documented in literature. In Ethiopia, Asfaw (2024) noted that limited resources made PjBL difficult to sustain, forcing teachers to rely on simulations rather than real equipment (Asfaw et al. 2024). In India, reported that financial constraints restricted student projects to small-scale prototypes rather than full industrial applications (Tagliacane et al. 2016). These parallels suggest that resource scarcity is a structural challenge for PjBL in many low or middle-income countries.

Time constraints is another recurring challenge. In Bangladesh and the Gambia, rigid curricula make it difficult to cover theoretical content, limiting the time available for in-depth project work. Researchers in other contexts repeat this concern. For instance, observed in Malaysia that balancing the curriculum requirements with project-based learning approach timelines often resulted in incomplete projects (Ishayati et al. 2025). These findings illustrate a fundamental tension between curriculum structures and the time-intensive nature of project work.

Students with diverse prior knowledge also complicate the implementations. Both Bangladesh and the Gambia, diverse academic backgrounds and uneven technological literacy among students hinders full participation in project work or even concentrating in class. This problem is widely acknowledged elsewhere. Chiang and Lee (2016) in Taiwan found that weaker students often disengaged during complex projects, while more advanced peers dominated group tasks (Chiang and Lee 2016). Similarly in Ghana, Amedorme and Fiagbe (2013) emphasized the need for scaffolding strategies to ensure that students with lower prior knowledge can still participate meaningfully (Amedorme and Fiagbe 2013a).

Systemic differences are evident in Bangladesh's national energy goals without corresponding educational policies versus The Gambia's donor-dependent model with weak institutionalisation. Industry engagement also differs, with The Gambia benefiting from stronger NGO partnerships compared to Bangladesh's government-reliant infrastructure.

In Bangladesh context, the government has articulated ambitious national renewable energy goals, as some participant mentioned during the interview, aiming to diversify the energy mix and expand access. However, these goals are not adequately mirrored in the education system, where PjBL adoption in TVET institutions remains fragmented and policy support is limited. Similarly, Guo et al. (2020) described as the policy-practice gap, whereby national strategies are not translated into coherent educational reforms (Guo, Saab, Lysanne S Post, et al. 2020b).

By contrast, the Gambia has adopted a donor-driven model, where PjBL is promoted through externally funded initiatives. This dynamic is common in aid-dependent contexts. Thus, the Gambia's reliance on NGOs and donor agencies creates short-term opportunities but raises questions about sustainability.

The findings reveal that while PjBL is universally valued for enhancing practical skills competencies, innovation, and employability, its effective implementation remains a challenge. Both Bangladesh and the Gambia face resource scarcity, time constraints, and student readiness barriers that reflect experiences in other low and middle-income countries. However, systemic differences show divergent pathways, like Bangladesh suffers from a policy practice gap, while The Gambia relies on a donor-driven weakly institutionalization model. The engagement further differentiates the two, with the Gambia benefiting from stronger NGO collaboration, whereas Bangladesh's approach remains largely government led.

CHAPTER FIVE

Discussion, Improvement, Implications, Recommendations, and Conclusion of Study

5.0 Discussion

The study reveals some significant potentials of (PjBL) that transform renewable energy education for both the Gambia and Bangladesh, while simultaneously identifying key systemic challenges that limit its effectiveness. Both nations recognise PjBL as an innovative, student-centered approach that effectively connects the theoretical knowledge with practical applications, developing critical thinking, technical competencies with workforce preparedness. These insights resonate strongly with the broader body of literature, that's consistently elaborates PjBL's capacity to enhance active learning and workforce readiness in both developed and developing country contexts (J. W. Thomas, 2000a; Kokotsaki et al., 2016b).

Globally, PjBL is increasingly recognised as a pedagogy approach capable of bridging the persistent gap between academic learning and professional practice. Immersing students in real-world projects, PjBL supports collaboration, creativity, and problem-solving skill that are essential in fast-evolving technical fields like renewable energy. Bell (2010) demonstrated PjBL is not only improves cognitive outcomes but it's also strengthens interpersonal skills which are critical for professional adaptability (Bell 2010b). Likewise, a study highlight that PjBL allows students to contextualise theoretical knowledge by applying it in practical, authentic environments, making it relevant to renewable energy education, where hands-on experience with technologies such as solar PV or wind systems is indispensable (Guo, Saab, Lysanne S Post, et al. 2020c).

It's comparable evidence from other low and middle-income contexts reinforce

es this conclusion. In Kenya, a study found that PjBL helped vocational students develop entrepreneurial mindsets by solving community-level energy issues (Gideon, Chepkwony, and Rop 2022), In Indonesia, a study demonstrated that renewable energy-focused PjBL projects not only improved student learning but also delivered tangible social benefits in rural communities(Sari et al. 2021). These examples underscore that PjBL is not only an instructional

approach but also a driver of innovation with the potential to connect education to sustainable development goals (United Nations Educational, Scientific, and Cultural Organization 2016).

Despite these opportunities, this study also confirms that systemic resource constraints. However, substantial obstacles emerge from resource constraints, time constraints, including inadequate laboratory facilities, insufficient funding, and lack of modern renewable energy equipment create significant barriers. This aligns with broader research across Africa and Asia. For instance, reported that Ethiopian TVET institutions struggled to maintain PjBL activities because of poor infrastructure and lack of specialised tools (Asfaw et al. 2024).

Notable differences appear in policy frameworks and support systems (Auliyani, Arianto, and Kholidya 2025). Bangladesh benefits from clear national renewable energy and targets (30% by 2040) that guide PjBL implementation, though institutional policies remain underdeveloped and private sector involvement is minimal. However, Bangladesh has articulated ambitious national renewable energy targets aiming to achieve by 30% of its energy supply from renewables by 2040. These targets provide a strategic rationale for integrating PjBL into renewable energy education, which is a signal for political commitment to the sector. However, the study reveals that institutional-level policies to operationalize these goals within TVET remain underdeveloped, leaving individual institutions without clear guidance on curriculum design, assessment, or industry engagement. This policy practice gap is not unique to Bangladesh. A study highlight a similar problem in Vietnam, where strong national energy policies were not adequately connected to educational strategies, resulting in the separate adoption of PjBL in technical institutions (Nguyen and Dinh 2019).

Conversely, The Gambia's initiatives rely heavily on international donor support, creating emerging guidelines but raising concerns about long-term sustainability. As noted in Tanzania, externally funded reforms often fail to become institutionalized once project funding ends (Vavrus 2009). Although donor engagement has facilitated the emergence of guidelines pilot programs in the Gambia, but lack of robust government-driven frameworks makes the system vulnerable to policy discontinuity and dependency.

Teacher preparedness presents another contrast, with Bangladesh facing significant gaps in educator training for PjBL. Educators often lack both the pedagogical knowledge and the technical expertise required to design, facilitate, and evaluate project-based activities. Also, in Ghana,

Amedorme and Fiagbe (2013) stressed that without systematic professional development, teachers struggled to integrate project methods into technical curricula (Amedorme and Fiagbe 2013b). while The Gambia maintains more structured (though underfunded) professional development programs. Instructors are offered targeted workshop opportunities through donor-funded initiatives, which improves their confidence in facilitating PjBL.

5.1 Suggestions for improvement

Participants offered several key recommendations to enhance Project-Based Learning (PjBL) in renewable energy education. P1 emphasised the need for well-equipped labs with modern technological materials, ensuring students accesses up-to-date tools for hands-on learning. P8 suggested a multi-faceted approach, calling for institutions to provide more resources and training for instructors, develop clear assessment guidelines, and foster industry partnerships to support real-world projects and mentorship opportunities. Similarly, P10 stressed the importance of modern technology and advanced equipment to align training with current industry standards and facilitate more effective learning.

From a policy perspective, P11 highlighted the need for engagement with decision-makers, such as the chairman or Director-General of technical education boards, to advocate for broader PjBL adoption, particularly in Bangladesh, where systemic reforms are needed. P15 focused on curriculum design, recommending that projects incorporate clear, measurable learning goals tied to industry needs. They also advocated critical thinking and inquiry-based tasks, where students analyse, synthesise, and evaluate solutions rather than simply replicating existing models. Open-ended questions and opportunities for creative problem-solving were seen as essential for deeper learning.

Collectively, these suggestions underscore the importance of modern infrastructure, institutional support, industry collaboration, policy engagement, and well-structured project designs to maximise the effectiveness of PjBL in renewable energy education.

5.2 Implications

The study's findings carry several some essential implications for renewable energy education, both The Gambia and Bangladesh. First, the lack of formal integration of (PjBL) in national curricula poses a significant risk of inconsistent implementation across institutions in both countries, potentially undermining the effectiveness of this pedagogical approach. Second, The Gambia's heavy reliance on donor funding for PjBL initiatives raises serious sustainability concerns, as these programs may struggle to continue without developing robust local funding mechanisms. Third, workforce development faces substantial challenges, particularly in Bangladesh where inadequate instructor training combines with outdated laboratory facilities to create barriers to developing industry-relevant skills among students. Finally, the wide variation in student preparedness levels exacerbates existing educational disparities, with resource-limited settings being particularly vulnerable to these equity concerns. These implications highlight the need for comprehensive reforms to ensure that an successful and equitable implementation of PjBL into renewable energy educations across both nations.

5.3 Recommendations

To address these challenges, several recommendations emerge. Policy reforms should institutionalize PjBL in technical curricula and align educational strategies with national energy objectives. Sustainable funding solutions must be developed through public-private partnerships and targeted investments in modern laboratory equipment. Capacity-building initiatives should be prioritise comprehensive teacher training, particularly in Bangladesh, while fostering stronger industry-academic collaborations. Regional cooperation holds additional promise through sharing best practices, resource pooling, and joint training programs.

5.4 Conclusion

In conclusion, PjBL have emerged a transformative pedagogical model with particular promise into TVET, especially in a fields lik, renewable energy where the integration of theory and practice knowledge is vital. This study, which examined the challenge and opportunity of PjBL in renewable energy training, Bangladesh and the Gambia, underscores its capacity to enhance active, student-centered learning, enhance critical thinking, foster innovation, and equip learners with the

technical competencies necessary for an increasingly dynamic global energy sector. However, it also highlights systemic barriers that prevent the full realisation of these benefits.

The findings confirm that both countries recognize the values of PjBL in bridging the gap between theoretical knowledge and industrial practice. Participants consistently emphasised its ability to build problem-solving skills, enhance employability, and prepare graduates for the challenges of real-world energy transitions. Yet, the study also reveals the extent to which contextual constraints, like policy gaps, resource limitations, teacher preparedness, and structural dependencies continue to hinder its effective implementation.

In Bangladesh, PjBL is positioned within a national context that is highly ambitious in terms of renewable energy goals, with policy targets aiming for 30% renewable energy integration by 2040. The absence of concrete institutional policies for embedding PjBL within curricula means that its adoption remains fragmented and inconsistent. Teacher preparedness represents another substantial barrier in Bangladesh. While the country has invested heavily in expanding TVET access, professional development for instructors has not kept pace. Without adequate teacher training, even well-resourced PjBL initiatives risk failing to achieve intended outcomes.

In contrast, the Gambia faces a different structural challenge. The country benefits from relatively strong engagement with non-governmental organizations (NGO) and donor-supported initiatives that facilitate hands-on training in renewable energy. Participants emphasized the role of external partnerships in providing equipment, materials, and sometimes even curricular frameworks. While this donor engagement is invaluable in the short term, it raises critical concerns about long-term sustainability. For the Gambia, the challenges lie not in recognizing the value of PjBL but in embedding it into sustainable national policies, supported by consistent domestic financing and institutional frameworks.

Despite these contextual differences, both Bangladesh and the Gambia grapple with common challenges that resonate with global experiences. Particularly in terms of laboratory facilities, modern equipment, and specialized tools. Where resource shortage has limited the capacity of instructors to design and deliver authentic project-based experiences. And also, the varying student readiness levels compound these difficulties. Students entering TVET institutions often bring diverse educational backgrounds, which complicates the facilitation of collaborative, inquiry-

driven projects. Where differences in prior knowledge create inequities in learning outcomes under PjBL.

finally, PjBL represents a powerful educational approach for renewable energy training in both countries, but its full potential remains constrained by systemic barriers. Bangladesh's primary challenges involve policy development and teacher training, while The Gambia must address the sustainability of donor-funded programs. Strategic investments in policy frameworks, sustainable financing, and educator development are essential to realise PjBL's benefits. Collaborative regional approaches and continued research into cost-effective implementation models will be crucial for developing robust technical education systems that can effectively support the global transition to renewable energy.

5.5 References

- Afeti, George, and Ayélé Léa Adubra. 2012. 'Lifelong Technical and Vocational Skills Development for Sustainable Socioeconomic Growth in Africa'. *Synthesis Prepared on the Occasion of the 2012 ADEA Triennale on Education and Training in Africa (Abidjan, ADEA)*.
- Ahmad, Mahmood, Tao Peng, Ashar Awan, and Zahoor Ahmed. 2023. 'Policy Framework Considering Resource Curse, Renewable Energy Transition, and Institutional Issues: Fostering Sustainable Development and Sustainable Natural Resource Consumption Practices'. *Resources Policy* 86:104173.
- Ahmad, Selamat Triono, Ronal Watrianthos, Agariadne Dwinggo Samala, Mukhlidi Muskhir, and Gimba Dogara. 2023. 'Project-Based Learning in Vocational Education: A Bibliometric Approach'. *International Journal of Modern Education and Computer Science* 15(4):43–56.
- Aisyah, Siti, and Dian Novita. 2025. 'Teachers' Perception of the Implementation of Project-Based Learning in Early Childhood Education in Indonesia: Project-Based Learning: A Perspective from Indonesian Early Childhood Educators'. *Cogent Education* 12(1):2458663.
- Allais, Stephanie. 2023. 'Why Skills Anticipation in African VET Systems Needs to Be Decolonized: The Wide-Spread Use and Limited Value of Occupational Standards and Competency-Based Qualifications'. *International Journal of Educational Development* 102:102873.
- Amedorme, Sherry K., and YA Fiagbe. 2013a. 'Challenges Facing Technical and Vocational Education in Ghana'. *Cell* 233:244833980.
- Amedorme, Sherry K., and YA Fiagbe. 2013b. 'Challenges Facing Technical and Vocational Education in Ghana'. *Cell* 233:244833980.
- Andriyanto, Arif, and Dwi Rahdiyanta. 2025. 'Systematic Literature Review the Influence of Project-Based Learning (PJBL) on Critical Thinking and Creative Thinking Skills of Vocational High School Students'. *International Journal of Research and Innovation in Social Science* VIII(XII):977–82. doi:10.47772/IJRISS.2024.8120082.
- Ariza, Jonathan Álvarez, and Tope Gloria Olatunde-Aiyedun. 2023. 'Bringing Project-Based Learning into Renewable and Sustainable Energy Education: A Case Study on the Development of the Electric Vehicle EOLO'. *Sustainability* 15(13):10275.
- Asfaw, Zelalem, Daniel Alemneh, Bekalu Ferede, Abu Santure, and Worku Jimma. 2024. 'Implementing Data-Driven Decision-Making to Improve the Quality of Education in Ethiopian Higher Learning Institutions'. *International Journal of African Higher Education* 11(3):49–75.
- Auliyani, Chaeriyatun Nissa, Fajar Arianto, and Citra Fitri Kholidya. 2025. 'A SYSTEMATIC LITERATURE REVIEW OF PROJECT-BASED LEARNING INTEGRATED WITH STEM EDUCATION: EXAMINING IMPLEMENTATION STRATEGIES, OUTCOMES, AND CHALLENGES'. *Jurnal Visi Ilmu Pendidikan* 17(1):214–31. doi:10.26418/jvip.v17i1.85610.
- Beckett, Gulbahar H., Jeanne Beck, Febriana Lestari, Junghun Yang, and Hwee Jean Lim. 2025. 'Qualitative Research Synthesis of Project-Based (Language) Learning and Teaching in East and

- Southeast Asia: 2002–24'. *Language Teaching Research* 13621688251313745. doi:10.1177/13621688251313745.
- Bell, Stephanie. 2010a. 'Project-Based Learning for the 21st Century: Skills for the Future'. *The Clearing House* 83(2):39–43.
- Bell, Stephanie. 2010b. 'Project-Based Learning for the 21st Century: Skills for the Future'. *The Clearing House* 83(2):39–43.
- Belwal, Rakesh, Shweta Belwal, Azlinor Binti Sufian, and Amal Al Badi. 2020. 'Project-Based Learning (PBL): Outcomes of Students' Engagement in an External Consultancy Project in Oman'. *Education+ Training* 63(3):336–59.
- Bermudo, Dely Muñoz. 2024. 'Impact of Project-Based Learning on the Motivation of Students at a Productive Technical Education Center in Ayacucho –CETPRO'. *Educational Administration: Theory and Practice*. doi:10.53555/kuey.v30i11.8740.
- Bernstein, Steven. 2017. 'The United Nations and the Governance of Sustainable Development Goals'. *Governing through Goals: Sustainable Development Goals as Governance Innovation* 213–39.
- Bexell, Magdalena, and Kristina Jönsson. 2017. 'Responsibility and the United Nations' Sustainable Development Goals'. Pp. 13–29 in Vol. 44. Taylor & Francis.
- Bin Adnan, Mohd Fahmi, and Azlin Asyiqin Abdul Rahman. 2024a. 'Challenges in Implementing Project-Based Learning in Malaysian Vocational Colleges During Teaching Practicum'. *International Journal of Academic Research in Progressive Education and Development* 13(4):Pages 2386-2393. doi:10.6007/IJARPED/v13-i4/23828.
- Bin Adnan, Mohd Fahmi, and Azlin Asyiqin Abdul Rahman. 2024b. 'Challenges in Implementing Project-Based Learning in Malaysian Vocational Colleges During Teaching Practicum'. *International Journal of Academic Research in Progressive Education and Development* 13(4):Pages 2386-2393. doi:10.6007/IJARPED/v13-i4/23828.
- Block, Brit-Maren, and Benedikt Haus. 2020. 'New Ways in Engineering Education for a Sustainable and Smart Future'. Pp. 1–9 in. IEEE.
- Blumenfeld, Phyllis C., Elliot Soloway, Ronald W. Marx, Joseph S. Krajcik, Mark Guzdial, and Annemarie Palincsar. 1991. 'Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning'. *Educational Psychologist* 26(3–4):369–98.
- Braun, Virginia, and Victoria Clarke. 2006. 'Using Thematic Analysis in Psychology'. *Qualitative Research in Psychology* 3(2):77–101.
- Brinkmann, Svend, and Steinar Kvale. 2018. 'Doing Interviews'.
- Carney, Stephen. 2022. 'Reimagining Our Futures Together: A New Social Contract for Education: By UNESCO, Paris, UNESCO, 2021, 186 Pages, ISBN 978-92-3-100478-0'. *Comparative Education* 58(4):568–69. doi:10.1080/03050068.2022.2102326.

- Castillo-Montoya, Milagros. 2016a. 'Preparing for Interview Research: The Interview Protocol Refinement Framework.' *Qualitative Report* 21(5).
- Castillo-Montoya, Milagros. 2016b. 'Preparing for Interview Research: The Interview Protocol Refinement Framework.' *Qualitative Report* 21(5).
- Chee, Ken Nee, Noraffandy Yahaya, Nor Hasniza Ibrahim, and Mohamed Noor Hasan. 2017. 'Review of Mobile Learning Trends 2010-2015: A Meta-Analysis'. *Journal of Educational Technology & Society* 20(2):113–26.
- Chiang, Chin-Ling, and Huei Lee. 2016. 'The Effect of Project-Based Learning on Learning Motivation and Problem-Solving Ability of Vocational High School Students'. *International Journal of Information and Education Technology* 6(9):709–12.
- Chu, Samuel Kai Wah, Yin Zhang, Katherine Chen, Chi Keung Chan, Celina Wing Yi Lee, Ellen Zou, and Wilfred Lau. 2017. 'The Effectiveness of Wikis for Project-Based Learning in Different Disciplines in Higher Education'. *The Internet and Higher Education* 33:49–60.
- Condliffe, Barbara. 2017. 'Project-Based Learning: A Literature Review. Working Paper.' MDRC.
- Creswell, John W. 2009. *Qualitative Inquiry and Research Design: Choosing among Five Approaches*. 2. ed., [Nachdr.]. Thousand Oaks: Sage.
- Creswell, John W., and Cheryl N. Poth. 2016. *Qualitative Inquiry and Research Design: Choosing among Five Approaches*. Sage publications.
- Darling-Hammond, Linda, Brigid Barron, P. David Pearson, Alan H. Schoenfeld, Elizabeth K. Stage, Timothy D. Zimmerman, Gina N. Cervetti, and Jennifer L. Tilson. 2015. *Powerful Learning: What We Know about Teaching for Understanding*. John Wiley & Sons.
- Deissinger, Thomas. 1994. 'The Evolution of the Modern Vocational Training Systems in England and Germany: A Comparative View'. *Compare* 24(1):17–36.
- Deissinger, Thomas. 2015. 'The German Dual Vocational Education and Training System as "Good Practice"?'. *Local Economy* 30(5):557–67.
- Dewey, John. 1938. 'An as Experience'. *Education* 6.
- Dhar, Urvi. 2021. 'Asian Development Bank (ADB), *Asian Development Outlook 2020: What Drives Innovation in Asia?*' *Journal of Asian Economic Integration* 3(1):98–100. doi:10.1177/2631684620982127.
- Du, Xiangyun, and Anette Kolmos. 2006. 'Process Competencies in a Problem and Project Based Learning Environment'. Samlignsnummer för enstaka enskilt utgivna arbeteb.
- Edel, Marion. 2022. 'Qualified Teaching and Training Staff as a Key for Implementation of Sustainable TVET Reforms'. Pp. 35–52 in *Technical and Vocational Teacher Education and Training in International and Development Co-Operation: Models, Approaches and Trends*. Springer.

- Euler, Dieter. 2013. 'Germany's Dual Vocational Training System: A Model for Other Countries?'
- Gideon, Cheruiyot David, Patricia Chepkwony, and Williter Rop. 2022. 'The Role of Technical and Vocational Education Training in Entrepreneurial Development in South Rift Region, Kenya'. *International Journal of Recent Research in Commerce Economics and Management* 17–24.
- Graham, Steve. 2018. 'A Revised Writer (s)-within-Community Model of Writing'. *Educational Psychologist* 53(4):258–79.
- Green, Shawn Lourens, and Elizabeth Catharina Elize du Plessis. 2023. 'Project-Based Learning to Promote Learner Autonomy in Training Hospitality Education at a Technical and Vocational Education and Training College'. *International Journal of Learning, Teaching and Educational Research* 22(7):136–55.
- Guest, Greg, Arwen Bunce, and Laura Johnson. 2006. 'How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability'. *Field Methods* 18(1):59–82. doi:10.1177/1525822X05279903.
- Guo, Pengyue, Nadira Saab, Lysanne S. Post, and Wilfried Admiraal. 2020. 'A Review of Project-Based Learning in Higher Education: Student Outcomes and Measures'. *International Journal of Educational Research* 102:101586. doi:10.1016/j.ijer.2020.101586.
- Guo, Pengyue, Nadira Saab, Lysanne S Post, and Wilfried Admiraal. 2020a. 'A Review of Project-Based Learning in Higher Education: Student Outcomes and Measures'. *International Journal of Educational Research* 102:101586.
- Guo, Pengyue, Nadira Saab, Lysanne S Post, and Wilfried Admiraal. 2020b. 'A Review of Project-Based Learning in Higher Education: Student Outcomes and Measures'. *International Journal of Educational Research* 102:101586.
- Guo, Pengyue, Nadira Saab, Lysanne S Post, and Wilfried Admiraal. 2020c. 'A Review of Project-Based Learning in Higher Education: Student Outcomes and Measures'. *International Journal of Educational Research* 102:101586.
- Guthrie, Hugh. 2009. *Competence and Competency-Based Training: What the Literature Says*. ERIC.
- Hanney, Roy, and Maggi Savin-Baden. 2013. 'The Problem of Projects: Understanding the Theoretical Underpinnings of Project-Led PBL'. *London Review of Education* 11(1).
- Haolader, Faruque A., Khan Md Foysol, and Che Kum Clement. 2017. 'Technical and Vocational Education and Training (TVET) in Bangladesh—Systems, Curricula, and Transition Pathways'. *Vocational Education and Training in Times of Economic Crisis: Lessons from around the World* 201–27.
- Haolader, Faruque A., and Reinhold Nickolaus. 2012. 'Technical and Vocational Education and Training-Curricula Reform Demand in Bangladesh. An Empirical Study of the Curricula of the Diploma-in-Engineering Programme in Bangladesh and the German Initial Vocational Training in the Dual System and the Curricular Effects'. *Journal of Systemics, Cybernetics and Informatics* 10(4):36–40.

- Hashim, Suhaizal. 2024. 'Beyond The Classroom: Linking TVET Educators' Knowledge and Skills for Industry 4.0 Readiness'. *Online Journal for TVET Practitioners* 9(1):24–36.
- Helle, Laura, Päivi Tynjälä, and Erkki Olkinuora. 2006. 'Project-Based Learning in Post-Secondary Education—Theory, Practice and Rubber Sling Shots'. *Higher Education* 51:287–314.
- Henrie, Curtis R., Lisa R. Halverson, and Charles R. Graham. 2015. 'Measuring Student Engagement in Technology-Mediated Learning: A Review'. *Computers & Education* 90:36–53.
- Hmelo-Silver, Cindy E. 2004. 'Problem-Based Learning: What and How Do Students Learn?' *Educational Psychology Review* 16(3):235–66.
- Holloway, Immy, and Kathleen Galvin. 2024. *Qualitative Research in Nursing and Healthcare*. Fifth edition. Hoboken, NJ: Wiley-Blackwell.
- Hossain, M. Khalid, AA Arnab, Ranjit C. Das, KM Hossain, MHK Rubel, Md Ferdous Rahman, H. Bencherif, ME Emeter, Mustafa KA Mohammed, and Rahul Pandey. 2022. 'Combined DFT, SCAPS-1D, and wxAMPS Frameworks for Design Optimization of Efficient Cs₂ BiAgI₆-Based Perovskite Solar Cells with Different Charge Transport Layers'. *RSC Advances* 12(54):35002–25.
- Insyasiska, Dewi, Siti Zubaidah, and Herawati Susilo. 2017. 'Pengaruh Project Based Learning Terhadap Motivasi Belajar, Kreativitas, Kemampuan Berpikir Kritis, Dan Kemampuan Kognitif Siswa Pada Pembelajaran Biologi'. *Jurnal Pendidikan Biologi Universitas Negeri Malang* 7(1):118842.
- Ishayati, Malisa, Triyanto Triyanto, and Peduk Rintayati. 2025. 'The Potential of Project-Based Learning Models (PjBL) in Strengthening Students' Independence Character: Systematic Literature Review'. *Social, Humanities, and Educational Studies (SHES): Conference Series* 8(1):614. doi:10.20961/shes.v8i1.99021.
- Islam, Md Shaiful, Md Kamrul Hasan, Shahin Sultana, Abdul Karim, and Mohammad Mosiur Rahman. 2021. 'English Language Assessment in Bangladesh Today: Principles, Practices, and Problems'. *Language Testing in Asia* 11:1–21.
- Jalinus, Nizwardi, Rahmat Azis Nabawi, and Aznil Mardin. 2017. 'The Seven Steps of Project Based Learning Model to Enhance Productive Competences of Vocational Students'. Pp. 251–56 in. Atlantis Press.
- Jamaludin, Nor Azliana Akmal, and Shamsul Sahibuddin. 2012a. 'Challenges of a Project-Based Learning Approach towards Requirement Engineering'. *International Journal of Computer Applications* 50(3).
- Jamaludin, Nor Azliana Akmal, and Shamsul Sahibuddin. 2012b. 'Challenges of a Project-Based Learning Approach towards Requirement Engineering'. *International Journal of Computer Applications* 50(3).
- Kallio, Hanna, Anna-Maija Pietilä, Martin Johnson, and Mari Kangasniemi. 2016. 'Systematic Methodological Review: Developing a Framework for a Qualitative Semi-structured Interview Guide'. *Journal of Advanced Nursing* 72(12):2954–65. doi:10.1111/jan.13031.

- Kiger, Michelle E., and Lara Varpio. 2020. 'Thematic Analysis of Qualitative Data: AMEE Guide No. 131'. *Medical Teacher* 42(8):846–54. doi:10.1080/0142159X.2020.1755030.
- Kilpatrick, William H. 1918. 'The Project Method'. *Teachers College Record* 19(4):1–5.
- King, N., C. Horrocks, and J. Brooks. 2019. 'Interviews in Qualitative Research'.
- Kokotsaki, Dimitra, Victoria Menzies, and Andy Wiggins. 2016a. 'Project-Based Learning: A Review of the Literature'. *Improving Schools* 19(3):267–77.
- Kokotsaki, Dimitra, Victoria Menzies, and Andy Wiggins. 2016b. 'Project-Based Learning: A Review of the Literature'. *Improving Schools* 19(3):267–77. doi:10.1177/1365480216659733.
- Kolmos, Anette, Jette Egelund Holgaard, and Nicolaj Riise Clausen. 2021. 'Progression of Student Self-Assessed Learning Outcomes in Systemic PBL'. *European Journal of Engineering Education* 46(1):67–89.
- Lee, Mi Yeon, and Jean S. Lee. 2025. 'Project-Based Learning as a Catalyst for Integrated STEM Education'. *Education Sciences* 15(7):871.
- Lee, Sunhwa. 2020. 'Challenges and Opportunities for Transforming Skills Development in Bangladesh: The Case of the Skills for Employment Investment Program'. Pp. 133–41 in *Anticipating and Preparing for Emerging Skills and Jobs*. Vol. 55, *Education in the Asia-Pacific Region: Issues, Concerns and Prospects*, edited by B. Panth and R. Maclean. Singapore: Springer Singapore.
- Lehmann, M., P. Christensen, X. Du, and M. Thrane. 2008. 'Problem-Oriented and Project-Based Learning (POPBL) as an Innovative Learning Strategy for Sustainable Development in Engineering Education'. *European Journal of Engineering Education* 33(3):283–95. doi:10.1080/03043790802088566.
- Lim, Weng Marc. 2025. 'What Is Qualitative Research? An Overview and Guidelines'. *Australasian Marketing Journal* 33(2):199–229.
- Liu, Huan. 2019a. 'Barriers of Project-Based Learning in Teaching and Learning of Chinese Technical and Vocational Education and Training (TVET): A Review'. *TVET@ Asia* 12(1).
- Liu, Huan. 2019b. 'Barriers of Project-Based Learning in Teaching and Learning of Chinese Technical and Vocational Education and Training (TVET): A Review'. *TVET@ Asia* 12(1).
- Maclean, Rupert, and pavlova margarita. 2013. *Revisiting Global Trends in TVET Reflections on Theory and Practice*. Bonn: UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training.
- Malterud, Kirsti, Volkert Dirk Siersma, and Ann Dorrit Guassora. 2016a. 'Sample Size in Qualitative Interview Studies: Guided by Information Power'. *Qualitative Health Research* 26(13):1753–60.
- Malterud, Kirsti, Volkert Dirk Siersma, and Ann Dorrit Guassora. 2016b. 'Sample Size in Qualitative Interview Studies: Guided by Information Power'. *Qualitative Health Research* 26(13):1753–60. doi:10.1177/1049732315617444.

- Malterud, Kirsti, Volkert Dirk Siersma, and Ann Dorrit Guassora. 2016c. 'Sample Size in Qualitative Interview Studies: Guided by Information Power'. *Qualitative Health Research* 26(13):1753–60.
- Markula, Anette, and Maija Aksela. 2022. 'The Key Characteristics of Project-Based Learning: How Teachers Implement Projects in K-12 Science Education'. *Disciplinary and Interdisciplinary Science Education Research* 4(1):2. doi:10.1186/s43031-021-00042-x.
- Martinez, Felipe, Sandy Taut, and Kevin Schaaf. 2016. 'Classroom Observation for Evaluating and Improving Teaching: An International Perspective'. *Studies in Educational Evaluation* 49:15–29.
- Martini, M., S. Sariyani, D. Marzuki, D. Apriyanti, M. Damaiyanti, and TUHB Yusof. 2024. 'Project-Based Learning (PjBL) Practice in Technical and Vocational Education and Training (TVET) in Indonesia and Malaysia: A Comparative Study. *European Modern Studies Journal*, 8 (1), 304–312'.
- Marzuki, Marzuki, Nanang Zakaria, and Masruri Masruri. 2024. 'Investigating the Capabilities of Adaptive Learning as a Cutting-Edge Approach to Model Development in an Educational Setting'. *Jurnal Kajian Pendidikan Dan Psikologi* 1(3):195–206.
- Mason, Jennifer. 2017. 'Qualitative Researching'.
- Mativo, John, Nicola Sochacka, Kathryn Youngblood, Doug Brouillard, and Joachim Walther. 2017. 'Developing Real-Life Problem-Based Learning (PBL) Activities through Partnership with Industry'. P. 28148 in *2017 ASEE Annual Conference & Exposition Proceedings*. Columbus, Ohio: ASEE Conferences.
- Matta, Corrado. 2022. 'Philosophical Paradigms in Qualitative Research Methods Education: What Is Their Pedagogical Role?' *Scandinavian Journal of Educational Research* 66(6):1049–62.
- Maurer, Markus, Faruque A. Haolader, and Sheikh Shahana Shimu. 2023. 'VET for All: Assessing the Case of Bangladesh'. *International Journal of Educational Development* 101:102819.
- Mergendoller, John R., Nan L. Maxwell, and Yolanda Bellisimo. 2006. 'The Effectiveness of Problem-Based Instruction: A Comparative Study of Instructional Methods and Student Characteristics'. *Interdisciplinary Journal of Problem-Based Learning* 1(2):49–69.
- Mertens, Donna M., and Sharlene Hesse-Biber. 2012. 'Triangulation and Mixed Methods Research: Provocative Positions'. *Journal of Mixed Methods Research* 6(2):75–79. doi:10.1177/1558689812437100.
- Mohd-Yusof, Khairiyah, Syed Helmi, Mohammad-Zamry Jamaludin, and Nor-Farida Harun. 2011. 'Cooperative Problem-Based Learning (CPBL): A Practical PBL Model for a Typical Course'. *International Journal of Emerging Technologies in Learning (IJET)* 6(3):12–20.
- Morse, Janice M., Michael Barrett, Maria Mayan, Karin Olson, and Jude Spiers. 2002. 'Verification Strategies for Establishing Reliability and Validity in Qualitative Research'. *International Journal of Qualitative Methods* 1(2):13–22.
- Mwaura, Grace, and Dominic Glover. 2021. 'Green Jobs for Young People in Africa: Work in Progress'. *Include Knowledge Platform: Leiden, The Netherlands*.

- Nassir, Lazat, Gulnar Kozhasheva, Gulnara Issayeva, Yekaterina Gavrilova, and Mariya Yessenova. 2025. 'Cluster Analysis of Student Satisfaction in a Criteria-Based Assessment Course with a Project-Based Learning Approach'. *Eurasia Journal of Mathematics, Science and Technology Education* 21(3):em2594.
- Nguyen, Giang Thi Kieu, and Huong Thi Dinh. 2019. 'Students' Evaluation of Using Google Classroom in Project-Based Learning in Faculty of English, Hanoi National University of Education'. *Vietnam Journal of Education* 3(2):40–44. doi:10.52296/vje.2019.41.
- OECD. 2019. *An OECD Learning Framework 2030*. Springer.
- O'Grady-Jones, Mary, and Michael M. Grant. 2023. 'Ready Coder One: Collaborative Game Design-Based Learning on Gifted Fourth Graders' 21st Century Skills'. *Gifted Child Today* 46(2):84–107.
- Okolie, Ugochukwu Chinonso, Elisha Nwonu Elom, Paul Agu Igwe, Michael Olayinka Binuomote, Chinyere Augusta Nwajiuba, and Ntasiobi CN Igu. 2021. 'Improving Graduate Outcomes: Implementation of Problem-Based Learning in TVET Systems of Nigerian Higher Education'. *Higher Education, Skills and Work-Based Learning* 11(1):92–110.
- Orb, Angelica, Laurel Eisenhauer, and Dianne Wynaden. 2001. 'Ethics in Qualitative Research'. *Journal of Nursing Scholarship* 33(1):93–96.
- Ossiannilsson, Ebba. 2016. 'Challenges and Opportunities for Active and Hybrid Learning Related to UNESCO Post 2015'. *Handbook of Research on Active Learning and the Flipped Classroom Model in the Digital Age* 333–51.
- Palinkas, Lawrence A., Sarah M. Horwitz, Carla A. Green, Jennifer P. Wisdom, Naihua Duan, and Kimberly Hoagwood. 2015. 'Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research'. *Administration and Policy in Mental Health and Mental Health Services Research* 42(5):533–44. doi:10.1007/s10488-013-0528-y.
- Patton, Michael Quinn, and Michael Quinn Patton. 2002. *Qualitative Research and Evaluation Methods*. 3 ed. Thousand Oaks, Calif: Sage Publications.
- du Plessis, Elize. 2023. 'Student Perceptions of Project-Based Learning in Technical and Vocational Education and Training (TVET) Hospitality Education: A Case of a TVET College in Gauteng'.
- Powell, M. 2001. 'A Comparative Study of TVET Projects — Implementation Experiences from Jamaica and The Gambia'. *International Journal of Educational Development* 21(5):417–31. doi:10.1016/S0738-0593(00)00066-3.
- Rahman, Mahmudur, Faruque A. Haolader, and Awal A. Khan. 2012a. 'Barriers of Implementing the Proposed Competency Based Training Programme in TVET Institutions in Bangladesh'. *International Journal of Engineering Research & Technology* 1(09):1–8.
- Rahman, Mahmudur, Faruque A. Haolader, and Awal A. Khan. 2012b. 'Barriers of Implementing the Proposed Competency Based Training Programme in TVET Institutions in Bangladesh'. *International Journal of Engineering Research & Technology* 1(09):1–8.

- Rahman, Mahmudur, Faruque A. Haolader, and Awal A. Khan. 2012c. 'Barriers of Implementing the Proposed Competency Based Training Programme in TVET Institutions in Bangladesh'. *International Journal of Engineering Research & Technology* 1(09):1–8.
- Ratih, Arista, Festiyed Festiyed, and Fitri Arsih. 2024. 'Implementation of Project-Based Learning in 21st Century Learning in Science Learning: A Systematic Literature Review'. Pp. 15–24 in Vol. 1.
- Rauner, Felix, and Rupert Maclean. 2008. *Handbook of Technical and Vocational Education and Training Research*. Vol. 49. Springer.
- Ravitch, Sharon M., and Nicole Mittenfelner Carl. 2019. *Qualitative Research: Bridging the Conceptual, Theoretical, and Methodological*. Sage publications.
- Rehman, Nadia, Wenlan Zhang, Amir Mahmood, Muhammad Zeeshan Fareed, and Samia Batool. 2023. 'Fostering Twenty-First Century Skills among Primary School Students through Math Project-Based Learning'. *Humanities and Social Sciences Communications* 10(1):1–12.
- Richards, Helen Mary, and Lisa Jennifer Schwartz. 2002. 'Ethics of Qualitative Research: Are There Special Issues for Health Services Research?' *Family Practice* 19(2):135–39.
- Romao, Lucas, Marcos Kalinowski, Clarissa Barbosa, Allysson Alex AraÃejo, Simone DJ Barbosa, and Helio Lopes. 2024. 'Agile Minds, Innovative Solutions, and Industry-Academia Collaboration: Lean R&D Meets Problem-Based Learning in Software Engineering Education'. *arXiv Preprint arXiv:2407.15982*.
- Saavedra, Anna Rosefsky, and V. Darleen Opfer. 2012. 'Learning 21st-Century Skills Requires 21st-Century Teaching'. *Phi Delta Kappan* 94(2):8–13.
- Sabaitytė, Jolanta, and Sigita Davidavičius. 2017. 'Challenges and Solutions of Adopting Public Electronic Services for the Needs of Z Generation'. *International Journal of Learning and Change* 9(1):17–28.
- Sari, Rima, Sumarmi Sumarmi, I. Astina, Dwiyono Utomo, and Ridhwan Ridhwan. 2021. 'Increasing Students Critical Thinking Skills and Learning Motivation Using Inquiry Mind Map'. *International Journal of Emerging Technologies in Learning (IJET)* 16(3):4–19.
- Shaw, James, Monica Gagnon, Andrea Carson, Denise Gastaldo, Brenda Gladstone, Fiona Webster, and Joan Eakin. 2022. 'Advancing the Impact of Critical Qualitative Research on Policy, Practice, and Science'. *International Journal of Qualitative Methods* 21:16094069221076929.
- Smith, Neville B. 1999. 'A Tribute to the Visionaries, Prime Movers and Pioneers of Vocational Education 1892 to 1917.' *Journal of Vocational and Technical Education* 16(1):67–76.
- Steghöfer, Jan-Philipp, Håkan Burden, Regina Hebig, Gul Calikli, Robert Feldt, Imed Hammouda, Jennifer Horkoff, Eric Knauss, and Grischa Liebel. 2018. 'Involving External Stakeholders in Project Courses'. *ACM Transactions on Computing Education (TOCE)* 18(2):1–32.

- Subrahmanyam, Gita. 2020. 'UNESCO-UNEVOC Study on the Trends Shaping the Future of TVET Teaching.' *UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training*.
- Syauqi, Khusni, Sudji Munadi, and Mochamad Bruri Triyono. 2020. 'Students' Perceptions toward Vocational Education on Online Learning during the COVID-19 Pandemic.' *International Journal of Evaluation and Research in Education* 9(4):881–86.
- Tagliacane, S. V., P. W. C. Prasad, G. Zajko, A. Elchouemi, and Ashutosh Kumar Singh. 2016. 'Network Simulations and Future Technologies in Teaching Networking Courses: Development of a Laboratory Model with Cisco Virtual Internet Routing Lab (Virl)'. Pp. 644–49 in *2016 International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET)*. Chennai, India: IEEE.
- Tansen, MH. 2012. 'Public Private Partnership (PPP) in the Technical Vocational Education and Training (TVET) Sector in Bangladesh: Challenges and Prospects'. *TVET Project, Save the Children in Bangladesh*.
- Thapa, Harish Singh. 2024. 'Development of Employability Skills through Work-Based Learning'. *Journal of Technical and Vocational Education and Training* 18(1):102–11.
- Thomas, Douglas, and John Seely Brown. 2011. *A New Culture of Learning: Cultivating the Imagination for a World of Constant Change*. Vol. 219. CreateSpace Lexington, KY.
- Thomas, John W. 2000a. 'A Review of Research on Project-Based Learning'.
- Thomas, John W. 2000b. 'A Review of Research on Project-Based Learning'.
- Tracy, Sarah J. 2010. 'Qualitative Quality: Eight "Big-Tent" Criteria for Excellent Qualitative Research'. *Qualitative Inquiry* 16(10):837–51. doi:10.1177/1077800410383121.
- Turyatemba, Eddy B., Hoseah Kiplagat, and Simon Wanami. 2023a. 'The Role of TVET Managers in the Implementation of Real-Life Project-Based Learning for Competence Development of TVET Trainees in Uganda'. *African Journal of Education, Science and Technology* 7(3):390–400.
- Turyatemba, Eddy B., Hoseah Kiplagat, and Simon Wanami. 2023b. 'The Role of TVET Managers in the Implementation of Real-Life Project-Based Learning for Competence Development of TVET Trainees in Uganda'. *African Journal of Education, Science and Technology* 7(3):390–400.
- Tyson, Lois. 2020. *Using Critical Theory: How to Read and Write about Literature*. Routledge.
- Ulazia, Alain, and Gabriel Ibarra-Berastegi. 2020. 'Problem-Based Learning in University Studies on Renewable Energies: Case of a Laboratory Windpump'. *Sustainability* 12(6):2495.
- United Nations Educational, Scientific, and Cultural Organization. 2016. *Reviews of National Policies for Education Education in Thailand An OECD-UNESCO Perspective: An OECD-UNESCO Perspective*. OECD Publishing.

- Varma, Charu, and Saroj Malik. 2023a. 'Perspective Chapter: TVET in the 21st Century—A Focus on Innovative Teaching and Competency Indicators'. in *Technical and Vocational Education and Training*. IntechOpen.
- Varma, Charu, and Saroj Malik. 2023b. 'Perspective Chapter: TVET in the 21st Century—A Focus on Innovative Teaching and Competency Indicators'. in *Technical and Vocational Education and Training*. IntechOpen.
- Vasilienė-Vasiliauskienė, V., J. Butvilienė, and T. Butvilas. 2016. 'Project-Based Learning: The Complexity and Challenges in Higher Education Institutions'. *Computer Modelling & New Technologies* 20(2):7–10.
- Vasiliene-Vasiliauskiene, Virgilija, Aidas Vasilis Vasiliauskas, and Jolanta Sabaityte. 2020a. 'Peculiarities of Educational Challenges Implementing Project-Based Learning.' *World Journal on Educational Technology: Current Issues* 12(2):136–49.
- Vasiliene-Vasiliauskiene, Virgilija, Aidas Vasilis Vasiliauskas, and Jolanta Sabaityte. 2020b. 'Peculiarities of Educational Challenges Implementing Project-Based Learning.' *World Journal on Educational Technology: Current Issues* 12(2):136–49.
- Vavrus, Frances. 2009. 'The Cultural Politics of Constructivist Pedagogies: Teacher Education Reform in the United Republic of Tanzania'. *International Journal of Educational Development* 29(3):303–11. doi:10.1016/j.ijedudev.2008.05.002.
- Vawda, Ayesha, and Leopold Remi Sarr. 2013. 'Bangladesh Education Sector Review: Seeding Fertile Ground-Education That Works for Bangladesh'.
- Wiles, Rose, Graham Crow, Sue Heath, and Vikki Charles. 2008. 'The Management of Confidentiality and Anonymity in Social Research'. *International Journal of Social Research Methodology* 11(5):417–28. doi:10.1080/13645570701622231.
- Wulansari, Rizky Ema, Rahmat Azis Nabawi, Dian Safitri, and Tee Tze Kiong. 2022. 'The Effectiveness of Project-Based Learning on 4Cs Skills of Vocational Students in Higher Education'. *Journal of Technical Education and Training* 14(3):29–37.
- Xu, Jing, and NHBA Wahid. 2024. 'The Effectiveness of PjBL in the Acquisition of Skills in Higher Vocational Education: A Qualitative Approach'. *Pakistan Journal of Life and Social Sciences* 22(2):16693–712.
- Zamir, Sharik, and Sumaira Zia. 2023. 'Exploring Perspectives of Private Sector Secondary School Teachers Towards Project-Based Learning'. *International Journal of Social Science & Entrepreneurship* 3(4):88–110.

APPENDIX 1: **PART A**

Interview Questions

- (1) How long have you been teaching renewable energy technology or similar subjects?
- (2) How would you define project-based learning in your own words?
- (3) What do you think are the main objectives of implementing PjBL in teaching renewable energy technology (RET) compared to other methods you may know?
- (4) How do you usually design or select projects for your students in renewable energy technology or similar subjects?
- (5) What are the potential benefits or advantages you see in using PjBL to teach renewable energy technology or a similar technology course?
- (6) In your opinion, how can PjBL help students gain practical skills needed in the renewable energy technology sector?
- (7) What challenges have you faced or do you anticipate in implementing PjBL in your renewable energy classes or similar subjects?
- (8) How do you handle these challenges, or what would you need to overcome them?
- (9) Does your institution have any policies, guidelines, or initiatives to support PjBL in teaching? (If yes, can you explain in detail?)
- (10) Is there anything else you would like to add about your experience with PjBL or suggestions for improvement?

APPENDIX 2: **PART B**

Here's a semi-structured interview/in-depth interview guide to explore the opportunities and challenges instructors face in implementing a project-based learning (PjBL) approach in teaching renewable energy technology or similar courses or topic at Technical and Vocational Education and Training (TVET) institutions in Bangladesh and The Gambia. This guide includes a mix of open-ended and specific questions aimed at gathering insights about the teaching environment, resources, instructional methods, and the support available for PjBL.

Introduce yourself and the purpose of the interview.

Assalaamu alalikum Dear Participant, I am Amadou Jallow from the Gambia. I am currently in the final year of my master's program at the Islamic University of Technology (IUT). As part of my master's degree requirements, I need to conduct a research study to write a thesis. The purpose of this interview is to gather insights for a research study I'm conducting as part of my thesis work. I aim to deepen my understanding of the project-based learning (PBL) approach in teaching renewable energy technology at your TVET institution.

Explain the confidentiality and voluntary nature of the interview.

I want to assure you that this interview is entirely confidential and voluntary. Any information you provide will be used solely for academic purposes as part of my research thesis, and your identity will be protected throughout the study. My goal is to create a comfortable and respectful environment where your insights can contribute meaningfully to my research.

Request your consent to record the interview,

To help me accurately capture your insights, I would like to record our conversation. The recording will be used strictly for reference purposes while I analyze the data for my thesis and will be kept confidential. If you're comfortable with this, may I have your consent to record our interview? All answered yes.

