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Research Article

ICT, Managerial Skills and Industry Partnerships for TVET Management Success in Bangladesh

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Abstract

The TVET (Technical and Vocational Education and Training) plays a pivotal role in developing skilled workforce to meet the demands of a rapidly changing labor market driven by IR4.0 and the emerging IR5.0 (Industrial Revelation). Despite the continuous government initiatives to strengthen the TVET sector in Bangladesh. Many institutions continue to face managerial challenges related to the effective use of information and communication technology (ICT), managerial competencies, industry institution collaboration, and organizational governance. Inadequate empirical evidence is available on how these factors collectively influence the overall success of TVET management. The aim of the study is to examine the critical determinants of TVET management success by investigating the effects of ICT application, managerial skills, institute industry partnerships, and management practices in Bangladesh. A quantitative research design adopted, and data collected from 109 principals and managers of TVET institutions using a structured five points Likert scale questionnaire. The reliability and validity of the measurement instrument were assessed using Cronbach's Alpha, Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). Descriptive statistics, correlation analysis, ANOVA, and multiple regression analysis were performed using SPSS and AMOS to test the proposed hypotheses. The research findings reveal that management practices and human resource practices are the two principal dimensions underlying effective TVET management. The regression model explains 80.8% of the variance in management success, indicating that ICT utilization, managerial competencies, institute-industry partnerships, and sound management practices significantly and positively contribute to organizational performance, while demographic characteristics have limited influence. The study concludes that successful TVET management requires an integrated approach that combines digital transformation, EduTech, effective governance, continuous professional development (CPD), and robust industry collaboration. These findings provide valuable evidence for policymakers, institutional leaders, and development partners. It helps to formulate strategies that enhance the quality, relevance, sustainability, and competitiveness of TVET institutions in Bangladesh and other rising countries undergoing similar educational and workforce transformations.

Keywords

TVET Management, ICT Application, Managerial Skills, Industry Partnership, Management Success

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1. Introduction

TVET institutions play a critical role in workforce development and economic growth. The transition toward Industry 4.0 and Industry 5.0 requires TVET institutions to adopt innovative management approaches, strengthen industry linkages, and integrate ICT into teaching and administration. Despite the growing importance of TVET in Bangladesh, limited research has examined how ICT application, managerial competencies, institutional partnerships, and critical management practices contribute to management success.

The contemporary landscape of Technical and Vocational Education and Training (TVET) institutes is undergoing significant evolution amidst the emergence of Industry 4.0 and the impending transition to Industry 5.0. In light of these transformative shifts, this research aims to comprehensively explore the critical managerial challenges confronting TVET institutions and their implications for organizational success. TVET education has seen significant evolution on a global scale over the years.

The study area revolves around the imperative to improve the quality and pertinence of skill education in Bangladesh amidst the nation's swiftly evolving economy. Regarding Institute Industry collaboration for the success of TVET management, the studies highlight the importance of collaboration between TVET institutions and industries for the success.

The use of information and communications technology (ICT) in education system is a way to support, improve, and optimize the way that knowledge is delivered. Nowadays ICT governs communication software to transmit, store, share or exchange information. ICT is one of the building block components of contemporary civilization, and it is becoming more and more significant in the ways that people interact and learn. ICT is being used more effectively in schools across the globe to enhance, support, and occasionally even completely transform the teaching and learning process, leading to improved academic outcomes.

The research will focus on educational managements for Technical Vocational Education & Training (TEVT) encompasses managerial skills course management, training system and with use of Information and Communication Technology (ICT) as well online platform connectivity. Abreast, institutional and professional standing worth of corresponding management of self-competencies enhance of ICT based teaching learning, pedagogical methods and its application.

Furthermore, our investigation can also motivate the researchers to formulated the relevant TVET promoting matrix in order to analyze the new AI related scheme from the stand point of TVET Governance. In this concluding chapter I synthesize my influences in relation to this and discuss the ways in which the study has contributed to the reimagining of TVET.

Understanding the critical management challenges faced by the management of TVET institutes is crucial for improving the overall effectiveness and efficiency of these institutions. By identifying these factors, such as curriculum development, resource management, staff development, and student support services, TVET managers or administrators can prioritize their efforts and allocate resources accordingly to address these critical areas for the success of TVET institutions.

An entrepreneur Dr. Sabur Khan has written an article titled ‘ICT and Education in Bangladesh’. He highlighted some important issues relating to ICTs such as digital inclusion, ICT driven sustainable knowledge economy, priority of in ICT education, ICT for social development etc. He argued that to improve the quality resources, we had used ICT to expand the educational opportunity, to improve the quality and relevance of education, and to increase the efficiency of the education system. The holistic works are relevance on academic management, institutional governance and quality of teachers as well as classroom environment.

Assessing how these demographic variables influence TVET management success allows for the development of tailored strategies and support systems, fostering an environment beneficial to effective management practices and improved outcomes. Furthermore, exploring the relationship between various factors including ICT utilization, managerial skills, institutional partnerships, and critical management factors reveals insights into management success, informing policymakers and administrators in designing comprehensive strategies to enhance TVET management practices and outcomes in Bangladesh.

2. Literature Review and Hypotheses Development

Starecek et. al. [12] conducted research on the challenges surrounding the formal and non-formal education of Generation Z, focusing on their distinct values and motivations compared to previous generations. They particularly examined how gender influences the personal characteristics and development of managerial skills within this demographic. The main objective was to analyze the personality and motivational traits of Generation Z, considering gender diversity, and their implications for managerial skill development.

Zahoor et. al. [14] conducted a study exploring the relationship between managers' digital literacy (MDL) and small and medium-sized enterprises' (SMEs) digital transformation, with a specific focus on gender as a moderating factor. Analyzing data from 158 SMEs in the United Arab Emirates, their research indicates that MDL significantly influences the extent of digital transformation within SMEs through the adoption of digital technologies. Interestingly, they discovered that this relationship is influenced by gender dynamics among managers. These findings offer valuable insights for policymakers and practitioners seeking to promote gender-inclusive strategies for enhancing digital readiness and competitiveness in SMEs.

Ferrary and Deo [7] investigated how gender diversity at middle management and staff levels influenced firm performance, challenged prior notions, and shed light on its strategic significance. Contrary to mixed evidence from previous studies, Mitchel's research, based on 159 large French firms, reveals a positive correlation between gender diversity at these operational layers and economic performance, contributing to enhanced competitiveness. Notably, a nonlinear relationship is observed, emphasizing the importance of achieving balanced diversity within the workforce. Ultimately, Mitchel's findings highlight the imperative of embracing gender diversity across organizational hierarchies to drive optimal performance outcomes.

Kunze et. al. [8] conducted a study aiming to contribute to the diversity literature by examining the organizational performance implications of age diversity. Drawing from social-identity and social-categorization theory, they proposed that age-diverse organizations may experience age-based subgrouping processes, leading to a shared perception of a negative age-discrimination climate, which in turn negatively affects organizational performance. The study introduced top managers' negative age-related stereotypes and diversity-friendly HR policies as organizational-level moderators that influence the social categorization processes in age-diverse companies. Structural equation modelling (SEM) was used to test the hypotheses using data from 147 companies. The results supported all hypotheses, indicating that low negative stereotypes among top managers and the presence of diversity-friendly HR policies can mitigate the negative impact.

Robinson [10] conducted a research study to investigate the criteria sought by employers when recruiting library and information professionals for special library environments in Jamaica. Using a content analysis approach, they examined 47 job advertisements spanning from the year 2013 to 2019 to explore the desired professional, generic, and personal attributes for these positions. The findings of the study revealed a strong emphasis on advanced computer skills, along with communication and interpersonal abilities. However, the researchers noted that while job advertisements provide insights into skills and qualifications sought, they may not fully reflect the actual characteristics of the individuals ultimately hired.

Chen et. al. [5] conducted a study to explore the relationship between professional training, higher academic qualifications, and the operating performance of audit firms in Taiwan. They focused particularly on examining the curvilinear effects of higher academic qualifications on operating performance and categorized the sample into national, regional, and local audit firms. Drawing from theoretical frameworks in industrial economics, they formulated a cross-sectional multiple regression equation to test their hypotheses. The findings revealed positive associations between both higher academic qualifications and professional training with the operating performance of audit firms.

Attah [4] researched to enhance policy efforts in fostering collaboration between schools and industries to promote skill acquisition for sustainable development in Nigeria's TVET system. Using a descriptive survey design, the study encompassed two research questions and null hypotheses. The entire population of 72 individuals was included, without sampling, and data was collected through a structured questionnaire comprising 30 items. Validation by three experts and reliability assessment using Cronbach's alpha yielded a coefficient of 0.74. The findings highlighted essential components of industrial practice policy and strategies for collaboration between schools and industries to ensure skill acquisition for sustainable development in the TVET system.

Mohamad et. al. [9] conducted a study focusing on the challenges of collaboration between TVET institutions and industries in Malaysia. Through purposeful sampling, 53 directors of TVET institutions and 30 industry representatives participated in the survey. The research identified common barriers to collaboration, including governance issues, funding constraints, management challenges, and cultural differences between industries and institutions. These findings highlight the complexities involved in fostering effective partnerships between TVET institutions and industries, underscoring the need for strategic approaches to address these barriers and enhance collaboration for workforce development.

Kumar [11] performed research to explore the impact of talent management practices on employee retention within this sector. The researcher states that in today's dynamic business landscape, HR departments play a vital role in securing and retaining talent crucial for organizational productivity and growth. The IT sector, known for its rapid expansion, faces significant challenges related to high employee turnover rates. Using a descriptive approach, the study examined how talent management strategies influence employee retention. A multiple regression model was employed to analyze the relationship between talent management variables and employee retention.

Ahmed and Manab [1] Ahmed explored on how Board Equity Ownership (BEO) moderates the relationship between Enterprise Risk Management (ERM) framework implementation, regulatory compliance, and the non-financial performance of financial institutions in Nigeria. Non-financial performance is categorized under employee skills and customer loyalty. The researchers stated that the financial sector's development in any economy now heavily relies on effective risk management practices.

Sukenti [13] conducted this research on exploring the definition, principles, and concepts of return assessment in financial management, specifically focusing on its impact within educational institutions. The researcher employed a literature review approach, utilizing secondary data from various sources. A qualitative descriptive method was employed to analyze the gathered data. The findings of this research suggested that financial management encompasses activities related to acquiring, utilizing, and managing company funds to achieve organizational objectives. Effective financial manage-

ment is crucial for advancing these goals, with decisions typically aimed at maximizing company outcomes.

Hassani and Wilkins [2] conducted this research on investigating the factors that impact student satisfaction and their intentions to stay and provide support in universities. They aimed to understand the influence of organizational identification and institution reputation on student satisfaction and behaviors. A conceptual model was developed and tested using structural equation modelling with data obtained from a survey of 419 first-year full-time undergraduate students in the United Arab Emirates. The findings revealed that perceived quality of teaching, organizational identification, and institution reputation significantly predicted student satisfaction, with satisfaction also influencing students' intentions to stay and provide support.

Abdullahi et. al. [15] conducted this research on the effect of talent management (TM) practices on employee performance (EP) among academic staff of Malaysian private universities (MPU), with a focus on the mediating role of employee engagement (EE). They employed both descriptive and quantitative approaches, surveying 314 academic staff members from MPU using a questionnaire. The study found that TM practices, including succession planning, promotion, and performance appraisal, significantly influenced EP, with EE mediating this relationship.

Industry and Institutes collaboration under the TVET echo system has always been lag behind and not fortified it. Major criticism has been levelled at the fact that the training offered does not correspond to actual labour market needs. Digital mind map is a digital tool that is becoming increasingly popular in today's pedagogical visual aids. Malaysia et al. [16] focused TVET student's competencies on using digital mind map in learning of their technical subjects (Rafidah). In its broader sense, AI can mimic human intelligence. Today, the gaps are bridged by the convergence of cloud computing, artificial intelligence (AI), the internet of things (IoT), humanoid robotics, autonomous vehicles, drones, 3D printing, and digital genetics sequencing.

The digital revolution is rapidly transforming the world of work and the skills profiles of many occupations. Asha et. al. [3] mentioned, the pace of change necessitates continuous skilling and reskilling, through lifelong learning. The majority of industries, products, processes and services are undergoing constant change, and new occupations are emerging. Lifelong learning, which covers the spectrum of non-formal, informal and formal learning, will become essential for TVET learners, who will require continual upskilling and reskilling to keep up with industry changes and unforeseen technological advances.

With the imminent arrival of the Fifth Industrial Revolution (IR 5.0), poised to leapfrog from the advancements of IR 4.0, the workforce landscape is set to undergo significant transformation. Projections indicate that within five years, a substantial portion (35%) of the skills deemed essential in today's workforce will undergo change. The IR4.0 revolution, characterized by advancements such as advanced robotics, autonomous transport, artificial intelligence, machine learning, advanced materials, biotechnology, and genomics, has already begun reshaping societal norms and occupational paradigms.

Based on the literature, the study proposes that ICT application, managerial skills, industry partnerships, and critical management practices positively influence TVET management success.

3. Research Objectives

RO1: To identify critical management factors affecting TVET management success.

RO2: To examine whether demographic variables significantly influence managerial skills, ICT utilization, industry partnerships, and TVET management success.

RO3: To investigate the effects of ICT utilization, managerial skills, industry partnerships, and critical management factors on TVET management success.

4. Hypotheses Development

Based on the literature and research objectives, the following hypotheses were developed: H1: Critical management practices significantly influence TVET management success. H2a: There is a significant difference between managers' age and handling critical management challenges. H2b: There is a significant difference between managers' age and ICT application. H2c: There is a significant difference between managers' age and managerial skills. H2d: There is a significant difference between managers' age and institute-industry partnership. H3: ICT application has a positive relationship with TVET management success. H4: TVET managers' skills have a positive relationship with management success. H5: Institute-industry partnership has a positive relationship with management success. H6: Critical management factors (management practices and human resource practices) positively influence TVET management success.

5. Research Methodology

Sampling plan is a structured approach to selecting a subset of items or individuals from a larger population for the purpose of making inferences or drawing conclusions about the entire population. In research, the size of the sample plays a crucial role in the accuracy and reliability of the results. Faber and Fonseca [6] highlight that both excessively small and excessively large sample sizes can lead to misleading conclusions. The purpose of an optimal sample size is contingent upon the specific nature of the study.

In this particular study, the entire group of interest, or what we call the "universe" or "total population," consists of the managers working in TVET institutions. Specifically, the study focuses on TVET institutions located in Bangladesh,

which amount to a total of 149 establishments. Therefore, we have a clear understanding and knowledge of the complete population size for this study. Only the TVET managers or the Principals of TVET institutions in Bangladesh are the sampling unit of the study.

The research process involves several sequential steps, beginning with defining the research problem, which entails identifying the specific issue or gap in knowledge that the study aims to address. Based on this review, researchers formulate research hypotheses, stating the expected relationships between variables. Next, researchers select an appropriate research design that aligns with the study's objectives and hypotheses.

The study employed a quantitative research design. The population consisted of managers and principals from 149 TVET institutions in Bangladesh. Using Yamane's sampling formula, a sample size of 109 respondents was determined. Data were collected using a structured five-point Likert-scale questionnaire. Reliability was assessed through Cronbach's Alpha (0.946). Data analysis was conducted using SPSS and AMOS through descriptive statistics, EFA, CFA, correlation analysis, ANOVA, and multiple regression.

Yamane [17], the Taro Yamane formula is a statistical sampling technique that is used to determine sample sizes in research methodology. It helps to improve the accuracy level in determining the chunk of a population to sample at a reasonable margin of error. Applying Taro Yamane's formula and determined the sample size is 109.

Taro Yamane's formula is $[n= N/1+N*(e)^2]$ (1)

The researcher employed the simple random sampling technique to achieve the study's objectives. Simple random sampling is categorized under non-probability sampling methods. To select participants, namely TVET managers or Principals, the researcher utilized a straightforward approach.

The self-designed questionnaire which has been made after studying the relevant literatures were served physically by researcher among selected TVET Principals and Managers. Research questionnaire prepared in a way of literature review and talking to the TVET Managers. The questionnaire is fourfold based on research objectives. A demographic information, gender, age, qualification, experience length and marital status.

Questionnaire was prepared using a "five-point Likert scale" ranging from 1 to 5. The scale ranges from point "5", representing "Strongly agree", to point "1", which signifies "Strongly Disagree". The questions were aimed at exploring respondents' views and perspectives on TVET management's success in terms of handling critical managerial issues and contribution of ICT for the success of institutions.

6. Results and Data Analysis

Data collection serves as a pivotal phase in any research endeavor, tailored to fulfill the objectives set forth. In this particular study, data were collected through primary data source. Primary data entails gathering firsthand information directly from the source.

The data was summarized, analyzed and focused on research objectives. SPSS and AMOS are used to see the impact of the Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) been done. Checking descriptive statistics (mean, median, mode, cross tabulation and percentage analysis) used to understand the patterns as well as characteristics of data. Besides, ANOVA, Chi-Square test, correlations and graphical presentation used as the integral part of data analysis and interpretation process.

Reliability Test

In order to determine the reliability of the used measurement scales for each of the sections, the Cronbach Alpha coefficient was used (Table 1).

Table 1. *Cronbach's alpha values.*

Reliability Statistics	
Cronbach's Alpha	**N of Items**
.946	24

To assess the reliability of the measurement scales used in each section, the researcher used the Cronbach Alpha (Table 1). The reliability statistics provided indicate that Cronbach's Alpha coefficient for the measurement scale used in the study is 0.946. The high Cronbach's Alpha coefficient of 0.946 indicates the measurement scale used in the study is highly reliable, as it demonstrates strong internal consistency among its items.

EFA was conducted to identify the factors among the set of observed variables such as resource allocation management (M1), staff and faculty management (M2), students' enrolment and retention (M3), ability to address critical issues (M4), communication (M5), financial management (M6), leadership turnover (M7), professional development (M8), marketing and outreach (M9), regulatory compliance (M10).

Table 2. *KMO and Bartlett's Test for adequacy.*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.799
Bartlett's Test of Sphericity	Approx. Chi-Square	446.919
	df	45
	Sig.	.000

Kaiser-Meyer-Olkin measure of sampling adequacy (KMO Test). The sample is adequate if the value of KMO is greater than 0.5. If it is closer to 1 that means the data is fit for the next process. The Table 2 shows KMO as 0.799 which means that the sample is adequate here and the data is significant.

Table 3. Total Variance Explained.

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings*
	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%	Total
1	4.554	45.540	45.540	4.096	40.958	40.958	3.696
2	1.257	12.568	58.108	.719	7.190	48.147	3.373
3	.958	9.578	67.686				
4	.733	7.326	75.013				
5	.606	6.064	81.077				
6	.539	5.393	86.470				
7	.502	5.021	91.490				
8	.375	3.749	95.239				
9	.283	2.829	98.068				
10	.193	1.932	100.000				

*Extraction Method: Principal Axis Factoring

Principal Component Analysis (PCA) with Varimax rotation was conducted, resulting in the extraction of two components as shown in Table 3. Together, these components explain 48.17% of the total variance in the data. Each component was named based on the items that loaded most strongly onto them. The first component, termed "resource management allocation," correlates with two items, while the second component, termed "staff faculty management," correlates with five items. These two components are deemed significant as their eigenvalues exceed 1. Removing the remaining eight items could lead to a loss of 52% of the information contained in the data, highlighting the substantial contribution of the identified components, which collectively account for 48% of the variance.

Figure 1 is the scree plot that shows eigen values of the factors. The scree plot technique is a method used in factor analysis to determine the optimal number of factors to extract from the data. It involves plotting the eigenvalues of each factor in descending order. A straight line is then drawn through these plotted eigenvalues, starting with the largest one. The last point on this line represents the cutoff point for factor extraction. The term "scree" refers to loose stones found around the base of a mountain. Similarly, the plot helps differentiate between the essential factors (the "mountain") and the less significant factors (the "scree"). Essentially, it helps researchers identify the point beyond which additional factors do not contribute meaningfully to explaining the variance in the data.

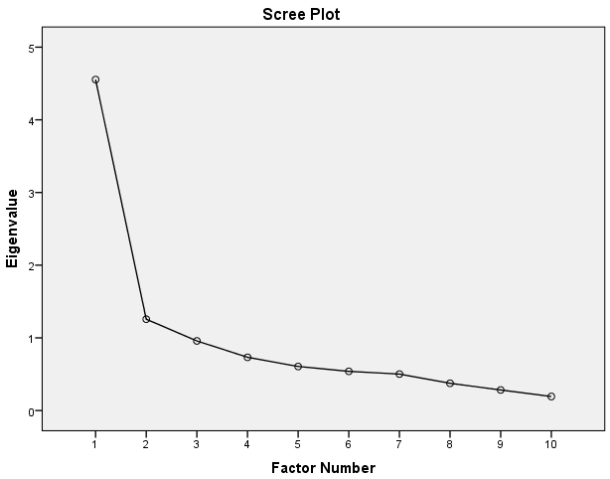


Figure 1. Scree Plot showing Eigen values of the factors.

Table 4. Rotated component matrix showing two distinctive components.

Rotated Component Matrix			
	Component		
	1	2	
F_I_M7	0.842		Leadership turnover
F_I_M10	0.749		Regulatory compliance
F_I_M8	0.732		Professional Development
F_I_M6	0.657		Financial Management
F_I_M9	0.589		Marketing and outreach
F_I_M3	0.557		Students' enrolment and retention
F_I_M2	0.554		Staff and Faculty Management
F_I_M5		0.775	Communication between Management and staff
F_I_M1		0.679	Resource Allocation Management
F_I_M4		0.589	Addressing the critical issue

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

In the rotated component matrix obtained from Principal Component Analysis with Varimax rotation, two distinct components were identified and the same is shown in Table 4. Component 1 is characterized by high factor loadings for factors related to leadership turnover, regulatory compliance, professional development, financial management, marketing and outreach, students' enrolment and retention, staff and faculty management, and addressing critical issues.

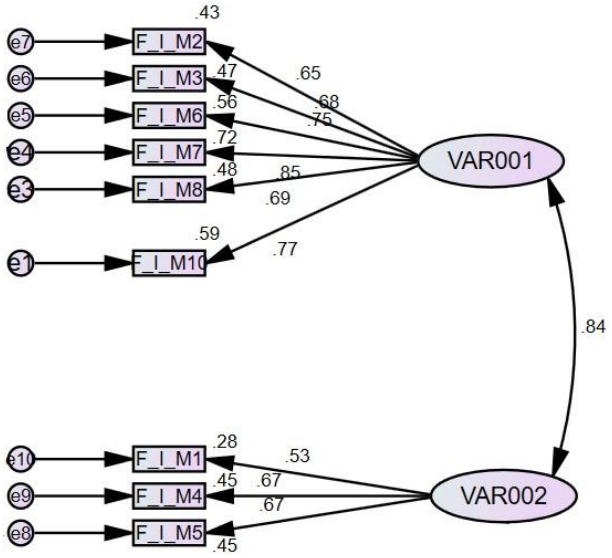


Figure 2. Confirmatory Factor Analysis (CFA) showing two latent variables.

The Principal Component Analysis (PCA) identified two latent variables out of the ten observed variables in the dataset. These latent variables were interpreted as Management Practices for variable VAR001 and Human Resource Practices for variable VAR002. CFA was then conducted using SPSS-AMOS software to validate the structure of the model. The CFA diagram illustrates that the six items related to Management practices, including leadership turnover and regulatory compliance, demonstrated strong relationships with the latent variable, as indicated by their high path coefficients ranging from. 65 to. 85. Additionally, the error loadings for these items were moderate, suggesting a good fit for the model. Similarly, the three items representing Human Resource Practices exhibited significant relationships with their latent variable, with path coefficients ranging from 0.53 to 0.67 and low error loadings. The strong correlation between the two latent variables further supports the model's validity in representing the running issues within the TVET setting. Overall, the CFA diagram indicates a good fit for the model, providing valuable insights into the management tasks in TVET institutions.

Means Plot (Gender and F1_M_Critical Managerial Challenges)

The Means plot is a visual representation of what we saw in the Compare Means output. The points on the chart are the average of each group. In the below four plots are the visual representation of above Table 3.

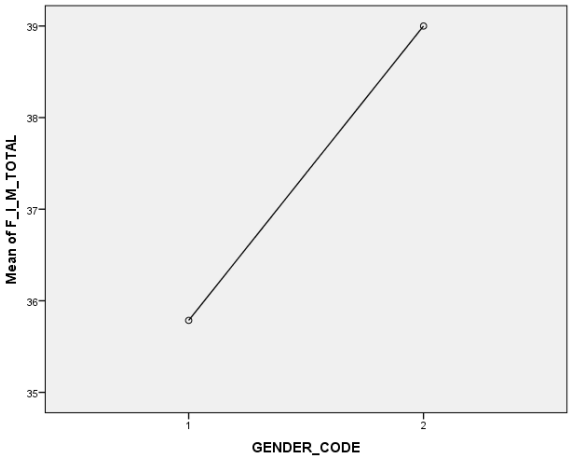


Figure 3. *Means Plot (Gender and F1_M_Critical Managerial Challenges).*

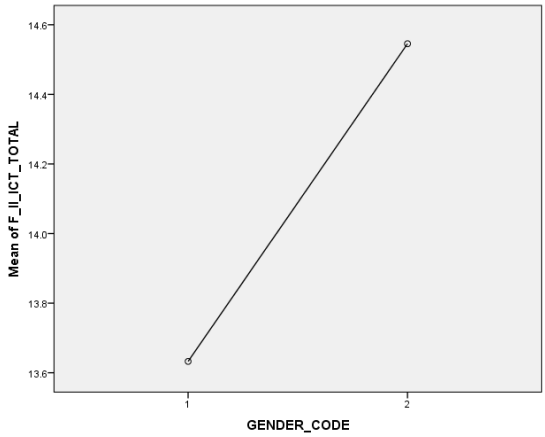


Figure 4. *Means Plot (Gender and FII_ICT Application).*

The above Figure 3 is the Means plot presenting descriptive statistics for Factor 1-Critical management challenges faced and TVET managers, categorized by gender. From the above figure it is seen that female managers/principals (Mean score 39) tend to report slightly higher mean scores in handling critical management challenges than male managers/principals (Mean score 35.79).

The above Figure 4. is the Means plot presenting descriptive statistics for Factor II-ICT application and TVET (Technical and Vocational Education and Training) managers, categorized by gender. From the above figure, it is seen that female managers/principals (Mean score 14.55) tend to report slightly higher mean scores in ICT application than male managers/principals (Mean score 13.63).

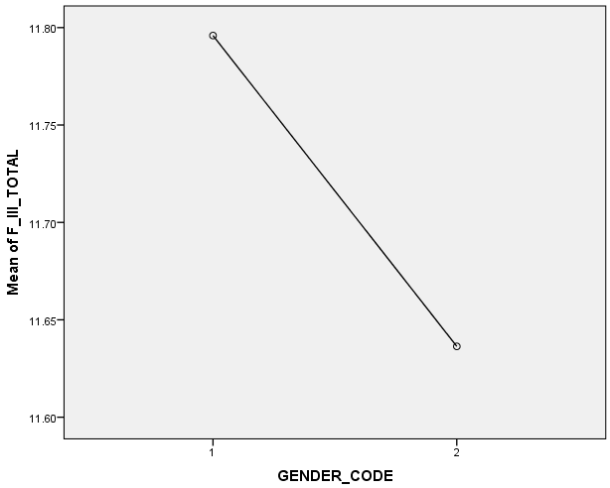


Figure 5. *Means Plot (Gender and FIII_TVET managers' skills).*

The above Figure 5. is the Means plot presenting descriptive statistics for Factor III-TVET managers' skills and TVET managers, categorized by gender. From the above figure, it is seen that male managers/principals (Mean score 11.80) tend to report slightly higher mean scores in than female managers/principals (Mean score 11.64).

Table 5. *Test of Homogeneity of Variances.*

Test of Homogeneity of Variances	Levene Statistic	df1	df2	Sig.
Critical Management Challenges	1.401	3	105	.247
ICT application	.596	3	105	.619
TVET Managers skills	1.303	3	105	.278
Institutional Partnership	1.506	3	105	.217

The above Table 5 tests the null hypothesis that the variance of the error term is constant across the cells defined by the combination of factor levels. Since the significance value of the test, 0.247,.619,.278 and. 217 are greater than the significance level (p>0.05), hence, null hypothesis is accepted. The first alternate hypothesis H2a: "There is a significant difference between age of the managers and handling critical management challenges" is rejected. This means that there is no significant difference between age of the managers and handling critical management challenges. This implies that age

alone does not influence in handling critical management challenges. There are other factors such as knowledge, experiences and decision-making capabilities that could contribute to handling critical managerial challenges. So, further research can be done in these areas. ICT technologies can also adapt to new technologies and development.

The Means plot is a visual representation of what we saw in the Compare Means output. The points on the chart are the average of each group. The four Means plots given below are the visual representation of above Table 5.

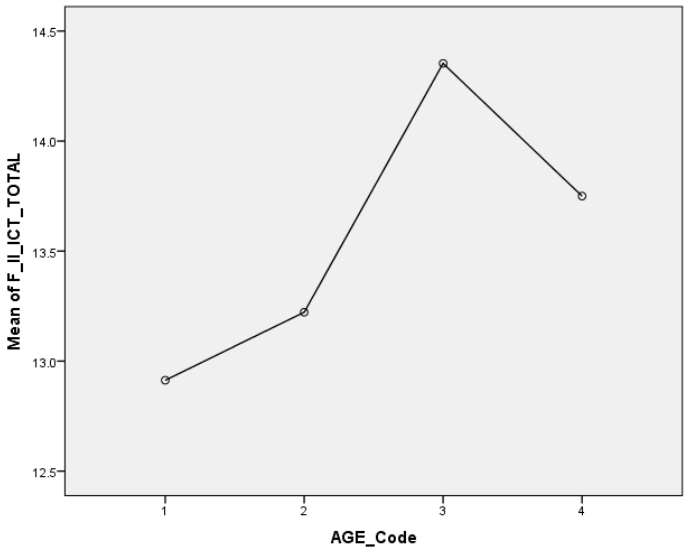


Figure 6. *Means Plot (Age and ICT application).*

The above Figure 6. is the Means plot presenting Mean values of ICT application and TVET managers, categorized by age of the respondents. From the above figure, it is seen for ICT application, the mean scores increase with the increase in age groups from level 1=30-39years; level 2=40-49 years to level 3=50-59 years, indicating that with increase in age of the managers/principals, the ability to apply ICT also increases, before decreasing slightly at level 4= above 60 years.

Table 6. *Test of Homogeneity of Variances.*

Test of Homogeneity of Variances				
	Levene Statistic	**df1**	**df2**	**Sig.**
Critical Management Challenges	2.198	2	106	.116
ICT application FII	.109	2	106	.897
TVET Managers skills FIII	.830	2	106	.439
Institutional Partnership FIV	.141	2	106	.869

The above Table 6 presents the results of the Test of Homogeneity of Variances for four variables: Critical Management Challenges, ICT application, TVET Managers skills, and Institutional Partnership. The Levene statistic measures the equality of variances across different groups or levels within each variable. For Critical Management Challenges, the Levene statistic is 2.198 with 2 and 106 degrees of freedom and a corresponding p-value of. 116. This suggests that there is no significant difference in variances across the levels for Critical Management Challenges. Similarly, for ICT application, TVET Managers skills, and Institutional Partnership, the Levene statistics are. 109,.830, and. 141, respectively, all with non-significant p-values (.897,.439, and. 869, respectively). These results indicate that there is no evidence to reject the assumption of homogeneity of variances across the different levels for each variable, allowing for valid comparisons between the groups.

Table 7. Model Summary for Predicting Management Success.

Model Summary										
Model	R	R Square	Adjusted R Square	Std. Error of the Est5imate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.899a	.808	.792	.39053	.808	51.411	5	61	.000	1.608

Predictors: (Constant), Managerial Practices, Managerial Skills, Industry-institute Partnership, Human Resource Practices, ICT
Dependent Variable: Management Success

The Model Summary Table 7 provides key statistics to assess the goodness of fit for a regression model predicting Management Success based on several predictor variables, including Managerial Practices, Managerial Skills, Industry-institute Partnership, Human Resource Practices, and ICT. The table shows that the model has an overall coefficient of determination (R-squared) of 0.808, indicating that approximately 80.8% of the variance in Management Success is explained by the predictors. The adjusted R-squared, which accounts for the number of predictors and sample size, is 0.792. The standard error of the estimate is 0.39053, representing the average deviation of observed values from the predicted values. Additionally, the Change Statistics section indicates that the R-squared change associated with adding the predictors to the model is significant (F Change = 51.411, $p < 0.001$), suggesting that the predictors collectively contribute to explaining the variance in Management Success. The above table we can understand that the regression model is statistically significant and provides a good fit for Management Success.

Table 8. Residuals Statistics for Regression Model Predicting Management Success.

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.4345	5.0532	3.3993	.77072	67
Std. Predicted Value	-2.549	2.146	.000	1.000	67
Standard Error of Predicted Value	.060	.187	.112	.033	67
Adjusted Predicted Value	1.3691	5.0613	3.3995	.77102	67
Residual	-.85978	.65448	.00000	.37544	67
Std. Residual	-2.202	1.676	.000	.961	67
Stud. Residual	-2.326	1.801	.000	1.012	67
Deleted Residual	-.95991	.75614	-.00020	.41692	67
Stud. Deleted Residual	-2.417	1.836	-.004	1.027	67
Mahal. Distance	.550	14.177	4.925	3.370	67
Cook's Distance	.000	.122	.019	.030	67
Centered Leverage Value	.008	.215	.075	.051	67

a. Dependent Variable: Management Success

The Residuals Statistics Table 8 provides a detailed summary of the predicted values and residuals for the regression model predicting Management Success. The predicted values range from 1.4345 to 5.0532, with a mean of 3.3993 and a standard deviation of 0.77072, indicating the spread of predicted Management Success scores. The standard error of the

predicted values is relatively small (mean = 0.112), suggesting precise predictions. The residuals, which are the differences between observed and predicted values, range from -0.85978 to 0.65448, with a mean of zero, indicating that the model's predictions are unbiased on average. The standardized residuals range from -2.202 to 1.676, showing most residuals fall within two standard deviations of the mean. The studentized residuals, which account for potential outliers, have a similar range, indicating consistency.

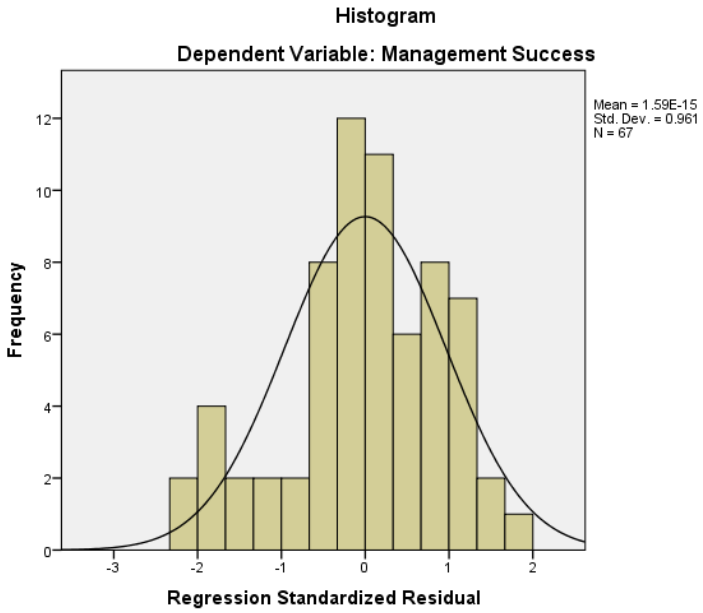


Figure 7. Regression Standardized Residuals for Management Success.

Figure 7 is the histogram depicting the distribution of the regression standardized residuals for the dependent variable "Management Success." The x-axis represents the residuals, while the y-axis indicates their frequency. The residuals follow roughly normal distribution, centered around zero, suggesting that the regression model's assumptions are reasonably met. The overlaying curve represents the normal distribution fit to the data. Key statistics provided include a mean of approximately zero (1.59E-15), a standard deviation of 0.961, and a sample size (N) of 67. The histogram indicates that the residuals are symmetrically distributed with no significant skewness or outliers, implying a good fit the regression model.

Previous studies emphasize four major determinants of TVET effectiveness. First, ICT adoption enhances communication, learning delivery, and institutional efficiency. Second, managerial skills, including technical, human, and conceptual competencies, improve institutional performance. Third, institute-industry collaboration strengthens curriculum relevance, practical training, and graduate employability. Fourth, management practices such as financial management, professional development, leadership continuity, communication, and regulatory compliance contribute to organizational effectiveness.

7. Findings

The findings indicate positive perceptions regarding resource allocation, financial management, leadership turnover management, professional development, and technical competencies. EFA identified two major latent dimensions: Management Practices and Human Resource Practices. CFA confirmed the validity of the measurement model. Regression analysis demonstrated that ICT application, managerial skills, industry-institution partnerships, management practices, and human resource practices significantly predict TVET management success. The model explained 80.8% of the variance in management success ($R^2 = 0.808$).

8. Recommendations and Conclusion

The results confirm that management success in TVET institutions is multidimensional. ICT integration improves operational effectiveness, while managerial competencies enhance decision-making and organizational performance. Industry collaboration contributes to curriculum alignment and employment opportunities. Effective governance and human resource practices further strengthen institutional success.

TVET institutions should invest in ICT infrastructure, strengthen industry collaboration, promote continuous professional development, and adopt evidence-based management practices. The study concludes that ICT utilization, managerial competencies, institutional partnerships, and effective management practices are critical drivers of TVET management success in Bangladesh.

Abbreviations

AI	Artificial Intelligence
ANOVA	Analysis of Variance
CFA	Confirmatory Factor Analysis
CPD	Continuous Professional Development
DOI	Digital Object Identifier
EduTech	Education Technology
EFA	Exploratory Factor Analysis
ERM	Enterprise Risk Management
ICT	Information and Communication Technology
MDL	Managers' Digital Literacy
PCA	Principal Component Analysis
SEM	Structural Equation Modeling
SME	Small and Medium-sized Enterprise
TVET	Technical and Vocational Education and Training

Author Contributions

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Data Availability Statement

Data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declared that there is no conflicts of interest.

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