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Digital Transformation Readiness of Technical and Vocational Education and Training Institutions: A Framework for Developing Countries

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Abstract— Technical and Vocational Education and Training (TVET) institutions in developing countries are under growing pressure to use digital technologies for teaching, administration, assessment, student records, and links with industry. However, digital transformation is not achieved by adding computers, internet access, or individual software systems. It requires institutional readiness across infrastructure, information systems, human resources, leadership, digital skills, data management, cybersecurity, finance, policy alignment, and change management. This study develops a TVET Digital Readiness Framework for assessing these capabilities and examines its relevance to Nepal and similar developing countries. The framework builds on previous e-readiness, information-system audit, enterprise architecture, ICT-in-education, and digital-government research published. Nepal is used as the main context because its public institutions had already adopted e-government policies, Government Enterprise Architecture, and the Digital Nepal Framework. The study also uses observations from the Inland Revenue Department (IRD), Government Integrated Data Center (GIDC), Center for Education and Human Resource Development (CEHRD), and TVET institutions to illustrate institutional readiness gaps. The proposed framework uses ten dimensions and a five-level maturity scale. It provides a structured method for identifying weaknesses, prioritizing investments, and testing readiness before large-scale digital transformation. The study concludes that TVET institutions in developing countries are generally at different stages of readiness and require coordinated institutional, technological, financial, and human-capacity development.

Keywords— TVET, digital transformation, digital readiness, e-readiness, enterprise architecture, Nepal, ICT governance

I. INTRODUCTION

Digital technology is increasingly changing how Technical and Vocational Education and Training (TVET)

institutions deliver teaching, manage administration, assess learners, maintain records, and connect graduates with employers. However, digital transformation is broader than introducing computers, internet services, or individual software applications. It requires changes in institutional processes, organizational capability, data management, applications, infrastructure, security, and interoperability. The World Bank notes that digital technologies produce sustainable benefits only when supported by appropriate institutions, skills, infrastructure, and governance [1].

Previous e-readiness studies in Nepal show that readiness depends on multiple and connected factors. Gupta, Marasini, and Shakya identified software and information systems, hardware, networks, ICT policies, security, and human resources as important dimensions of e-government readiness [2]. Marasini and Shakya further highlighted human-resource and infrastructure readiness [3] [4], while Gupta and Shakya emphasized information-system auditing, security, and governance [5] [6] [7]. These findings are relevant to TVET, but they do not provide a sector-specific readiness framework covering the wider organizational conditions required for digital transformation.

This study therefore asks whether TVET institutions in developing countries are sufficiently prepared for digital transformation and how readiness can be assessed and validated in Nepal and similar contexts. Its objectives are to identify the major dimensions of TVET digital readiness, develop an integrated assessment framework, examine Nepalese institutional evidence, and propose a method for validating the framework. The study contributes a practical readiness model linking technology with organizational, human, financial, governance, security, and policy capabilities.



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II. LITERATURE REVIEW

A. From Digitalization to Digital Transformation

Digitalization generally refers to the use of digital technologies to improve existing activities. Digital transformation is broader because it can change organizational processes, structures, services, decision-making, and relationships. This distinction is important for TVET institutions. A school can digitize student records without changing the way information is collected, verified, shared, or used. Similarly, installing a learning management system does not automatically improve teaching if instructors lack digital skills or if institutional processes remain manual.

The World Bank's *World Development Report 2016* identifies digital infrastructure, skills, institutions, and effective regulations as important foundations for obtaining digital dividends [1]. The report also warns that technology alone does not guarantee better outcomes. This principle applies directly to TVET because digital transformation requires institutional capability in addition to ICT equipment.

B. E-Readiness

E-readiness literature provides an important foundation for assessing institutional capability. Gupta, Marasini, and Shakya developed an e-readiness assessment for Nepalese ministries using six major areas: software and information systems, ICT hardware, network systems, ICT plans and policies, ICT security, and human resources [2]. Their approach demonstrates that readiness should be examined across several organizational dimensions rather than through a single technology indicator.

Marasini and Shakya's study of human-resource readiness found that ICT plans, infrastructure, hardware, and software are insufficient without capable personnel [3]. Their infrastructure study similarly examined the availability and status of ICT infrastructure as a foundation for e-government [4]. These findings are particularly relevant to TVET institutions where instructors, administrators, management, and technical staff must operate digital systems.

The present framework extends these ideas from e-government to TVET digital transformation. It adds leadership, governance, financial sustainability, data interoperability, change management, and institutional readiness because these factors influence whether technology can be sustained and integrated.

C. Information-System Governance and Security

Information-system audit provides another important dimension. Gupta and Shakya argued that information systems require systematic review of security, controls, reliability, and organizational risks [5] [6]. Their study of cloud-computing security also highlighted concerns related to data control, confidentiality, availability, and dependence on external infrastructure [7].

These issues are increasingly important for TVET. Student records, examination results, certificates, staff information, financial records, and institutional reports contain sensitive information. Weak authentication, poor backup, uncontrolled access, or inadequate disaster recovery can therefore create operational and legal risks.

Gupta and Marasini's research on machine learning and cybersecurity further shows the emerging role of automated techniques in intrusion and anomaly detection [8]. Although advanced security technologies were still developing, the underlying principle is relevant: cybersecurity must be considered as an institutional capability rather than an optional technical feature.

D. Enterprise Architecture and Government Systems

Enterprise Architecture (EA) provides a method for aligning organizational strategy, processes, information, applications, and technology. The Open Group's TOGAF 9.2 identifies Business, Data, Application, and Technology Architecture as major architectural domains [9]. Security and governance can be treated as cross-cutting concerns.

Nepal's Government Enterprise Architecture (GEA) similarly provided a national architectural approach for improving interoperability and alignment among government information systems [10]. Marasini and Gupta's analysis of government software development in Nepal found the importance of aligning software projects with government architecture and e-government objectives [11]. Their study of government software project success further identified project management, requirements, leadership, resources, stakeholder participation, and sustainability as important factors [12].

These studies support the argument that TVET systems should not be developed as isolated applications. A sector-wide architecture can define common processes, data standards, applications, infrastructure, security controls, and integration requirements.



E. Digital Skills and ICT in Education

UNESCO's ICT Competency Framework for Teachers emphasizes that effective ICT integration requires teacher competencies, professional development, curriculum integration, and institutional support [13]. This is particularly important for TVET because instructors must often combine technical skills with practical training and digital learning resources.

Digital transformation also requires administrative staff to develop digital skills. ICT capability should therefore include basic digital literacy, information management, digital communication, cybersecurity awareness, system-specific training, and continuous professional development.

F. National and Developing-Country Context

The United Nations E-Government Survey 2018 placed Nepal at an EGDI score of 0.4748 and rank 117. Nepal's Online Service Index was substantially stronger than its Telecommunication Infrastructure Index, indicating that development of online services did not necessarily correspond to equal development of infrastructure and human capability [14].

Nepal's Digital Nepal Framework, published in 2019, identified digital foundation and education among eight

priority sectors and proposed 80 digital initiatives [15]. The framework recognized connectivity, digital skills, cybersecurity, data, and institutional capacity as important enablers. This national policy environment provides a basis for aligning TVET digital transformation with national digital development.

III. METHODOLOGY/ CONCEPTUAL FRAMEWORK

This study uses a **conceptual framework-development and comparative case approach**. Literature was reviewed to identify established dimensions of e-readiness, ICT adoption, information-system governance, enterprise architecture, digital education, cybersecurity, and organizational change. The study then mapped these dimensions to the requirements of TVET institutions.

The framework was developed by combining four evidence groups: (1) international literature and standards; (2) Nepalese e-readiness and information-system research; (3) national digital-government and education policies; and (4) institutional observations from IRD, GIDC, CEHRD, and TVET institutions. The resulting model contains ten dimensions.

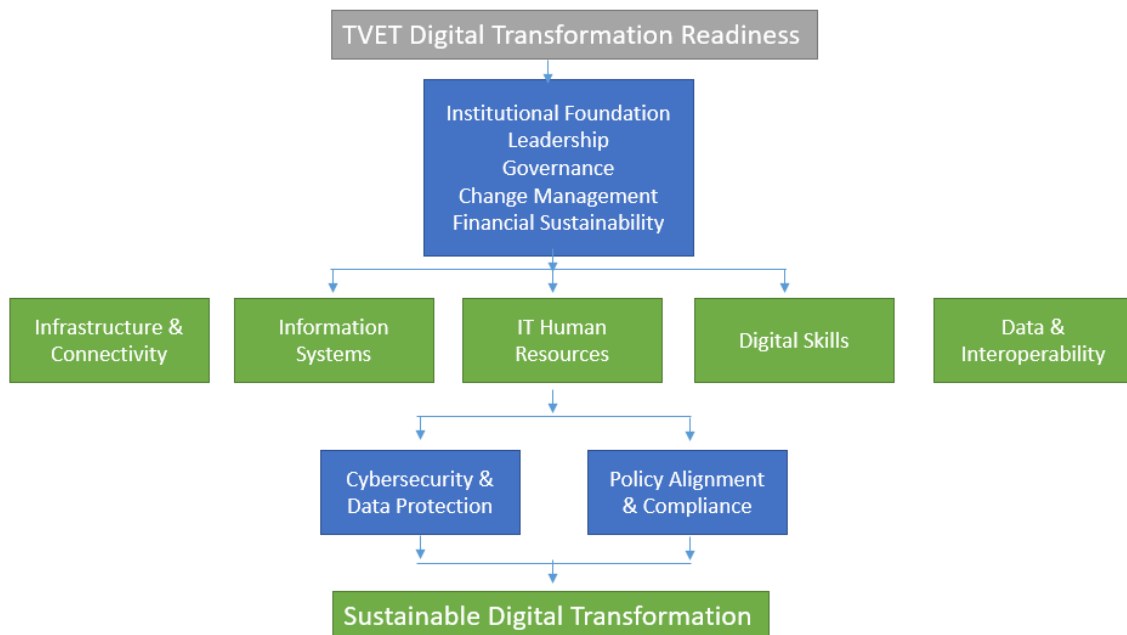


Fig 1. TVET Digital Readiness Framework



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Each dimension is assessed on a five-level maturity scale:

Level 1 – Initial: mostly manual processes and limited ICT capability.

Level 2 – Developing: basic digital tools exist, but systems and capabilities are fragmented.

Level 3 – Defined: policies, responsibilities, systems, standards, and processes are formally established.

Level 4 – Integrated: major systems, data, people, and processes are connected and managed.

Level 5 – Transformative: digital capabilities continuously improve institutional performance, teaching, administration, and external engagement.

The overall readiness score can be calculated as:

$$TDR = \frac{\sum_{i=1}^{10} w_i D_i}{\sum_{i=1}^{10} w_i}$$

where:

- TDR = TVET Digital Readiness score
- D_i = score of the i -th readiness dimension
- w_i = weight assigned to the i -th dimension
- $i=1, \dots, 10$ = the ten dimensions of the TVET-DTRF

If **equal weights** are used, the formula simplifies to:

$$TDR = 1/10 \sum_{i=1}^{10} D_i$$

This second version is probably better formula since different weights for the ten dimensions has not empirically been established.

Framework validation should occur in three stages: **content validation**, using experts to review dimensions and indicators; **pilot validation**, using selected TVET institutions; and **empirical validation**, using survey data and statistical methods such as reliability analysis, exploratory factor analysis, and confirmatory analysis.

IV. ANALYSIS AND DISCUSSION

The framework indicates that TVET digital readiness is a multidimensional institutional capability. No single factor is sufficient. Reliable connectivity without capable staff produces underused infrastructure. Skilled staff without appropriate applications create manual workarounds. Applications without common data standards produce duplication. Digital systems without security and backup create operational risk. Policies without leadership and funding produce weak implementation.

The first major issue is **infrastructure readiness**. Developing-country institutions may face unstable connectivity, limited bandwidth, inadequate devices, power interruptions, and insufficient technical support. Marasini and Shakya's infrastructure research confirms that ICT infrastructure is a basic requirement for electronic services [4]. However, infrastructure should be assessed together with availability, reliability, scalability, maintenance, and support.

The second issue is **institutional capacity**. Gupta, Marasini, and Shakya's e-readiness model identifies human resources as a core dimension [2]. Marasini and Shakya similarly argue that skilled human resources are necessary for implementing ICT systems [3]. For TVET, this includes IT personnel, instructors, administrators, and managers.

The third issue is **fragmentation**. Nepalese government software research highlights the importance of alignment with enterprise architecture and government objectives [11]. Independent development of systems can result in duplicated databases, incompatible applications, inconsistent reporting, and higher maintenance costs.

The fourth issue is **security and sustainability**. Information-system audit research [5] [6] and cloud-security research [7] show that security, control, availability, and data protection must be embedded into system planning. Financial sustainability is equally important because software, infrastructure, licensing, support, cybersecurity, and staff training create recurring costs.

Therefore, a TVET institution should not be classified as “ready” merely because it owns ICT equipment. Readiness should reflect whether the institution can **operate, govern, secure, integrate, finance, and continuously improve digital services**.

V. CASE STUDIES AND EXAMPLES

A. Inland Revenue Department

The Inland Revenue Department (IRD) provides an important example of a government institution that has moved toward extensive use of information systems. Institutional observation indicates that digital services require more than software development. The organization needs dedicated IT functions, permanent technical staff, continuous support, appropriate policies, institutional knowledge, and reliable infrastructure.

A key lesson from the IRD observation is the importance of **institutional ownership**. Dependence on temporary projects or external consultants can create knowledge gaps when systems require long-term maintenance. For TVET institutions, this suggests that digital transformation should include permanent IT responsibility and clear ownership of systems and data.

B. Government Integrated Data Center

The Government Integrated Data Center (GIDC) demonstrates the infrastructure side of digital government. Observation of GIDC identified challenges related to government priority, budget availability, skilled human resources, infrastructure, and institutional capacity.

These issues correspond directly to the readiness framework. Technology infrastructure cannot be separated from financing, human resources, governance, and political commitment. A data center may provide technical capacity, but institutions still require reliable connectivity, skilled

personnel, security procedures, disaster recovery, and clear service responsibilities.

C. Center for Education and Human Resource Development

CEHRD was established through the integration of major education-related functions and illustrates the importance of institutional coordination. Education systems generate large volumes of information about institutions, students, teachers, curricula, examinations, and services. Fragmented systems make it difficult to obtain consistent information for planning and decision-making.

The CEHRD example therefore supports the **data management and interoperability** dimensions of the framework. TVET systems similarly require common definitions and identifiers for students, institutions, instructors, qualifications, courses, assessments, and graduates.

D. TVET Institutions and Schools

Observation of TVET institutions indicates that schools may use separate systems for registration, student management, examinations, accounting, learning, and administration. Commercial school-management systems may provide useful functions, but independent procurement can produce different databases, software standards, and reporting structures.

The resulting risk is not necessarily the existence of multiple systems. The problem arises when these systems cannot exchange information or follow common standards.

TABLE I
 Illustrative Institutional Readiness Comparison

Institutional Context	Infrastructure	Human Capacity	Governance	Data/Integration	Security	Overall Readiness
IRD-type central agency	High	Medium-High	High	Medium-High	Medium-High	High
GIDC-type shared infrastructure	High	Medium	Medium	High	High	Medium-High
CEHRD-type education agency	Medium	Medium	Medium	Medium	Medium	Medium
Large TVET institution	Medium	Medium	Medium	Low-Medium	Medium	Medium
Small TVET institution	Low-Medium	Low-Medium	Low-Medium	Low	Low-Medium	Low-Medium

Note: The table is an analytical classification based on institutional observations and the framework dimensions; it is not a statistical measurement of individual organizations.

The comparison demonstrates that readiness is uneven. Central agencies may possess stronger infrastructure and governance, while individual TVET institutions may face

greater resource and human-capacity constraints. A national TVET framework should therefore support both



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institutional readiness improvement and sector-level coordination.

VI. POLICY RECOMMENDATIONS

A. Establish a national TVET digital-readiness program

The national TVET authority should assess institutions using a common readiness instrument before major digital investments. Institutions should receive a maturity score and a gap-analysis report.

B. Strengthen digital literacy

Digital literacy programs should cover teachers, administrators, managers, and technical staff. Training should include digital communication, information management, cybersecurity awareness, online teaching tools, data quality, and responsible use of institutional information.

C. Develop permanent ICT capacity

TVET institutions should have defined ICT positions and responsibilities. Small institutions may use shared technical-support arrangements, but ownership and accountability should remain clearly defined.

D. Develop common infrastructure standards

Minimum standards should cover internet connectivity, local networks, devices, backup, server or cloud services, power protection, technical support, and disaster recovery.

E. Establish interoperability standards

A common TVET data model should define students, institutions, instructors, programs, qualifications, examinations, certificates, employers, and graduates. New applications should support standardized APIs and data exchange.

F. Integrate cybersecurity into procurement

Security requirements should be included in system design, procurement, implementation, and maintenance. Regular audits should examine access control, backup, logging, vulnerabilities, privacy, and disaster recovery.

G. Ensure financial sustainability

Budgets should include recurring expenditure for licensing, hosting, maintenance, cybersecurity, technical support, upgrades, and staff training. Digital transformation should therefore be treated as a continuing institutional program rather than a one-time project.

H. Align TVET transformation with national policy

TVET digital initiatives should be mapped to Nepal's national ICT policy, Government Enterprise Architecture, and Digital Nepal Framework so that sector investments support national standards and avoid unnecessary duplication [11] [15].

VII. CONCLUSION

Digital transformation readiness in TVET institutions is a multidimensional capability involving technology, people, organizations, information, finance, security, governance, and policy. This study developed a TVET Digital Readiness Framework containing ten dimensions: digital infrastructure and connectivity; existing information systems; IT human resources and institutional capacity; leadership and governance; digital skills; data management and interoperability; cybersecurity and data protection; financial sustainability; national policy alignment; and change management and institutional readiness.

The framework extends earlier Nepalese e-readiness research. Gupta, Marasini, and Shakya established the importance of infrastructure, software, networks, policies, security, and human resources [2]. Gupta and Shakya's information-system audit studies emphasized security, controls, and governance [5] [6] [7]. Marasini and Shakya's studies reinforced the importance of human resources and infrastructure [3] [4]. Research by Marasini and Gupta on AI, cybersecurity, government software development, and project success further demonstrates the need for coordinated technological and organizational capability [16] [8] [11] [12]. The proposed TVET framework brings these concerns together within an education-sector readiness model.

The Nepal cases demonstrate why such a framework is necessary. Observations from IRD, GIDC, CEHRD, and TVET institutions show that infrastructure, institutional ownership, human resources, governance, interoperability, security, and funding are interconnected. Nepal's Digital Nepal Framework also provides a national policy basis for digital transformation [15].

The principal contribution is therefore a **practical and testable readiness framework** rather than a simple ICT checklist. It can help TVET authorities assess institutions before investment, identify weaknesses, prioritize interventions, and monitor progress.



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The study has limitations. The framework is conceptually developed and the institutional comparison is based on selected observations rather than a statistically representative national sample. The weighting of dimensions also requires empirical validation.

Future research should apply the framework to a larger sample of Nepalese TVET institutions, test indicator reliability, conduct factor analysis, derive evidence-based weights, and examine whether higher readiness scores are associated with improved administrative efficiency, teaching quality, learner outcomes, and employment-related services. The framework can subsequently be adapted and tested in other developing countries.

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