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Engineering Technology in Digital Transformation Linked with Vocational Training

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Abstract

Digital transformation in vocational education and training (VET) is more than introducing computers and software into schools. It reorganises teaching, learning, assessment and governance on the basis of concrete technological layers: network and data infrastructure, digital learning platforms, simulation and virtual reality, the Internet of Things, digital twins and artificial intelligence. This paper examines how these layers have been applied in Vietnamese VET during 2021-2026, drawing on policy documents, official statistics of the Ministry of Education and Training, sector conference reports and published studies. The findings show that the institutional framework has developed rapidly through Resolution No. 57-NQ/TW, Resolution No. 71-NQ/TW, the 2025 Law on Vocational Education and the Digital Competence Framework for Learners. Actual progress, however, has lagged behind targets: only about half of VET institutions met the digital transformation criteria by 2025, the sector database has not yet met the security conditions for linking to the national database, and technologies for practical training are unevenly distributed. The main bottleneck lies not in administrative software but in bringing technology into hands-on workshop hours, in teachers' digital pedagogical competence and in enterprise participation. Using the case of the newly merged Phu Tho province and Vinh Phuc College of Engineering and Technology, the paper proposes five groups of solutions for a "practice-centred" digital transformation, emphasising shared digital workshops, occupation-specific digital competence standards and co-investment mechanisms with enterprises.

Keywords: Digital Transformation, Vocational Training, VET, Engineering Technology, Digital Competence, Simulation-Based Practice

1. Introduction

Over the past five years, digital transformation has become a requirement with targets and deadlines in Vietnam's vocational education system. Decision No. 2222/QD-TTg of 30 December 2021 of the Prime Minister approved the Programme on Digital Transformation in Vocational Education to 2025, with orientation to 2030, setting as its key target that 70% of VET institutions would apply digital transformation in teaching and learning by the end of 2025. Subsequently, the Politburo issued Resolution No. 57-NQ/TW of 22 December 2024 on breakthroughs in science, technology, innovation and national digital transformation, and Resolution No. 71-NQ/TW of 22 August 2025 on breakthroughs in education and training; the National Assembly then adopted the amended Law on Vocational Education, effective from 1 January 2026. Vocational training has thus been placed at the intersection of the two largest policy streams of the present period: national digital transformation and education reform.

The picture inside school workshops, however, is far less uniform than the documents suggest. Some colleges already use electro-pneumatic simulation software, PLC laboratories connected to the Internet of Things (IoT) and digital learning repositories; others still teach welding, turning and industrial electrics largely with ageing equipment and slide presentations. A 2025 report by the managing authority acknowledged that only just over 50% of VET institutions met the basic digital transformation requirements and that the 70% target would be difficult to reach on time (Quang Huy, 2025) [21]. The question is therefore no longer whether digital transformation is needed, but which engineering technologies it should rely on, at which stage of the training process, and why results have been slower than expected.

Vocational training has one feature that makes digital transformation harder than in theory-based education: most of the

curriculum is practice, and learning outcomes are measured by the ability to perform real tasks on real equipment. A well-designed e-lecture does not teach a student to produce a weld that meets the standard. If digital transformation stops at digitising records or putting lectures online, a school may meet many criteria on paper without touching the core of training quality. Conversely, technologies that act directly on occupational skills, such as simulation, virtual reality, digital twins or IoT sensors, demand considerably higher costs, technical capability and cooperation with enterprises.

This tension is not unique to Vietnam. Across countries, vocational systems have found it easier to digitise administration and theoretical instruction than to digitise the workshop, because the workshop is where cost, safety and tacit know-how converge. A digital attendance system can be rolled out in a few weeks across a whole college; a digital welding workshop requires simulators, trained instructors, revised assessment criteria and, ideally, an employer willing to recognise simulator hours as part of competence development. The difference in difficulty explains why aggregate indicators can look encouraging while classroom and workshop practice changes slowly.

Domestic research on this topic is fairly abundant but mostly concerns educational management or general solutions for a single school (Nguyen Dong Van & Do Thi Ngan, 2025; Tran Vuong Ngoc, 2024; Hoa Cuc Huong, 2023) [13, 29, 5]. Few studies examine where each technological layer is used, for which occupations, and how it connects with the labour market. Moreover, the legal framework and the network of institutions changed substantially in 2025-2026, so earlier assessments need updating.

The paper addresses three research questions: (1) which technological layers constitute digital transformation in vocational training and which stages of training they affect; (2) how these layers have been applied in Vietnam in 2021-2026 and where the main bottlenecks lie; (3) what solutions are needed for digital transformation to be genuinely linked with vocational training, particularly in local engineering colleges such as Vinh Phuc College of Engineering and Technology. The paper does not use a quantitative model; it offers an in-depth situational analysis based on secondary sources, policy documents and an illustrative case.

2. Theoretical Background and Literature Review

2.1 Digital transformation and the place of engineering technology in vocational training

The international literature commonly distinguishes three concepts. Digitisation is the conversion of information from physical to digital form. Digitalisation is the use of digital technology to improve an existing process. Digital transformation is a systemic process in which digital technologies trigger changes in structures, in value creation and in the ways stakeholders interact (Vial, 2019) [34]. In a school, digital transformation truly happens only when the way curricula are designed, lessons are organised, learners are assessed and enterprises are engaged changes as a result of data and digital technology.

Decision No. 2222/QD-TTg defines digital transformation in VET as carrying out vocational education activities in a digital environment and promoting ICT use in management, teaching, testing and assessment. A ministerial-level research project led by the National Institute for Vocational Education and Training, with Dr Nguyen Duc Ho as principal investigator, approaches digital transformation from two sides: as a process, it means bringing and sharing data on school activities in the digital environment; as an outcome, it means creating new value for learners, enterprises and society (Huyen Trang, 2025) [7]. This approach implies that digital transformation should be measured by output value, not merely by the number of software systems deployed.

In this paper, "engineering technology in digital transformation linked with vocational training" refers to the set of technical solutions (hardware, software, data, connectivity and intelligent tools) organised into a system that directly supports three groups of activities in a vocational school: teaching theory, teaching practice, and managing training in connection with the labour market. A technology is regarded as linked with vocational training only when it makes the formation of occupational skills more effective, safer, cheaper or closer to real production.

2.2 Technological layers of a digital vocational school

From an engineering perspective, the technologies serving digital transformation in vocational training can be grouped into five stacked layers. Each lower layer is a precondition for the one above, but the value for vocational training is concentrated in the upper layers.

The first layer is digital infrastructure: local networks, Internet connections, Wi-Fi, servers or cloud services, end-user devices and information security solutions. This foundation is often underestimated; in many schools Wi-Fi covers only the administrative block and lecture halls, while workshops have hardly any stable connection.

Infrastructure decisions also shape what is pedagogically possible higher up. A workshop without reliable connectivity cannot host cloud-based simulation, cannot stream data from training rigs to a teacher's dashboard and cannot let students consult manufacturers' digital service manuals at the workbench. Conversely, connecting workshop equipment to the school network without segmentation exposes administrative systems to the experimentation that students legitimately perform when learning to configure industrial devices. Network design is therefore a didactic as well as a technical matter.

The second layer is data and management platforms: databases of learners, teachers, programmes and equipment; training management and finance software; digital diploma systems; and links with sector and national databases. This layer determines whether a school "knows itself": which occupations have high dropout, which equipment is out of order, where graduates are employed.

The third layer is digital teaching platforms: learning management systems (LMS), digital learning repositories, e-lectures, technical videos, online question banks and blended-learning tools. This layer suits occupational theory and common subjects such as informatics, foreign languages and occupational safety.

Its contribution to vocational training should not be underestimated, however. Short technical videos showing a correct operation from the operator's viewpoint, step-by-step procedures accessible on a tablet at the machine, and online quizzes on safety rules before entering the workshop all prepare students for practice and free up workshop time for doing rather than explaining. The value of this layer depends less on the platform than on whether its content is designed around concrete workshop tasks.

The fourth layer, specific to vocational training, is

technology for practical instruction. It includes engineering simulation software (electrical circuits, pneumatics, hydraulics, PLC, CNC), virtual reality (VR) and augmented reality (AR) for dangerous or material-intensive operations such as welding, spray painting and machine operation; IoT-connected training equipment; and digital twins of machines and production lines. A digital twin is a digital model continuously synchronised with its physical counterpart, enabling observation, testing and prediction before acting on real equipment (Tao *et al*., 2019) [26]; in training, students can make repeated trial-and-error attempts without damaging machines or compromising safety. The systematic review by Radianti *et al*. (2020) [22] shows that immersive VR is particularly useful for procedural and manipulative skills, but its effectiveness depends heavily on pedagogical design.

The fifth layer is intelligent technology, mainly artificial intelligence (AI) and learning analytics, which can support personalised learning paths, automated marking, early warning of dropout risk, or image analysis of welds and machined parts. Zawacki-Richter *et al*. (2019) [38] found that most AI applications in education concentrate on administration and assessment, while educators' role in designing them remains marginal; in vocational schools, where teachers' occupational know-how is the hardest thing to digitise, this is an important caveat.

The five layers are interdependent. A genuine digital workshop combines all of them: real equipment fitted with sensors, recorded operating data, instructions on the learning platform, a stable network and tools that help teachers analyse results. It is this combination that distinguishes a "digital vocational school" from a vocational school with a lot of software.

The layered view also clarifies sequencing. Schools that invest in the upper layers without the lower ones tend to end up with simulators that cannot be updated, connected equipment whose data are never stored, or AI tools without data to learn from. Schools that invest only in the lower layers obtain efficient administration but little change in skills. A balanced pathway builds enough infrastructure and data capability to support a small number of well-designed practical applications, then expands them occupation by occupation.

2.3 Digital competence of learners and teachers

Technology delivers value only when its users are competent. Internationally, the European Union's Digital Competence Framework for Citizens, DigComp 2.2, comprises five areas and 21 competences (Vuorikari *et al*., 2022) [36], while the Digital Competence Framework for Educators, DigCompEdu, covers six areas, from professional engagement to facilitating learners' digital competence (Redecker, 2017) [23]. In 2024 UNESCO published AI competency frameworks for students and teachers, emphasising a human-centred mindset, the ethics of AI and system design capabilities.

In Vietnam, the Ministry of Education and Training issued Circular No. 02/2025/TT-BGDDT of 24 January 2025 on the Digital Competence Framework for Learners, effective from 11 March 2025. The framework comprises 6 competence areas with 24 component competences, divided into 4 proficiency levels from basic to advanced across 8 grades, and applies to learners throughout the national education system, including VET. It serves as the basis for programme standards, curriculum development and learning materials. This is a significant change for vocational schools: digital competence is no longer a "nice-to-have soft skill" but part of measurable learning outcomes.

However, the general framework describes competences at a universal level, such as working with data, communicating in digital environments, creating digital content and staying safe online. The digital competence of an industrial electrician, by contrast, consists in reading PLC data, configuring HMI screens and diagnosing faults through software; that of a machinist consists in programming and simulating CNC programs. The gap between general and occupation-specific digital competence is precisely where engineering technology in vocational training has to step in. The TPACK model of Mishra and Koehler (2006) [10] suggests the same on the teachers' side: teaching well with technology requires the intersection of technological, pedagogical and content knowledge.

Occupation-specific digital competence also has an attitudinal and safety dimension that general frameworks treat only briefly. A technician working on a networked production line must understand that changing a parameter in a PLC can stop a line or endanger a co-worker, and that connecting a personal device to an industrial network may introduce security risks. Such competences are best developed in realistic practical contexts rather than in stand-alone informatics courses, which again points to the workshop as the main site of digital competence development in vocational training.

2.4 Literature review and research gap

International studies point to two trends. Spöttl and Windelband (2021) [24] show that digitalisation does not eliminate intermediate-level technical work but restructures its tasks: workers perform fewer repetitive operations and spend more time monitoring, diagnosing and troubleshooting automated systems. Avis (2018) [1] warns against "technological optimism", in which policy assumes that investing in modern equipment will automatically raise training quality. What these studies share is that equipment is only a necessary condition; teachers' competence, curriculum design and enterprise involvement determine whether technology turns into occupational skills.

Domestic studies fall into three groups. The first deals with digital transformation in VET management; Nguyen Dong Van and Do Thi Ngan (2025) [13], for example, identify problems of infrastructure, human resources and mechanisms in VET institutions. The second consists of case studies of digital transformation solutions at particular schools, such as Viet Duc College of Nghe An (Hoa Cuc Huong, 2023) [5] and Vinh Phuc College (Tran Vuong Ngoc, 2024; Nguyen Thi Le Dung & Pham Thi Dieu Thuong, 2025) [29, 14]. The third group studies the application of a specific technology to a vocational module, for instance PC-SIMU and CADe-SIMU software in teaching the electro-pneumatic systems module at Viet Duc Ha Tinh Technical College (Dong Van Nam, 2025) [4], a smart electrical training model based on Tuya switches for electrical trades at Lao Cai College (Tran Thi Hong Hoa & Hoang Duc Luong, 2025) [28], or VR and AR in mechanical practice.

In general, the first two groups remain at the level of orientation and rarely address specific technologies, whereas the third is very concrete but detached from the system-level and policy picture. This paper seeks to connect the two ends:

it places each technological layer within the new policy framework, compares targets with reported results, and updates the context following the 2025 restructuring of the state apparatus and the merger of provinces.

International experience offers useful reference points, although it cannot be transferred mechanically. In Germany, the Federal Ministry of Education and Research and the Federal Institute for Vocational Education and Training (BIBB) ran the joint initiative "VET 4.0" from 2016 to 2018. It screened 14 recognised training occupations to identify how digitalisation was changing work processes and skill requirements, and it found that digitalisation had reached all of them, though at different speeds depending on the company and the occupation (Zinke, 2019) [37]. The initiative also included a special programme on digital transformation in inter-company vocational training centres, which give small firms access to up-to-date equipment. In Singapore, the SkillsFuture movement launched in 2015 has made lifelong, modular upskilling of adults a national priority, while also facing a persistent social preference for academic over vocational pathways (Tan, 2017; Lim *et al*., 2024) [25, 9]. In the Republic of Korea, Meister high schools were introduced in 2010 as industry-tailored vocational schools with autonomy over curricula and close partnerships with employers, and their graduates have achieved stronger labour market outcomes than those of other vocational schools (Park & Yu, 2023) [17]. China has invested in simulation-based practical training in vocational colleges, using VR and AR in fields such as automotive repair, aircraft maintenance and spray painting (Trong Nhan, 2025) [30]. Three lessons stand out for Vietnam: shared training centres reduce the cost of advanced equipment; industry participation is essential for keeping technology current; and modular digital learning is particularly valuable for adult and short-course learners.

3. Research Methodology

3.1 Approach

The paper adopts a qualitative, descriptive-analytical approach without a quantitative model, for two reasons: the object of study has been changing very quickly in institutional and organisational terms during 2025-2026, and sector-specific digital transformation indicators have not been published as a consistent institution-level dataset.

3.2 Data sources

Data were collected from four sources: (i) policy documents, including Decision No. 2222/QD-TTg, Decision No. 2239/QD-TTg, Resolution No. 57-NQ/TW, Resolution No. 71-NQ/TW, Law on Vocational Education No. 124/2025/QH15, Law No. 123/2025/QH15, Circular No. 02/2025/TT-BGDDT and Decision No. 1266/QD-TTg of 14 July 2026 approving the National Digital Transformation Strategy; (ii) official figures and reports of the Ministry of Education and Training released at conferences in 2025-2026; (iii) published academic works; (iv) materials on Phu Tho province and Vinh Phuc College of Engineering and Technology.

3.3 Analytical framework

Building on the five technological layers in Section 2.2 and the task groups of Decision No. 2222/QD-TTg, the analysis is organised around five pillars: (1) institutions, policies and targets; (2) digital infrastructure, data and digital governance; (3) teaching technology, particularly for practical training; (4) digital competence of teachers and learners; (5) linkages with enterprises. Each pillar is examined through three questions: what exists, how far it has progressed against targets, and where it is stuck. The case of Phu Tho province and Vinh Phuc College of Engineering and Technology is used to test system-level observations against a concrete context.

The specific methods are document analysis and synthesis, content analysis of policy texts, comparison of targets with results, and case study. Because some figures were reported at conferences without a publicly available original report, the authors cross-checked several sources and state the date of each figure.

4. Current State of Engineering Technology in Digital Transformation Linked with Vocational Training

4.1 Institutions, policies and targets

The period 2021-2026 has produced the densest body of policy on digital transformation in VET to date, which can be grouped into three layers of documents.

The layer of Party guidelines comprises Resolution No. 57-NQ/TW, which aims for Vietnam to be among the top three Southeast Asian countries in digital competitiveness by 2030, with the digital economy accounting for over 30% of GDP, creating strong demand for technical workers able to operate in digital environments; and Resolution No. 71-NQ/TW, which identifies VET as playing a key role in developing a skilled workforce and targets at least 80% of VET institutions meeting national standards and 20% being invested in to a level comparable with developed Asian countries by 2030. The Resolution also states plainly that the VET system remains fragmented and outdated.

The legislative layer was renewed almost simultaneously. On 10 December 2025, the National Assembly adopted the amended Law on Vocational Education with 433 of 439 deputies in favour; the Law has 9 chapters and 46 articles and took effect on 1 January 2026 (Thanh Hai, 2025) [27]. It expands the autonomy of VET institutions, establishes national occupational skills standards linked to enterprise requirements, and for the first time provides for enterprise-level workforce training funds (Hoang Huong, 2025) [6]. On the same day, Law No. 123/2025/QH15 amending the Law on Education stipulated that the State invests in comprehensive digital transformation of education and training through digital infrastructure, digital platforms and a national education and training database. This is the first time digital transformation has been recognised as a State investment responsibility at the level of law in the education sector.

The layer of programmes and plans is closest to schools. Decision No. 2222/QD-TTg remains the backbone, with targets for 2025 and 2030, while Circular No. 02/2025/TT-BGDDT adds a digital competence standard for learners. For the 2025-2026 school year, the Ministry of Education and Training required VET and continuing education institutions to treat digital transformation and AI as the breakthrough element. The National Digital Transformation Strategy approved by Decision No. 1266/QD-TTg of 14 July 2026 provides a new framework for sectoral programmes, and some provinces, such as Thai Nguyen, have issued plans for digital transformation in VET for 2026-2030.

Table 1 summarises selected targets of Decision No. 2222/QD-TTg and their implementation according to published figures.

Table 1: Selected digital transformation targets in VET and their implementation

Target	2025 milestone	2030 milestone	Implementation according to published figures
VET institutions applying digital transformation in teaching and learning	70%	Extended to the whole system	Just over 50% of 1,545 institutions (2025); the managing authority judged the 70% target unlikely to be met on time
Digital map of the VET institution network	Established	Linked with authentication and information look-up systems	Network being restructured; 382 public institutions fewer in 2025
Specialised inspections conducted in the digital environment	50%	70%	No aggregate figures published
High-quality colleges offering digital training programmes	Gradual	100%	Concentrated in high-quality colleges and schools with international projects
VET database connected to the national database	According to the sector roadmap	Connected and shared	As of November 2026, security conditions for connection not yet met

Source: Compiled by the authors from Decision No. 2222/QD-TTg; Quang Huy (2025) [21]; Tuong San (2026) [31]; Vietnam+ (2026) [35].

Table 1 shows that the targets are designed around the logic of "the share of institutions that have applied", that is, they measure coverage rather than depth. A school with training management software and a repository of e-lectures can be counted as having applied digital transformation in teaching and learning even if students' practical sessions have not changed at all. This is one reason why the gap between reports and the reality of workshops remains wide.

4.2 Network context and training scale

Digital transformation in vocational training is taking place alongside the largest restructuring of the institutional network ever undertaken. In 2025, state management of VET was transferred from the Ministry of Labour, Invalids and Social Affairs to the Ministry of Education and Training. The number of VET institutions fell sharply, from about 1,545 cited in the assessment of Decision No. 2222/QD-TTg to 1,163 in September 2025, comprising 518 public and 645 non-public institutions. As of 31 December 2025, compared with the end of 2024, the country had 382 fewer public institutions, namely 22 colleges, 73 intermediate schools and 248 centres, while private institutions increased by 21 (Tuong San, 2026) [31].

In terms of scale, in 2021-2025 the system trained about 10.45 million people, of whom 8.8 million received certificates or diplomas, with an employment rate of graduates above 80% (Van Dung, 2025) [33]. In the 2024-2025 school year, over 80% of graduates found jobs immediately, 70-75% of them in their field of training. Nevertheless, the training structure remains heavily skewed towards short courses: in the first half of 2025, around 1 million people enrolled, but only about 100,000 at college and intermediate levels, while some 900,000 were at elementary level or in other programmes.

These figures carry two implications. Restructuring is both a challenge, because merging schools entails merging very different software, data and procedures, and an opportunity, because a larger school can pool resources to invest in digital infrastructure and digital workshops of sufficient scale. In addition, with about 90% of learners in short programmes, flexible learning technologies such as online learning, micro-learning and digital certificates have great potential, yet this segment receives little attention in indicators designed around the school as the unit.

A third implication concerns the regional distribution of capacity. As public intermediate schools and VET centres are consolidated, fewer but larger institutions will serve wider catchment areas. Learners in rural and mountainous districts may face longer distances to the nearest college. In this setting, digital technologies are not only a means of improving quality but also a means of maintaining access, for instance through blended programmes in which theory and simulation are completed online and intensive practical blocks are organised at the college or at a partner enterprise.

4.3 Digital infrastructure, data and digital governance

In the infrastructure and data layer, the clearest results are in digitisation. According to a report at the national conference on digital transformation in education on 6 November 2026, 66.6 million diplomas have been digitised, but about 44 million are not yet linked to citizen identification numbers, and of the roughly 12 million synchronised to VNeID only about 1.2 million have been verified by their holders; the National Digital Education Governance Platform has been deployed in only 6 localities (Vietnam+, 2026) [35]. Deputy Prime Minister Le Tien Chau identified five bottlenecks, including that the VET database does not yet meet the information security conditions required to connect with the national database; the others are slow verification and use of data, governance platform infrastructure not yet ready for scaling, ineffective use of data to cut administrative procedures, and a shortage of resources for digital transformation.

At school level, training management software, online admissions, web portals and digital signatures are now common in colleges. The problem is whether these systems communicate with one another. A school may use admissions, training management, accounting and LMS software from four different vendors; it then becomes very difficult to answer basic questions such as which occupation has high dropout or where graduates work. A forum of technology colleges held in August 2025 at Hanoi High-Tech College made a practical observation: to transform digitally, one must first have the "digital", meaning equipment, connectivity and technical conditions.

In schools formed through mergers, learner data from the former schools have different structures, and occupation and subject codes are inconsistent. Without cleaning and standardisation, merging systems merely produces a larger, not a more reliable, data store. This is exactly what the Ministry's orientation for 2026-2030 towards databases that are "accurate, complete, clean, live, unified and shared"

seeks to address.

Information security is a rarely mentioned weakness. Vocational workshops contain many networked devices (CNC machines, PLCs, cameras, sensors), and students frequently practise network configuration; if the workshop network is not separated from the administrative network, data risks are considerable.

A further issue is the human capacity behind infrastructure. Many colleges have only a small IT unit whose staff manage networks, software licences, websites and user support simultaneously. When digital transformation adds learning platforms, connected workshops and data integration, the workload grows faster than staffing. In practice, teachers of IT or electronics are often drawn in informally, which is unsustainable and diverts them from teaching. Planning for digital transformation therefore needs to include positions and competences for system administration, data management and information security, not only equipment budgets.

4.4 Teaching technology, especially for practical training

This pillar determines whether digital transformation is genuinely linked with vocational training. The current situation can be described at three levels.

The first and most widespread level is digitised learning materials and blended learning. Most colleges have e-lectures, and many have an LMS, lecture-recording studios and online question banks. In Ho Chi Minh City, Cao Thang Technical College, Ho Chi Minh City College of Economics and Technology, Thu Duc College of Technology and Nam Saigon Polytechnic College have implemented digital-school criteria, digital competence modules and e-learning studios; Ly Tu Trong College of Technology applies a flipped-classroom model combined with a digital library and CNC practice (Quang Huy, 2025) [21]. However, the quality of materials varies, and many e-lectures are in fact slide decks uploaded online.

A frequent pattern is that digital materials are produced in short campaigns linked to competitions or evaluation rounds, then left without updating. Because vocational content changes with equipment and standards, outdated materials quickly lose relevance. Sustainable practice requires a production and review cycle tied to curriculum revision, with clear ownership by subject groups and with time recognised in teachers' workloads.

The second level is simulation and smart training models for individual vocational modules, the most dynamic area, driven by teachers at moderate cost. At Viet Duc Ha Tinh Technical College, integrating PC-SIMU and CADe-SIMU into the electro-pneumatic systems module reduced trial-and-error time on real equipment and helped students diagnose faults on their own (Dong Van Nam, 2025) [4]. Lao Cai College built a smart electrical model based on Wi-Fi-connected Tuya switches, enabling students to wire, configure and script device control (Tran Thi Hong Hoa & Hoang Duc Luong, 2025) [28]. Nha Trang College of Engineering and Technology developed a control model for household electrical appliances using PLC, HMI and a mobile application (Nguyen Thi My Na, 2025) [15]. These models bring precisely the technologies workers will meet on the job into practical sessions, at a cost affordable to local colleges.

The third level is digital workshops, VR and digital twins at system scale, currently concentrated in a few high-quality colleges or schools with international projects. Vien Dong College integrates AI, big data, automation, simulation and VR into teaching. LILAMA 2 International Technology College, under the Vietnamese-German programme "Reform of TVET in Viet Nam" implemented with GIZ, has delivered advanced training on connecting IoT gateways through PLC programming on HMI interfaces for teachers from partner schools and company trainers. Meanwhile, vocational colleges in China already use virtual spray-painting systems, VR-based aircraft maintenance and AR "practice assistant" glasses for automotive repair (Trong Nhan, 2025) [30]; the gap with most Vietnamese vocational schools remains considerable.

Table 2 maps the technological layers against occupational groups and their current prevalence, based on the literature reviewed.

Table 2: Application of practical-training technologies by occupational group

Occupational group	Suitable technologies	Value for occupational skills	Current prevalence
Industrial and domestic electrics	Circuit simulation software, IoT models, smart home, PLC-HMI	Practising wiring, configuration and safe fault diagnosis	Fairly common, mostly developed by departments themselves
Mechatronics, automation	PLC simulation, digital twins of production lines, industrial robots, IoT gateways	System understanding, programming, monitoring, troubleshooting	Moderate, concentrated in high-quality colleges
Metal cutting, CNC	CAD/CAM, CNC program simulation, networked CNC machines	Programming, collision checking, tool-path optimisation	Moderate
Welding	VR welding simulation, cameras for weld analysis	Lower material consumption; training posture, speed and torch angle	Low, due to high investment cost
Automotive technology	Diagnostic tools, manufacturers' digital service data, AR for assembly	Data-based diagnosis, procedure look-up	Moderate, dependent on links with manufacturers
Information technology, electronics	Virtual labs, cloud environments, embedded devices	Programming, network configuration, information security	Fairly common
Accounting, business, services	Business software, enterprise simulation, AI tools	Processing transactions on real software	Fairly common

Source: Compiled and qualitatively assessed by the authors from the studies and reports cited.

Table 2 reveals a paradox: the occupations that need simulation most, because practice on real equipment is costly or dangerous (welding, industrial machine operation), are those where simulation is least common, owing to high equipment prices and few domestic suppliers. Conversely, business, services and IT, which are easier to digitise, have progressed faster. Looking only at the share of schools that "have applied digital transformation" hides this paradox.

The same pattern appears in assessment. Digital tools are now widely used for theory tests, but practical assessment

still relies mostly on direct observation and paper checklists. Technologies that could make practical assessment more consistent, such as recording performance data from training rigs, video-based assessment of operations or simulator logs of welding parameters, are rarely used. Since assessment shapes teaching, the absence of digitally supported practical assessment also slows the integration of technology into practical lessons.

As for AI, by the 2025-2026 school year its use in vocational schools was largely limited to teachers using generative tools to prepare lessons and questions, and students using them for look-up and language learning; even at this level, students' skills are limited, as a survey at Vinh Phuc College found for English learning. Deeper applications such as weld-image analysis, early dropout warning or personalised learning paths have hardly appeared at school scale.

4.5 Digital competence of teachers and learners

Teachers are the decisive link. In 2025, Vietnam had 71,951 VET teachers, of whom 29.9% held a master's degree, 44.5% a bachelor's degree, 8.8% a college qualification and 15% an intermediate qualification (Quang Huy, 2025) [21]. Over 70% met the occupational skills standard for teaching practice, but only about 50% were able to teach in an integrated way combining theory and practice. This figure matters greatly, because simulation, digital twins and IoT workshops all require integrated lessons in which students understand principles, test them on a digital model and then perform them on real equipment. Teachers unfamiliar with integrated teaching tend to use simulation software merely as a presentation tool.

Three groups of teachers can be identified by digital readiness: young teachers in electrics, electronics and IT, who proactively develop their own models and simulations; highly skilled, experienced teachers who are wary of new technology, particularly in machining, welding and construction; and teachers of common subjects, proficient in office software but less connected to occupations. Current training programmes are usually designed for all three groups alike and focus on e-lectures, whereas the second group needs ways to bring technology into the practical lessons of their own trade.

On the learners' side, Circular No. 02/2025/TT-BGDDT provides a basis for including digital competence in learning outcomes, but translating it into standards for each occupation and level is still at an early stage. Learners' entry profiles are diverse (lower-secondary graduates, upper-secondary graduates, workers changing occupation), and their digital competence varies widely, while programmes tend to assume a common baseline.

Learners' access to devices adds another layer of inequality. Most students own smartphones, but fewer have laptops capable of running engineering software such as CAD/CAM or PLC programming environments. When simulation exercises are assigned as homework, students without suitable devices are disadvantaged. Schools that open computer rooms in the evenings, provide device lending or choose browser-based and mobile-friendly tools can reduce this gap, but such measures are not yet systematic.

4.6 Linkages with enterprises and the digital labour market

On the positive side, school-enterprise relations have been strengthened. In 2025, more than 85% of VET institutions had signed cooperation agreements with over 7,200 enterprises across many sectors (Tuong San, 2026) [31]. Dual training and in-company training models have expanded, and the 2025 Law on Vocational Education for the first time provides for enterprise workforce training funds.

However, linkages in the area of digital transformation remain thin. Most cooperation revolves around internships, recruitment and scholarships; joint development of digital workshops, sharing of industrial software, provision of real production data for exercises, or secondment of experts to co-teach new technologies remain rare. Foreign-invested factories use manufacturing execution systems, multi-axis CNC machines, robots and sensors far more advanced than school workshops, and this gap cannot be closed with school budgets alone.

Several factors explain this thinness. Enterprises, particularly small and medium-sized ones, have limited capacity to engage beyond hosting interns. Larger enterprises may be willing to share equipment or software but often find school procurement and asset management rules cumbersome when donating or lending equipment. Intellectual property and data confidentiality concerns make firms cautious about sharing production data. On the school side, few colleges have staff dedicated to managing industry partnerships around technology. These are not insurmountable barriers, but they require explicit mechanisms rather than goodwill alone.

Labour market demand is also moving in two opposite directions: demand for workers able to operate and monitor automated systems and work with data is rising fast, yet many enterprises in industrial provinces still recruit unskilled labour for simple operations, weakening incentives for long-term vocational learning. The VET system therefore remains skewed towards short courses and lacks pull from high-technology sectors. Digital transformation in vocational training is closely tied to local investment attraction and labour use policies. ### 4.7. The case of Phu Tho province and Vinh Phuc College of Engineering and Technology.

For vocational schools, this duality means that digital transformation must serve two audiences at once. For young people in college-level programmes, the priority is depth: mastery of the automated and data-driven systems they will operate. For adult workers in short courses, the priority is breadth and flexibility: basic digital skills, safety in digital workplaces and quick upskilling on specific equipment. A single model of digital transformation designed around full-time college students will not meet the needs of the second audience, which in numerical terms is the larger one.

4.6.1 Phu Tho province after the merger

From 1 July 2025, the new Phu Tho province was formed by merging the former provinces of Vinh Phuc, Phu Tho and Hoa Binh. After the merger, Phu Tho became one of the three localities with the largest education systems in the country, with 4 public universities, 50 VET institutions and 1,957 other educational institutions. The province has more

than 2 million workers; besides 31 state-owned enterprises employing nearly 9,000 workers, more than 23,000 foreign-invested and private enterprises employ over 559,000 workers. The former Vinh Phuc area is a developed industrial zone with many industrial parks in automotive, motorcycle, electronics and mechanical engineering, where demand for technicians able to work with automated lines is very high.

The province has set ambitious targets for digital human resources: training 5,000 AI experts, engineers and technicians; equipping 80% of the workforce with basic digital skills; ensuring that 50% of graduates meet international foreign-language standards; and raising the share of workers with qualifications or certificates to 75% by 2030. For 2026, it aims for at least 85% of trainees to be employed after training, with non-agricultural vocational training accounting for about 70%, while promoting retraining, occupational conversion and digital skills.

Yet provincial leaders themselves acknowledge that the quality of vocational training has not kept pace with labour market needs, that links with enterprises are ineffective, and that many enterprises still prefer to recruit unskilled workers for simple operations in textiles, footwear and electronics. Phu Tho is also implementing a scheme to substantially reorganise its VET and continuing education centres. This context places the province's engineering colleges in the position of having both to scale up digital skills training for large numbers of people and to raise the level of training for high-technology occupations.

4.6.2 Vinh Phuc College of Engineering and Technology: conditions and current state

Vinh Phuc College of Engineering and Technology was established under a decision announced on 22 January 2025, by merging Vinh Phuc Vocational College into Vinh Phuc College of Economics and Technology and renaming the latter. The College provides training at college, intermediate and elementary levels and continuing training, teaches the upper-secondary continuing education programme, and engages in training cooperation, applied research and production services. In the subsequent reorganisation of the province's educational institutions, Vinh Phuc College ceased operation after its health sciences division was transferred to Phu Tho Medical College and its teacher-training division to Hung Vuong University, with the remaining units merged into Vinh Phuc College of Engineering and Technology. The press has described this as one of the cases in which the benefits of merger are more clearly visible.

Within less than two years, the College has therefore twice absorbed organisational units, learners, teachers and facilities from different institutions. This has created three features relevant to digital transformation: diverse training equipment acquired through many projects; software and data inherited from several sources that need to be consolidated; and a teaching staff with a broad professional base, which favours interdisciplinary programmes but calls for a differentiated strategy for developing digital competence.

These features translate into concrete tasks. The College needs a unified catalogue of occupations, modules and equipment across its campuses; a single learner record system with cleaned historical data; a map of workshops showing which practical modules each can support and with what technology; and a professional development plan that distinguishes between teachers who already use simulation and those who are new to it. Such tasks are less visible than purchasing new equipment, but they determine whether later investments can be used effectively across the merged institution.

Studies of the predecessor schools show that digital transformation had already been recognised as an urgent requirement. Tran Vuong Ngoc (2024) [29] argues that digital transformation is necessary to improve the quantity and quality of training at Vinh Phuc College. Nguyen Thi Le Dung and Pham Thi Dieu Thuong (2025) [14] propose strengthening teachers' digital competence, building a digital learning ecosystem, improving equipment management and maintenance, renewing teaching methods with technology, and expanding equipment sharing; the last proposal has become far more feasible now that the schools are under a single management.

Regarding enterprise linkages, the College pursues a 2+1 training model, in which students study at the College and work in enterprises, seen as a strategic way of linking training with production. Nguyen Thi Van (2025) [16] shows that this model improves occupational skills, shortens graduates' adaptation period in enterprises and increases the employment rate after graduation. From a digital transformation perspective, the year in industry under the 2+1 model is a natural "technology bridge": students gain access to production lines, software and real production data that the College could hardly afford on its own.

The location of the College adds to this potential. The former Vinh Phuc area hosts major manufacturers in the automotive, motorcycle and electronics sectors, whose production systems embody exactly the automation, sensor and data technologies that occupational standards increasingly require. If the industry year is structured so that students systematically encounter these systems, and if company mentors are involved in assessing digital competences, the College can offer training close to the technological frontier without bearing the full cost of replicating industrial equipment.

Table 3 summarises the current state of the technological layers at the College according to the analytical framework, together with the priority direction for each layer.

Table 3: Current state and priority directions of technological layers at Vinh Phuc College of Engineering and Technology

Technological layer	Current state	Priority direction
Digital infrastructure	Network infrastructure inherited from predecessor schools; coverage of workshops uneven	Standardise the network across campuses; extend stable connectivity to workshops; separate workshop and administrative networks
Data and digital governance	Training management software and learner data from several predecessor schools being consolidated	Build a single learner record system; unify occupation, module and equipment codes; clean historical data
Digital teaching platforms	E-lectures and digital learning materials deployed in many modules, with uneven quality	Redesign materials around concrete workshop tasks; establish a review cycle tied to curriculum revision
Practical-training technology	Electrical, mechanical and automotive training equipment from various projects; simulation software used in some modules	Map workshops against modules; expand low-cost simulation and IoT models; seek shared or co-invested advanced equipment
Digital competence and enterprise linkages	Digital competence training for teachers; 2+1 training with enterprises in the province	Differentiate teacher training by occupation; give the industry year a defined technology content and joint assessment

Source: Compiled by the authors from published materials and the analysis in this paper.

The case shows that for schools formed through mergers, 2025-2027 is a favourable "window" to redesign the technology architecture systematically rather than simply adding up old systems.

5. Overall Assessment

5.1 Achievements

Overall, the institutional framework has changed qualitatively. Digital transformation in VET is now embedded in the Politburo's guidelines, enshrined in law as a State investment responsibility, and supported by a digital competence standard for learners; the consolidation of state management under the Ministry of Education and Training makes it possible to design data and digital platforms coherently.

Digital governance infrastructure is now common at school level, and diploma digitisation at national scale has reached tens of millions of records. Numerous practical-training models (electro-pneumatic simulation, smart IoT electrics, PLC-HMI) developed by teachers in local colleges show that bottom-up innovation is real and can be scaled up at reasonable cost. School-enterprise linkages have expanded in number, and graduate employment has remained above 80%.

5.2 Limitations

Alongside these results, the limitations can be seen as four gaps.

The gap between targets and implementation. The target of 70% of institutions applying digital transformation in teaching and learning by 2025 was not met; the sector database had not met the security conditions for connecting to the national database by late 2026; and the national digital education governance platform has been deployed in only 6 localities.

The gap between management and practice. Technology has entered management far faster than practical instruction. This is the core limitation, because the distinctive value of vocational training lies in practice, and the occupations most in need of simulation show the lowest level of application.

The gap between schools. High-quality colleges, schools in large cities and those with international projects are well ahead of local schools, especially VET centres. Without sharing mechanisms, digital transformation risks widening rather than narrowing quality gaps between institutions.

The gap between school and factory. Technology in enterprises, especially foreign-invested ones, is years ahead of schools; current cooperation consists mainly of internships and recruitment rather than co-investment in training technology.

These four gaps are interrelated. The focus on coverage-based indicators reinforces the management-practice gap; the cost of practical technologies widens the gap between well-resourced and other schools; and weak co-investment with enterprises leaves the school-factory gap to be closed by public budgets alone. Addressing any one gap in isolation is therefore unlikely to be sufficient.

5.3 Causes

Objectively, technology for practical training is costly, has a short life cycle and requires intensive maintenance, exceeding the financial autonomy of most local schools; the 2025 mergers interrupted many investment plans; and the domestic market for vocational training technology solutions is still small, with equipment mostly imported.

Procurement rules add to these constraints. Public procurement procedures are designed for standard goods and are poorly suited to software subscriptions, cloud services or equipment bundled with training and maintenance. Schools often buy hardware with one-off capital budgets but lack recurrent budgets for licences, updates and repairs. As a result, equipment ages quickly and software versions fall behind those used in industry. Financial autonomy, expanded under the 2025 Law, offers some room for manoeuvre, but only schools with strong revenue bases can use it fully.

Subjectively, the measurement of digital transformation still favours coverage over depth, encouraging investment in what is easy to count. Digital competence training for teachers is diffuse and not differentiated by occupation. There are no occupation-specific digital competence standards to operationalise the general framework. Mechanisms for mobilising enterprises to co-invest in training technology are unclear, and enterprise workforce training funds have only just been legislated.

At a deeper level lies the mindset of treating technology as a self-sufficient solution, as Avis (2018) [1] warns: when digital transformation is understood mainly as procurement, schools easily end up with equipment but without lesson scenarios, operators or maintenance budgets, and after a few years the equipment becomes a "display" asset.

6. Solutions for Digital Transformation Linked with Vocational Training

Based on the above analysis, the paper proposes five groups of solutions oriented towards a "practice-centred" digital transformation. This orientation means that every technology investment is judged by one question: what does

it change in the learner's practical session?

6.1 Measuring the depth of digital transformation

The set of digital transformation criteria should include indicators reflecting how far technology has entered vocational training, such as the share of practical modules using simulation, VR or connected equipment; the share of practical hours supported by digital learning materials; the number of practical exercises using real production data; and the share of learners meeting occupation-specific digital competence standards. These indicators should be linked to quality accreditation and the recognition of institutions meeting national standards under Resolution No. 71-NQ/TW, so that investment incentives shift from what is easy to count towards what creates value for occupational skills.

Measurement should also become more evidence-based. Rather than relying solely on self-reported checklists, institutions could report data generated by their own systems, such as LMS usage in practical modules, workshop booking and utilisation records, or simulator logs. Periodic external reviews, including classroom and workshop observation, would help verify that reported indicators correspond to real changes in teaching and learning. Over time, such data would allow the Ministry and provinces to identify which technologies and practices are associated with better employment outcomes.

6.2 Shared regional digital workshops by occupational group

Instead of each school investing in all expensive technologies, shared digital workshops should be established at high-quality colleges or large merged schools to serve several institutions in the region. Each workshop would focus on an occupational group in high regional demand, which for the Phu Tho area means mechatronics, automation, automotive technology and electronics; it would combine simulation, VR, digital twins and IoT-connected real equipment; and it would be open to students of other schools through online booking, accompanied by a shared digital repository of technical videos, simulation-based practical scenarios and a bank of fault cases.

Governance arrangements are critical for such workshops. Clear rules are needed on cost-sharing between host and user schools, scheduling, maintenance responsibility and the recognition of credits earned there. Enterprises can be invited to contribute equipment or software in exchange for priority access to graduates or the use of the workshop for their own staff training. A provincial or regional coordinating body under the Department of Education and Training could manage the network of shared workshops and monitor their utilisation.

At school level, priority should go to technologies with a high ratio of skill value to cost: simulation software for electrical circuits, pneumatics, PLC and CNC (many available in low-cost educational editions), self-built IoT models, and cameras for recording standard operations as learning materials. Expensive technologies such as VR welding simulators or industrial robots should be acquired through sharing or co-investment with enterprises.

6.3 Occupation-differentiated digital pedagogical training for teachers

Teacher training should shift from "teaching teachers to use software" to "teaching teachers to design technology-enhanced practical lessons". Each course should be tied to an occupational group, with outputs in the form of practical lesson scenarios integrating simulation, digital materials and real equipment. Young, tech-savvy teachers can be paired with highly skilled experienced teachers in materials development teams, combining technological knowledge with occupational know-how in the spirit of TPACK. Teachers also need training in the responsible use of AI, including its limitations and risks of error.

In parallel, the development of digital materials and simulation models should count towards teachers' standard workload and be recognised as initiatives or school-level research tasks, and teachers should be given opportunities for short internships in technology enterprises.

6.4 Occupation-specific digital competence standards integrated into curricula

Building on Circular No. 02/2025/TT-BGDDT and the national occupational skills standards under the 2025 Law on Vocational Education, schools, sector councils and enterprises should jointly develop digital competence standards for each occupation and level. For industrial electrics at college level, such a standard might include reading and analysing operating data from PLCs, configuring HMIs, using switchboard design software, diagnosing faults through monitoring systems and observing information security in industrial networks. These standards should be distributed across modules and assessed through technology-based practical tasks rather than isolated in a separate informatics subject; learners with weak entry competence could take a self-paced online preparatory module.

For elementary and continuing training programmes, micro-courses combining online learning with short workshop practice should be developed, leading to verifiable digital certificates.

Assessment practices should evolve accordingly. Practical examinations can include tasks that require the use of diagnostic software, data interpretation or system configuration, and simulator or rig data can complement observation in judging performance. Where enterprises participate in assessment, as in dual or 2+1 models, shared digital assessment forms make it easier to align school and workplace judgements of competence.

6.5 Co-investment in training technology with enterprises and labour-market-linked data

School-enterprise relations should be upgraded from "hosting interns" to "co-investing in training technology": enterprises sponsoring or lending equipment and industrial software with recruitment commitments; jointly building enterprise-branded training labs; providing anonymised production data and real fault cases as exercises; and seconding experts to co-teach. The enterprise workforce training funds under the 2025 Law on Vocational Education should soon be operationalised through guidance allowing their use for co-investment in training equipment located at schools, and provincial investment incentives could be linked to commitments to participate in vocational training.

For the 2+1 model at Vinh Phuc College of Engineering and Technology, the year in industry should be designed with a deliberate technology focus: a predefined list of technologies, software and digital processes that students

must encounter, an electronic logbook, and joint assessment by teachers and company mentors.

The College can also act as a pilot for the province. Given its scale after merger and its location in an industrial area, it is well placed to host a shared digital workshop for mechatronics, automation and automotive technology serving other VET institutions in Phu Tho, and to develop occupation-specific digital competence standards for its key trades together with partner enterprises. Documenting and sharing such pilots would help other merged schools avoid reinventing the same solutions.

On data, the VET database should be completed to meet security requirements for connection with the national database and linked with social insurance and employment data, enabling schools to track graduates' employment with real data. Merged schools should use the current period to standardise occupation and module codes, clean data before integration and separate workshop networks from administrative networks.

6.6 Implementation roadmap

The five groups of solutions differ in cost, lead time and the actors responsible. A phased approach can help schools and provinces sequence them realistically.

In the short term (2026-2027), the priority is to consolidate foundations. Merged schools should complete data cleaning and the integration of management systems, segment workshop networks, and map their workshops against practical modules and available technologies. Each school can select two or three occupations with strong labour demand and develop a small number of simulation-integrated practical scenarios, using low-cost software and self-built models. Teacher development should start with pilot teams pairing technology-savvy and highly skilled teachers in these occupations. At the system level, the Ministry and provinces can begin piloting depth-oriented indicators alongside existing coverage indicators.

In the medium term (2027-2028), the focus shifts to sharing and standardisation. Provinces can designate host colleges for shared digital workshops in priority occupational groups and establish governance rules for their use. Occupation-specific digital competence standards can be developed for the pilot occupations and integrated into revised curricula and assessment. Enterprise co-investment arrangements, supported by guidance on enterprise workforce training funds, can be formalised in agreements covering equipment, software, data and mentoring.

In the longer term (2029-2030), the aim is to scale and connect. Successful scenarios and standards can be extended to other occupations; shared workshops can be networked across provinces; and the VET database, connected securely to national databases, can provide reliable information on learners' pathways and employment. By 2030, digital transformation would then be judged not only by the share of schools that have adopted digital tools, but by evidence that technology has changed how occupational skills are formed and recognised.

The roadmap implies clear roles. The Ministry of Education and Training sets standards, indicators and data infrastructure; provincial authorities coordinate shared workshops and link investment policy with training; colleges redesign curricula, develop teachers and manage partnerships; and enterprises contribute technology, data and mentoring. Without such a division of roles, the risk is that each actor waits for the others, and digital transformation remains a matter of reporting rather than of practice.

7. Conclusion

From an engineering technology perspective, digital transformation in vocational training combines five layers: digital infrastructure, data and digital governance, digital teaching platforms, practical-training technology and intelligent technology. The distinctive value for vocational training lies in the upper layers, where technology directly contributes to the formation of occupational skills, but these are also the hardest layers to invest in and implement.

The analysis of 2021-2026 shows that Vietnam has made major progress in institutions and digital governance infrastructure, and that many practical-training technology models have been developed by teachers themselves. However, results lag behind targets; technology has entered management faster than practice; gaps between schools and between schools and enterprises remain large; and teachers' capacity for technology-integrated teaching is the decisive bottleneck.

The case of Phu Tho province and Vinh Phuc College of Engineering and Technology shows that mergers both pose the challenge of consolidating systems and open an opportunity to redesign the technology architecture and share resources. The five proposed groups of solutions revolve around a single orientation: the learner's practical session as the yardstick of digital transformation.

This paper relies mainly on secondary data and qualitative assessment. Future research could survey teachers, learners and enterprises at engineering colleges in Phu Tho province to quantify the extent and effectiveness of each technological layer, or conduct pedagogical experiments with simulation-integrated practical scenarios.

Despite these limitations, the paper contributes in two ways. Conceptually, it proposes a five-layer view of engineering technology in vocational digital transformation that distinguishes administrative digitisation from technology that shapes occupational skills. Practically, it shows that coverage-based indicators can mask the slow progress of practice-oriented technologies, and it offers concrete directions for policymakers and colleges seeking to make digital transformation matter in the workshop.

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