Pathways for Teaching Model Reform Driven by the Interaction between New Quality Productive Forces and Vocational Education: The Case of Electrical Automation Technology

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Abstract: *Electrical automation teaching must prepare students to commission interconnected equipment, diagnose faults and judge technical changes against operating requirements. These tasks bring the relationship between new quality productive forces and vocational education into the classroom: industrial change reshapes competence requirements, while skilled graduates and college technical services can support the adoption and improvement of production technologies. This paper develops a teaching reform proposal for the three-year higher vocational Electrical Automation Technology programme. It combines policy and document analysis, conceptual comparison and instructional design, using the national professional teaching standard and research on project-based learning, workplace learning and authentic assessment. The analysis identifies coordination problems involving curriculum sequencing, practical training, enterprise participation, assessment and resource provision. A proposed project, upgrading a conveying and sorting cell while examining its energy use, connects programmable logic controller programming, variable-frequency drives, human-machine interfaces and industrial networking. Students move from requirement analysis and simulation to supervised commissioning, fault diagnosis and evidence-based review. Assessment combines project documentation and operating records with individual explanation and transfer tasks. The proposed reciprocal mechanism depends on translating workplace requirements into assessable learning tasks and returning reviewed teaching outcomes to enterprise discussion, staff training or technical service. These routes require sustained teacher coordination and explicit responsibility for accepting changes. The paper presents a design for subsequent piloting; it reports no institutional intervention or measured learning gains. A future evaluation should examine competence transfer separately from any claim about enterprise productivity, because a functioning classroom prototype provides insufficient evidence of industrial impact.*

Keywords: *new quality productive forces; vocational education; electrical automation technology; teaching model reform; project-based learning; authentic assessment*

1. Introduction

A student may program a motor start-stop sequence correctly and still struggle to explain why a conveyor fails after a drive parameter changes. In an integrated automation task, electrical circuits, control logic and communication settings affect the same operating behaviour. A course sequence that assesses these elements separately provides limited evidence that students can commission a complete system or identify the source of a fault. This problem is particularly relevant to Electrical Automation Technology, a three-year higher vocational programme with the professional code 460306. Its 2025 national teaching standard includes PLC technology and applications, motor speed control, and industrial networking and configuration among the core professional courses[1].

China's discussion of new quality productive forces gives vocational education a related policy task. Innovation, changes in production factors and industrial transformation require workers who can use and improve technologies in specific production settings[2]. The 2022 opinion on modern vocational education reform and the 2025 education outline place industry-education integration and the development of skilled personnel within a wider education and industrial

agenda[3,4]. For a college department, this agenda must be translated into decisions about what students do, which equipment they use and how teachers judge their work. Adding technological terminology to an unchanged syllabus leaves these decisions unresolved.

This paper asks how the reciprocal relationship between industrial development and vocational education can inform a practicable teaching model for electrical automation. Policy and document analysis establishes the professional and institutional context; conceptual comparison identifies differences between teaching arrangements; instructional design specifies a project and its assessment. The paper draws selectively on relevant educational research and makes no claim to a systematic review. The conveying and sorting example is a proposed learning project for students who have completed introductory electrical and electronic engineering and basic PLC study. It is not an account of an intervention at the author's institution. The contribution is a traceable connection between the proposed reciprocal mechanism, classroom tasks and evidence of competence, together with conditions under which that connection could be tested. The analysis uses policy documents to define educational responsibilities and the professional standard to identify relevant content. Educational studies inform the organisation of tasks and assessment. These sources have different evidential roles: a policy objective establishes an expectation, while a study offers findings bounded by its participants and design. The proposed teaching arrangements are reasoned applications of those sources and remain open to revision after testing.

2. Conceptual Foundations and Reciprocal Mechanisms

2.1 New quality productive forces and professional competence

New quality productive forces describe a policy conception of productivity development led by innovation and changes in the organisation and use of production factors[2]. At programme level, the concept should guide attention to identifiable changes in work. For electrical automation, these include coordinating devices through industrial networks, interpreting operating data and evaluating control changes against production constraints. A new controller or software platform alone does not establish a change in productive capability. Its relevance depends on whether people can commission it reliably, maintain it and use it to solve an operating problem.

Professional competence therefore includes an explanation of system behaviour alongside the ability to perform a procedure. Students should connect an input signal to a state transition, a commanded speed to an observed process response, and an alarm to a justified diagnostic action. Energy awareness extends this reasoning to the relationship between electricity consumption and accepted output. The national teaching standard provides a curricular basis for such integration through its core courses, practical teaching requirements and provision for simulated learning environments[1]. The proposed model translates those provisions into connected tasks; it does not treat a particular equipment brand, project format or digital platform as a national requirement.

2.2 From industrial requirements to educational responses

The first direction of influence begins with a change in a workplace task. For example, an enterprise may need technicians to adjust a conveyor's operating sequence while retaining sorting accuracy and handling communication interruptions. A teacher and an enterprise practitioner can examine the task, separate essential principles from site-specific arrangements and define a version suitable for students. Requirements then become a project brief, expected evidence and assessment criteria. This translation is necessary because an industrial task can contain commercial restrictions, hazards or complexity that a teaching environment cannot reproduce.

The reverse direction has several possible routes. Graduates may apply tested diagnostic methods at work; continuing education may help existing staff learn unfamiliar control systems; college technical services may investigate a bounded equipment problem with an enterprise. These contributions depend on workplace opportunities, supervision and the quality of the proposed solution. A classroom project can prepare a technical note for practitioner review, but its educational success does not demonstrate a productivity gain. The reciprocal mechanism proposed here requires feedback: practitioners identify omissions or unsuitable assumptions, and teachers revise later tasks. Colleges should record which requirement changed, why it changed and what learning evidence the revision is expected to produce.

2.3 Educational foundations and limits of transfer

Situated learning directs attention to participation in the practices through which knowledge is used[5]. For the present design, students work with requirements, drawings and commissioning records that resemble professional documents, while teachers retain responsibility for instructional support. Research on learning environments at the boundary between

school and work also suggests examining how tasks, resources and participants are organised[6]. These perspectives help define the conditions for a useful project; they do not establish that placing students near equipment will automatically produce transferable competence.

Project-based learning research provides a basis for connecting sustained practical work with explicit learning outcomes[7]. A variable-speed-drive study provides a relevant example of a subject-specific application[8]. Research on Learning Factories 4.0 in technical vocational schools reported development in subject-related competence without identifying positive development in multidisciplinary digital competence[9]. This difference supports examining separate learning outcomes when evaluating an equipment-rich environment. Neither study establishes the likely effect of the present model in a Chinese higher vocational programme. Authentic assessment adds a further design requirement: the task, its context and the evidence used for judgement should represent the competence being assessed[10]. Accordingly, the proposed model combines a working system with records of reasoning and an individual response to a changed condition. Whether students retain and transfer these capabilities requires a subsequent evaluation.

3. Teaching Model Design and Comparative Analysis

3.1 From separate exercises to a connected engineering task

The proposed model organises selected content around a shared conveying and sorting problem while preserving the short lessons needed to explain unfamiliar concepts. Students first interpret the process requirements and trace the existing control sequence. They then prepare a change proposal, test it in simulation and obtain teacher approval for commissioning. Measured operation and a technical review complete the project. Teachers revisit electrical principles when a practical decision requires them, such as interpreting a sensor signal or selecting a drive setting. Foundational knowledge remains assessable within this sequence.

Table 1 describes two design positions for comparison. The conventional column is an analytical baseline, not a survey finding about current colleges. Both arrangements can contain explanation, demonstration and practical work; their difference concerns how tasks and evidence are connected. In the proposed model, a device-level exercise leads to a decision about the whole cell, and students must explain the consequences of that decision. A short individual diagnostic check before practical work helps teachers distinguish missing prerequisite knowledge from difficulty integrating knowledge. Students who need support receive a worked example or targeted practice before taking responsibility for a larger part of the system.

Table 1 Comparison of teaching arrangements for electrical automation

Dimension	Conventional subject-centred teaching	Proposed model
Learning unit	Separate device or course exercise	Integrated process requirement
Content sequence	Topics follow course boundaries	Concepts support linked project tasks
Student activity	Reproduce a demonstrated procedure	Explain, test and revise a solution
Teacher role	Explain and verify prescribed steps	Teach concepts and review decisions
Practical resources	Devices used in isolation	Simulation linked to a training cell
Enterprise contribution	Occasional examples or visits	Review requirements and evidence
Assessment	Final answer or operation check	Process records and individual transfer

3.2 Evidence across the project cycle

The learning task is to upgrade control of a conveying and sorting cell and examine whether an operating change reduces energy use under comparable conditions. The system boundary includes the PLC, drive, sensors, HMI and relevant network connections. The brief specifies accepted sorting behaviour, recovery requirements and the measurements available. Students must preserve those requirements when proposing an operating change. A lower electricity reading alone cannot satisfy the brief if fewer acceptable items are processed.

Table 2 links the three teaching stages to resources and assessable evidence. Preparation produces a documented design that another student can inspect. Implementation tests whether that design corresponds to the behaviour of the training cell. Review requires an explanation of observed differences and a response to a changed condition. Each group maintains a shared project record, with named contributions and dated revisions. Teachers use it to select questions for

individual assessment, avoiding reliance on the appearance of the final demonstration. Enterprise practitioners may comment on the brief and final technical report within agreed access limits; teachers make grading decisions against the published criteria. Feedback at each stage identifies the next action needed. An unexplained mismatch between the state model and program should be resolved before commissioning; an ambiguous energy comparison requires a revised measurement plan. Students can then demonstrate how feedback changed the design, providing assessable evidence of revision.

Table 2 Tasks and evidence in the proposed project

Stage	Learning task	Resources	Evidence	Assessment focus
Preparation	Analyse process; design control	Brief; drawings; simulator	I/O list; state model; test plan	Requirement traceability
Implementation	Commission; diagnose; measure	Training cell; manuals; meter	Program versions; test and fault logs	Reasoning; reliable operation
Review and transfer	Compare runs; address a change	Operating data; review prompts	Technical report; individual defence	Valid comparison; transfer

4. Challenges in Implementation

4.1 Curriculum boundaries and timing

Integrated work can expose mismatched teaching schedules. Students may reach the project before learning the networking concepts needed to interpret a communication fault, while another course has already assessed the relevant drive settings. A common project therefore requires teachers to agree on prerequisite knowledge and the timing of instruction. Without this agreement, integration can increase student workload while leaving course boundaries intact. A shared map should identify which teacher introduces each concept, where students practise it and which evidence demonstrates its use. The map can also reveal repeated instruction that consumes time needed for commissioning and reflection.

4.2 The gap between training tasks and operating conditions

Training equipment makes faults observable and limits practical risk, yet its regular input sequence may conceal the uncertainty of production work. A demonstration that always uses the same objects and settings gives students little reason to investigate variability. Teachers can introduce bounded changes in object spacing, sensor response or communication conditions through approved simulation and test arrangements. These variations require explicit limits and a reproducible baseline. They should also correspond to learning objectives. Arbitrary faults may consume the available lesson without helping students distinguish a wiring problem from a program or parameter error.

4.3 Sustaining enterprise participation

An enterprise practitioner may be willing to review a project but unable to attend weekly classes or disclose production data. A teaching design that assumes continuous access is vulnerable to scheduling and confidentiality constraints. Participation is more manageable when it involves defined decisions, such as reviewing a task brief or commenting on diagnostic evidence. Colleges need a named academic coordinator, an agreed review schedule and a procedure for removing confidential details. Practitioner comments should be retained with the resulting curriculum decision, including a reason when a suggestion exceeds the students' level or available equipment.

4.4 Judging individual learning in group work

A functioning group system can conceal substantial differences in competence. One student may write most of the program while another prepares the report without understanding the control sequence. Conversely, a student who identifies an error may have contributed more learning evidence than a polished final product reveals. Contribution records, teacher observation and individual explanation address different parts of this problem. Assessment must also remain feasible: asking teachers to score every logged action would produce an administrative burden. A small set of decision points and a targeted individual defence can provide evidence without treating document volume as achievement.

4.5 Resources and teacher preparation

A department may have only a few compatible training cells and teachers with unequal experience across control, drives and networking. Purchasing more equipment cannot by itself resolve these constraints. Teachers need time to rehearse the project, check expected behaviour and prepare diagnostic prompts. Groups can rotate between simulation, documentation and practical testing, provided access to the physical cell remains sufficient to assess commissioning competence. Shared equipment also needs a recoverable configuration so that one group's changes do not invalidate another group's baseline. These arrangements require staff workload and maintenance responsibilities to be recognised in the teaching plan.

5. Reform Pathways for Electrical Automation Technology

5.1 Translate professional requirements into a bounded project

The curriculum team should begin with a project brief for an existing educational conveying and sorting cell. The proposed upgrade addresses an identified operating issue, such as unnecessary conveyor operation during an empty interval, while maintaining the specified sorting process. The brief states the operating sequence, acceptable output, available sensors and the limits of student modification. It also defines which quantities can be measured. Students inspect the drawings and operating description before suggesting a solution. A preliminary explanation of the signal path from sensor to controller to actuator reveals whether they can connect the equipment to their prior study.

The team then maps learning outcomes to deliverables. Students produce an I/O list that includes signal names, addresses, meanings and expected states. A state model specifies operating states, transition conditions, permitted outputs and recovery behaviour. These documents must correspond to the program and HMI tags used later. Teachers provide a partially completed example when students are unfamiliar with this representation, then ask them to justify the remaining transitions. Required knowledge from PLC programming, motor speed control and industrial networking enters the project at the relevant decision points[1]. The final brief should be demanding enough to require integration, while remaining achievable with the class's prerequisite knowledge and actual equipment.

5.2 Link simulation with supervised commissioning

Simulation begins with tests derived from the state model, including normal sequencing, missing input conditions and an interrupted cycle. Students record the expected response before observing the simulated response. They check that commands and status indications use consistent meanings across the PLC and HMI. Drive parameters must be selected from the equipment documentation and the teaching setup. A network configuration record identifies connected devices and their relevant settings so that later faults can be traced. Teachers review the control proposal and test evidence before students proceed to the physical cell.

Practical commissioning follows an agreed sequence, beginning with inspection and verification of inputs, then controlled checks of outputs and combined operation. Students work within the training equipment's approved operating conditions under teacher supervision. Protective functions and interlocks remain in place; simulated faults must not be created by bypassing them. The teacher determines how each fault condition can be represented safely. A successful simulation is provisional because physical timing, signal quality and mechanical response can differ from the model. Students use a commissioning log to record the test condition, expected and observed behaviour, corrective action and retest result. When a parameter or program changes, they retain the previous version and repeat the affected tests.

5.3 Develop diagnosis through evidence and explanation

Fault tasks should require students to choose an observation that can distinguish competing explanations. If the conveyor receives a run command but does not move, students may need to compare the PLC output state, drive status and permissive conditions. The assessment concerns the logic of this investigation as well as the eventual correction. Teachers can first model one diagnosis aloud, explaining why a particular reading is useful, and then reduce support during later tasks. A fault bank should cover different system layers without making every exercise a complete breakdown of the cell.

For each approved fault scenario, students record the symptom, initial hypotheses, checks performed and evidence for the conclusion. A diagnostic log should identify an unsuccessful hypothesis when it affected the investigation. This

allows teachers to distinguish a reasoned revision from repeated trial and error. Peers can review whether the proposed explanation fits all observed signals, while the teacher uses a changed condition to test individual understanding. For example, the same visible symptom can be presented with different status information, requiring a different next check. The resulting evidence is a student's ability to interpret and discriminate between conditions. It does not justify a claim that the student will diagnose every fault on unfamiliar industrial equipment.

5.4 Evaluate energy use under comparable operating conditions

The energy task starts with a baseline established before any optimisation. Students define the measurement boundary, confirm what the meter measures and record its resolution. Each run records electricity use, elapsed time, accepted output and rejected items, together with operating conditions that could affect the comparison. An appropriate classroom indicator is electrical energy per accepted item, calculated as the measured energy within the declared boundary divided by the number of accepted items. A run producing no accepted output cannot be assigned a meaningful value for this indicator. Its outcome should be reported separately.

Students then test a justified change, such as an idle-state control adjustment or a permitted speed setting, while retaining the required sorting performance. Baseline and modified runs use comparable loads, object sequences and measurement boundaries. Repeated runs help reveal variability; the report states the run count and reports the observed spread without treating small differences as reliable savings. Students consider throughput and quality alongside energy per accepted item. Lower speed may reduce measured consumption while extending processing time, so the decision must use the full brief. If the available meter cannot resolve the expected difference, the report should explain that limitation. The learning outcome is the ability to design and interpret a fair comparison; any energy benefit remains a result to be measured during a future trial.

5.5 Combine assessment with a manageable improvement cycle

Assessment should follow a rubric agreed before teaching. It covers the consistency of the design documents, demonstrated system operation, diagnostic reasoning and interpretation of operating data. The group submits program files, the revised I/O list and state model, selected logs and a technical report. Each student then explains a design choice and responds to a changed condition in an individual defence. Teachers judge whether the explanation is consistent with the submitted work and whether the student can use the underlying principle in a related task. A student who cannot explain the shared solution needs further evidence before receiving credit for that competence.

A department can pilot the model within an existing integrated practical module before extending it across courses. Teachers first rehearse the project and agree on benchmark examples for assessment. During the pilot, they record equipment access, support required and points where students cannot proceed. After assessment, an enterprise reviewer can examine a concise technical note containing the problem, evidence and limitations. Any later use in staff training or technical service requires a separate agreement and validation for that setting. The curriculum team uses the review to revise tasks for the next cohort. This provides a documented route for industrial requirements to influence teaching and for educational work to inform professional discussion.

6. Conclusions and Limitations

6.1 Implications for teaching reform

The reciprocal relationship between new quality productive forces and vocational education becomes educationally useful when it is expressed through specific work requirements and observable learning outcomes. In the proposed electrical automation model, requirements enter through a bounded conveying and sorting project. Students connect control logic with drives, interfaces and industrial networking, then use commissioning and diagnostic evidence to explain system behaviour. Energy comparison adds a requirement to consider accepted output and measurement conditions when judging a technical change. These activities provide a coherent basis for connecting knowledge that is often taught in separate courses.

Implementation depends on coordination across the curriculum and on an assessment process that identifies individual competence. The two comparative tables define the intended changes in teaching organisation and the evidence expected across the project cycle. They do not rank existing institutions or report the effects of an intervention. Colleges considering this design should first confirm prerequisites, access to equipment and the time available for teacher preparation. Enterprise participation can begin with the review of requirements and technical reports. If that participation

leads to a revised project or a separately validated technical service, the decision and supporting evidence should be documented so that the proposed feedback mechanism can be examined.

6.2 Limitations and a future evaluation

This paper develops a conceptual and instructional proposal from selected policy documents and educational research. It contains no student dataset, classroom observation or enterprise productivity measurement. The illustrative cell also simplifies production conditions and assumes that the programme has appropriate equipment and staff supervision. Research from other educational systems supports design choices but cannot establish the effectiveness of this particular combination. The proposal therefore requires adaptation to local teaching schedules and an empirical evaluation before claims about learning improvement can be made.

A pilot should use a common prerequisite assessment, an individual practical task after the project and a later transfer task with changed operating conditions. Where a suitable comparison class is available, the study should record differences in prior attainment, teaching time and equipment access before interpreting outcome differences. Assessors should use a common rubric and check agreement on a sample of work. Process evidence should include student support needs and the time teachers spend reviewing records. Enterprise impact requires a separate investigation of actual adoption and operating outcomes, with attention to other changes occurring in the workplace. Competence evidence, practitioner approval and a productivity effect are distinct findings and should be reported separately.

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