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DEVELOPMENT OF A COMPETENCY-BASED TEACHING MODEL FOR VOCATIONAL EDUCATION USING MODERN PEDAGOGICAL TECHNOLOGIES

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Abstract. This article develops an integrative teaching model aimed at organizing vocational education on the basis of modern pedagogical technologies. The purpose of the study is to substantiate a pedagogical mechanism that supports the integrated development of vocational learners' theoretical knowledge, practical skills, digital competence, decision-making abilities in problem situations, teamwork skills, and capacity for independent learning. The study employed systems analysis, comparative analysis, pedagogical modelling, a competency-based approach, design-based research, and expert evaluation methods.

Keywords: vocational education, pedagogical technology, teaching model, competency-based approach, project-based learning, blended learning, simulation, dual education, digital competence, authentic assessment.

1. INTRODUCTION The development of the digital economy, industrial automation, artificial intelligence, robotics, and data-driven management systems is changing the content of occupations in the labour market. Modern employers expect specialists not only to possess theoretical knowledge, but also to perform tasks in real production settings, identify technological problems, use digital tools, collaborate with colleagues, and adapt rapidly to new conditions.

The future readiness of a vocational education system is determined by its ability to respond quickly to labour-market changes, introduce flexible curricula, strengthen links with industry, and support the transition from education to employment [1].

Modern pedagogical technologies turn the learner into an active participant in the educational process. Project-based learning supports the creation of a real product or technological solution, problem-based learning develops the analysis of occupational situations, simulation enables repeated practical actions in a safe environment, and blended learning combines the opportunities of classroom and digital learning environments.

The use of technology in vocational education is not limited to computers, electronic boards, or presentations. Didactic effectiveness emerges only when digital tools are integrated with educational objectives, curriculum content, pedagogical methods, practical activities, and the assessment system. UNESCO-UNEVOC indicates that the digital transformation of vocational education requires the coordinated development of infrastructure, teacher competence, open educational resources, and a culture of lifelong learning [2].

Uzbekistan is implementing institutional reforms aimed at aligning vocational education with labour-market needs, introducing international education programmes, and strengthening the integration of education and industry. Presidential Decree No. PF-158 of 16 October 2024 set tasks to

reorganize technical colleges, introduce international programmes, and establish the "Vocational Education" platform [3].

Cabinet of Ministers Resolution No. 245 of 19 April 2025 approved the organization of the Vocational Education Development Fund and the procedure for using its resources [4]. Presidential Resolution No. PQ-316 of 23 October 2025 focuses on implementing reforms in the vocational education system, improving curricula, and increasing management efficiency [5].

In March 2025, UNESCO began adapting the DELTA programme to national conditions in Tashkent to develop the digital competencies of technical and vocational education and training educators. This initiative demonstrates the need to strengthen systematic preparation of vocational educators in digital pedagogy [6].

Nevertheless, modern pedagogical technologies are often applied in isolation in vocational education practice. Some lessons use the project method, while others employ an electronic platform or simulation. However, an integrated model that connects these tools with occupational standards, workplace practice, learning outcomes, and assessment criteria has not yet been sufficiently developed.

2. LITERATURE REVIEW

The competency-based approach evaluates educational outcomes not by the volume of information acquired, but by the learner's ability to perform occupational tasks independently and to an appropriate standard. Occupational competence integrates knowledge, practical skills, professional thinking, responsibility, communication, and the ability to evaluate the results of one's own activity.

Systematic studies of competency-based education show that the approach is interpreted differently across educational systems. Nevertheless, outcome orientation, active learning, practical tasks, and clearly defined assessment criteria are common features [7].

In project-based learning, learners work for a defined period on an occupational problem, commission, or production task. At the end of the process, they create a tangible product, technological solution, service, software application, project document, or presentation.

A bibliometric analysis of vocational education shows that project-based learning is emerging as an important approach for developing problem-solving, critical thinking, collaboration, and vocational-technical skills [8].

Blended learning combines classroom instruction, independent digital learning, and practical activity. Part of the theoretical material is studied through videos, electronic modules, interactive tasks, or micro-lessons. Classroom and workshop time is then directed towards problem solving, practice, project development, and pedagogical support.

Recent studies of blended learning in vocational education report positive effects on learner engagement, flexibility, and the integration of theory and practice. At the same time, internet access, digital literacy, the quality of learning materials, and teachers' digital competence are identified as essential conditions [9].

A project-based blended learning model can develop digital skills and teamwork alongside occupational competencies [10].

Simulation-based instruction makes it possible to reproduce a real production process, technical equipment, service situation, or management problem in a safe learning environment. Simulation may

range from a simple role-play situation to a virtual laboratory, training simulator, digital twin, or virtual and augmented reality system.

A meta-analysis covering 145 empirical studies found that simulation-based instruction had a strong positive effect on the development of complex skills. The overall effect size was Hedges' g = 0.85. The outcome depends on the provision of pedagogical guidance, step-by-step support, and reflection alongside the simulation [11].

Dual education combines theoretical and practical instruction at an educational institution with real work activity in an enterprise. In Uzbekistan, the mechanisms for admission to and organization of dual education in vocational education institutions are regulated by relevant government resolutions [12].

The effectiveness of dual education increases when responsibilities are clearly distributed between the educational institution and the enterprise. The enterprise should not serve only as a placement site, but as a partner that participates in shaping and assessing learning outcomes.

A teacher's digital competence is broader than the ability to operate technical devices. It includes selecting digital resources, designing learning content, managing learner activity, organizing digital assessment, providing individual support, and ensuring information security.

Within the DigCompEdu framework, educators' digital competence is described through 22 competencies across six areas. These include professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence [13].

UNESCO's ICT Competency Framework for Teachers comprises 18 competencies and 64 specific objectives. The framework links digital technologies with policy, curriculum, pedagogy, assessment, educational management, and teachers' professional development [14].

3. RESEARCH MATERIALS AND METHODS

The study was organized as a conceptual-analytical and design-based investigation. Its purpose was not merely to describe existing pedagogical technologies, but to integrate them into a unified practical system for vocational education.

1. Identify contemporary requirements and challenges in vocational education.

2. Analyse the didactic potential of pedagogical technologies.

3. Define the structural blocks of the teaching model.

4. Establish functional relationships among the blocks.

5. Develop an algorithm for implementing the model within an instructional module.

6. Develop criteria and indicators for assessing competencies.

Systems analysis was used to examine the objectives of vocational education, curriculum content, pedagogical methods, digital tools, workplace practice, and assessment as an interconnected system.

Comparative analysis was used to compare the advantages and limitations of traditional teaching, project-based learning, blended learning, simulation, problem-based learning, and dual education.

Pedagogical modelling was used to represent relationships among the goal-oriented, content-related, technological, organizational, assessment, and outcome components of vocational education. Scientific and regulatory sources were examined through content analysis. To evaluate the practical relevance of the model, an expert evaluation method involving vocational subject teachers, instructors of workplace training, employers, and researchers was proposed.

Experts are expected to rate the model on a scale from 1 to 5 according to clarity of objectives, compliance with occupational standards, practical orientation, coherence of pedagogical technologies, appropriateness of digital tools, clarity of assessment criteria, and adaptability to different vocational fields.

A quasi-experimental design is recommended for testing the model. The experimental group is taught using the Integrative Vocational Teaching Model (IVTM), while the control group follows the existing methodology. The stability of knowledge and skills is measured through pre- and post-assessment, together with a delayed assessment after 6–8 weeks.

Mean values, standard deviations, Student's t-test, ANCOVA, Mann–Whitney and Wilcoxon tests, Cohen's d effect size, Cronbach's alpha reliability coefficient, and correlation analysis may be used to analyse the results.

4. RESEARCH RESULTS

The study resulted in the development of the Integrative Vocational Teaching Model (IVTM). The model represents modern pedagogical technologies not as a collection of separate methods, but as a unified didactic system designed to develop occupational competence.

The logical sequence of the model is as follows: occupational standard and labour-market demand → initial diagnostics → competency-based objectives → modular learning content → problem-based task → digital micro-lesson → simulation and practical exercise → group project → dual workplace practice → electronic portfolio → authentic assessment → reflection and correction → specialist prepared for professional activity (Table 1).

Table 1.

Structural Blocks of the Model

Model block	Core content	Tools	Expected outcome
Diagnostic and goal-oriented	Assessment of initial knowledge, skills, and digital readiness	Entry test, practical task, interview	Individual needs and clear objectives
Competency and content-oriented	Development of module content based on occupational standards	Competency map, modular curriculum	Content aligned with labour-market requirements
Technological and process-oriented	Integration of pedagogical technologies	Problem-based learning, projects, flipped classroom	Active and independent learning activity

Model block	Core content	Tools	Expected outcome
Digital and practical environment	Digital platform, simulation, and workplace learning	LMS, virtual laboratory, simulator	Integration of theory and practice
Assessment and reflection	Comprehensive assessment of occupational performance	Rubric, portfolio, observation	Transparent assessment and reflection
Outcome and correction	Analysis of results and adjustment of the process	Analytics, reassignment, roadmap	Sustainable occupational competence

Scientific commentary on the table. Table 1 presents the functions of the six blocks within the Integrative Vocational Teaching Model and the functional relationships among them. The diagnostic and goal-oriented block identifies learners' initial knowledge, practical readiness, and digital skills, thereby generating baseline information for subsequent stages. The competency and content-oriented block aligns this information with occupational standards and employer requirements. The technological and process-oriented block and the digital and practical environment transform learning content into activity through problem-based tasks, projects, simulation, and workplace practice. The assessment and reflection block measures outcomes not only through a final score, but also through practical performance, the project product, problem solving, and self-assessment indicators. The outcome and correction block assigns individual tasks and repeated practice according to identified deficiencies. Thus, the model is not linear; it operates as a recurring pedagogical cycle based on feedback.

The pedagogical technology selection matrix is an analytical tool used to determine the most appropriate teaching technology by considering the educational objective, curriculum content, learners' level of readiness, and available conditions (Table 2).

Table 2.

Pedagogical Technology Selection Matrix

Technology	Primary purpose	Application in vocational education	Assessment format
Problem-based learning	Analysis and decision-making	Equipment failure or a production problem	Problem-solving map
Project-based learning	Creation of a product or solution	Component, software, service model, or business project	Project product and defence
Blended learning	Integration of classroom and digital learning	Theory online and practice in the workshop	Online test and practical task

Technology	Primary purpose	Application in vocational education	Assessment format
Simulation	Practice in a safe environment	Virtual equipment or emergency situation	Action algorithm
Dual education	Acquisition of workplace experience	Enterprise assignment and placement	Workplace observation
Electronic portfolio	Demonstration of development over time	Reports, videos, projects, and certificates	Portfolio evaluation

The table shows that pedagogical technology in vocational education should be selected according to the expected learning outcome rather than its popularity. Problem-based learning is appropriate for analytical tasks such as identifying the cause of a malfunction and making decisions. Project-based learning develops integrated occupational competencies because it results in a tangible product, service, or technological solution [8]. Blended and flipped learning allow learners to study theoretical material independently and devote classroom time to practice and consultation [9; 10]. Simulation is used to practise hazardous, expensive, or infrequently repeated processes in a safe environment [11]. Dual education makes it possible to test acquired skills in a real workplace and receive an employer's assessment [12]. Therefore, several technologies may be applied sequentially within one module, but each technology must be linked to a specific task and an appropriate assessment tool.

Pedagogical Scenario of the Learning Process

Stage 1. Presentation of an occupational problem. The teacher presents a situation closely resembling a real production or service process. Learners identify the problem, analyse available information, and propose initial solutions.

Stage 2. Theoretical preparation. Learners receive a short video, electronic text, infographic, technical instruction, and interactive test. The theoretical material is directly linked to the practical task.

Stage 3. Simulation exercise. Learners practise occupational actions through a virtual laboratory, simulator, model, or role-play simulation.

Stage 4. Practical task. The learner independently performs the task in a workshop, laboratory, or practical training area. The teacher provides support through guiding questions and feedback.

Stage 5. Group project. Learners create a real product or technological solution in small groups. The roles of project leader, technical implementer, quality controller, and presenter are distributed within the group.

Stage 6. Workplace practice. The project or task is tested under enterprise conditions. An enterprise specialist evaluates work discipline, compliance with technological requirements, safety, and quality of performance.

Stage 7. Defence of results and reflection. The learner justifies the completed work, selected technology, errors made, and results achieved. The direction of further development is then determined.

Table 3.

Algorithm for Organizing a 16-Week Module

Week	Main activity	Pedagogical technology	Outcome
1	Initial diagnostics	Test, interview, practical task	Initial competency profile
2	Definition of occupational problem and objectives	Problem-based learning	Individual objective
3–4	Theoretical micro-modules	Blended learning, flipped classroom	Core knowledge
5–6	Demonstration and initial exercises	Demonstration, collaboration	Action algorithm
7–8	Simulation tasks	Virtual laboratory, simulator	Safe practical experience
9–10	Independent practical task	Activity-based learning	Performance of an occupational operation
11–12	Group project	Project-based learning	Product or solution
13–14	Workplace practice	Dual education	Workplace competence
15	Portfolio and project defence	Authentic assessment	Demonstration of occupational outcomes
16	Final assessment and reflection	Test, practical examination, interview	Final competency profile

The 16-week algorithm in the table organizes learning according to the sequence “diagnostics – preparation – practice – independent activity – workplace practice – assessment.” Diagnostics in the first week prevent all learners from receiving tasks of identical difficulty. Theoretical micro-modules in Weeks 3–4 develop the core knowledge required for subsequent practical activities. During Weeks 5–10, pedagogical support is gradually reduced through demonstrations, simulation, and independent practical tasks, while learner autonomy increases. The group project in Weeks 11–12 develops collaboration, time management, and presentation skills alongside technical knowledge. Workplace practice in Weeks 13–14 tests competencies developed in the learning environment against real employment requirements. In Weeks 15–16, the combined use of a portfolio, project defence, and practical examination enables comprehensive assessment of outcomes.

Within the IVTM, the digital environment consists of a learning management system, electronic portfolio, virtual laboratory, digital simulator, video lessons, interactive tasks, and learning analytics.

When selecting digital learning content, its alignment with the curriculum, pedagogical value, effect on learning outcomes, inclusiveness, reliability, safety, and technical compatibility should be considered. The European Commission's guidelines on digital education content also recommend quality, safety, and effectiveness criteria for selecting, creating, adapting, and evaluating resources [15].

Artificial intelligence can be used to provide individualized explanations, generate task variants, identify errors, adapt learning materials, and conduct preliminary analysis of performance results. According to the OECD's 2026 analysis, artificial intelligence creates opportunities to adapt occupational standards, qualification requirements, and curricula more rapidly to labour-market changes [16].

Assessment of occupational competencies. The use of written tests alone is insufficient in vocational education. A test may measure theoretical knowledge, but it cannot fully demonstrate a learner's ability to configure equipment, identify a technical fault, serve a customer, or manage a production process (Table 4).

Table 4.

Components of Occupational Competence Assessment and Their Weights

Assessment component	Weight	Assessment tool
Theoretical knowledge	20 percent	Test, oral question, concept map
Practical skill	35 percent	Practical examination, observation sheet
Project product	20 percent	Project rubric, expert evaluation
Problem solving and reflection	15 percent	Case study, report, interview
Digital and collaboration competence	10 percent	Electronic portfolio, group assessment

The weights of the assessment components are distributed in accordance with the practice-oriented nature of vocational education. The 35 percent allocated to practical skills indicates that the learner's ability to perform a technological operation safely, independently, and to the required standard is the principal outcome. The allocation of 20 percent each to theoretical knowledge and the project product shows that knowledge itself and the ability to apply it in creating an integrated product or solution are equally important. The 15 percent allocated to problem solving and reflection evaluates the learner's ability to identify errors, justify decisions, and improve performance. The 10 percent share for digital and collaboration competence treats these skills not as isolated outcomes, but as components that support the performance of an occupational task. The proposed weights are recommended for the general model and may be adjusted by experts according to the level of occupational risk, qualification stage, and module content.

The Integrated Vocational Competence Index is calculated using the following formula:

IVCI = 0.20K + 0.35P + 0.20Q + 0.15S + 0.10D

where IVCI is the Integrated Vocational Competence Index; K is theoretical knowledge; P is practical skill; Q is the quality of the project product; S is problem solving and reflection; and D is digital and collaboration competence.

The interpretation levels of the Integrated Vocational Competence Index are presented in Table 5.

Table 5.

Interpretation Levels of the Integrated Vocational Competence Index

Score	Level	Description
0–49	Reproductive	Performs the task using detailed instructions and continuous assistance
50–69	Operational	Performs a standard task with partial independence
70–84	Productive	Performs an occupational task independently, safely, and to the required standard
85–100	Innovative	Develops solutions in new situations and improves the process

The table converts the numerical result of the Integrated Vocational Competence Index into pedagogical meaning. A reproductive level of 0–49 points indicates that the learner cannot independently perform occupational actions and requires detailed guidance. At the operational level of 50–69 points, standard tasks are completed partially, but teacher or instructor support remains necessary in complex situations. A productive level of 70–84 points indicates sufficient preparation to perform an occupational task independently in accordance with safety and quality requirements. At the innovative level of 85–100 points, the learner does not merely repeat an existing algorithm, but proposes a solution adapted to a new situation and can improve the process. These thresholds serve not only for ranking, but also for corrective decision-making: a result below 70 points requires individualized repeated practice, while a result above 70 points supports more complex projects and independent tasks.

5. DISCUSSION

The proposed model differs by treating modern pedagogical technologies not as isolated methods, but as an integrated process for developing occupational competence.

Project-based learning enables learners to create a real product. However, if the necessary theoretical preparation and practical exercises are not organized before the project, project activity may become merely an organizational assignment. For this reason, the IVTM places the project after the digital micro-lesson and simulation stages.

Blended learning allows access to learning materials from any location. However, moving vocational education entirely to distance delivery limits the development of many practical skills. In the IVTM, digital learning is used for theoretical preparation, independent practice, feedback, and

portfolio development. Activities in workshops and enterprises serve to develop occupational performance.

Simulation allows learners to make mistakes in a safe environment, but it cannot fully replicate the equipment, time constraints, responsibility, and production requirements of real employment conditions. Therefore, simulation does not replace dual workplace practice; it serves as a preparatory stage for real activity.

Dual education provides real work experience. However, not every task performed in an enterprise automatically produces a learning outcome. The workplace assignment must be linked to learning objectives and assessment criteria, and the enterprise mentor must know in advance which competencies are to be observed and assessed.

The OECD's analysis of the effects of innovative technologies on vocational education notes that virtual reality, augmented reality, simulators, and artificial intelligence expand the possibilities of practical training. However, pedagogical design and educator preparation remain decisive alongside technological infrastructure [17].

A key feature of the IVTM is the continuity of assessment. Assessment is viewed not as the final control stage of the educational process, but as a pedagogical mechanism that directs the learner's further development. The electronic portfolio preserves evidence of occupational development and serves as a shared outcome-oriented tool for the learner, teacher, and employer.

Scientific Novelty of the Study

1. Modern pedagogical technologies were integrated into a unified system for developing occupational competence.

2. An Integrative Vocational Teaching Model consisting of six functional blocks was developed for vocational education.

3. The sequence of digital learning, simulation, project activity, and dual workplace practice was substantiated.

4. An integrated index assessing occupational competence through five structural components was proposed.

5. An algorithm for implementing the model within a 16-week vocational module was developed.

6. The responsibilities of the teacher, learner, and enterprise mentor were clarified.

Practical Significance of the Study

The developed model can be used to improve the curricula of technical colleges and vocational education institutions, design instruction in specialized subjects and workplace training, organize dual education programmes, develop criteria for assessing occupational competencies, conduct professional development courses for teachers, and create electronic learning resources.

6. CONCLUSIONS AND RECOMMENDATIONS

Modern vocational education should not be limited to providing specialists with theoretical information. Learners must be able to apply acquired knowledge in real occupational situations, identify problems, develop technological solutions, and evaluate the results of their activity.

The Integrative Vocational Teaching Model developed in this study provides for the reorganization of vocational education on the basis of competency-based, practical, and digital approaches. The model combines project-based learning, blended learning, simulation, dual workplace practice, electronic portfolios, authentic assessment, and reflection within a unified didactic sequence.

1. Review curricula on the basis of occupational standards and the real tasks required by employers.

2. Develop a competency map for each vocational module.

3. Convert theoretical topics into short digital micro-modules.

4. Increase the proportion of problem-based tasks in classroom and workshop instruction.

5. Organize at least one practical group project in each module.

6. Use simulations and virtual laboratories for hazardous or expensive technological processes.

7. Involve enterprise specialists in task development and assessment.

8. Introduce an electronic portfolio system for learners.

9. Use practical examinations, project defence, and reflective interviews alongside tests in final assessment.

10. Develop teachers' digital, methodological, and occupational competencies through an integrated programme.

A teaching model developed on the basis of modern pedagogical technologies helps align vocational education with the requirements of the labour market, industry, and the digital economy. Its principal outcome is the preparation of a specialist who can independently, safely, and effectively perform an occupational task rather than merely reproduce knowledge.

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