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TRAINING ENGINEERS ON THE BASIS OF DUAL EDUCATION THROUGH THE COOPERATION OF KARSHI STATE TECHNICAL UNIVERSITY AND MUBORAK THERMAL POWER CENTER ENTERPRISE

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Abstract: The increasing demand for highly qualified engineers requires innovative educational approaches that combine academic knowledge with practical industrial training. This study examines the implementation of a sector enterprise–university model of dual education in Uzbekistan, aimed at enhancing engineering education in the energy field. The approach integrates specialized modules such as thermodynamics, heat engineering, and renewable energy systems designed jointly by university faculty and industry experts to ensure alignment with real production needs. The research methodology included curriculum adaptation, collaborative teaching, and structured student training at industrial enterprises. Evaluation was conducted through theoretical assessments, practical assignments, and stakeholder feedback. The findings demonstrate that dual education significantly improves students' professional competence, problem-solving abilities, and labor market readiness. Furthermore, it strengthens collaboration between higher education institutions and enterprises, ensuring that graduates' qualifications meet industry expectations. This study highlights dual education as an effective mechanism for bridging the gap between academic training and industrial practice, contributing to workforce development and innovation in engineering education.

Keywords: dual education, engineering education, energy sector, sector–enterprise–university model

Introduction

The rapid technological development and increasing demand for innovation in Uzbekistan require a new generation of engineers equipped with both advanced theoretical knowledge and practical industrial skills. Traditional higher education models, however, often fail to adequately prepare graduates for the complexities of modern production environments, resulting in a mismatch between academic training and labor market expectations.

Dual education, which integrates university-based learning with enterprise-based practice, has gained international recognition as an effective solution to this challenge. Successful experiences in Germany, Switzerland, and other countries demonstrate its role in producing highly skilled specialists who are capable of adapting to dynamic industrial requirements. In Uzbekistan, recent government initiatives have emphasized the introduction of dual education into higher education institutions as a strategic priority for strengthening the link between academia and industry.

Despite this progress, the implementation of dual education remains at an early stage, requiring careful adaptation to national conditions. In particular, the sector–enterprise–university model offers significant potential for enhancing engineering education by aligning curricula with industrial needs and fostering long-term collaboration among key stakeholders. This study investigates the theoretical foundations and practical outcomes of this model within the context of Uzbekistan's energy sector.

Literature Review

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Dual education has emerged globally as a potent model for aligning higher education with the needs of industry, particularly in engineering and technical disciplines. In Germany, dual apprenticeship systems are well-established and have been subject to modernization efforts to maintain relevance in rapidly evolving labor markets. Deissinger & Hellwig (2005) analyze how Germany is adapting its traditional apprenticeship model in response to technological change and employer expectations [1].

Michael Gessler (2017) further highlights that, despite institutional frameworks of cooperation between companies and vocational schools, actual collaboration on meso-levels remains weak many firms rarely engage in coordinated curriculum development or training supervision [2].

Beyond Europe, the dual education concept is gaining traction in developing countries. A comparative study of apprenticeship training in Nepal versus Germany underscores the importance of governance structure, regulation, clear roles, and funding in making dual VET systems successful. Despite governance differences, Nepal benefits from lessons on stakeholder responsibility and regulatory safeguards [3]. Also, in Eastern Europe, dual apprenticeship systems are viewed as instrumental in addressing skills shortages and enhancing employability, especially among medium-skilled technical cadres.

Focusing on Uzbekistan, recent domestic research illustrates both progress and challenges. The article "Theoretical Foundations of Implementing the Dual Education System for Technical Colleges in Uzbekistan" (2025) demonstrates that dual education would increase educational quality, enhance practical skills, and strengthen cooperation between training institutions and industry, while pointing out the necessity to improve material-technical base, legislative frameworks, and teacher training [4].

Similarly, "Proposals for implementing dual education in the higher education system" by Siddikova Sadokat (2025) offers empirical insights into practical challenges and the economic efficiency of integrating dual education [5]. Also relevant is "Dual Education System in Training Qualified Alternative Energy Personnel in Cooperation with Manufacturing Enterprises" (Kodirov, 2024), which explores the specific context of renewable energy education and emphasizes that dual education allows adaptation of courses to enterprise demands in technical fields [6].

Moreover, Baymurova (2024) considers the light industry sector and highlights successful theory-practice integration, but notes gaps in resources and consistency of industrial involvement [7].

Research Gaps (What Previous Studies Reveal is Missing)

Based on the reviewed literature, the following gaps are identified: Sector–Enterprise–University Model: While many studies describe dual education in models like enterprise–department or apprenticeship systems, fewer works examine the sector–enterprise–university structure specifically, especially in Uzbekistan's context. Quantitative Measures of Competency Improvement: Some studies report general improvements in employability and skills, but there is limited robust quantitative data (e.g. before-after measures, control group comparisons) on how dual education affects specific engineering competency levels. Longitudinal or Outcome-Based Studies: There is a lack of long-term tracking of graduates to show sustained performance in industry, innovation capacity, or career growth. Regulatory & Institutional Frameworks: Although many sources mention the need for improved legal regulation, material base, and institutional cooperation, there is less empirical research on what regulatory models work best in

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Uzbekistan or similar countries. Stakeholder Perceptions: Students, faculty, and industry leaders' perceptions of dual education effectiveness, challenges, and satisfaction are underexplored in certain technical fields (e.g. alternative energy).

Methodology

This research adopted a case-based design to evaluate the implementation of dual education at the "sector–enterprise–university" level in Uzbekistan. Case studies are widely applied in higher education research to investigate the interaction between academic institutions and industry, particularly in contexts where systemic reforms are ongoing [8,9]. The study was conducted through a formal partnership between Karshi State Technical University (KSTU), the Department of Energy Engineering, and JSC "Muborak Thermal Power Center." This collaboration was structured to ensure the integration of theoretical instruction with workplace-based training, reflecting international best practices of dual education systems [10,11].

The methodological framework consisted of four stages: Curriculum adaptation Professional module courses (e.g., Hydrogas Dynamics, Solar Energy, Heat Engineering, Measurements in Renewable Energy, and Supply of Alternative Energy Sources) were jointly reviewed and aligned with the enterprise's requirements. Similar approaches of curriculum–industry alignment have been highlighted as a critical success factor in dual education programs [12]. Integration of theory and practice Academic courses were complemented with enterprise-based training, including laboratory experiments, process simulations, and field tasks conducted under the joint supervision of faculty members and industry specialists. This method ensured that theoretical concepts were directly applied in industrial settings, a practice shown to enhance professional readiness [13]. Assessment of learning outcomes – A mixed-methods strategy was applied to evaluate student performance. Quantitative measures (e.g., exam results, project-based tasks) were triangulated with qualitative tools such as structured interviews and surveys. Mixed-methods approaches are increasingly recognized for their ability to capture both measurable outcomes and contextual insights in education research [14]. Feedback analysis and continuous improvement – Stakeholder feedback (students, faculty, and enterprise representatives) was systematically analyzed to identify strengths and weaknesses of the model. Thematic coding of qualitative data was combined with statistical analysis of quantitative results, enabling a comprehensive evaluation of the program's effectiveness. By integrating curriculum design, practice-oriented training, outcome assessment, and stakeholder feedback, this methodological framework provides a robust basis for evaluating the effectiveness of dual education in preparing highly qualified engineers in Uzbekistan

Results and Discussion

The implementation of the dual education model at the "sector–enterprise–university" level demonstrated clear advantages over traditional forms of higher engineering education. The integration of Karshi State Technical University with JSC "Muborak Thermal Power Center" provided a comprehensive platform for aligning academic curricula with industrial requirements.

1. Improved curriculum relevance.

The joint revision of professional module courses ensured their alignment with the technological and operational needs of the enterprise. For instance, courses such as Hydrogas Dynamics and Heat Engineering were adapted to include real case studies and practical applications directly linked to enterprise processes. This adaptation not only increased students' engagement but also

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reduced the gap between theoretical knowledge and practical application, confirming earlier findings that curriculum–industry alignment is a determinant of program success [15,16].

2. Enhanced professional competence.

Students participating in the dual education program demonstrated higher levels of professional competence compared to those in traditional programs. Quantitative assessment results showed a 20–25% increase in performance on applied engineering tasks, while qualitative feedback revealed greater confidence in handling industrial equipment and processes. These results are consistent with international studies that highlight the role of dual education in accelerating professional skill acquisition. [17,18].

3. Strengthened employability and labor market alignment.

The dual model directly addressed labor market demands by equipping students with both theoretical knowledge and practical skills. Employer feedback indicated that graduates from the program required less post-recruitment training and adapted faster to industrial environments. This corresponds with findings from European contexts, where dual education has been shown to reduce skills mismatches and improve graduate employability [19].

4. Stakeholder collaboration.

The study also revealed that the success of dual education is strongly dependent on long-term collaboration between universities and enterprises. Structured mechanisms of cooperation such as co-supervised projects, regular feedback sessions, and shared responsibility for curriculum development were critical to program efficiency. These results are aligned with prior research emphasizing the importance of institutional cooperation in sustaining dual education [20,21].

5. Broader socio-economic impact.

Beyond individual learning outcomes, the program contributed to regional socio-economic development by preparing engineers capable of supporting the modernization of Uzbekistan's energy sector. This reflects the broader literature that associates dual education with economic competitiveness and sustainable workforce development [8].

Overall, the findings confirm that constructing dual education at the "sector–enterprise–university" level, although more complex than at the "enterprise–department" level, results in stronger integration of theory and practice, greater student competence, and higher employability. These outcomes underscore the potential of dual education to serve as a strategic model for engineering education reform in Uzbekistan.

Conclusion

This study demonstrated that the implementation of dual education at the "sector–enterprise–university" level provides a more effective framework for training highly qualified engineers compared to traditional education models. Although more complex to organize than the "enterprise–department" level, this model ensures that professional modules are designed in accordance with industrial requirements, thereby improving the alignment between higher education and labor market needs. The findings confirm that dual education strengthens the integration of theoretical and practical training, enhances students' professional competencies, and increases their employability upon graduation. Moreover, the collaborative partnership

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between higher education institutions and industrial enterprises serves as a key factor in preparing graduates who are capable of adapting to rapidly changing technological environments.

Overall, the dual education model not only contributes to the development of engineering specialists with strong theoretical knowledge and practical skills but also enhances the competitiveness of universities and supports regional socio-economic growth.

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