



## A NEW APPROACH TO FORMING A SAFETY CULTURE IN FUTURE ENGINEERING PERSONNEL

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**ABSTRACT.** This article discusses modern approaches to forming a safety culture among future engineering personnel. In the context of rapid technological development, digitalization, and increasing industrial complexity, ensuring occupational safety has become one of the key priorities in engineering education. The study analyzes pedagogical strategies, innovative teaching methods, and digital tools aimed at developing safety awareness, risk assessment skills, and responsible professional behavior in engineering students. Particular attention is given to simulation-based learning, case studies, and competency-based education. The results show that integrating safety culture into engineering curricula significantly improves students' readiness for real industrial environments and reduces occupational risks in future professional practice.

**KEYWORDS:** safety culture, engineering education, occupational safety, risk management, competency-based learning, innovation, digital technologies, industrial safety, engineering students

### INTRODUCTION

In the modern era of rapid technological development and global industrialization, engineering education is undergoing significant transformation. The increasing complexity of engineering systems, automation of production



processes, and integration of digital technologies into industrial environments have created new challenges for ensuring occupational safety. In this context, the concept of safety culture has become a fundamental aspect of engineering education and professional training.

Safety culture can be defined as a system of values, knowledge, attitudes, and behavioral patterns that ensure safe interaction between individuals and technological systems. In engineering practice, safety culture is not only related to compliance with technical regulations but also involves a deep understanding of risk management, prevention of accidents, ethical responsibility, and continuous improvement of safety standards.

The importance of safety culture in engineering education is growing due to the increasing number of complex industrial systems such as automated factories, power plants, construction technologies, transportation systems, and digital infrastructures. In such environments, engineers play a critical role in ensuring safe operation and preventing potential hazards. Therefore, future engineers must be equipped not only with technical knowledge but also with strong safety competencies.

Modern higher education institutions are responsible for preparing engineers who are capable of working in high-risk environments while maintaining safety standards. However, traditional teaching methods are often insufficient for developing practical safety skills. Lecture-based learning may provide theoretical knowledge, but it does not always prepare students for real-life industrial risks and emergency situations.

In response to these challenges, modern pedagogical approaches emphasize the importance of interactive learning methods, such as simulation training, case studies, project-based learning, and digital technologies. These methods allow students to experience realistic scenarios and develop practical decision-making skills.



Another important factor influencing safety education is digital transformation. Technologies such as virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) have significantly expanded opportunities for practical training. These tools enable students to simulate dangerous industrial situations in a safe environment, thereby improving their understanding of risk factors and appropriate responses.

Moreover, globalization and international labor market demands require engineers to comply with global safety standards. This increases the importance of integrating international safety practices into engineering curricula. As a result, safety culture is becoming a key component of professional engineering identity.

Therefore, the main objective of this article is to analyze modern approaches to forming safety culture among future engineers and to propose effective pedagogical and technological strategies for improving safety education in higher education institutions.

## RESEARCH METHODS

This study employs a range of modern scientific and pedagogical research methods to analyze the process of forming a safety culture among future engineering personnel. The primary objective of the research is to identify effective pedagogical strategies and innovative approaches that enhance safety competencies in engineering education and ensure their practical implementation in higher education institutions.

First, the **method of literature analysis** was applied. Through this method, scientific, pedagogical, and methodological sources from both local and international scholars were reviewed. The literature analysis provided a theoretical understanding of safety culture, its structural components, and its role in engineering education. It also helped to identify key trends in modern safety training, including competency-based education and digital learning integration.



Second, the **comparative analysis method** was used to examine and compare international and national experiences in engineering education. Educational systems from different countries were analyzed to determine how safety culture is integrated into engineering curricula. This comparison revealed that countries with advanced engineering education systems widely use simulation technologies, problem-based learning, and industrial collaboration as key tools for developing safety competencies.

Third, the **pedagogical observation method** was applied in higher education institutions. Students' behavior during laboratory sessions, practical training, and independent learning activities was observed. Special attention was given to their ability to follow safety rules, respond to risky situations, and apply theoretical knowledge in practice. The observations showed that although students possess theoretical knowledge of safety rules, their practical decision-making skills in emergency situations require further development.

Fourth, the **systematic analysis and generalization method** was used to organize and interpret the collected data. This method allowed the identification of relationships between educational approaches and safety competence development. Based on this, a conceptual framework for improving safety culture in engineering education was developed.

In addition, **competency-based learning approaches, problem-based learning methods, and digital education tools** were analyzed. These approaches emphasize student-centered learning and the development of practical skills, such as risk assessment, hazard identification, and emergency response.

Overall, the combination of these research methods ensured a comprehensive analysis of safety culture formation in engineering education. The results provide a strong scientific basis for improving teaching strategies and integrating modern technologies into the learning process.

## MAIN PART – SAFETY CULTURE IN ENGINEERING EDUCATION



Safety culture in engineering education is a fundamental component of professional training for future engineers. It refers to a system of knowledge, skills, attitudes, and behaviors that ensure safe interaction with technical systems, industrial processes, and working environments. In modern engineering practice, safety culture is not limited to compliance with safety rules; it also includes risk awareness, preventive thinking, and professional responsibility.

The importance of safety culture has increased significantly due to the rapid development of industrial technologies. Modern engineering systems such as automated production lines, energy systems, chemical plants, construction technologies, and transportation infrastructures are highly complex. In such environments, even minor technical errors can lead to serious consequences, including equipment damage, financial losses, or human injuries. Therefore, engineers must be trained to prioritize safety in every aspect of their professional activity.

The key components of safety culture in engineering education include:

- risk identification and hazard analysis;
- knowledge of occupational safety regulations;
- ability to make decisions in emergency situations;
- professional responsibility and ethical behavior;
- teamwork and communication in safety management.

To develop these competencies, engineering education must go beyond traditional lecture-based teaching. Practical training, laboratory work, and real-world simulations are essential for preparing students for industrial environments.

In recent years, **digital technologies** have played an increasingly important role in safety education. Virtual Reality (VR) and Augmented Reality (AR) technologies allow students to experience realistic industrial scenarios in a controlled and risk-free environment. These technologies significantly improve



students' ability to understand hazards and respond effectively to emergency situations.

Another effective method is the **case study approach**, where real industrial accidents are analyzed to identify their causes, consequences, and preventive measures. This method helps students develop critical thinking and learn from real-world failures.

### 1. Table

#### Safety culture formation in engineering education

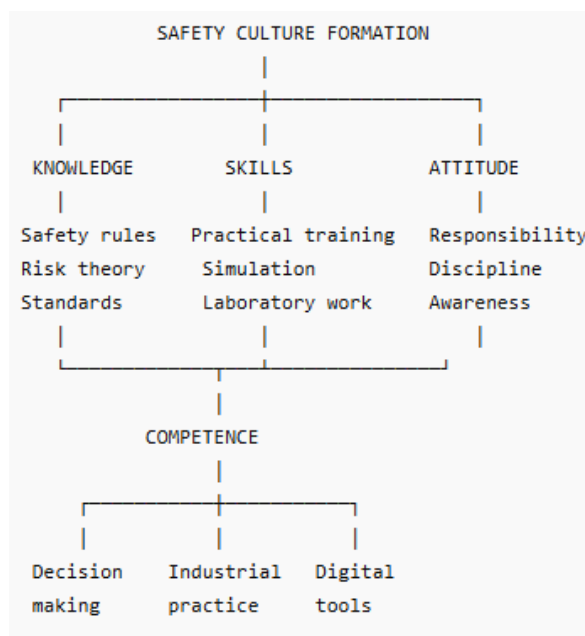
Element	Tavsif (Description)	Natija (Outcome)	Element
Knowledge (Bilim)	Safety rules, technical regulations, risk concepts	Theoretical understanding of safety	Knowledge (Bilim)
Skills (Ko'nikma)	Practical training, laboratory work, simulations	Ability to apply safety rules in practice	Skills (Ko'nikma)
Attitude (Munozarali yondashuv)	Responsibility, discipline, awareness	Formation of safety mindset	Attitude (Munozarali yondashuv)
Competence (Kompetensiya)	Decision-making in emergency situations	Professional readiness	Competence (Kompetensiya)
Digital tools	VR, AR, simulation systems, online platforms	Improved practical experience	Digital tools



Industrial practice	Internship in enterprises	Real-world safety experience	Industrial practice
Element	Tavsif (Description)	Natija (Outcome)	Element
Knowledge (Bilim)	Safety rules, technical regulations, risk concepts	Theoretical understanding of safety	Knowledge (Bilim)

Project-based learning also contributes to the development of safety culture by engaging students in practical engineering tasks that require risk assessment and safety planning. Through such activities, students learn how to apply theoretical knowledge in real-life situations.

The role of instructors is also crucial in forming safety culture. Teachers must act not only as knowledge providers but also as role models who demonstrate safe behavior and professional responsibility.



In conclusion, safety culture is an essential element of engineering education that ensures the preparation of competent, responsible, and safety-conscious engineers capable of working in modern industrial environments.

### CONCLUSION

Safety culture is one of the most important components in the training of future engineering personnel in modern higher education systems. In the context of rapid industrial development, digital transformation, and increasing complexity of



engineering technologies, the role of safety-oriented thinking has become more significant than ever. Engineers today are not only responsible for designing and operating technical systems but also for ensuring the safety of people, equipment, and the environment. Therefore, the formation of a strong safety culture is an essential requirement for modern engineering education.

The results of this study show that independent and systematic development of safety culture significantly improves students' professional competencies. In particular, students who are trained through modern pedagogical approaches demonstrate higher levels of awareness regarding occupational safety rules, better risk assessment skills, and improved ability to make correct decisions in emergency situations. This confirms that safety culture should not be treated as an additional topic, but rather as an integral part of engineering education.

The research also highlights that traditional teaching methods alone are not sufficient for developing practical safety skills. While theoretical knowledge is important, it must be combined with practical experience and real-world simulation. In this regard, modern educational technologies such as virtual reality (VR), augmented reality (AR), simulation systems, and digital learning platforms play a crucial role. These tools allow students to practice safety procedures in realistic but risk-free environments, thereby strengthening their practical competencies.

Another important finding of the study is the effectiveness of competency-based and problem-based learning approaches. These methods encourage students to actively engage in the learning process, analyze real-life cases, and develop independent solutions to complex engineering problems. As a result, students become more responsible, creative, and confident in their professional abilities.

Furthermore, the study confirms that collaboration between higher education institutions and industrial enterprises is highly important in strengthening safety culture. Practical training, internships, and real production experience help students better understand industrial risks and safety requirements. This connection between



theory and practice ensures the preparation of highly qualified engineers who are ready to work in real industrial environments.

In addition, the research emphasizes the importance of developing personal qualities such as responsibility, discipline, critical thinking, and self-learning abilities. These qualities are directly connected to safety culture and play a key role in professional success.

In conclusion, the formation of safety culture among future engineering personnel is a complex and continuous process that requires the integration of modern pedagogical methods, digital technologies, and practical training. Higher education institutions must focus on creating innovative learning environments that support the development of safety competencies. Strengthening safety culture not only improves the quality of engineering education but also contributes to reducing occupational risks and ensuring sustainable industrial development.

Thus, safety culture should be recognized as a strategic priority in engineering education, aimed at preparing highly competent, responsible, and safety-conscious engineers for the future.

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