

ECONOMY AND BUSINESS

Research paper/Түпнүсқа мақала/Оригинальная статья

DOI: https://doi.org/10.51885/3107-2755_SSADH_2026_1_6

IRSTI 14.35.07

JEL: I23, O33, J24

Jolanta Słonec *, Justyna Michaluk 

Lublin University of Technology, Lublin, Poland

Quality of engineering education in the era of digitalization and globalization

ABSTRACT. The purpose of this article is to examine and evaluate the standards of engineering education in the face of the challenges of digitization and globalization, and to identify important areas that require modification of educational programs to meet the demands of today's labor market. The study focuses on the effectiveness of current educational methods and tools in developing technical, global and interpersonal competences crucial in the era of Industry 4.0. The article analyses the transformation of engineering education, focusing on the incorporation of modern technologies, such as artificial intelligence and digital twins, and the development of global and interdisciplinary skills. The empirical part presents the results of a study conducted at the Lublin University of Technology, which revealed a high overall standard of educational quality, although areas for improvement, such as infrastructure and curriculum flexibility, were recognized. The research methods used were literature review and an online survey conducted using a questionnaire. The survey was conducted in the 2024-2015 academic year and involved 54.4% of all university students. Overall, the quality of education was rated at a good - good plus level on a five-point scale, with second-degree students rating the quality higher than first-degree students, and men rating it higher than women. The quality of the infrastructure at the university was rated the lowest. Among the students of individual faculties, the highest quality of education was rated by the students of the Faculty of Electrical Engineering and Computer Science, and the highest by the Faculty of Civil Engineering and Architecture. The results of the research highlight the need to implement more innovative and sustainable educational techniques, as well as to strengthen cooperation between universities and the industrial sector in order to prepare students more effectively for the challenges of the global labor market. It is also recommended to implement an 'Education 5.0' model that integrates technology, humanism and sustainability goals, providing a personalized and interdisciplinary approach to engineering education. The most important areas for improving the quality of education at the university include: the actual flexibility of the study program, the attractiveness of the course offerings, and the staffing of classes.

KEYWORDS: engineering education, digitalization, globalization, Industry 4.0, Education 5.0.

CONFLICT OF INTEREST: The authors declares that there is no conflict of interest.

ACKNOWLEDGEMENTS AND FUNDING: The study had no sponsorship support (own resources).

FOR CITATION: Słonec, J., Michaluk, J. (2026). Quality of engineering education in the era of digitalization and globalization. *Social Sciences & Digital Humanities*, 1(1), 87-101. https://doi.org/10.51885/3107-2755_SSADH_2026_1_6

Article history:

Received: 20.01.2026

Accepted: 10.02.2026

Published: 31.03.2026

* Corresponding author: Jolanta Słonec, e-mail: j.sloniec@pollub.pl

Цифрландыру және жаһандану дәуіріндегі инженерлік білім сапасы

АҢДАТПА. Мақаланың мақсаты цифрландыру және жаһандану сын-қатерлері жағдайында инженерлік білім беру стандарттарын зерделеу және бағалау және бүгінгі еңбек нарығының талаптарына сәйкес білім беру бағдарламаларын өзгертуді қажет ететін маңызды бағыттарды анықтау болып табылады. Зерттеу Индустрия 4.0 дәуірінде маңызды техникалық, жаһандық және тұлғааралық құзыреттерді дамытудағы қазіргі білім беру әдістері мен құралдарының тиімділігіне назар аударады. Мақалада жасанды интеллект және цифрлық егіздер сияқты заманауи технологияларды енгізуге, жаһандық және пәнаралық дағдыларды дамытуға баса назар аудара отырып, инженерлік білімнің трансформациясы талданады. Эмпирикалық бөлімде инфрақұрылым мен оқу жоспарының икемділігі сияқты жақсартуды қажет ететін салалар мойындалғанымен, білім сапасының жоғары жалпы стандартын анықтаған Люблин технологиялық университетінде жүргізілген зерттеу нәтижелері берілген. Қолданылған зерттеу әдістері әдебиеттерге шолу және сауалнама арқылы жүргізілген онлайн сауалнама болды. Сауалнама 2024-2015 оқу жылында жүргізілді және оған барлық университет студенттерінің 54,4%-ы қатысты. Жалпы алғанда, білім сапасы бес балдық шкала бойынша жақсы – жақсы плюс деңгейінде бағаланды, екінші дәрежелі студенттер сапаны бірінші дәрежелі студенттерге қарағанда жоғары, ал ерлер әйелдерге қарағанда жоғары бағалады. Университеттегі инфрақұрылым сапасы ең төмен бағаға ие болды. Жекелеген факультеттердің студенттері арасында ең жоғары білім сапасын электротехника және информатика факультетінің студенттері, ал ең жоғары бағаны құрылыс және сәулет факультетінің студенттері иеленді. Зерттеу нәтижелері студенттерді әлемдік еңбек нарығының сын-қатерлеріне тиімдірек дайындау үшін инновациялық және тұрақты білім беру әдістерін енгізу, сондай-ақ университеттер мен өнеркәсіптік сектор арасындағы ынтымақтастықты нығайту қажеттілігін көрсетеді. Сондай-ақ, инженерлік білімге жекелендірілген және пәнаралық тәсілді қамтамасыз ететін технологияны, гуманизмді және тұрақтылық мақсаттарын біріктіретін «Білім 5.0» үлгісін енгізу ұсынылады. Университетте білім беру сапасын арттырудың маңызды бағыттарына мыналар жатады: оқу бағдарламасының нақты икемділігі, курс ұсыныстарының тартымдылығы және сыныптардың кадрлық құрамы.

ТҮЙІН СӨЗДЕР: инженерлік білім, цифрландыру, жаһандану, Индустрия 4.0, Білім 5.0.

МҮДДЕЛЕР ҚАҚТЫҒЫСЫ: Авторлар мүдделер қақтығысының жоқтығын мәлімдейді.

ҚАРЖЫЛАНДЫРУ ЖӘНЕ АЛҒЫС: Зерттеуге демеушілік қолдау көрсетілмеді (жеке ресурстар).

ДӘЙЕКСӨЗ ҮШІН: Słonic, J., Michaluk, J. (2026). Цифрландыру және жаһандану дәуіріндегі инженерлік білім сапасы. *Social Sciences & Digital Humanities*, 1(1), 87-101. https://doi.org/10.51885/3107-2755_SSADH_2026_1_6

Качество инженерного образования в эпоху цифровизации и глобализации

АННОТАЦИЯ. Целью данной статьи является изучение и оценка стандартов инженерного образования в условиях вызовов цифровизации и глобализации, а также выявление важных областей, требующих модификации образовательных программ для соответствия требованиям современного рынка труда. Исследование фокусируется на эффективности современных методов и инструментов образования в развитии технических, глобальных и межличностных компетенций, имеющих решающее значение в эпоху Индустрии 4.0. В статье анализируется трансформация инженерного образования с упором на внедрение современных технологий, таких как искусственный интеллект и цифровые близнецы, а также развитие глобальных и междисциплинарных навыков. Эмпирическая часть представляет результаты исследования, проведенного в Люблинском технологическом университете, которое выявило высокий общий стандарт качества образования, хотя были признаны области для улучшения, такие как инфраструктура и гибкость учебной программы. В качестве методов исследования использовались обзор литературы и онлайн-опрос, проведенный с использованием анкеты. Опрос проводился в 2024-2015 учебном году и охватил 54,4% всех студентов университета. В целом качество образования было оценено на уровне «хорошо - хорошо плюс» по пятибалльной шкале, причем студенты второй ступени оценили качество выше, чем студенты первой ступени, а мужчины - выше, чем женщины. Качество инфраструктуры в университете было оценено ниже всего. Среди студентов отдельных факультетов наивысшее качество образования оценили студенты факультета электротехники и компьютерных наук, а наивысшее - факультета гражданского строительства и архитектуры. Результаты исследования подчеркивают необходимость внедрения более инновационных и устойчивых образовательных технологий, а также укрепления сотрудничества между университетами и промышленным сектором в целях более эффективной подготовки студентов к вызовам мирового рынка труда. Также рекомендуется внедрить модель «Образование 5.0», которая объединяет цели технологий, гуманизма и устойчивости, обеспечивая персонализированный и междисциплинарный подход к инженерному образованию. Наиболее важными областями для повышения качества образования в университете являются: фактическая гибкость учебной программы, привлекательность предлагаемых курсов и кадровое обеспечение занятий.

КЛЮЧЕВЫЕ СЛОВА: инженерное образование, цифровизация, глобализация, Индустрия 4.0, Образование 5.0.

КОНФЛИКТ ИНТЕРЕСОВ: Авторы заявляют об отсутствии конфликта интересов.

ФИНАНСИРОВАНИЕ И БЛАГОДАРНОСТИ: Исследование не имело спонсорской поддержки (собственные ресурсы).

ДЛЯ ЦИТИРОВАНИЯ: Słonieć, J., Michaluk, J. (2026). Качество инженерного образования в эпоху цифровизации и глобализации. *Social Sciences & Digital Humanities*, 1(1), 87-101. https://doi.org/10.51885/3107-2755_SSAHD_2026_1_6

LITERATURE REVIEW

Digitalization and globalization have had a significant impact on engineering education, creating the need to adapt curricula to meet the changing needs of the labor market. Currently, key aspects of engineering education are modern technologies (such as artificial intelligence and the Internet of Things) and global skills. The authors point out that existing educational frameworks, such as the NRC Framework, rely too heavily on scientific models and do not fully reflect the specific nature of engineering, which emphasizes optimization and multiple solutions to problems. The proposed set of nine practices considers key aspects such as problem formulation, testing and improving solutions, and prototyping to foster a better preparation of students for professional reality. Grounded in global technological change, the approach offers a more comprehensive vision of engineering education, responding to the challenges of digitalization and globalization (Lavi et al., 2022). They examined 13 cases involving digital transformation (DT) frameworks and models, highlighting their significance for educational practices, ranging from classroom settings to systemic changes in universities. The authors noted the need for comprehensive approaches to integrating technology, such as digital tools and hybrid learning models. The text also offers guidance for universities and researchers to promote the development of innovative teaching methods in engineering (Nor et al., 2019). According to research, the engineers of tomorrow should not only have advanced technical skills but also the ability to work in culturally diverse international groups. Therefore, universities need to include aspects in their curricula that develop global skills, such as an understanding and respect for cultural diversity, the ability to communicate effectively in an international context, and an openness to lifelong learning. It is important to adequately prepare future engineers to work in a global world where international cooperation and respect for diverse cultures are necessary (Shah & Sadeghzadeh, 2017). Technical students in higher education should be prepared to seek sustainable answers to the complex challenges of the modern world, which requires the development of important interpersonal skills, such as collaboration in multidisciplinary teams or flexibility toward innovative technologies (Diaz Lantada, 2020).

Equally important are modern methods of teaching industrial engineering, particularly highlighting the benefits of digital technologies and innovative methodologies. We highlight the importance of modern technologies like e-learning platforms in teaching hard and soft skills in Industry 4.0, and select cases from various countries like Poland, Italy, Spain, and Sweden demonstrate effective teaching methods in practice (Hernandez-de-Menendez et al., 2020). Researchers have identified seven key areas for digital transformation, which include improving teachers' skills, supporting students online, and forming partnerships with universities and industry. This adaptation process is considered important for universities and can transform teaching and learning, giving greater flexibility and accessibility in learning while preparing students for the challenges of the digital world (Caeiro Rodriguez et al., 2021).

The impact of online and hybrid teaching methods on engineering programs is also important, indicating the growing importance of these methods in higher education. Frankly, it is important to note how coronavirus has accelerated the adoption of these technologies, providing flexibility in teaching but also posing challenges in engaging students and maintaining quality online education (Gamage et al., 2022). Various universities widely use Moodle as a support for traditional teaching, but its total access to online content can lead to information overload and absenteeism among students. A study based on the Delphi methodology, with expert input, identifies key elements of effective Moodle use that reduce these negative effects and enrich student learning (Mogos et al., 2018).

Accreditation, especially in the context of international agreements such as the Washington Accord, is important for raising the standards of engineering education globally, ensuring that programs comply with international standards. Globalization and increasing competition in the labor market make accreditation an increasingly important tool to support the professional mobility of engineers and the quality of educational programs, especially in developing countries (Oleskow-Szlapka et al., 2020).

In an era of globalized industry and engineering practices, the role of the engineer of the future is becoming increasingly complex, necessitating modifications in the engineering education system. The Malaysian Ministry of Higher Education (MOHE) is emphasizing the education of competitive engineers through the development of programs that provide mobility, flexibility, and adaptation to changing technologies and conditions. This article examines the response of Malaysian universities to these demands, highlighting the need for a new concept of engineering education that incorporates a flexible curriculum, skills development of academic staff, and methods of educating engineers relevant to the needs of the market in 2020 and beyond (Simarro & Couso, 2021).

Among other researchers, Lavi R. and Bidemi H. emphasize the importance of modern teaching methods and technology in engineering education. They emphasize the need to change traditional educational strategies, noting the increased value of digital technologies and innovative approaches, such as learning through hands-on engineering experiences and problem solving (Yeakub Ali et al., 2021). Both articles highlight the need to adapt educational programs to the changing environment of the global labor market, proposing new teaching methods that engage students in hands-on and interactive learning processes (Al-Zoubi et al., 2023). Texts on the quality of engineering education in the era of digitization and globalization note the increasing importance of modern technologies in the learning process (Gkrimpizi et al., 2024a). The use of digital technologies, such as digital twins, in engineering teaching helps prepare students for the needs of today's industry. Gkrimpizi T., Peristeras V., and Magnisalis I. emphasize the importance of digital transformation and the challenges of introducing new educational tools and hybrid teaching methods (Gkrimpizi et al., 2024b). In relation to the fourth industrial revolution, they discuss how technological advances affect the need to adapt curricula to better prepare engineers for global challenges. According to this research, engineering education must consider global labor market needs and future technologies. Raising the profile of digital competences and interdisciplinary skills is necessary to maintain a high level of engineering education. The interaction of universities with industry and the use of innovative teaching methods are important factors in preparing students for the current challenges of a global society. Research confirms that engineering education must adapt to the increasing demands of the digital and globalized labor market (Rasul et al., 2023).

Engineering education is evolving towards an 'Engineering Education 5.0' paradigm that goes further than the technologies of Industry 4.0, combining ethics, humanism, and sustainability goals in the education of future engineers. Universities currently teach specialized skills for managing modern manufacturing systems, a prerequisite for Industry 4.0, which is based on technologies like IoT, robotics, data analytics, and augmented reality. 'Engineering Education 5.0' and Industry 4.0-related education underscore the necessity of continuously updating curricula to keep pace with modern technologies and rapidly evolving market demands (Infante et al., 2024; Victor-Akinyemi, 2023).

CHANGES OF THE ENGINEERING SECTOR

Sectoral changes stem from several sources, primarily: technical advancements, escalating globalization, demands for sustainability, and shifts in consumer tastes.

Developments and transformations in the sector are:

1. Automation and digitalization.
 - Industry 4.0: The application of the Internet of Things (IoT), artificial intelligence, big data, and cloud technologies to enhance manufacturing processes.
 - Robotization: The escalating deployment of industrial robots in manufacturing facilities, resulting in enhanced efficiency while simultaneously diminishing the necessity for manual labor.
2. Green transformation
 - Decarbonization: Mitigating CO₂ emissions through the transition to renewable energy sources and the advancement of energy-efficient technologies.
 - Circular economy: Emphasizing recycling and waste reduction in industrial methodologies.
 - Regulatory modifications: Escalating environmental restrictions compel corporations to implement more sustainable methods.

3. Personalization and adaptability
 - Rising demand for tailored products.
 - Advancement of technologies like 3D printing that facilitate swift prototyping and brief production cycles.
4. Globalization versus regionalization
 - Re-shoring: the practice of relocating production nearer to consumer markets to minimize supply chain length and mitigate the risk of global disruptions.
 - Diversification of supply chains: The pursuit of alternate suppliers and markets in reaction to geopolitical concerns and the COVID-19 epidemic.
5. Emerging industry sectors
 - Renewable technologies: Rapid expansion of solar, wind, and hydrogen technology sectors.
 - Electrification of transportation: Augmentation of electric vehicle manufacturing and advancement of charging infrastructure.
6. Impact of Artificial Intelligence (AI)
 - Utilization of AI in production optimization, demand forecasting, inventory management, and predictive maintenance of equipment.
7. HR Issues
 - The Growing Importance of Digital Skills Among Workers.
 - Skilled Workforce Shortages in Traditional Industry Sectors.

Sectoral changes arise from multiple reasons, chiefly: technological innovations, increasing globalization, sustainability concerns, and alterations in consumer preferences. The principal advancements and changes in the field are automation and digitization.

In the literature, the skills needed in engineering sector are divided into essential and optional.

Essential skills are:

⇒ knowledge

- engineering principles
- engineering processes
- machinery products
- technical drawings

⇒ skill/competence

- adjust engineering designs
- approve engineering design
- ensure compliance with safety legislation
- perform scientific research
- use technical drawing software

Optional skills are:

⇒ knowledge

- engineering products
- contamination exposure regulations
- renewable energy technologies

⇒ skill/competence

- analyse environmental data
- abide by regulations on banned materials
- assess project resource needs
- collect mapping data
- develop efficiency plans for logistics operations.

RESEARCH ON THE QUALITY OF ENGINEERING EDUCATION BASED ON THE EXAMPLE OF LUBLIN UNIVERSITY OF TECHNOLOGY (POLAND)

To improve the quality of education for engineers, a study of the quality of education of students at the Lublin University of Technology (Poland) was conducted in the academic year 2024-2025. Basic information about the study is included in Tables 1 and 2.

Table 1. Number and structure of respondents

Specification		Number	Structure, %
Gender	Woman	955	29.8
	Man	2187	68.2
Level of study	First cykle	2376	74.1
	Second cykle	831	25.9
Form of studies	Full-time	2598	81
	Part-time	609	19

Source: Own elaboration

As it is a technical university, most students are men, therefore almost 70% of the respondents were men. Almost 3/4 of students studied at first-cycle level and slightly more than 1/4 at second-cycle level. Over 80% of respondents were full-time students and slightly less than 20% were studying part-time.

Table 2. Number and structure of respondents depending on the faculty

Faculty	Number	Structure, %	Total number of students	Share of respondents, %
Construction and Architecture	629	19.6	1103	57
Electrical Engineering and Computer Science	1145	35.7	2186	52.4
Environmental Engineering	219	6.8	411	53.3
Mechanical Engineering	518	16.2	959	54
Mathematics and Technical Computer Science	246	7.7	468	52.6
Management	450	14.0	772	58.3
Total	3207	100	5899	54.4

Source: Own elaboration

In terms of the structure of responses, almost 55% of students took part in the survey across the entire university, and it should be noted that more than half of students from each faculty took part in the survey. The faculty with the largest participation in the survey was the Faculty of Management (58.3%), and the smallest number of students participated in the survey from the Faculty of Electrical Engineering and Computer Science (52.4%).

Then, basic information about the quality of education was presented.

The Figure 1 shows the overall assessment of the quality of education in the entire university on a five-point Likert scale.

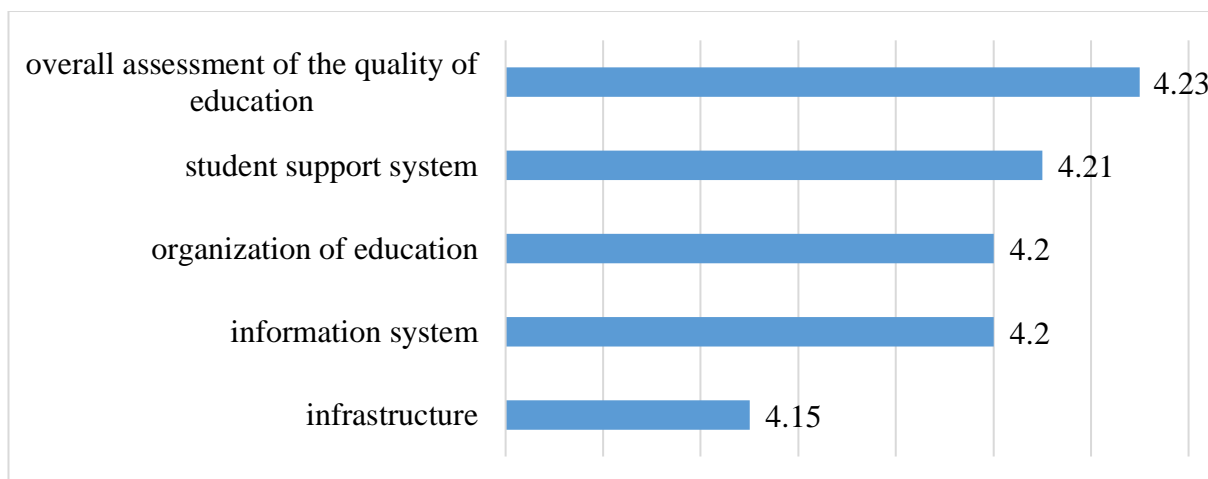


Figure 1. Assessments of the quality of education

Source: Own elaboration

The data obtained indicate that the overall assessment of the quality of education and the elements examined was at a good – good plus level. All elements of the quality of education at the university (overall assessment, student support system, organization of education, information system, infrastructure) were rated above good. The overall quality of education was rated the highest (4.23) and the infrastructure the lowest (4.15). The lowest infrastructure rating is due to several reasons. The oldest buildings of the university (Faculty of Management) date back to the early 20th century and although they have been renovated many times, their quality is lower. The second reason for the low assessment of infrastructure concerns the rapid aging of IT and research equipment. Although the infrastructure is constantly being gradually replaced, sometimes it does not meet the modern requirements of science and research.

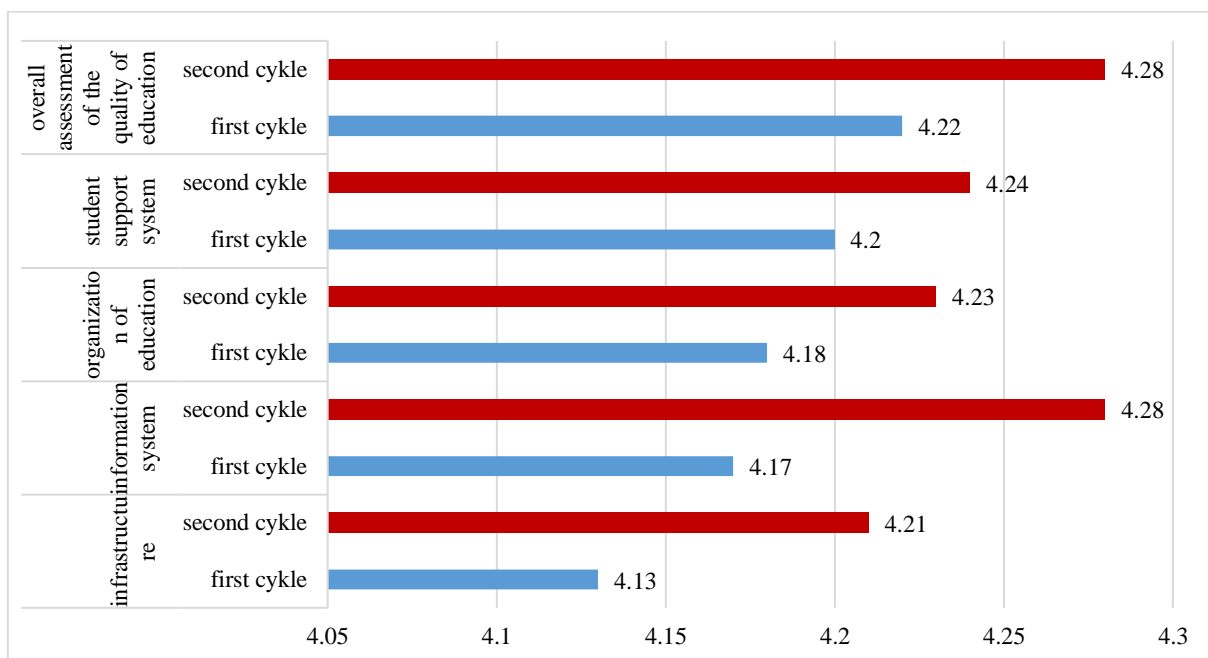


Figure 2. Assessment of selected aspects of the educational process according to the level of studies criterion

Source: Own elaboration

The Figure 2 shows the assessment of individual elements of the quality of education by students of the first and second cycle of studies. As can be seen from the figure, each characteristic

of the quality of education is rated higher by second-cycle students than by first-cycle students, and the differences in ratings range from 0.04 (*student support system*) to 0.11 (*information system*).

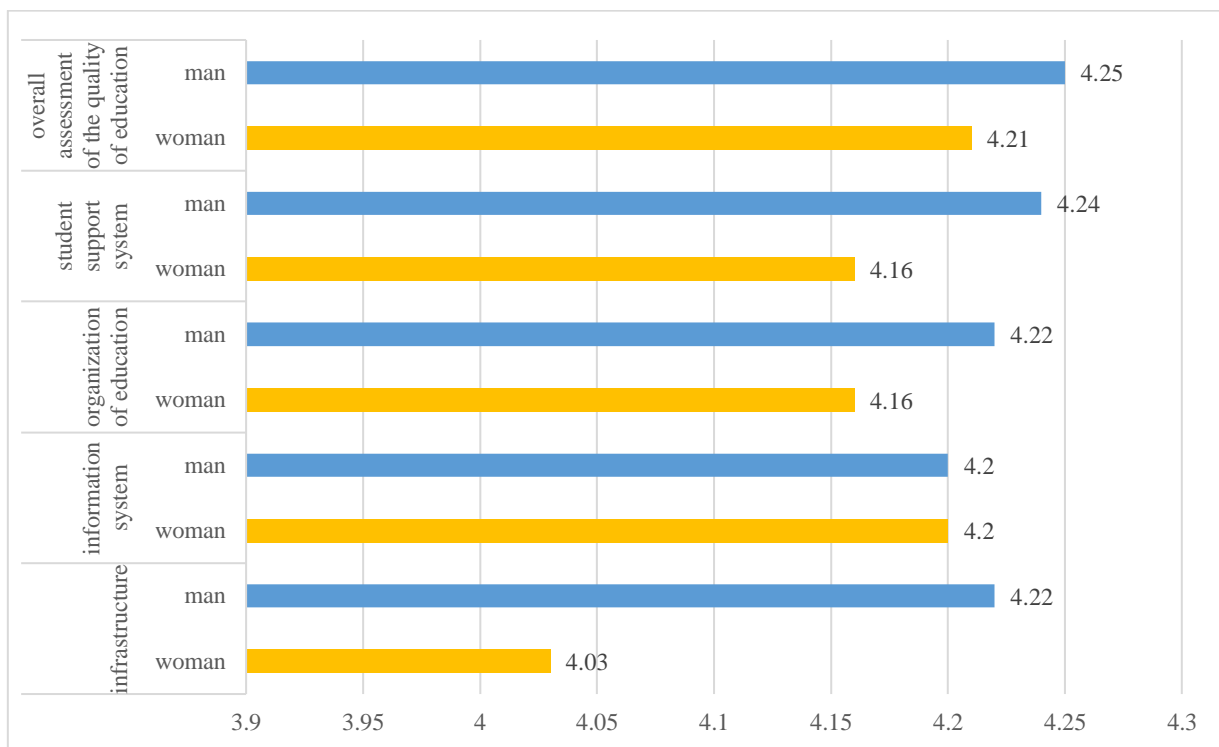


Figure 3. Assessment of selected aspects of the educational process according to gender

Source: Own elaboration

Figure 3 presents the assessment of the same characteristics of the quality of education depending on the respondent's gender. In general, men rate individual aspects higher than women, apart from the *information system*, where the rating is the same for women and men. The biggest difference in the assessment concerns *infrastructure*, which men rate at 4.22 and women at 4.03.

This observed gender-based differentiation in the perception of quality indicators underlines the importance of taking into account the diverse expectations and experiences of students when assessing the effectiveness of educational processes. While gender disparities are relatively minor, they may reflect deeper issues related to inclusivity, accessibility, or communication within specific educational components. In order to obtain a more nuanced understanding of the overall educational environment, it is also essential to analyze these quality indicators across different faculties. Figure 4 presents a comparative assessment of selected aspects of the educational process by faculty, allowing for the identification of structural strengths and areas in need of improvement within each academic unit.

Differences across faculties may stem from a variety of structural and organizational factors, including the specificity of academic programs, availability of modern infrastructure, staff qualifications, and faculty-level management practices. By analyzing the distribution of student perceptions at the faculty level, it becomes possible to identify best practices that contribute to higher satisfaction, as well as systemic weaknesses that may hinder the overall quality of education. Such a comparison offers valuable insights for institutional benchmarking and targeted improvements. Figure 4 illustrates how students from different faculties assess key dimensions of the educational process, providing a more granular perspective on how quality is experienced across the university.

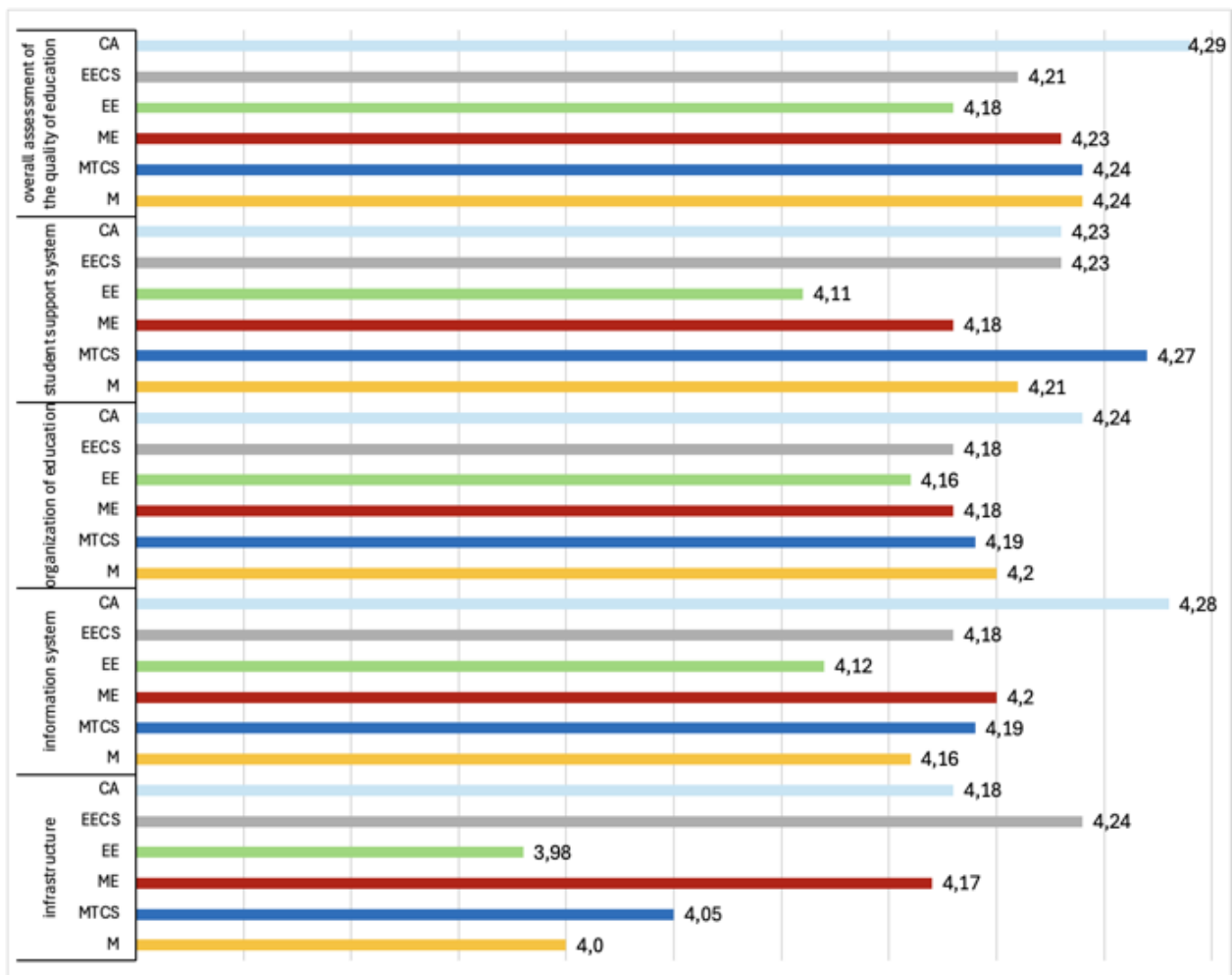


Figure 4. Assessment of selected aspects of the educational process according to faculty (faculties: CA – Construction and Architecture, EESC - Electrical Engineering and Computer Science, EE - Environmental Engineering, ME - Mechanical Engineering, MTCS – Mathematics and Technical Computer Science, M – Management)

Source: Own elaboration.

The overall level of quality of education was assessed the highest by students of the Faculty of Civil Engineering and Architecture (4.29) and the lowest by students of the Faculty of Electrical Engineering and Computer Science (4.18). However, it should be noted that the overall assessment of the level of quality of education was high.

Reference to other aspects of the educational process, the *information system* was rated the highest by students of the Faculty of Civil Engineering and Architecture (4.28), the *student support system* was rated the highest by students of the Faculty of Mathematics and Technical Computer Science (4.27), and the *infrastructure* was rated the highest by students of the Faculty of Electrical Engineering and Computer Science (4.24), while *organization of education* were rated the highest by students of the Faculty of Civil Engineering and Architecture (4.24). The lowest rated aspect of the educational process at the university was the *infrastructure* at the Faculty of Environmental Engineering (3.98).

An in-depth analysis of the obtained results showed that the overall assessment of the quality of education had a clear connection with the assessment of individual elements of the education process and their aspects. The calculated correlation indices ranged from 0.672 to 0.826.

The obtained results allow us to indicate those elements and aspects of the educational process carried out at the university that received a lower score, and therefore in which irregularities may potentially occur. This concerns aspects such as:

1. In the area of organization of studies:

- actual flexibility of the study program (the possibility of actual choice of elective subjects, diploma blocks and study specializations),
 - valuation of ECTS points (adequacy of assigning ECTS points to the actual workload of students),
 - construction of class schedules (daily and weekly schedule of classes),
 - attractiveness of the offer of elective subjects, diploma blocks and study specializations,
2. In the area of infrastructure: places for students to rest (so-called relaxation zones),
3. In the area of student support: organization of additional internships, apprenticeships, trainings to obtain or improve students' competences.

Comparing the detailed results of the quality assessment of engineering education at Lublin University of Technology and the directions for the development of engineering education, it should be stated that in various areas of competency acquisition, there are spheres for improvement. In the area of technical competencies:

- Class staffing (competencies of academic teachers and their preparation for classes),
- The quality of educational materials provided by academic teachers,
- Support for students by academic teachers during the educational process,
- Organization of additional internships, placements, and training to acquire or enhance students' competencies,
- The functioning of the remote learning platform and the transmission of information and materials,
- Actual flexibility of the study program (the possibility of genuinely choosing elective subjects, diploma blocks, and study specializations),
- The attractiveness of the elective courses, diploma blocks, and study specializations offered,
- The possibility of participating in scientific circles.

In the area of methodological competencies:

- Availability of library resources and databases (reading room hours, ease of using the system, access to the system from outside the university),
- Equipping classrooms and facilities with teaching and research equipment,
- Support for students in job searching (job fair, mobile Career Office, career counseling),
- Organization of the graduation process,
- Support for students by academic teachers in the educational process,
- The functioning of the information system.

In the area of social competencies:

- The possibility of organizing participation in events organized by the university,
- Organization of national and international exchanges.

In the area of personal competencies:

- Interpersonal relationships between students and academic teachers,
- Integration and activity of the student environment.

COMPARATIVE ANALYSIS OF THE RESULTS OF THE FACULTY OF MANAGEMENT AGAINST OTHER FACULTIES OF LUBLIN UNIVERSITY OF TECHNOLOGY

The analysis of the assessment of the quality of education at Lublin University of Technology in the academic year 2023/2024 made it possible to compare the results achieved by the Faculty of Management with other faculties of the university. The analysis covered aspects such as the overall quality of education, infrastructure, the student support system and the organization of the teaching process.

Overall quality of education

The overall assessment of the quality of teaching at the Faculty of Management reached 4.22, which places the faculty in a higher range of average scores compared to other faculties of the university. The best results in this category were achieved by students of the Faculty of Building and

Architecture (4.29), while the Faculty of Electrical Engineering and Computer Science scored slightly lower with 4.18.

Infrastructure

Infrastructure was rated differently depending on the department. In the Faculty of Management, the average score was 4.03, suggesting the need for improvements, especially in student relaxation areas and lecture theatre facilities. Compared to other departments, the infrastructure of the Faculty of Electrical Engineering and Computer Science was rated the best (4.24), while the Faculty of Environmental Engineering received the lowest score of 3.98.

Student support system

The Faculty of Management received an average score of 4.24 in student support, coming close to the leading results in this area. Students positively assessed the opportunity to get involved in research clubs and the functioning of the student government but noted shortcomings in the organization of additional internships and training. Compared to others, the Faculty of Mathematics and Technical Informatics scored highest in this category (4.27).

Organization of education

The organization of the teaching process at the Faculty of Management scored 4.06, suggesting a stable but in need of improvement result. The Faculty of Building and Architecture received the highest score (4.24), mainly due to the flexibility of the curriculum and well-planned classes. The Faculty of Management, like the other faculties, emphasizes the need to better adapt the timetables and to make the proposals for elective subjects more attractive.

Conclusions

Analysis of the results indicates that the Faculty of Management achieves satisfactory results in the assessment of the quality of education, ranking close to the university average. However, there are areas for improvement, especially regarding infrastructure and curriculum flexibility. Improving these aspects, together with continuing student support, could significantly increase student satisfaction. These results can serve as a basis for recommendations to the faculty authorities, which can be applied to increase competitiveness towards other Polish universities and within the university.

PROSPECTS FOR CHANGES IN ENGINEERING EDUCATION

Nine trends characterize Education 4.0:

1. Learning can occur at any location and at any time.
2. Students will engage with a combination of tools, programs, and strategies that they favor most.
3. Educational tools will be tailored to the individual learning preferences of each learner.
4. Students will engage in self-directed learning, while instructors will assume the role of mentors.
5. Students will engage in experiential learning through internships and collaborative projects.
6. Students must enhance their organizational skills and improve time management to accomplish their responsibilities within a reduced timeframe.
7. Students will create personalized curriculum tailored to their interests.
8. Evaluations will be determined on outcomes rather than tests.
9. Data interpretation will be an essential competence that must be incorporated into all curriculum (Lyngdorf et al., 2024).

Universities must adopt a more multidisciplinary approach, as Industry 4.0 has many elements necessitating competence across multiple fields.

Table 3. Competencies required by the Industry 4.0 workforce

Technical competencies	Methodological competencies	Social competencies	Personal competencies
<ul style="list-style-type: none"> • State-of-the-art knowledge 	<ul style="list-style-type: none"> • Creativity 	<ul style="list-style-type: none"> • Intercultural skills • Language skills 	<ul style="list-style-type: none"> • Flexibility

<ul style="list-style-type: none"> • Technical skills • Process understanding • Media skills • Coding skills • Understanding IT security 	<ul style="list-style-type: none"> • Entrepreneurial thinking • Problem-solving • Conflict-solving • Decision-making • Analytical skills • Research skills • Efficiency orientation 	<ul style="list-style-type: none"> • Communication skills • Networking skills • Ability to work in a team • Ability to be compromising and cooperative • Ability to transfer knowledge • Leadership skills 	<ul style="list-style-type: none"> • Ambiguity tolerance • Motivation to learn • Ability to work under pressure • Sustainable mindset • Compliance
<p><i>Source: (Victor-Akinyemi, 2023)</i></p>			

To maintain their market share, industrial enterprises are working on meeting the changing needs and desires of their customers, who demand more personalized products. This has caused efforts of enterprises to adapt production processes to be more efficient and flexible. In the future, factories will be completely digital; different production units will be integrated and managed by central computer. This approach is currently known as Industry 4.0, which is evolving and impacting global goods production. The advent of Industry 4.0 means that universities must take responsibility for providing students with the necessary skills to effectively perform tasks in future industries. More than ever, universities need to update their existing curricula and develop programs to support the training of the future workforce. Content and competencies must be developed and ideally balanced with technology in appropriate educational programs aimed at training future professionals.

New curricula need to be developed, considering technologies and topics related to the Industry 4.0 environment. The technologies are diverse and interconnected; the most important ones, considered the pillars of Industry 4.0, include: autonomous robots, simulation, horizontal and vertical integration, industrial internet of things, augmented reality, the cloud, additive technology, cybersecurity, and big data and analytics.

Innovations in higher education include:

- developing innovative educational programs and incorporating innovative elements into existing programs
- introducing innovative learning and teaching methods (i.e. student-centered learning and learning based on solving real-world problems)
- active interaction with the business community and scientific research, organization of continuing education programs and events within and within enterprises
- effective networking in scientific research, scientific and technological innovation.

REFERENCES

- Al-Zoubi, A., Castro, M., Shahroury, F. R., & Sancristobal, E. (2023). Impact of remote labs in preparing students for Work 4.0. *IEEE Global Engineering Education Conference (EDUCON)*.
- Caeiro Rodriguez, M., Manso Vázquez, M., Fernández, A., & Sørensen, L. (2021). Teaching soft skills in engineering education: A European perspective. *IEEE Access*, 9, 29222–29242. <https://doi.org/10.1109/ACCESS.2021.3058829>
- Diaz Lantada, A. (2020). Engineering education 5.0: Continuously evolving engineering education. *International Journal of Engineering Education*.
- Gamage, K. A. A., Gamage, A., & Dehideniya, S. C. P. (2022). Online and hybrid teaching and learning: Enhance effective student engagement and experience. *Education Sciences*, 12(10), 651. <https://doi.org/10.3390/educsci12100651>
- Gkrimpizi, T., Peristeras, V., & Magnisalis, I. (2024). Defining the meaning and scope of digital transformation in higher education institutions. *Administrative Sciences*, 14(3), 48. <https://doi.org/10.3390/admsci14030048>

- Gkrimpizi, T., Peristeras, V., & Magnisalis, I. (2024). Digital transformation in engineering education: Trends and challenges. *Engineering Education*, 12(3), 245–260.
- Hernandez-de-Menendez, M., Escobar Díaz, C. A., & Morales-Menendez, R. (2020). Engineering education for smart 4.0 technology: A review. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 14, 789–803. <https://doi.org/10.1007/s12008-020-00662-6>
- Infante, A., Infante Moro, J. C., Gallardo Pérez, J., & Nguyen, T.-L. (2024). Aspects to be taken into account by teachers for the correct use of Moodle as a support tool for face-to-face teaching. *Campus Virtuales*, 13(2), 215.
- Lavi, R., Marti, D., Du, X., & Mitra, A. (2022). Transforming engineering education through technology. *IEEE Transactions on Education*.
- Lyngdorf, N. E. R., Jiang, D., & Xiangyun, D. (2024). Frameworks and models for digital transformation in engineering education: A literature review using a systematic approach. *Journal of Engineering Education*.
- Mogos, R. I., Bodea, C. N., Dascalu, M. I., Safonkina, O., Lazarou, E., Trifan, E. L., et al. (2018). Technology enhanced learning for Industry 4.0 engineering education. *Revue Roumaine des Sciences Techniques. Série Électrotechnique et Énergétique*, 63, 429–435.
- Nor, N. M., Rajab, N., & Ismail, K. M. (2019). Educating the engineer of 2020: Malaysian scenario. University Teknologi Malaysia / College of Science and Technology, Kuala Lumpur, Malaysia.
- Oleskow-Szlapka, J., Ortega-Mier, M., Ordieres-Mere, J., Facchini, F., Mossa, G., & Lundquist, J. (2020). Innovative methodologies and digital tools for higher education in industrial engineering and management. In 14th International Technology, Education and Development Conference (INTED2020) (pp. 1019–1027).
- Rasul, A. A., G., M., & Taylor, B. A. (2023). Developing a skilled workforce for future industry demand: The potential of digital twin-based teaching and learning practices in engineering education. *Sustainability*, 15(23), 16433. <https://doi.org/10.3390/su152316433>
- Shah, M., & Sadeghzadeh, M. (2017). Self-designed drone as a platform for engineering education. In Proceedings of the LACCEI International Multiconference for Engineering, Education and Technology.
- Simarro, C., & Couso, D. (2021). Engineering practices as a framework for STEM education: A proposal based on epistemic nuances. *International Journal of STEM Education*, 8(1), Article 8. <https://doi.org/10.1186/s40594-021-00271-1>
- Victor-Akinyemi, B. H. (2023). Enhancing science, technology, engineering and mathematics (STEM) curriculum with integration of artificial intelligence (AI). Department of Curriculum & Instruction, Federal College of Education, Okene.
- Yeakub Ali, M., Ya'akub, S. R., Singh, R., Al Hazza, M. H. F., & Adesta, E. (2021). Quality assurance in engineering education: Accreditation and its global influence. In Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management. IEOM Society International.

Information about the authors

Sloniec Jolanta – PhD. Dr. Sc., professor at Lublin University of Technology, Department of Enterprise Organization, Lublin, Poland, e-mail: j.sloniec@pollub.pl, ORCID: <https://orcid.org/0000-0002-8869-5059>

Justyna Michaluk – Msc., assistant professor at Lublin University of Technology, Department of Enterprise Organization, Lublin, Poland, e-mail: j.michaluk@pollub.pl, ORCID: <https://orcid.org/0009-0006-5969-9989>

Авторлар туралы мәліметтер

Sloniec Jolanta – PhD. д-р., Люблин технологиялық университетінің Кәсіпорындарды ұйымдастыру департаментінің профессоры, Люблин, Польша, e-mail: j.sloniec@pollub.pl, ORCID: <https://orcid.org/0000-0002-8869-5059>

Justyna Michaluk – магистр, Люблин технологиялық университетінің Кәсіпорындарды ұйымдастыру департаментінің доценті, Люблин, Польша, e-mail: j.michaluk@pollub.pl, ORCID: <https://orcid.org/0009-0006-5969-9989>

Сведения об авторах

Śloniec Jolanta – Доктор наук, профессор Люблинского политехнического университета, кафедра организации предприятий, Люблин, Польша, e-mail: j.slonec@pollub.pl, ORCID: <https://orcid.org/0000-0002-8869-5059>

Justyna Michaluk – Магистр, доцент Люблинского политехнического университета, кафедра организации предприятий, Люблин, Польша, e-mail: j.michaluk@pollub.pl, ORCID: <https://orcid.org/0009-0006-5969-9989>