PRELIMINARY COMMUNICATION
DOI: 10.63395/STEDConf14022025925D449
Submitted: 21.08.2025.
Accepted: 16.09.2025.

THE CONCEPT AND SIGNIFICANCE OF ERGONOMICS IN HIGHER EDUCATION WITH A FOCUS ON MECHANICAL ENGINEERING

Darina Dupláková[1], Ján Duplák[1], Dejan Kojic[2], Enes Sukic[3], Anton Vorina[4]

[1]Technical University of Kosice Faculty of Manufacturing Technologies with a Seat in Presov, Bayerova 1, 080 01 Presov, Slovakia
[2]Technical Faculty, University PIM, Despota Stefana Lazarevica bb, 78000 Banja Luka, Bosnia and Herzegovina
[3]Faculty of Information Technology and Engineering—FITI, University Union—Nikola Tesla, 11070 Belgrade, Serbia
[4]School of Economics, Vocational College Celje, Mariborska 2, 3000 Celje, Slovenia

Coresponding author: Darina Dupláková, Technical University of Kosice Faculty of Manufacturing Technologies with a Seat in Presov, Bayerova 1, 080 01 Presov, Slovakia

ABSTRACT

Ergonomics constitutes an integral part of engineering design, specifically in the development of technical systems where human physical and cognitive characteristics are systematically considered. Higher education in mechanical engineering requires the structured integration of ergonomic principles into curricula, not only from a theoretical perspective but also in terms of their practical applicability in engineering practice. This paper aims to analyse the current role of ergonomics within university-level mechanical engineering education and to emphasize the necessity of aligning academic instruction with real-world industrial requirements. The implementation of ergonomic approaches in industrial settings contributes to the reduction of workload, enhancement of occupational safety, and optimization of productivity. Through the analysis of academic curricula, scientific literature, and professional standards, key areas of ergonomics education are identified, with a focus on the needs of contemporary mechanical engineering practice. The evaluation also includes the assessment of digital tools, simulation technologies, and hands-on projects that enable students to apply acquired knowledge to solve specific engineering problems. Furthermore, the paper discusses opportunities for interdisciplinary integration with fields such as manufacturing engineering, technical equipment design, and automation. The conclusion presents proposals for the adaptation of educational content and instructional methods, aiming to increase the practical relevance and effectiveness of ergonomics education in mechanical engineering programs.

Keywords: ergonomics, mechanical engineering, analysis, higher education.

INTRODUCTION

In mechanical engineering, ergonomics comprises principles and methods designed to adapt technical systems to human physiological, psychological, and cognitive characteristics. The goal is to optimize interaction between the operator, the machine, and the work environment. Higher technical education integrates ergonomic knowledge into student training to develop their abilities to design equipment and workplaces that respect anthropometric parameters, motor capabilities, sensory perception, and the operator's mental workload. (Aslanides et al, 2019; Górska et al, 2018) Industrial practice requires the systematic application of ergonomic principles, especially in the design of control elements, workplace component arrangement, selection of appropriate working postures, and minimizing the physical and mental strain on users. Rationalization of these aspects enables the reduction of operator errors, increased operational reliability of equipment, and extension of service life. Ergonomic solutions also consider the requirements of various user groups, specifics of the work environment, and the nature of the operated technologies. In automated and digitised production systems, it is essential to rigorously apply ergonomic criteria in the design of human–machine interfaces to ensure flawless, safe, and intuitive operation of technical devices. Education in this area includes methods of analysing workload within the work

system, assessing working postures, handling operations, visual and informational demands, as well as identifying risk factors affecting the operator's long-term health. (Avila-Chaurand et al, 2019; Hignett et al, 2018) Integration of ergonomic principles into technical education in mechanical engineering allows for the optimization of design, construction, and operation of mechanical systems in terms of reliability, safety, efficiency, and sustainability of production processes. (Oakman et al. 2020; Järvelin-Pasanen et al., 2019) The presented article provides an analysis of selected pedagogical approaches to the education process of ergonomics abroad and within Slovakia.

ASSESSMENT OF ERGONOMICS IN HIGHER EDUCATION WITH A FOCUS ON MECHANICAL ENGINEERING - ABROAD

Two universities from the global ranking of the best universities offering study programs in ergonomics for mechanical engineering were selected: University of Nottingham (UK) – MSc Human Factors and Ergonomics and Universidad Nacional de Ingeniería (Peru) – Master of Specialization in Ergonomics. (QS World University Rankings, 2025)

Table 1. Technical comparison of Ergonomic Study programs - University of Nottingham and Ergonomics and Universidad Nacional de Ingeniería.

Criterion	Nottingham (UK)	Nacional de Ingeniería (Peru)
Duration	12/24 months	24 months
Form	online/in-person	In-person only
Language	English	Spanish
Accreditation	CIEHF (Chartered)	Professionally oriented, without CIEHF
Structure of module	Engineering ergonomics	Systemic ergonomic intervention

Study programs focused on ergonomics at the University of Nottingham (UK) and the Universidad Nacional de Ingeniería (Peru) represent two distinct approaches to professional education in this field. Despite several differences, they also exhibit common features that reflect the fundamental requirements and current trends in ergonomics as an interdisciplinary science. Differences are primarily observable in the mode of study delivery. The University of Nottingham offers both full-time and distance learning options with a duration of 12 or 24 months, providing significant flexibility, especially for international students and working professionals. In contrast, the program at the Universidad Nacional de Ingeniería is strictly delivered in a face-to-face format with a fixed duration of 24 months, requiring the physical attendance of students. The language of instruction also reflects the geographical and cultural orientation of both programs. While the British program is conducted in English, offering global accessibility and broader opportunities for international employment, the Peruvian program is delivered in Spanish, targeting primarily domestic applicants and the specific needs of the local labour market.

A fundamental distinction lies in the matter of accreditation. The program in Nottingham is certified by the CIEHF (Chartered Institute of Ergonomics and Human Factors), which enables graduates to obtain the internationally recognized status of "Chartered Ergonomist." In Peru, a comparable accreditation is lacking; however, the program is oriented towards the practical application of ergonomic principles within systemic interventions tailored to specific working conditions. The content structure of the programs also reveals different emphases. In the UK, the curriculum is modular, focusing on engineering ergonomics and technical applications, whereas in Peru, emphasis is placed on comprehensive systemic approaches and the implementation of solutions directly within organizational processes. Entry requirements also differ – Nottingham requires at least an upper second-class (2:1) honors degree in engineering or design, while in Peru, demonstrated professional experience in an engineering-related field is considered sufficient.

Table 2. Advantages and disadvantes of Ergonomic Study programs - University of Nottingham and Ergonomics and Universidad Nacional de Ingeniería.

	University of Nottingham (UK)	Universidad Nacional de Ingeniería (Peru)
Advantages	International accreditation (CIEHF)	Strong practical focus on systemic ergonomic interventions
	Possibility of online study	Instruction in Spanish (advantage for the local market)
	Modular structure focused on technical ergonomics	Emphasis on applications in industrial environments
	Globally recognized "Chartered Ergonomist" title	Lower entry requirements (work experience sufficient)
	Instruction in English (advantage for global job market)	
Disadvantages	Higher entry education requirements	Lack of international accreditation (CIEHF)
	Higher tuition fees	Mandatory physical presence (without online options)
	English may be a barrier for non-English speakers	Limited applicability outside the Spanish-speaking market

Common features of the programs lie in their shared objective of preparing specialists capable of diagnosing and addressing ergonomic issues within the work environment. Both curricula emphasise an interdisciplinary approach that integrates technical, design, and human-centered aspects of ergonomics. The programs prepare graduates for the practical application of ergonomic principles with a focus on enhancing the safety, efficiency, and comfort of users of technical systems and workspaces. From a didactic and educational perspective, the study program at the University of Nottingham is characterised by a modern pedagogical style based on the integration of research and practice. Instruction includes simulations, laboratory work utilising virtual reality (VR), as well as methodologies such as design thinking and user-centered design. Students are guided towards conducting independent scientific research, culminating in the completion of a final research thesis.

Table 3. Educational assessment of Ergonomic Study programs - University of Nottingham and Ergonomics and Universidad Nacional de Ingeniería.

Criterion	Nottingham (UK)	UNI Peru
Teaching Methodology	Modern, combining research and practice, laboratory simulations, VR	Classical, lecture-based, industrial case studies
Focus	Human-Machine Interaction, cognitive and physical ergonomics	Work environment, Occupational Health and Safety (OHS), systemic interventions
Innovative Methods	Simulations, VR, design thinking, user-centred design	Minimal (traditional techniques, systems analysis)
Practical application	Product and technical system development, automotive/aerospace industries	Industrial working conditions, organizations, OHS
Independent Research	Mandatory scientific research project	Final exam / case study
Technological Equipment	Strong (VR systems, HCI laboratories)	Limited
Collaboration with industry	Industrial partners, real-world projects	Local enterprises, regional case studies

The focus of the program at the University of Nottingham is primarily oriented towards Human-Machine Interaction (HCI), cognitive and physical ergonomics, as well as the development of technical systems and products applicable, for example, in the automotive and aerospace industries.

The university is equipped with state-of-the-art technological facilities, including HCI laboratories and VR systems. It collaborates with industrial partners on real-world projects, which significantly enhances the practical value of the study program. Another strong feature is the possibility of online learning and international CIEHF accreditation, which increases the global employability of graduates.

In contrast, the program at the Universidad Nacional de Ingeniería is based on a traditional lecture-driven approach, supplemented by case studies derived from industrial practice. Its primary focus is on systemic ergonomic interventions in the workplace, occupational health and safety (OHS), and the improvement of working conditions within enterprises and organizations. Innovative methods such as simulations or VR are practically not employed in this program; instruction is oriented towards conventional techniques such as systems analysis and workplace assessment. Students are required to develop a written case study with an emphasis on local conditions. Technological infrastructure is limited; however, there is cooperation with regional industries, enabling the practical application of acquired knowledge within the local industrial sector. Common features of both programs include an emphasis on the practical application of ergonomic knowledge and the development of an interdisciplinary perspective on human work within technical and industrial systems.

In both cases, the objective is to prepare specialists capable of solving ergonomic problems with the aim of improving efficiency, safety, and the quality of working life. The University of Nottingham program is suitable for those interested in an international career with a focus on technical and research-oriented ergonomics, whereas the Universidad Nacional de Ingeniería program primarily prepares professionals for practical roles in local industrial enterprises, with an emphasis on systemic solutions to ergonomic challenges.

ASSESSMENT OF ERGONOMICS IN HIGHER EDUCATION WITH A FOCUS ON MECHANICAL ENGINEERING - SLOVAKIA

In the context of Slovakia, “Ergonomics” does not exist as an independent study program, as is the case in the aforementioned foreign institutions, but rather constitutes an integral part of the educational curricula of various technical faculties. For the purpose of this evaluation, two faculties were selected – the Faculty of Manufacturing Technologies at the Technical University of Košice (FVT TUKE) and the Faculty of Materials Science and Technology at the Slovak University of Technology in Bratislava (MTF STU). (Internal documents FVT, 2025; internal documents MTF, 2025) These faculties were chosen to ensure the best possible comparability in terms of discipline, level of study, and faculty focus.

At the Faculty of Manufacturing Technologies of the Technical University of Košice, ergonomics education is delivered with an emphasis on the practical mastery of industrial ergonomics methods, aimed at the design and optimisation of workplaces, work systems, and processes. The course content focuses on the analysis of the human-machine-environment system using modern software tools for digital simulation of working conditions and physical workload, as well as the evaluation of workplace environmental parameters (such as noise and lighting). The educational process includes lectures and laboratory exercises, where students actively perform practical measurements under simulated conditions and subsequently process the collected data using specialized software. A significant component of the methodology is the digitalization of workplaces, which corresponds with Industry 4.0 trends. The practical component forms a substantial part of the course, thus preparing students for solving specific engineering tasks in real industrial environments.

The ergonomics instruction at the Faculty of Materials Science and Technology of the Slovak University of Technology in Bratislava is designed primarily as a theoretical-systemic discipline, with an emphasis on the application of ergonomics in the context of corporate occupational health

and safety (OHS) management systems and the economic evaluation of ergonomic measures. The course content includes the fundamental principles of ergonomics, work standardization, statistical evaluation methods, and the development of ergonomic projects from a management perspective. An important part of the educational process involves teamwork on projects, preparation of presentations, and interpretation of ergonomic analysis results for corporate management. The practical component is represented mainly by case studies and the analysis of real production systems, without substantial use of measurement and simulation technology.

Table 4. Educational assessment of Ergonomic Study programs - Faculty of Manufacturing Technologies and Faculty of Materials Science and Technology in Trnava.

Criterion	**TUKE - Faculty of Manufacturing Technologies**	**STU – Faculty of Materials Science and Technology in Trnava**
Focus	Industrial ergonomics, Human-Machine-Environment systems	OHS, enterprise programs, standardization
Methodology	Laboratory measurements, software analysis, Industry 4.0 tools	Theoretical preparation, presentations, legislative approach
Practical/Software use	High – software support (modelling of noise, lighting, workload)	Lower – emphasis on system evaluation and regulations
Examination	Combination of continuous assessment + practical outputs	Written exam 80%, 20% team projects
Real Problem Solving	Industrial cases, digital checklists	Mainly conceptual (cost/benefit), fewer specific measurements
Preparation for Practice	Direct contact with industrial environment	Managerial approach to OHS, system planning
Teamwork	Less emphasis	Significant part of education

From a methodological perspective, the Faculty of Manufacturing Technologies favors an experimental, technical-application approach, whereas the Faculty of Materials Science and Technology emphasizes systemic and managerial aspects of ergonomics implementation.This distinction is reflected in the pedagogical process through a differing proportion of practical instruction – while students in Košice solve specific tasks using digital tools and real-world measurements, in Bratislava, analytical and evaluative methods dominate, focusing on corporate environments and applicable legislation. Both approaches have their justification – the model of the Faculty of Manufacturing Technologies is particularly suitable for future technologists and industrial engineers who will be engaged in the design and optimization of workplaces and production systems. Conversely, the approach of the Faculty of Materials Science and Technology is aimed at preparing ergonomic specialists and occupational health and safety (OHS) managers capable of implementing ergonomic principles at the level of corporate management and optimizing work processes in accordance with legislative requirements and economic criteria.

A significant finding of this comparison is the fact that ergonomics education at both institutions reflects current trends and practical needs – the model of the Faculty of Manufacturing Technologies integrates the requirements of Industry 4.0, while the approach of the Faculty of Materials Science and Technology develops a systemic and value-oriented perspective on ergonomics as part of corporate management. From a didactic point of view, both approaches can be considered complementary, resulting in the preparation of graduates capable of meeting a broad spectrum of labour market demands in the fields of ergonomics and industrial engineering.

Assessment of the Use of Digital Tools, Simulation Technologies, and Practical Assignments in Ergonomics Education

In the context of the utilization of digital tools, simulation technologies, and practical assignments, this comparison focuses on the approach to ergonomics education at the Faculty of Manufacturing Technologies, Technical University of Košice (FVT TUKE), and the Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava (MTF STU), alongside selected international universities — the University of Nottingham (UK) and Universidad Nacional de Ingeniería (Peru). The comparison primarily examines the use of digital tools, simulation technologies, practical exercises, and teaching methodologies, as well as the characterisation of students' practical preparation for real industrial environments.

Table 5. Educational assessment of Ergonomic Study programs - Faculty of Manufacturing Technologies and Faculty of Materials Science and Technology in Trnava.

Category	TUKE - Faculty of Manufacturing Technologies	STU – Faculty of Materials Science and Technology in Trnava	Nottingham (UK)	UNI Peru
Digital Simulations	Software modeling, Industry 4.0	Minimal	VR, HCI, simulations	Almost none
Real Measurements	Noise, lighting, load	None	HCI labs, VR tests	System analysis
Team Tasks/Projects	Partially	Significant	Individual and group	System projects
OHS/System Ergonomics	Partial	Dominant	Supplementary	Main focus
Industry Practice	Model tasks	Case studies	Industrial partnerships	Field visits

At FMT TUKE, the methodology for teaching the course "Ergonomics" is based on a combination of theoretical preparation and practical laboratory measurements, strongly supported by software simulation tools. Students work with specialised software for modelling and analysing noise, lighting, and physical workload, aligning with the requirements of industrial engineering within the Industry 4.0 framework. The course enables the application of knowledge in ergonomic design, rational work organisation, and workplace optimisation directly through practical assignments, enhancing student readiness for real industrial production conditions.

At STU, the "Ergonomics" course is oriented towards theoretical and systemic aspects, with emphasis on legislative requirements, risk assessment, and the economic efficiency of ergonomic interventions. The practical component is implemented through team projects, case studies, and preparation of analytical presentations. However, direct use of experimental measurements or modern simulation technologies is lacking, which may limit students' applied skills in physical ergonomics and digital workplace design.

At the University of Nottingham, ergonomics education is delivered at a high technological level, routinely employing simulation and virtual reality (VR) tools, as well as laboratory Human-Computer Interaction (HCI) equipment. Students actively participate in research projects, and their training includes solving real industrial cases in direct collaboration with industry partners. The curriculum is designed so that graduates master modern methods of work system design and product design from a human interaction perspective.

At the Universidad Nacional de Ingeniería in Peru, the "Ergonomics" course focuses primarily on systemic assessment of the work environment and occupational safety in the context of the local industry. The course has a traditional character with an emphasis on case studies and site visits but without significant use of digital simulation tools or advanced laboratory technologies. This educational approach equips students with the ability to analyse and improve

work systems from organisational and systemic perspectives, but does not provide the technical skills necessary for detailed ergonomic modelling.

From the perspective of pedagogical practice, it is evident that Slovak institutions (FVT TUKE and MTF STU) integrate ergonomics into broader industrial engineering study programs, without offering an independent ergonomics program at the second-cycle level, unlike selected foreign universities. Abroad, ergonomics is taught within accredited specialized study programs (e.g., MSc Human Factors and Ergonomics), enabling comprehensive education, including research and specialization.

From a professional viewpoint, it can be concluded that the University of Nottingham employs the most advanced technologies in ergonomics education, dominated by VR and HCI simulations. FVT TUKE emphasizes practical education with a focus on Industry 4.0 and digitalization. MTF STU prioritizes systemic and economic evaluation within occupational health and safety (OHS), while UNI Peru prefers a traditional approach focused on operational conditions without significant technological support.

CONCLUSIONS

Analysis of Ergonomics Education in the Field of Mechanical Engineering Confirms the Importance of Systematic Integration of Ergonomic Principles into Higher Education with Emphasis on Practical Application. Foreign programs (Nottingham, UNI Peru) offer specialized curricula with differing focuses — technical-engineering versus systemic-interventional approaches. In Slovakia, ergonomics is incorporated within broader study programs with varied methodologies — TUKE utilizes digital tools and practical simulations, whereas STU emphasizes systemic and managerial aspects. Both concepts address practical needs; however, a standalone study program in Ergonomics is currently absent. For the future, it is advisable to consider establishing an independent accredited study program titled "Ergonomics in Mechanical Engineering," which would integrate both technical-application and systemic-managerial approaches with a focus on digital technologies (VR, HCI, simulations) and Industry 4.0. Such a program would strengthen the preparation of specialists capable of comprehensively addressing ergonomic challenges in modern manufacturing systems and enhance graduates' competitiveness in the international labour market.

ACKNOWLEDGEMENTS

This work was supported by grant No. KEGA 014TUKE-4/2024 and grant No. VEGA 1/0302/25.

DECLARATIONS OF INTEREST STATEMENT

The authors affirm that there are no conflicts of interest to declare in relation to the research presented in this paper.

LITERATURE

Aslanides, M., Arévalo, N., Ghram, R., Mebarki, B., & Tey, F. (2019). Professional Ergonomists Education: lessons learned from worldwide existing programs. *In Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018) Volume IV: Organizational Design and Management (ODAM), Professional Affairs, Forensic 20* (pp. 718-726). Springer International Publishing.

Avila-Chaurand, R., Prado-León, L., González-Muñoz, E., Landa-Avila, I. C., & Valenzuela-Gómez, S. (2019). Experiences in the development and implementation of an academic master degree in ergonomics in Mexico. *In Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018) Volume IV: Organizational Design and Management (ODAM), Professional Affairs, Forensic 20* (pp. 678-692). Springer International Publishing.

Górska, E., & Kossobudzka-Górska, A. (2018, August). Ergonomics Teaching Concept at Technical Universities Based on Warsaw University of Technology. *In Congress of the*

International Ergonomics Association (pp. 672-682). Cham: Springer International Publishing.

Hignett, S., & Gyi, D. (2018, August). Ergonomics/human factors education in United Kingdom. *In Congress of the International Ergonomics Association* (pp. 28-35). Cham: Springer International Publishing.

Internal documents – FVT. (2025). Internal documents. Available at: https://maisportal.tuke.sk/portal/studijneProgramy.mais

Internal documents – MTF. (2025). Internal documents. Available at: https://is.stuba.sk/katalog/brozura_katalog.pl

Järvelin-Pasanen, S., & Räsänen, K. (2019). Ergonomics integrated into degree program in health promotion in the university of Eastern Finland. *In Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018) Volume IV: Organizational Design and Management* (ODAM), Professional Affairs, Forensic 20 (pp. 304-309). Springer International Publishing.

Oakman, J., Hignett, S., Davis, M., Read, G., Aslanides, M., Mebarki, B., & Legg, S. (2020). Tertiary education in ergonomics and human factors: quo vadis?. *Ergonomics, 63*(3), 243-252.

QS World University Rankings. (2025). Ranking. Available at: https://www.topuniversities.com/university-rankings