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# The academic transition to industry 5.0: AI literacy, awareness, and readiness for human–AI collaboration in European higher education

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## Abstract

The transition to Industry 5.0 requires advanced digital competencies and a structured readiness for human–AI collaboration at the institutional level. This study investigates the levels of AI literacy, Industry 5.0 awareness, and readiness for human–AI collaboration among 296 respondents (91 faculty members and 193 students) from four European countries (Romania, Greece, Italy, and Poland). The research design employs structured questionnaires and non-parametric statistical analyses (Mann–Whitney U test). The findings reveal statistically significant differences ($p<0.001$) in favor of students, who demonstrate higher levels of AI literacy (68% familiar/very familiar compared to 42% of faculty) and greater readiness for human–AI collaboration. Faculty members report only partial integration of these competencies into teaching activities (60.4%). The results confirm the presence of an intergenerational gap indigital competencies and highlight the urgent need for continuous professional development programmes for academic staff, systematic curricular integration of Industry 5.0 principles, and the development of collaborative pedagogical practices. This study provides empirical evidence to support institutional reform strategies aligned with the requirements of the emerging industrial paradigm.

**Keywords:** Industry 5.0; AI literacy; Human–AI collaboration; Higher education; Digital skills; Curricular transformation.

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## Introduction

Industry 5.0 represents a paradigmatic shift in industrial thinking, moving beyond the automation-centered model of Industry 4.0 and placing three fundamental dimensions at its core: human-centricity, sustainability, and resilience [7,9,20]. Within this framework, collaboration between humans and intelligent systems is no longer optional but constitutes a strategic necessity for achieving both economic competitiveness and social responsibility.

The success of this transition depends significantly on the advanced digital competencies of actors within educational systems and entrepreneurial ecosystems [14,23]. However, existing literature and empirical observations indicate a substantial gap between the competencies required by Industry 5.0—such as human–AI collaboration, data literacy, and sustainability awareness—and the current level of preparedness within higher education institutions.

This study seeks to quantify this gap by investigating three interrelated constructs:

*AI literacy*– the perceived level of knowledge, familiarity with AI tools, and their applicability in academic and professional contexts.

*Industry 5.0 awareness* – the degree of understanding of the core pillars of Industry 5.0 (human– AI collaboration, sustainability, resilience) and their educational implications.

*Human–AI Collaboration Readiness* – psychological preparedness and perceived competencies for effective engagement in human–AI environments.

The comparison focuses on two distinct groups—university faculty and students—from four European countries (Romania, Greece, Italy, and Poland), totaling 296 respondents. The central hypothesis posits that students demonstrate higher digital literacy and greater preparedness for Industry 5.0 than faculty members, reflecting generational differences in exposure to emerging technologies.

The contribution of this study unfolds along three principal dimensions. First, it quantifies intergenerational gaps in Industry 5.0-related competencies in higher education using robust statistical methods. Second, it positions educators as a critical leverage point in institutional transformation processes, emphasizing their central role in mediating and operationalizing the Industry 5.0 paradigm. Third, it provides empirical evidence to inform curricular reform strategies and professional development initiatives within the European higher education context [4,23,31].

## Theoretical framework

### Industry 5.0 as an emerging paradigm

Industry 5.0 is described in the specialised literature as a conceptual evolution of Industry 4.0, moving beyond the strict emphasis on automation and efficiency and placing at its core the cooperation between humans and intelligent systems. According to Martini et al. [18], the new industrial revolution is structured around three main dimensions—human-centricity, sustainability, and resilience—which function as guiding principles for integrating digital technologies into complex socio-economic contexts. In a similar vein, Ghobakhloo et al. [9] conceptualise Industry 5.0 as a physical– digital–social ecosystem in which technologies such as artificial intelligence, the Internet of Things (IoT), and digital twins collaborate with human operators to achieve more personalized, flexible, and high-quality production processes.

Maddikunta et al. [16] and Gurrammagari and Boopathy [10] portray Industry 5.0 as a transformative stage aimed at harmonizing workplaces by simultaneously enhancing the productivity and creativity of both humans and technologies. Nahavandi [20] argues that employee efficiency can be increased by delegating repetitive tasks to autonomous systems, thereby freeing time for creative and collaborative activities alongside intelligent robots.

Within this perspective, learning organizationals and educational institutions are expected to function as socio-technical ecosystems in which artificial intelligence operates as a “co-worker,” contributing to innovation, reflective practice, and organizationalal development [34]. In this context, AI is conceptualised not only as an automation technology but also as a mechanism for augmenting human capabilities within the broader Industry 5.0 framework.

### AI literacy and educational dimensions

The concept of AI literacy has evolved from a narrowly technical understanding of artificial intelligence to a broader perspective that incorporates societal awareness, ethical considerations, and practical applicability. Kusetogullari et al. [14] define AI literacy as the combination of conceptual knowledge about AI, familiarity with generative tools and applications, and the ability to critically evaluate the role and limitations of AI across diverse contexts. This definition is particularly relevant for the present study, as it highlights three complementary levels of competence: theoretical, practical, and reflective.

The literature consistently emphasises that AI literacy is not limited to technical knowledge but constitutes a component of broader digital literacy required for navigating a socio-economic environment transformed by rapid technological development. In the context of Industry 5.0, AI literacy must therefore be complemented by an understanding of sustainability principles and human– AI collaboration.

Contemporary frameworks describe progressive levels of AI competence—from basic awareness to advanced expertise—integrating operational skills, critical thinking, legal and regulatory understanding, and awareness of risks and opportunities associated with AI. Within Industry 5.0, AI literacy is closely connected to digital literacy and the development of transversal skills, becoming essential for participation in a labor market significantly shaped by digitalisation and automation. Research on interdisciplinary learning and transversal skill development in higher education indicates that students need to integrate cognitive, social, and digital competencies to respond effectively to contemporary demands, reinforcing the importance of incorporating AI literacy into academic training profiles [23,24].

Teacher training emerges as a critical factor in strengthening AI literacy and preparing educational systems for transformations associated with Industry 5.0. Studies on training needs and competency models for educators highlight the necessity of continuously updating both initial and continuing professional development programmes, enabling teachers to integrate digital technologies and AI effectively into their pedagogical practices [12,22,31].

Furthermore, research on digital counseling and educational guidance suggests that support services can become more flexible and accessible through the use of online platforms and intelligent tools, thereby creating conditions for the expanded integration of AI solutions in educational and professional guidance [28]. Investigations into the educational use of social networks indicate that digital media can function not only as socialization environments but also as learning spaces that foster collaboration and self-regulation—competencies relevant for AI-augmented educational practices [25].

**Industry 5.0 awareness and necessary skills**

Industry 5.0 awareness involves more than familiarity with terminology; it requires a substantive understanding of the implications of its core pillars—human-centricity, sustainability, and resilience—for the design of educational systems, organizationalal processes, and professional trajectories. The literature emphasises the importance of transdisciplinary education, data literacy, and heightened awareness of the environmental, social, and economic impacts of emerging technologies for both students and academic staff.

Research examining the transition from traditional career counseling services to intelligent guidance systems indicates that students' educational and professional decisions are increasingly mediated by digital tools and AI-based platforms. This development necessitates a critical understanding of how such technologies influence career paths and professional identity formation [3,11,29].

In addition, studies focused on occupational sustainability and lifelong learning underline the role of psychological factors—such as perfectionism and workaholism—as potential obstacles to adaptation in rapidly changing professional environments. These findings highlight the need for educational interventions that balance performance demands with well-being and sustainable professional development [32].

**Human–AI collaboration readiness**

Readiness for human–AI collaboration is conceptualized in recent literature as a multidimensional construct that integrates technical competencies, attitudinal dispositions, and psychosocial factors, including trust in intelligent systems, openness to change, and recognition of the complementary roles of humans and machines. Research on human–robot collaboration and human-centric smart manufacturing demonstrates that, within Industry 5.0, humans are increasingly expected to assume creative, decision-making, and supervisory roles, while repetitive tasks are delegated to autonomous systems.

Studies analyzing the perceived impact of AI on academic learning reveal a nuanced balance between opportunities—such as participatory and community-based learning approaches, rapid feedback mechanisms, and expanded access to information—and concerns related to dependency, academic integrity, and ethical considerations. These findings suggest that readiness for human–AI collaboration is closely linked to the development of critical thinking skills and responsible attitudes among both students and faculty [5].

Participatory and community-oriented approaches proposed in contemporary literature, which emphasise co-creation and stakeholder involvement in development processes, can also inform the design of AI-augmented learning experiences. Such approaches contribute to shaping educational environments in which human–AI collaboration is anchored in local needs and institutional contexts [17].

Moreover, research on school resilience and teacher leadership underscores the central role of educators in fostering learning communities capable of managing uncertainty and technological transformation [4]. Complementary studies on transversal competencies, conflict management, and emotional intelligence further demonstrate that socio-emotional and collaborative skills constitute an essential foundation for effective human–AI collaboration, extending beyond purely technical expertise [1,21].

## Methodology

**Research design and ethical responsibility**

The study adopted an empirical design with descriptive and inferential components, using standardized questionnaires to collect data from two independent groups: university faculty and students enrolled in higher education programmes.

The research was conducted in accordance with ethical guidelines for educational research and the administration of online surveys, obtaining the approval of the relevant ethics committee (where applicable) and adhering to the following principles: voluntary participation, informed consent, protection of anonymity and confidentiality, as well as the right of participants to withdraw from the study at any time.

Before completing the questionnaire, respondents were provided with clear information regarding the purpose of the research, the type of data collected, the method of storage and processing, and the absence of any major risks. They were also informed that no personal identification data were collected and that they can omit any question or discontinue the completion without any consequences. The data were stored electronically and accessible exclusively to the research team.

**Instruments and operationalization**

Two standardized questionnaires were used, developed within the European project BOOST-AI: Questionnaire 1 – Teaching and Academic Staff, Title: "Survey on AI and Sustainable Entrepreneurship in Industry 5.0 – Educators & Academic Staff"; Questionnaire 2 – Higher Education Students, Title: "Survey on AI and Sustainable Entrepreneurship in Industry 5.0 – HE Students".

Both instruments were structured into several sections:

Demographic data (country, field of activity, level of education/experience); Level of familiarity with AI and Industry 5.0; Perceived competencies in AI (self-assessment); Familiarity with sustainable entrepreneurship; Challenges and barriers regarding the use of AI; Educational needs and priority topics for the curriculum; Perceived useful resources; Preferred teaching methods.

For this article, only 3 concepts out of the 6 investigated through the two questionnaires are analyzed, operationalized distinctly at the questionnaire level: AI Literacy, Industry 5.0 awareness, and Human–AI Collaboration Readiness.

*AI literacy* is defined as the perceived level of knowledge regarding AI, familiarity with specific tools, and the perception of their applicability in educational and professional contexts, measured by items such as “How familiar are you with Industry 5.0 and AI tools?” (for educators) and “How familiar are you with AI concepts?” (for students), evaluated on a four-point Likert scale, in line with recent approaches to AI literacy frameworks [14].

*Industry 5.0 awareness* targets the degree to which respondents know and understand the core pillars of Industry 5.0 – human-AI collaboration, sustainability, and resilience – being evaluated through the same familiarity items, interpreted from the perspective of knowledge of the concept and its implications, also on a four-point Likert scale, in line with the literature describing Industry 5.0 as a human-centric, sustainable, and resilient paradigm [10,18].

*Human–AI Collaboration Readiness* is conceptualised as the willingness and confidence to collaborate with AI systems, including perceptions of human-machine collaboration and one’s own competencies in the field. At the instrument level, this construct is measured, for teachers, through open-ended items such as “Have you incorporated I5.0 and AI into teaching?”, and for students through Likert items related to confidence in their own AI skills (“Do you feel confident in AI skills?”), the definition being anchored in the literature on Industry 5.0 as a human-centric solution based on collaboration between humans and robots [20].

### Sample and data collection procedure

The study sample consists of 296 respondents, of which 91 are university faculty members (30.7%) and 193 are students (65.2%), while 12 partially completed questionnaires (4.1%) were excluded from the analysis. The distribution of respondents by country is relatively balanced: 78 from Romania (26.4%), 72 from Greece (24.3%), 68 from Italy (23%), and 78 from Poland (26.4%), which gives the study a transnational coverage at the European level. The inclusion criteria targeted, in the case of professors, a minimum of three years of experience in higher education and involvement in teaching activities in fields such as business, engineering, or entrepreneurship, and in the case of students, enrollment in bachelor’s or master’s programmes at the participating universities. The questionnaires were administered online via the Google Forms platform between March and May 2025, with the participation link distributed through institutional email, learning management system platforms (Moodle, Blackboard), and departmental social media, under conditions of voluntary participation and anonymity; the average completion time was estimated at 12–15 minutes, in accordance with best practices for online surveys in the university environment.

### Data analysis

The data analysis was conducted in two complementary stages, using IBM SPSS v27 and Microsoft Excel for statistical processing and database organizational. In the first stage, descriptive, the responses to the Likert scale items were synthesized in the form of absolute and relative frequencies, with indicators of central tendency and dispersion (mean and standard deviation) calculated, and distributions of responses by categories (“Very familiar,” “Familiar,” “Slightly familiar,” “Not familiar”) constructed, accompanied by tables and graphical representations to facilitate interpretation.

In the second stage, inferential, non-parametric statistical tests were applied, considering the ordinal nature of the Likert items and the fact that most distributions do not meet the assumption of normality (Shapiro-Wilk test, $p<0.05$). Consequently, the differences between teachers and students were analyzed using the Mann–Whitney U test for independent groups, which compares the ranks of responses between the two categories of participants and does not assume normality of distributions, making it suitable for samples with possible asymmetries. For each analysis, the U statistic, p-value, and effect size (r) were reported, calculated based on the standardized Z score using a significance threshold of $\alpha=0.05$ ($p<0.05$ considered significant, $p<0.001$ very significant).

### Study limitations

The study presents a series of limitations that must be considered when interpreting the results. First of all, the sample is non-probabilistic, based on the self-selection of participants, which limits the possibility of generalizing the conclusions to the entire population of teachers and students in the European space. Secondly, the data is based on self-assessments of competencies and the level of familiarity with AI and Industry 5.0, which can introduce perception errors through tendencies to overestimate or underestimate one’s own abilities.

Additionally, the cultural and structural differences between the included countries—in terms of educational systems, economic context, and the pace of digital technology adoption—could not be thoroughly controlled and may influence the profile of the responses. Another aspect is the timing of data collection (March–May 2025), in a context marked by rapid developments in the field of AI, especially generative AI, which may lead to subsequent changes in the level of awareness and attitudes toward these technologies. Last but not least, it is possible that individuals more interested in AI and the Industry 5.0 theme are overrepresented in the sample, generating a potential response bias specific to voluntary online surveys.

## Results

### AI Literacy

The results regarding AI literacyare presented in (Table 1), which includes the distributions by levels of familiarity for teachers and students.

**Table 1:** Level of familiarity with artificial intelligence (AI Literacy) among teachers and students.

| Level of familiarity | Faculty (n=91) 4 | % Faculty | Students (n=193) | % Students |
|---|---|---|---|---|
| Very Familiar | 34 37 | 4,4% | 48 | 24,9% |
| Familiar | 16 91 | 37,4% | 83 | 43,0% |
| Slightly Familiar | | 40,7% | 47 | 24,3% |
| Not Familiar | | 17,6% | 15 | 7,8% |
| Total | | 100% | 193 | 100% |

The majority of teachers (78.1%) position themselves between the categories “Slightly Familiar” and “Familiar,” indicating conceptual familiarity with AI, but not necessarily practical mastery of AI tools. The “Very Familiar” level is marginal (4.4%), reflecting a low presence of applied expertise.

This suggests that teachers have theoretical knowledge about AI—probably from articles, conferences, or informal discussions—but limited experience in using AI in pedagogical or research contexts. The distribution indicates a stage of gradual assimilation of digital competencies in the university educational sphere.

Almost 67.9% of students declare themselves “Familiar” or “Very Familiar” with AI, indicating frequent exposure to AI concepts and their use in educational, social, or professional contexts. The distribution shows a positive skew toward the higher levels, confirming the increased interest in emerging technologies and familiarization through hands-on experiences (AI courses, applications, generative tools like ChatGPT, Copilot, etc.). Only 7.8% of students claim to be “Not Familiar,” compared to 17.6% of professors – a difference that reflects the “digital nativity” of current students, who have grown up with ubiquitous digital technologies.

To test the differences between groups, the Mann–Whitney U test for independent samples was applied. The results show that students achieve significantly higher AI literacy scores than faculty members.

Statistic U=9371, p-value=0.000323 (*p<0.001 indicates a very statistically significant difference). indicates that the response distributions of the two groups are fundamentally different. Effect size (r=0.32) is medium, suggesting that the difference is not only statistical but also practical – that is, the difference in AI literacy between students and teachers is not merely due to chance, but reflects a real and significant gap in practical experience and knowledge.

**Preliminary conclusion:** The AI literacy analysis highlights an intergenerational gap in digital skills between students and teaching staff. Both categories exhibit a comparable level of conceptual understanding of AI; however, students report significantly higher operational familiarity and confidence in using these technologies, while teachers remain primarily at a theoretical and exploratory level.

These findings support the need for the development of continuous training programmes for teachers, focused on the practical use of AI, the explicit integration of AI competencies into the curriculum as part of digital and sustainable literacy, and the promotion of pedagogical approaches that foster human–AI collaboration, which can mitigate generational skill gaps. Overall, the results suggest that the transition to Industry 5.0 involves not only the adoption of technological infrastructure but also the consolidation of an integrated cognitive culture, where AI is embraced as an educational and professional partner, not just as a technological tool.

**Industry 5.0 awareness**

The results regarding Industry 5.0 awareness follow the same analytical structure as AI Literacy, considering that the items used are identical and AI represents a central component of the Industry 5.0 paradigm. Familiarity with “Industry 5.0 and its principles as well as AI tools” among faculty and familiarity with AI among students (used as a proxy for understanding Industry 5.0) are highlighted in (Figure 1).

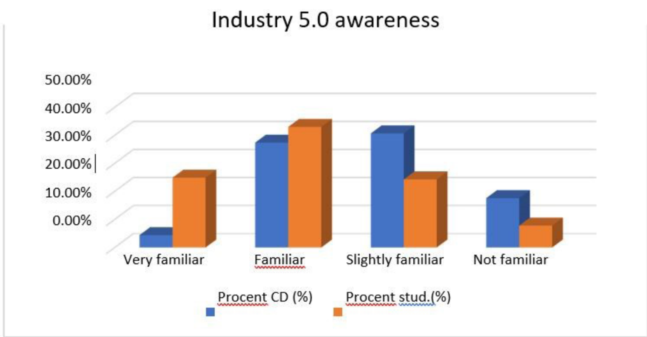


**Figure 1:** The level of familiarity with Industry 5.0 (Industry 5.0 awareness) among faculty and students.

The teachers present a profile similar to that observed in AI Literacy. Approximately 78.1% consider themselves “Slightly Familiar” or “Familiar” with Industry 5.0. The “Very Familiar” component remains marginal (4.4%), suggesting that Industry 5.0 is perceived more as an emerging theme than as a consolidated paradigm in current educational practice.

This indicates a general awareness of industrial change, but limited practical experience. Teachers understand the conceptual directions of Industry 5.0, but they have not yet integrated its principles into course design or teaching methodology.

Students exhibit a much higher level of awareness regarding Industry 5.0 through the proxy of AI (67.9% Familiar or Very Familiar). The distribution indicates that, although students are not necessarily familiar with the terminology of Industry 5.0, they possess the technological foundations that underpin this concept.

This is an important observation: the current generation of students may not explicitly name “Industry 5.0,” but they are already living in its ecosystem—using AI daily, thinking in terms of sustainability and digital collaboration. Students have a much higher level of technological awareness, which facilitates the rapid internalization of the Industry 5.0 paradigm through applied learning.

To test the differences between the two groups, the same Mann–Whitney U test for independent samples was applied, comparing the ranks of responses regarding familiarity with Industry 5.0/AI. The results are identical to those reported for AI Literacy, U=9371, p<0.001, r=0.32, indicating significantly higher scores among students and a medium effect size.

This confirms that students not only claim to be more familiar with AI, but also exhibit a higher level of awareness of the Industry 5.0 framework, either through explicit knowledge or through natural immersion in emerging digital contexts. The results suggest a more advanced adoption of the Industry 5.0 paradigm among students and highlight the needfor professional development strategies dedicated to educators, in order to reduce the generational asymmetry regarding competencies and representations related to Industry 5.0.

**Preliminary conclusion:** The analysis of the Industry 5.0 awareness criterion highlights a marked contrast between the two investigated groups. The teaching staff possesses a predominantly conceptual understanding of the paradigm, which is still in a consolidation stage, indicating the need for professional training programmes dedicated to Industry 5.0. Students exhibit much higher levels of technological familiarity, which positions them favorably to understand and rapidly adopt this paradigm, even if they do not always explicitly use the associated terminology.

The results indicate an asymmetry in digital development between generations, justify investments in the professionalization of teaching staff, and suggest that students can function as vectors for the transition to Industry 5.0. At the same time, they support the opportunity to develop an integrated curricular strategy focused on human–AI collaboration, sustainability, and transdisciplinary education.

**Human–AI collaboration readiness**

*The Human–AI collaboration readiness* criterion reflects the respondents' willingness and ability to work effectively in an environment where humans and AI systems collaborate. In the two questionnaires, the construct was measured through different but conceptually comparable indicators, that served as proxies for human–AI collaboration readiness.

For educators, readiness for human–AI collaboration was assessed through an open-ended item regarding the integration of Industry 5.0 principles, AI, and sustainability into teaching activities, with responses coded into three categories ("Yes," "Partial," "No"), as presented in (Table 2). For students, readiness was measured through a Likert scale item regarding confidence in their own AI competencies and their ability to apply these competencies in Industry 5.0-related entrepreneurial contexts, with three response levels ("Confident," "Slightly confident," "Not confident"), also summarized in (Table 2).

**Table 2:** The level of readiness for human–AI collaboration among teachers and students.

| Category | Faculty (n=91) | % Faculty | Students (n=193) | % Students |
|---|---|---|---|---|
| Yes/Confident | 15 | 16,5% | 56 | 28,9% |
| Partial/Slightly Confident | 55,7% | 55 | 60,4% | 108 |
| No/Not Confident | 15,5% | 21 | 23,1% | 30 |
| Total | 91 | 100% | 193 | 100% |

Descriptive analysis shows that the majority of teachers are in a phase of partial integration of AI and Industry 5.0 into their teaching activities, while human–AI collaboration remains, overall, in an early stage, marked by fragmented initiatives and a significant segment of teachers who have not yet adopted this approach.

In contrast, students (84.6%) report high levels of confidence (high or moderate) in using AI, indicating a high psychological and technological readiness for human–AI collaboration, especially in applied contexts such as projects or digital entrepreneurship.

From an inferential perspective, although the items used for the two groups do not allow for a direct statistical comparison, the harmonized scores on numerical ranks (Yes/Confident = 3; Partial/Slightly = 2; No/Not = 1) indicate a significantly higher readiness of students compared to teachers, suggesting that they are more prepared for Industry 5.0 educational scenarios, while the teaching staff is in a gradual adoption stage, conditioned by curricular and institutional resources ($U=7854.5$; $p=0.004$).

The preliminary conclusion is that students have a predominantly positive and usage-oriented attitude toward AI, while teachers perceive human–AI collaboration as a gradual challenge and request methodological guidance and practical training; overall, the criterion highlights the need for intergenerational harmonization of AI competencies through training programmes, co-creation, and systematic curricular integration in the spirit of Industry 5.0.

**Overview of results**

The study investigated three complementary dimensions of preparedness for Industry 5.0 – AI Literacy, Industry 5.0 awareness, and Human–AI collaboration readiness – among students and faculty from four European universities.

The results highlight a clear intergenerational gap: students exhibit significantly higher levels of AI literacy, a more advanced awareness of the Industry 5.0 paradigm, and superior readiness for human–AI collaboration, with differences showing both statistical significance ($p<0.001$) and practical relevance (medium effect sizes).

Teaching staff are "at the crossroads of change": although they possess a solid conceptual understanding, the integration of Industry 5.0 principles and AI into teaching practice is predominantly partial (60.4%), with a minority reporting complete integration (16.5%), suggesting both willingness and dependence on institutional support and adequate pedagogical resources.

In contrast, students appear as potential vectors for the transition to Industry 5.0, with their "native" digital literacy and positive attitudes toward AI providing important psychological and technological capital that can be leveraged for institutional change if supported by curricular policies and educational co-creation initiatives.

**Educational implications**

**Implications for higher education institutions:** The results suggest that the systematic integration of the Industry 5.0 paradigm into the curriculum is no longer a prospective option, but an immediate necessity. Students are already at an advanced stage of readiness, and institutions have the responsibility to leverage this potential through curricular structures that recognize, channel, and amplify existing competencies. In this context, the reform of professional development for educators becomes critical: there is a need for continuous training programmes focused on AI, digital tools, and pedagogical methodologies specific to Industry 5.0, coupled with access to appropriate technical resources (AI testing environments, software licenses) and institutional time dedicated to experimenting and co-creating educational materials.

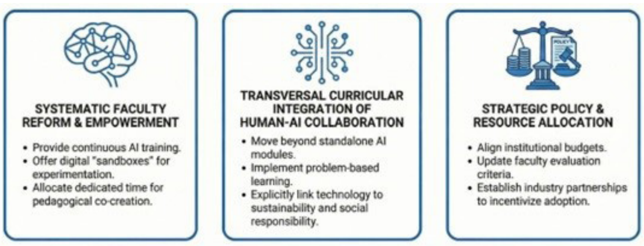


**Figure 2:** Educational implications of industry 5.0 in higher education.

**Implications for curriculum design:** From the perspective of curriculum design, the mere inclusion of AI as a "module" or isolated discipline is insufficient. Human–AI collaboration should be conceptualized as a cross-cutting paradigm, integrated into multiple disciplines and learning scenarios, so that students can practice the responsible use of AI in varied contexts. Additionally, the dimensions of sustainability and social responsibility must be explicitly articulated in relation to AI and Industry 5.0, moving beyond purely declarative or compliance-based approaches. This involves a methodological transition from predominantly transmissive models to strategies centered on collaborative learning, problem-based learning, case studies, and projects that effectively use AI tools.

**Implications for institutional policies:** At the level of institutional policies, the results indicate the need for dedicated investments in the professionalization of teaching staff and in digital infrastructure that would enable the real adoption of Industry 5.0 in education. Evaluation and academic recognition mechanisms should include, among the performance criteria, the degree of integration of Industry 5.0-specific methodologies and tools into teaching activities. Moreover, strengthening partnerships with the economic environment—especially with companies and startups in the AI field—can accelerate the transfer of knowledge and best practices, providing students and professors with authentic contexts for developing human–AI collaboration skills.

**Limitations and future perspectives**

The study presents several limitations that warrant caution in generalizing the results, particularly the use of a non-probabilistic sample, the self-assessment nature of the measurements, and the possible effects of cultural and institutional differences among the participating countries.

Future research could expand the sample to include a larger number of universities and national contexts, utilize mixed - methods designs (combinations of questionnaires, in-depth interviews, and observation), and longitudinally track the same cohorts of students and faculty to capture the evolution of competencies over time.

Additionally, it would be relevant to systematically investigate the impact of specific pedagogical interventions—training programmes, curriculum redesign, implementation of human–AI collaboration modules—on the level of AI Literacy, Industry 5.0 awareness, and Human–AI collaboration readiness.

## Conclusion

The transition to Industry 5.0 involves a profound transformation both in terms of competencies and the mindsets of educational actors. The study shows that while students are largely prepared for this change—through a higher level of AI literacy, a greater awareness of the Industry 5.0 paradigm, and an increased willingness to collaborate with AI—educators are in a stage of gradual adoption, often limited by access to resources, reduced training opportunities, and institutional constraints.

This situation does not indicate a structural blockage, but rather outlines a window of opportunity: through targeted investments in the professionalization of teachers and deliberate curricular reform, higher education institutions can significantly accelerate the transition to Industry 5.0. Students are already vectors of change; teachers can become powerful facilitators of it, if supported.


**Figure 3:** Educational implications of industry 5.0 in higher education.

Operationally, three main directions of action can be formulated.

Strategic integration of Industry 5.0 in Higher Education In the short term (6–12 months), it is necessary to implement rapid training programmes for teaching staff – micro-credits, webinars, and practical workshops – focused on the use of AI tools and pedagogical design specific to Industry 5.0. In the medium term (12–18 months), a curricular redesign process is necessary to systematically integrate Industry 5.0 themes, human–AI collaboration, and sustainability as cross-cutting axs of study programmes. In the long term (18 months and beyond), it becomes essential to strengthen partnerships with industry, invest in digital infrastructure, and develop centers of excellence dedicated to Industry 5.0 in universities, capable of supporting continuous innovation in education.

Overall, the study contributes to mapping the current state of competencies associated with Industry 5.0 in higher education and provides empirical arguments for the necessity of coherent institutional reform.

The future does not depend so much on the availability of students—who are already proving to be vectors of change—but on the willingness and capacity of institutions to invest in transforming the teaching staff and the curricular architecture, so that AI becomes an authentic partner in the educational process, not just a technological accessory.

## Declarations

**Author contributions:** All authors contributed equally to the conceptualization and design of the study, to the development and administration of the online questionnaire, to data collection and interpretation, and to the writing, review, and editing of the manuscript. All authors have read and agreed to the published version of the manuscript.

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**Institutional review board statement:** The study was conducted in accordance with the Declaration of Helsinki and approved by the Scientific Research Ethics Committee for the Fundamental Field: Social Sciences of the National University of Science and Technology POLITEHNICA Bucharest (approval No. 92/2/31.01.2025).

**Informed consent statement:** Informed consent was obtained from all subjects involved in the study; by completing the online questionnaire, participants indicated their voluntary agreement to take part in the research.

**Data availability statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

## References


1. Balgiu AB, Simionescu-Panait A, Mărgărit AI. Adapting and validating the Wong and Law emotional intelligence scale among Romanian students. Journal of Educational Sciences & Psychology. 2024; 15: 215–226.
2. Broo DG, Kaynak O, Sait SM. Rethinking engineering education at the age of Industry 5.0. Journal of Industrial Information Integration. 2022; 25: 100311.
3. Dascălu MI, Bodea C-N, Stănică IC, Mitrea DA, Hainagiu SM, Neagu SN, Ursachi T. From traditional career services to intelligent systems for career guidance: A study of career services diversity in higher education institutions. IGI Global. 2024.
4. Dogaru M. School resilience: Elements which are increasing it within the school: Teacher's leadership. In: Soare E, Langa C, editors. Education facing contemporary world issues. Proceedings of EDU WORLD 2018: The 8th International Conference. European Proceedings. 2019; 2191–2200.
5. Dogaru M, Pisică O, Popa CȘ, Răgman AA, Tololoi IR. The perceived impact of artificial intelligence on academic learning. Frontiers in Artificial Intelligence. 2025; 8: 1611183.
6. Đorđević L, Ćoćkalo D, Bakator M, Novaković B. Entrepreneurship in Society 5.0: Integrating technology and humanistic values for a sustainable future. Industrija. 2023; 51.
7. European Commission. Industry 5.0. Research and Innovation. Retrieved October 18, 2024.
8. Fitsilis P, Tsoutsa P, Damasiotis V, Kyriatzis V. Uncovering key trends in Industry 5.0 through advanced AI techniques. arXiv. 2024.
9. Ghobakhloo M, Iranmanesh M, Tseng ML, Grybauskas A, Stefanini A, Amran A. Behind the definition of Industry 5.0: A systematic review of technologies, principles, components, and values. Journal of Industrial and Production Engineering. 2023; 40: 432–447.
10. Gurrammagari DR, Boopathy P. A survey on AI integration into Industry 5.0. GU Journal of Science. 2025; 38: 99–113.
11. Hainagiu SM. Career counselling – Essential part of the personal and professional development process for the students and young researchers in the engineering field. Anuarul Universităţii „Petre Andrei" din Iaşi. Fascicula Asistenţă socială, Sociologie, Psihologie. 2020.
12. Ianoș MG, Tebeanu AV. A study on initial training and competence model for teachers in professional and technical education. In: Proceedings of the 14th International Scientific Conference eLearning and Software for Education: eLearning Challenges and New Horizons. Carol I National Defence University. 2018; 3: 63–70.
13. Kumar Y, Kaur K, Singh G. Machine learning aspects and its applications towards different research areas. In: 2020 International Conference on Computation, Automation and Knowledge Management (ICCAKM). IEEE. 2020; 150–156.
14. Kusetogullari A, Kusetogullari H, Andersson M, Gorschek T. GenAI in entrepreneurship: A systematic review of generative artificial intelligence in entrepreneurship research: Current issues and future directions. arXiv. 2025.
15. Madanaguli A, Sjödin D, Parida V, Mikalef P. Artificial intelligence capabilities for circular business models: Research synthesis and future agenda. Technological Forecasting & Social Change. 2024; 200: 123189.
16. Maddikunta PKR, Pham QV, Prabadevi B, Deepa N, Dev K, Gadekallu TR, Liyanage M. Industry 5.0: A survey on enabling technologies and potential applications. Journal of Industrial Information Integration. 2022; 26: 100257.
17. Manasia LM, Dima G, Ianoș MG, Ioniță IR, Pârvan A, Stoica SD, Tornariti E. Collaborative futures: A practical guide to participatory community development. Generis Publishing. 2025.
18. Martini B, Bellisario D, Coletti P. Human-centered and sustainable artificial intelligence in Industry 5.0: Challenges and perspectives. Sustainability. 2024; 16: 5448.
19. Micu A, Căpățînă A, Micu AE, Muntean MC. Regenerative artificial intelligence: A paradigm shift in sustainable business model innovation. Economics and Applied Informatics. 2025; 2025.
20. Nahavandi S. Industry 5.0—A human-centric solution. Sustainability. 2019; 11: 4371.
21. Neagu SN, Hodrea RA, Ionescu SC. Conflict management in education: Fostering skills for lifelong learning. In: EDULEARN24 Proceedings: 16th International Conference on Education and New Learning Technologies. IATED Academy. 2024; 3969–3976.
22. Oproiu GC. A study on the training and formation needs of teaching staff in technical universities. In: Scientific Research and Education in the Air Force (AFASES 2014). "Henri Coandă" Air Force Academy. 2014; 623–628.
23. Oproiu GC. Interdisciplinarity – A modern approach on the learning process. Journal of Educational Sciences & Psychology. 2016.
24. Oproiu GC. Students' perception of the development of transversal competencies in higher education. Anuarul Universităţii "Petre Andrei" din Iaşi. Fascicula Asistenţă socială, Sociologie, Psihologie. 2026; 33.
25. Oproiu GC, Ianoș MG, Litoiu N. Social networks: Learning tools or just socializing environment? In: Proceedings of the 15th International Scientific Conference eLearning and Software for Education (eLSE 2019). 2019; 219–224.
26. Popescu A. The role of artificial intelligence in digital marketing strategies. Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series. 2023; 3: 127–134.
27. Rame R, Purwanto P, Sudarno S. Industry 5.0 and sustainability: An overview of emerging trends and challenges for a green future. Innovation and Green Development. 2024; 3: 100173.
28. Șerbanescu LE, Ciuchi OM. Digital counseling and guidance of students – Real and effective support during the pandemic periods. Revista de Cercetare și Intervenție Socială. 2021; 75: 87–103.
29. Stănică IC, Hainagiu SM, Neagu SN, Litoiu N, Dascălu MI. How to choose one's career? A proposal for a smart career profiler system to improve practices from Romanian educational institutions. In: ICERI2022 Proceedings: 15th International Conference of Education, Research and Innovation. IATED Academy. 2022; 7423–7432.
30. Takawira B, Pooe D. SME readiness for Industry 5.0: A systematic literature review. Southern African Journal of Entrepreneurship and Small Business Management. 2025; 17: a946.

31. Tripon C, Tebeanu A-V, Gonta I. Conexiuni educaționale dincolo de conținut. O perspectivă aplicativă pentru profesori. Volumul I. Editura Universitară. 2023.

32. Vieriu AM, Hainagiu SM. Perfectionism and workaholism as barriers to lifelong learning and occupational sustainability: A cross-professional analysis. Sustainability. 2025; 17.

33. Vyhmeister E, Castane GG. When industry meets trustworthy AI: A systematic review of AI for Industry 5.0. arXiv. 2024.

34. Zaharia A. GenAI – valuable teammate of learning organizationals. Journal of Communication and Behavioural Sciences. 2025; 6.