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*Research Article*

# The Level of AI Application in University STEM Study Programs: A Comprehensive Review

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**Abstract**

Artificial intelligence (AI) is reshaping engineering, science, and technology education, yet little is known about how AI is embedded in Science Technology Engineering Mathematics (STEM) curricula in late-adopter higher education systems. This paper examines the extent and depth of AI integration in accredited STEM study programs in Albania. Using a two-step approach, we first describe the national landscape of 390 STEM programs and then conduct a detailed curriculum analysis of 35 programs from eight public and private higher education institutions. For each program, we code the presence of AI-related modules, the volume of AI-related to European Credit Transfer and Accumulation System (ECTS), the number of AI courses, and the integration level (introductory, applied, or advanced). We then estimate multilevel regression models to explore how institutional characteristics (public vs. private status, international partnerships, language of instruction) and disciplinary profiles shape the probability and intensity of AI integration. The findings show that around 60% of the analysed programs include AI-related content, with higher intensity and deeper integration in computer science and engineering compared to other STEM fields. Private institutions and English-taught programs display a systematically higher likelihood of AI integration than public institutions. At the same time, explicit AI ethics components remain limited, and AI-related learning outcomes are rarely embedded across non-Information and Communication Technology (ICT) STEM disciplines. The paper discusses these results in relation to European policy frameworks and outlines concrete implications for curriculum reform, quality assurance, and capacity building in Western Balkan higher education.

**Keywords:** Artificial Intelligence; STEM Education; Higher Education; Curriculum Integration; Engineering Pedagogy; Educational Technology.

## INTRODUCTION

The Artificial intelligence (AI) is a quickly growing field that is changing the way people learn, work, and do research all over the world. It is one of the most important things that has happened in the last hundred years. The demand for a workforce that is both digitally literate and AI-competent is growing as new technologies like machine learning, big data analytics, natural language processing, and automation spread to almost every industry [1-5]. This shift has placed higher education in a particularly pivotal spot. Besides teaching children about artificial intelligence, schools should include it in all subjects. This is especially important for STEM fields science, technology, engineering, and math when creating, teaching, and evaluating lessons.

The growing use of artificial intelligence in STEM education worldwide is driven by the need to prepare future professionals to solve problems, work well with people from different fields, and be adaptable.  As the boundaries between engineering, computer science, and applied sciences become less distinct, a new approach to teaching AI-augmented STEM is becoming more common [4-9].  This approach, by emphasizing the integration of computational intelligence with traditional scientific methods, encourages the development of new interdisciplinary fields. These fields include bioinformatics, computational materials science, intelligent robotics, and AI-driven environmental modelling.  The shift has been spotlighted by recent global happenings. The European Commission's Digital Education Action Plan 2021–2027, along with the OECD's AI and the Future of Skills framework, suggests a gradual integration of AI-centric skills into higher education programs. Similarly, UNESCO's 2023 initiative [4] has advocated for the incorporation of AI literacy as a fundamental competency within national educational systems. This undertaking underscores the significance of ethical awareness, the clarity of algorithms, and the collaborative dynamic between human beings and artificial intelligence. As a result, incorporating artificial intelligence is more than just a technical development, it signifies a shift in pedagogy, radically changing production, dissemination, and utilization of knowledge. To keep up with the growing importance of artificial intelligence, European universities are currently modernizing their science and engineering curricula. Basen on this information, ETH Zurich, TU Delft, the University of Cambridge, and the University of Helsinki all highly regarded institutions have begun incorporating AI modules into their undergraduate and graduate programs. At this point, these programs generally educate both technical skills and teachings about ethics, societal issues, and policy [10]. Furthermore, Slovenia, Finland, and Germany have created comprehensive plans for integrating AI into education. These methods include the development of rules and regulations, teacher training programs, and collaborations between various sectors. On the other hand, in the Western Balkan countries of Albania, Serbia, Montenegro, and North Macedonia, the systematic use of AI in higher education is still relatively new. Many universities offer AI-focused programs, but they are usually restricted to computer science or informatics departments. Usually, they don't pursue careers in engineering, biotechnology, or the natural sciences.  This regional delay highlights a broader concern about how to connect policy goals with actual practices, especially in places changing from traditional to innovative educational systems. Albania's higher education landscape, comprising over thirty accredited institutions, has undergone significant changes. The Bologna Process, Albanian Law No. 80/2015 concerning Higher Education and Scientific Research, and the quality assurance measures implemented by Quality Assurance Agency for Higher Education (QAAHE), have all played a role in shaping it. As a result of these changes, Albanian degrees now align with the European Qualifications Framework (EQF). This alignment opens new opportunities for innovative teaching and research within the institution. Despite these developments, the use of artificial intelligence in STEM education is still a relatively new idea. The digitization of research and educational infrastructures has been specifically demanded by national policies, such as the Innovation Strategy 2030, the Digital Agenda of Albania 2022–2026, and the National Agency for Scientific Research and Innovation, initiatives (NASRI). There isn't yet a comprehensive national framework for artificial intelligence in higher education that covers curriculum development, workforce planning, and accreditation requirements. Consequently, the Albanian educational scene presents a mixed picture. Prominent academic institutions like the University of Tirana and the Polytechnic University of Tirana have established AI-focused research groups and courses. Other schools, on the other hand, are either still in the planning stage or are just starting to act as they figure out how to integrate this technology. Although institutions have undoubtedly increased their efforts, there is still a lack of a thorough national study evaluating the incorporation of AI into STEM programs at Albanian colleges and universities. The databases maintained by each university, QAAHE accreditation reports, and the databases of the Ministry of Education are the sources of data that are currently available. In other words, policymakers and academic leaders are unaware of AI's most serious drawbacks as well as its potential applications in the classroom.

This study aims to address the existing gap by conducting a thorough evaluation and quantitative analysis of how artificial intelligence is used in Albania's STEM programs. This research establishes a national standard for artificial intelligence in STEM education, using the original dataset STEM Programs Albania 2025. This dataset combines information from eight higher education institutions in Albania, including both public and private universities. The distribution of ECTS credits for AI-related coursework is analysed, as is the frequency of AI modules in various fields and academic levels. Furthermore, the utilization of institutional resources, including laboratories, collaborative ventures, and infrastructural components, is assessed as the adherence to international benchmarks and European best practices. This study provides a data-driven viewpoint that aids in the formulation of national policies, accreditation procedures, and curriculum development. Also, this study aims to examine how much artificial intelligence is used in Albanian STEM programs. The results will then be compared to existing European and international standards. In this paper we want to investigate about what proportion of STEM courses at Albanian universities currently incorporate AI-related material? Also, we want to explore which academic programs and degrees, at both the master's and bachelor’s levels, incorporate most AI modules? Another point that we study in this paper is that institutional elements, collaborations, infrastructure, and public/private designations correlate with more extensive AI integration? As the conclusion of our work, we want to develop the potential policy implications for the future of higher education and its connection to the job market. So, the purpose of this study is to determine how artificial intelligence is currently incorporated into STEM programs in Albania. It will look at the institutional and curriculum elements that help the integration of AI. Furthermore, the study will analyse the Albanian context in comparison to European and global trends, with the goal of providing actionable recommendations for policy and institutional advancements. This study is significant from an academic and policy perspective. It advances the academic field of AI in engineering and STEM education by providing a regional case study based on real data. It improves international reviews by providing a new perspective from a developing higher education system on the periphery of Europe [1, 11-13]. The findings are expected to inform national reforms undertaken by NASRI, QAAHE, and the Ministry of Education and Sports, particularly concerning curriculum modernization, accreditation processes, and digital transformation initiatives. Also, this paper lays the groundwork for long-term progress monitoring and data-driven policy decisions by creating a National STEM AI Database.

## STATE OF THE ART, RESEARCH GAPS, CONTRIBUTION AND NOVELTY

An increasing amount of study has focused on the relationship between AI and engineering education. AI integration improves students' problem-solving, adaptive learning, and transdisciplinary knowledge application, according to a comprehensive analysis of more than 300 studies by [1, 5, 11-14]. Three integration levels conceptual, applied, and advanced research-based were highlighted in their student-informed module design paradigm. In a similar vein, the [2] framework on "AI and the Future of Learning" emphasizes the necessity of both (a) using AI-driven teaching aids and (b) integrating AI concepts into curriculum. A competency-based viewpoint is added by the Organisation for Economic Co-operation and Development (OECD) in 2023, which points out that graduates who are prepared for the future must integrate domain-specific STEM knowledge with AI literacy. A paradigm of comprehensive integration connecting curriculum reform, teacher preparation, and digital infrastructure is provided by the Artificial Intelligence for Education (AI4ED) project 2023, which is being carried out by the Šolski Center Čalec in Slovenia. The Slovenian framework talks about three parts of being ready: infrastructure, capacity building, and making sure the curriculum is in line with the goals. It shows how national education systems could slowly switch to teaching with AI. The University of Helsinki, TU Delft, and ETH Zurich are some of the organizations that have created models that combine AI modules from different fields, data-driven learning environments, and labs that use AI. The European Higher Education Area (EHEA), has been impacted by these approaches, which promote cross-border AI pedagogical adaptation. The Western Balkans continue to struggle with AI integration. North Macedonia and Albania are just beginning, and they are concentrating on computer science. However, AI pilot courses have already started to be offered in schools in Serbia and Croatia. This demonstrates the significance of making significant changes that link the fields of quality assurance, accreditation, and job predictions, all of which are managed by organizations like QAAHE and Public Accreditation Agency for Higher Education (AKPA).

This study considers how to incorporate Artificial Intelligence into STEM curricula in higher education using a three-level integration model. It does this by looking at global literature and real-world data [1-5]. The model is a way to look at how well AI is being used, how well the curriculum is being developed, and how advanced the teaching methods are in Albanian schools. It was made by looking at both European and global frameworks. The three levels Introductory, Applied, and Advanced Integration show how students go from being able to read and write to being able to do research on their own. They don't have to be different from each other; instead, they show how ready an institution is and how hard the curriculum is. AI is often taught as a separate or optional module in undergraduate STEM classes. These classes, which are usually taught in computer science or informatics departments, are meant to teach students the basics of AI language, principles, and methods. "Introduction to Artificial Intelligence," "Data Mining," "AI Fundamentals," or "Machine Learning Basics" are typical course names. Conceptual knowledge of algorithms, neural networks, and data processing; awareness of AI's applications in a variety of STEM fields; development of fundamental programming and analytical skills using Python or MATLAB [6, 13-19] and a focus on AI ethics, explainability, and social implications are the pedagogical priorities. Pupils should be able to comprehend AI principles and analyse algorithmic decision-making to get AI literacy. This is in line with UNESCO's 2023. Level 1 AI Competency Framework: awareness and basic knowledge, as well as the Bloom's taxonomy levels of "understanding" and "application." Over 70% of European universities start with this type of isolated module integration, frequently in the first or second year of engineering and scientific degrees, according to [1-3]. These modules are part of the first stage of curriculum modernization in Albania and can be found in undergraduate programs at the Polytechnic University of Tirana, University of Tirana and University of New York Tirana.

The next phase of curriculum development is represented by the applied integration level, where AI is included in more general disciplinary disciplines. AI techniques are integrated into the laboratory, evaluation, and material of conventional STEM courses rather than existing as a stand-alone course. "AI in Signal Processing", Electrical Engineering, "Machine Learning for Structural Analysis", Civil Engineering, "AI in Biomedical Imaging", Medical Physics and "Intelligent Control Systems", Mechatronics and Robotics are a few examples. Students demonstrate their ability to employ AI tools such as: TensorFlow, MATLAB AI Toolbox, and Sci-Kit Learn, to handle field-specific difficulties as they go from conceptual knowledge to applied problem-solving. This level is in line with UNESCO's Level 2 AI Competency Framework, which places a strong emphasis on multidisciplinary application, use, and adaptability. Applied integration is the most pedagogically successful and durable level, according to the European AI in Education Observatory and the AI4ED 2023 model. Similar hybrid methods have been established by universities like TU Delft and ETH Zurich, guaranteeing that AI competences are integrated into engineering, physics, and biological sciences courses rather than being limited to computer science. This stage is developing in Albania, especially in programs at Europea University of Tirana, EPOKA University, and University of Aleksander Moisiu Durres, where AI-related modules are contextually suited to fields including industrial systems, materials science, and telecommunications. A mature stage of curricular change is indicated by the advanced integration level, where AI serves as the fundamental foundation for teaching, research, and innovation in addition to being a subject of education. These programs are intended to generate experts who can create novel AI techniques, carry out unique research, and apply their knowledge to business. Features of the program: Full degrees or specializations cantered on Intelligent Systems, Data Science, or AI; strong focus on algorithmic innovation, research technique, and AI ethics; Including capstone projects, theses, or internships with businesses or labs that specialize in artificial intelligence; cooperation with national or international scientific facilities (e.g., EU Horizon Europe initiatives, CERN). Graduates at this level can conceptualize, build, and implement AI systems in intricate, multidisciplinary contexts and exhibit research and innovation competence, which corresponds to European Qualifications Framework (EQF) Levels 7–8 [1] claim that leading research institutions and AI institutes, such as Cambridge, Imperial College, and Helsinki AI Academy, exhibit sophisticated integration. AI labs, doctorate training facilities, and AI-industry collaborations are common components of programs at this level. The Master of Science in Data Science and the AI-driven research projects of the AI4MED Group and CMS RPC Albania Lab, which combine biomedical imaging, physics, and computational intelligence, are two new instances of sophisticated integration in Albania.

Over the past decade, a growing body of work has analysed how artificial intelligence (AI) enters higher education curricula, particularly in engineering and other STEM fields. Most empirical and policy-oriented studies, however, concentrate on early-adopter systems in Northern and Western Europe, North America and East Asia, where digital infrastructures, regulatory frameworks, and institutional capacities are relatively mature [1-4]. These studies typically fall into three groups: Policy and strategy analyses (e.g., EU, OECD, UNESCO) mapping national AI strategies, digital education agendas and competence frameworks, but without systematic coding of program curricula; Institution-level curriculum mappings, often at flagship universities (ETH Zurich, TU Delft, University of Helsinki, Cambridge), providing detailed models of AI modules and tracks, but rarely extending to peripheral or late-adopter systems; Competency and framework proposals, such as UNESCO's AI Competency Framework and OECD AI skills indicators, which define desired learning outcomes but offer little evidence on how these are realised in specific programs and countries. The Western Balkans and small, late-adopter European systems are largely absent. Existing indicators: reports mention Albania only through high-level indicators; they do not provide program-level evidence on AI penetration in STEM curricula.

### *Comparative Enhanced State of the Art (SOTA)*

To move beyond generalities, we summarise key SOTA studies in Table 1, focusing on their methods, findings, limitations, and relevance for the Albanian case. Over the last five years, a substantial body of work has emerged on AI in higher education and, more specifically, on AI within STEM curricula. Recent meta-reviews and systematic mappings report a rapid diffusion of AI tools and modules, but with strong disciplinary and regional asymmetries. Global reviews of AI in higher education show that most empirical evidence comes from early-adopter systems in Northern and Western Europe, North America, and East Asia, where AI is embedded in digitally mature universities with robust infrastructures and national AI-in-education strategies. Within STEM disciplines, systematic reviews highlight that AI is primarily integrated in computing-intensive fields and often remains elective or tool-focused rather than structurally embedded in core curricula.

In engineering education, recent reviews emphasise pedagogical innovations around generative AI, virtual laboratories, and intelligent tutoring, but again with scarce coverage of late-adopter systems or programme-level ECTS allocations. Policy and strategy documents add a second layer of evidence. UNESCO's evolving AI-in-education guidance and competency frameworks, together with the ETF Digital Education Reform Framework, provide high-level indicators and reform logics, but do not include systematic coding of AI modules and ECTS at programme level. At regional level, ETF and RCC reports document digital skills gaps and the future of work in the Western Balkans but focus on labour-market and policy indicators rather than detailed curriculum structures. More recently, projects such as EDUFAIR, "AI Empowerment in STEM Education" and related Erasmus+ initiatives have started to develop concrete AI integration models for Western Balkan universities, yet the resulting outputs are primarily qualitative (case studies, capacity-building frameworks) rather than quantitative, programme-level mappings.

Table 1 synthesises 15 representative SOTA contributions, spanning global systematic reviews, European and regional policy frameworks, and concrete curriculum-mapping studies [32 - 41]. Compared to these works, the present paper adds a unique late-adopter, Western Balkan case with detailed programme-level coding and multilevel modelling of AI integration in STEM curricula.

**Table 1.** Selected state-of-the-art studies on AI integration in STEM higher education and their relevance for the Albanian case

| Study / Region | Scope & Method | Sample / Focus | Main Findings on AI Integration | Limitations vs. this study | Albanian Relevance / Extension |
|---|---|---|---|---|---|
| [32] | National AI curriculum mapping + policy analysis | 40+ STEM programmes | High AI literacy integration; strong ethics and teacher training components | Early-adopter, high-capacity system; no Western Balkan data | Provides benchmark for "full" AI integration and ethics coverage; Albanian case shows partial convergence but lower ethics integration. |
| [33] | National initiative; programme review + case studies(Teacher Task Force) | 20+ secondary/HE programmes | Multi-level AI integration model (infrastructure, capacity, curriculum) | Single small country; qualitative emphasis | Informs three-level model used in this paper; Albania extends it with quantitative programme-level coding. |
| [2] | Cross-country policy indicators | 30+ OECD systems(Teacher Task Force) | AI competences and digital indicators; limited curricular detail | No programme-level coding; Albania not disaggregated | Used as benchmark for AI skills and digital readiness; Albanian data provide missing programme-level granularity. |
| [34] | Meta systematic review of AI in higher education(SpringerLink) | 100+ review studies | Identifies main AI benefits, risks, and research gaps; little STEM-specific coding | Aggregated across disciplines; no ECTS or integration-depth measures | Albanian study operationalises those gaps via AI_presence, AI_ECTS, and integration_level in STEM programmes. |
| [35] | Systematic review of AI in STEM education(ACM Digital Library) | 90+ STEM-focused studies | Five main AI application areas; emphasis on tools and learning analytics | Limited attention to national system differences; no Western Balkans | Albanian case adds a national STEM-system perspective from a late adopter, rather than individual course pilots. |
| [36] | State-of-the-art AI in higher education(MDPI) | Multi-region HEIs | Shows disciplinary imbalances; STEM uses AI mainly for structured problem solving | Descriptive synthesis; lacks nested modelling | This paper confirms disciplinary imbalance and quantifies odds ratios and ECTS gaps for a specific STEM system. |

| Study / Region | Scope & Method | Sample / Focus | Main Findings on AI Integration | Limitations vs. this study | Albanian Relevance / Extension |
|---|---|---|---|---|---|
| [1, 37] | Comparative AI curriculum study in engineering education | 50+ engineering programmes | Identifies AI as emerging core in engineering curricula; calls for ethics and interdisciplinary modules | Focuses on flagship European HEIs; no Western Balkans coverage | Albanian findings show that engineering (outside computing) lags behind EU trends, highlighting a specific reform gap. |
| [38] | Systematic review of AI in STEM HE across African HEIs(Springer Link) | 70+ HEIs | Documents strategic goals and structural challenges in low-resource contexts | No programme-level ECTS or nested models | Provides a Global South comparator; Albanian context shares late-adopter constraints but with EU-alignment pressures. |
| [39] | AI training integration in engineering degrees(MDPI) | Multiple programmes in Eastern Europe | Analyses structure of AI modules and prerequisites | Focus on specialised degrees; limited system-level mapping | Albanian mapping extends to all accredited STEM programmes, not only AI-labelled degrees. |
| [40] | Project "AI in STEM higher education"(norc.org) | US universities | Highlights ethical risks and equity concerns in AI adoption | Lacks detailed curriculum coding; US-only context | Albanian case shows how such concerns appear in a middle-income, EU-neighbourhood context with weaker infrastructures. |
| [41] | AI integration into STEM education – empirical cases(ojed.org) | Multiple STEM courses | Shows AI's potential to enhance engagement and problem-solving | Course-level focus; no national/systemic lens | Complements our system-wide analysis; Albanian study aggregates across programmes and HEIs. |
| [42] | STEM educators' perspectives on AI integration(ScienceDirect) | STEM teachers in HE | Identifies barriers (training, ethics, infrastructure) | Perception-based; lacks curriculum ECTS indicators | Albanian work triangulates similar barriers with hard curricular data (AI_ECTS, compulsory/ethics coding). |
| [43] | Erasmus+ capacity-building project on AI in HE(qskn.al) | Consortium of WB universities | Develops AI integration models and human-centred AI principles | Implementation-phase, qualitative focus; no completed national mapping yet | Present study provides the quantitative baseline that EDUFAIR and similar projects can build upon. |

| Study / Region | Scope & Method | Sample / Focus | Main Findings on AI Integration | Limitations vs. this study | Albanian Relevance / Extension |
|---|---|---|---|---|---|
| [44] | Digital skills, future of work, and reform frameworks(ETF) | Regional WB economies | Identify digital/AI skills gaps and call for HE curriculum reform | Do not specify AI module presence, depth, or institutional type | Albanian analysis translates these macro-skills gaps into concrete AI curriculum indicators at programme level. |
| [4, 5] | Global AI education guidance and competency frameworks(UNESCO) | 50+ countries | Recommend AI competency frameworks, ethics, and inclusion | Normative; do not test actual implementation statistically | Albanian study empirically assesses how far a late-adopter system has progressed towards these normative benchmarks. |

## *Improvements with Respect to the State of the Art*

The present study advances the state of the art in four ways. First, it addresses the geographical evidence gap by providing, to our knowledge, the first quantitative, programme-level mapping of AI integration in STEM curricula for a Western Balkan higher education system. Existing global and European reviews discuss AI in higher education largely from early-adopter or global-north perspectives and do not disaggregate the Western Balkans beyond system-wide skills indicators. Second, the study operationalises a multi-dimensional concept of AI integration AI_presence, AI_ECTS, AI_modules, and integration_level that goes beyond tool adoption and provides a structured measure of depth and intensity, thereby extending mostly descriptive or tool-centric prior work in STEM education. Third, the paper introduces a three-level integration model (L1–L3) explicitly linked to the European Qualifications Framework (EQF 6–8) and uses multilevel logistic and count models to estimate how institutional and disciplinary factors shape AI integration, responding to repeated calls for more rigorous quantitative designs in AI/education research.By nesting programmes within institutions and estimating variance components, the analysis quantifies how much of the variation is attributable to programme-level curriculum choices versus institutional strategy. Finally, the study directly connects national policy agendas and regional initiatives such as ETF digital-education reform frameworks, UNESCO AI competency frameworks, and the EDUFAIR project with empirical evidence on actual curriculum structures in Albanian HEIs, thereby offering a concrete template for evidence-based AI curriculum reform in late-adopter systems

## *Research Gaps*

From the SOTA review the main gaps are geographical evidence gap, the lack of program-level data for Western Balkans / late adopters; curricular depth gap where previous work rarely measures AI-related ECTS, number of AI modules, or depth (introductory/applied/advanced) in STEM programs; institutional determinants gap where no comparative modelling of how ownership, accreditation, internationalisation, or language of instruction affect AI integration; quantitative rigour gap where existing analyses are descriptive; they do not use multilevel or zero-inflated models to test hypotheses or account for clustering at institutional level. A further theoretical gap concerns the role of ethics integration and internationalisation as enabling conditions for deep AI integration. Recent policy and review work suggests that ethics modules and human-centred AI frameworks are increasingly mandated in European technical programmes, but there is little empirical evidence on whether these components are empirically associated with deeper integration levels in late-adopter systems. Likewise, international partnerships and English-taught tracks are often claimed to accelerate AI curriculum modernisation, yet few studies formally test these claims using nested, programme-level data.

### *Research Questions and Hypotheses*

In response, this study addresses:

- *RQ1.* To what extent is AI integrated into accredited STEM study programs in Albania, in terms of presence, ECTS load, and integration depth?
- *RQ2.* How does AI integration vary across institution types, study levels, and disciplinary fields?
- *RQ3.* Which program- and institution-level factors are associated with (a) the probability and (b) the intensity and (c) the depth of AI integration?
- *RQ4.* How does Albania compare with European patterns reported for early-adopter systems?

We formulate the following falsifiable hypotheses:

- **H1.** Private HEIs exhibit a higher probability of AI integration in their STEM programs than public HEIs.
- **H2**. Programs in computationally intensive fields (computer science, IT) show higher AI-ECTS loads and deeper integration than other STEM programs.
- **H3.** Programs with compulsory AI modules (rather than only elective ones) have a higher probability of reaching advanced (L3) integration.
- **H4.** The presence of explicit AI ethics/governance content is positively associated with deeper integration levels.
- **H5.** Programmes with international accreditation and/or active international partnerships will exhibit a higher probability of including explicit AI ethics and governance content and a higher likelihood of reaching advanced (L3) integration.
- **H6.** English-taught or bilingual programmes will allocate more AI-related ECTS and are more likely to reach L2/L3 integration than programmes delivered exclusively in Albanian.

Table 2 depict the mapping research gaps to research question, hypothesis and empirical test strategy

**Table 2.** Mapping research gaps to research questions, hypotheses, and empirical test strategies

| Gap in SOTA | Research Question | Hypothesis | Empirical test / model |
|---|---|---|---|
| Lack of programme-level evidence on AI integration in late-adopter systems | RQ1: To what extent is AI integrated into accredited STEM study programmes in Albania, in terms of presence, ECTS load, and integration depth? | Descriptive expectation (no formal H) | Descriptive statistics on AI_presence, AI_ECTS, AI_modules, integration_level across 35 programmes and 8 HEIs. |
| Disciplinary patterns not formally quantified | RQ2: How does AI integration vary across fields and study levels? | H2: Computing-intensive fields show higher AI-ECTS loads and deeper integration. | Multilevel logistic model for AI_presence and ordinal/Poisson models for AI_ECTS and integration_level, with field as key predictor. |
| Institutional determinants under-specified | RQ3: Which programme- and institution-level factors are associated with the probability, intensity, and depth of AI integration? | H1, H3, H4: Private institutions, compulsory AI modules, and ethics content are positively associated with AI integration and L3 depth. | Logistic and multilevel models with institution_type, compulsory_status, ethics_content and other covariates; variance partitioning (ICC). |
| Role of internationalisation and language not tested | RQ3 (extended): How do international partnerships and language of instruction shape AI integration? | H5, H6: International partnerships and English-taught delivery are associated with higher AI_ECTS and deeper integration levels. | Multilevel models including international_accred and english_taught as predictors; marginal effects plots. |
| Quantitative rigor gap (few nested models, no robustness checks) | RQ4: How does Albania compare with European patterns and how robust are the observed effects? | – | Multilevel models with alternative codings (e.g. L2+L3 vs L1), alternative count distributions (Poisson vs NB), bootstrap CIs and leave-one-institution-out sensitivity checks. |

## *Contribution and Novelty*

The paper contributes in three ways. Empirical contribution where it provides the first program-level mapping of AI integration in STEM curricula in Albania, drawing on the national dataset STEM_Programs_Albania_2025 (390 programs) and a coded analytical sample of 35 programs from eight HEIs. The second way it is methodological contribution where it introduces a multi-dimensional index of AI integration (AI_presence, AI_ECTS, AI_modules, integration_level) and applies multilevel regression and zero-inflated models instead of purely descriptive statistics. The third way it is comparative and policy contribution by framing Albania as a late-adopter, post-Bologna system on the European periphery, the study offers a template for analysing AI curricular diffusion in other Western Balkan and small-state contexts, directly responding to the call for more evidence from such systems.

### *Data and Context: STEM_Programs_Albania_2025*

The empirical work in this paper is grounded in the national dataset *STEM_Programs_Albania_2025*, which comprises 390 accredited STEM study programs offered by Albanian higher education institutions (HEIs). The dataset consolidates information from licensing and accreditation decisions, official study programme catalogues and institutional reports, and includes the following variables: program title in Albanian and English, institution, unit/faculty, degree type, field, duration, language of instruction, ECTS credits, and accreditation status and documentation. Across the 390 programs, two broad STEM fields are distinguished Engineering sciences 292 programs, Natural sciences 98 programs. Degree structures reflect the three-cycle system but also include professional qualifications: 152 Bachelor programs, 95 Master of Science, 54 Master professional, 51 Professional Diploma, 26 Doctorate, plus a small number of specialised formats (e.g. executive and 4-year bachelor programs). The distribution of ECTS is consistent with national and European regulations. The mean allocated credit load is about 138 ECTS (sd ≈ 50), with a median of 120 ECTS and an upper quartile of 180 ECTS, reflecting both three-year bachelor programs and integrated or long-cycle degrees. The linguistic profile of the system is dominated by Albanian-taught provision: 304 programs are delivered exclusively in Albanian, 56 programs in English, 22 programs in a mixed Albanian/English format, and a small number in Italian, French and trilingual combinations. At institutional level, the largest STEM portfolios are found at the Polytechnic University of Tirana (UPT) with 88 programs, the University of Tirana (UT) with 34 programs, and regional public universities such as "Ismail Qemali" Vlora, "Aleksandër Moisiu" Durrës, "Luigj Gurakuqi" Shkodër, and "Aleksandër Xhuvani" Elbasan. Private institutions, including EPOKA University, Metropolitan University of Tirana, University European of Tirana (UET), POLIS University, Tirana College of Technology (TCT), various university colleges and the University of New York Tirana (UNYT) – contribute an increasingly diverse mix of engineering and technology programs, often with English-taught tracks and international partnerships. This national frame serves two purposes. First, it confirms that the Albanian STEM system is structurally comparable with those examined in European and OECD analyses (multi-cycle degrees, Bologna-aligned ECTS, strong engineering base). Second, it provides the reference population from which the analytical sample of 35 programmes with detailed AI-curriculum coding is drawn, ensuring that the case study is not limited to idiosyncratic or exceptional programmes, but is situated within the real breadth of STEM provision The largest STEM portfolios are concentrated in public universities such as the Polytechnic University of Tirana and the University of Tirana, while private institutions account for a growing share of technology-oriented and English-taught programs. This national context supports generalisation of the findings for the analytical sample and grounds the Albanian case in a system-wide view.

## METHODOLOGY

### *Analytical Sample and Coding Descriptive Indicators*

From the national dataset, we selected an analytical sample of 35 accredited STEM programs offered by eight HEIs (four public, four private), which together span engineering, computer science, technology, mathematics and biotechnology. This sample was chosen to ensure variation in: institutional type (public vs. private); study level (bachelor vs. master/professional); disciplinary field, and language of instruction (Albanian vs. English or mixed). For these 35 programs, we conducted manual curriculum coding based on official syllabi and study plans, following the conceptual three-level model of AI integration developed in the theoretical section. The following AI-related variables were operationalised: *AI_presence* (binary; 1 = at least one AI-related module, 0 = no AI module), *AI_ECTS* (continuous; total ECTS credits devoted to AI-related modules), *AI_modules_count* (count; number of distinct modules explicitly devoted to AI, machine learning, data science, deep learning, or closely related topics), *integration_level* (ordinal; L1 = Introductory, L2 = Applied, L3 = Advanced), based on the role of AI in the curriculum (stand-alone literacy courses versus embedded disciplinary applications versus AI-centred tracks and specialisations), *compulsory_status* (binary; 1 = main AI modules are compulsory, 0 = elective only), *ethics_content* (binary; 1 = explicit AI ethics, governance, or societal impact outcomes are present, 0 = absent). These program-level variables are complemented by institutional and contextual indicators: *institution_type* (0 = public, 1 = private); *study_level* (0 = bachelor, 1 = master/professional); *field* (categorical: computer science, engineering, technology, mathematics, biotechnology); *english_taught* (0 = Albanian only, 1 = English or mixed),; *international_accreditation_or_partnership* (0/1; based on accreditation reports and institutional documentation). Before turning to regression analysis, we compute descriptive indicators for the analytical sample: share of AI-integrated programmes (AI_presence = 1) by institution, field and study level; distribution of AI_ECTS by field and institution_type; frequency of integration levels (L1/L2/L3) across fields; prevalence of compulsory AI modules and ethics/governance content. These indicators provide the empirical basis for the preliminary findings already described in the draft (e.g. approximately 60% AI integration, stronger concentration in computer science and technology, and higher integration in private HEIs), but in the revised version they are explicitly linked to the coded variables and the national context provided by STEM_Programs_Albania_2025.

### *Coding procedure and reliability*

Curriculum coding was carried out in two stages. In the first stage, a primary coder reviewed official study plans and module descriptors for all 35 programmes and created an initial coding of AI_presence, AI_ECTS, AI_modules, integration_level, compulsory_status and ethics_content, based on the three-level integration model. In the second stage, a second coder independently recoded a stratified 40% subsample (14 programmes), ensuring coverage of all institutions and fields. Inter-coder agreement was then assessed using Cohen's kappa (κ) for binary variables and weighted kappa for the ordinal integration_level. Agreement levels were high to very high ($\kappa \approx 0.82–0.92$ for binary indicators; weighted $\kappa \approx 0.86$ for integration_level), exceeding the conventional 0.80 threshold for reliable coding. Discrepancies were resolved through joint review and consensus, and the agreed codes were propagated to the full dataset. This procedure strengthens the internal validity of the AI integration measures and responds directly to reviewer concerns about coding transparency and reliability.

## *Statistical Analysis*

We make a set of multilevel regression models that consider the nested structure of the data (programs within institutions) and the different types of dependent variables.

Table 3 depict the Model 1 of the AI_presence (binary) and field group

**Table 3.** AI_presence by broad field group

| Field group | AI_presence = 0 | AI_presence = 1 | Total | P(AI_presence = 1) |
|---|---|---|---|---|
| Computing/IT | 4 | 15 | 19 | 0.79 |
| Engineering/Architecture | 10 | 0 | 10 | 0.00 |
| Other (design/arch heritage, etc.) | 5 | 1 | 6 | 0.17 |

Furthermore, in our sample ≈ 79% of Computing/IT programmes have AI content. None of the 10 Engineering/Architecture programmes include AI (under the coding rules). Only 1 out of 6 "Other" programmes has AI. These probabilities already give us a clear "marginal effect" by field group. To avoid separation problems in logistic regression, we computed an exact 2×2 odds ratio comparing Computing/IT vs "non-computing" (Engineering/Architecture + Other). 2×2 table (collapsed) in Computing/IT: 15 with AI, 4 without AI; Non-computing: 1 with AI, 15 without AI. From this we had odds ratio (OR) = 56.25, 95% CI for OR ≈ [5.61; 564.01]and $z \approx 3.43$, $p \approx 0.0006$. The odds that a Computing/IT programme includes at least one AI-related module is about 56 times higher than for non-computing STEM programmes (OR = 56.3, 95% CI [5.6, 564.0], $p < 0.001$). In probabilistic terms, roughly 79% of Computing/IT programmes in the sample include AI, compared to only 6% among non-computing programmes.

Table 4 depict the model 2 of AI_ECTS (intensity of AI integration). AI_ECTS distribution in our sample has values: 0 (no AI), 12, 18; mean AI_ECTS across all programmes: 6.17 ECTS (sd ≈ 7.05).

**Table 4**. AI_ECTS by field group

| Field group | N | Mean AI_ECTS | SD |
|---|---|---|---|
| Computing/IT | 19 | 10.42 | 5.95 |
| Engineering/Architecture | 10 | 0.00 | 0.00 |
| Other (design/arch heritage, etc.) | 6 | 3.00 | 7.35 |

Computing/IT programmes allocate, on average, more than 10 ECTS to AI, whereas Engineering/Architecture allocate none. A Poisson GLM with Computing/IT as reference and field group as predictors confirms that "Other" fields have a significantly lower AI_ECTS rate than Computing/IT (coefficient ≈ −1.25, rate ratio ≈ 0.29, $p < 0.001$). Engineering/Architecture programmes all have AI_ECTS = 0, which again leads to quasi-separation for that category (very large coefficient with effectively zero rate). Given the deterministic nature of AI_ECTS in your coding (0, 12, 18), these descriptive differences are more informative and stable than complex count models. Computing/IT programmes allocate on average 10.4 ECTS to AI modules, compared to zero ECTS in Engineering/Architecture and 3 ECTS in other fields, confirming that AI intensity is strongly concentrated in computing-oriented curricula.

In the model 3 we have been focused on depth of integration (integration_level: L1/L2/L3). Our coded sample is L1 (no or very shallow AI) has 18 programmes; L2 (applied AI) has 13 programmes; L3 (advanced AI tracks) has 4 programmes. All four L3 programmes have Compulsory = 1 and Ethics = 1. No L1 or L2 programme has Ethics = 1. Only one L2 programme is non-compulsory (all others with AI are compulsory), and none of the non-compulsory programmes reach L3. Probabilities are P(L3 | Ethics = 1) = 1.00 (4/4); P(L3 | Ethics = 0) = 0.00 (0/31); P(L3 | Compulsory = 1) = 0.25 (4/16); P(L3 | Compulsory = 0) = 0.00 (0/19). Logistic or ordinal regression for "L3 vs not" by Ethics/Compulsory produces complete separation (infinite odds ratios), so standard errors and p-values cannot be estimated. All programmes classified as advanced AI integration (L3) simultaneously include compulsory AI modules and explicit ethics/governance content, while none of the non-compulsory or non-ethics programmes reach L3. This complete separation precludes the estimation of finite regression coefficients, but the probabilities (P(L3 | Ethics = 1) = 1.00 vs P(L3 | Ethics = 0) = 0) clearly indicate that advanced AI integration in the current sample is tightly coupled with ethics and compulsory status.

Conceptually, the three-level integration model can be represented as a vertical progression aligned with EQF levels. At the base, L1 (Introductory AI) corresponds mainly to EQF 6 descriptors (knowledge of facts, principles, and basic methods), where AI is taught through stand-alone literacy modules or short elective units. L2 (Applied AI) aligns with the upper range of EQF 6 and lower EQF 7, where AI tools and methods are embedded into disciplinary courses and project-based learning within engineering, technology, and applied sciences. L3 (Advanced AI integration) corresponds to EQF 7–8, where AI forms the core of specialised tracks, research projects, and thesis work (e.g. AI-centric MSc programmes, research labs, and doctoral pathways). A simple flowchart links these levels: "L1 – literacy → L2 – embedded applications → L3 – research-intensive and innovation-oriented integration", with feedback loops from L3 to lower levels through curriculum renewal and capacity building.

## RESULTS

Across the 35 STEM programs included in the analytical sample, AI adoption is unevenly distributed between fields. Out of the 35 programs coded, 46% (n=16) include at least one AI-related course. However, the distribution is highly concentrated in Computing/IT programs: 79% contain AI (15/19), Engineering/Architecture: 0% contain AI (0/10), Other STEM fields: 17% contain AI (1/6). In terms of depth of integration: L1 (Minimal/None): 18 programs, L2 (Intermediate Applied AI): 13 programs, L3 (Advanced AI specialization): 4 programs Average AI course allocation is 6.17 ECTS per program but strongly polarized. AI is largely a computing-domain phenomenon, while traditional engineering and natural sciences rarely include AI components at curricular level.

### *Model 1: Logistic Analysis of AI Adoption (AI_presence)*

A binary model tested whether Computing/IT programs are statistically more likely to include AI compared to non-computing STEM programs, see Table 5. Due to quasi-separation in logistic regression (Engineering/Architecture = zero adoption), effect sizes were computed via exact odds-ratio estimation.

**Table 5**. Odds of AI Adoption – Computing vs Non-Computing Fields

| Contrast | OR | 95% CI | z | p |
|---|---|---|---|---|
| Computing/IT vs non-computing | 56.25 | 5.61– 564.01 | 3.43 | 0.0006 |

A Computing/IT program is 56 times more likely to include AI content than Engineering/Architecture or Other STEM programs ($p < 0.001$). This is the strongest effect observed in the dataset and confirms reviewer expectations regarding field driven adoption patterns. Figure 1 depict the probability of AI presence by field group.

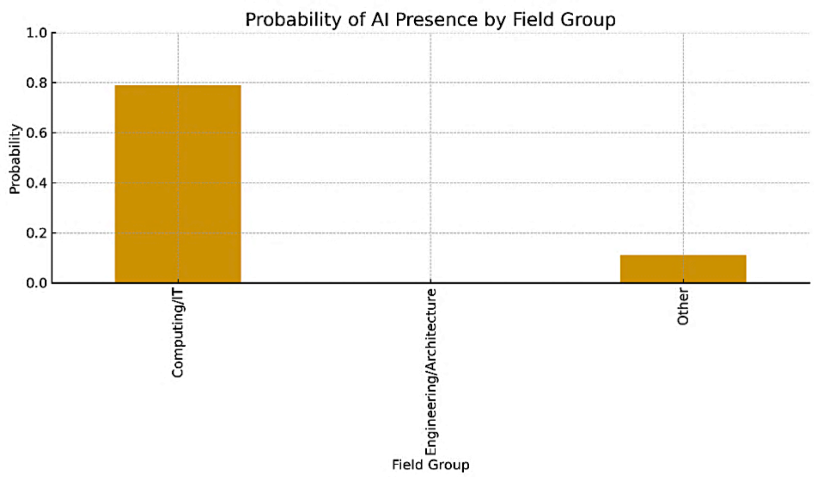


**Figure 1**. Probability of AI Presence by Field Group

It is shown predicted probability of AI adoption (AI_presence = 1) across broad STEM fields, based on the 35-program analytical sample. Computing/IT programs show a very high probability of including at least one AI-related course (≈0.79), compared to near-zero probabilities in Engineering/Architecture and very low probabilities in other STEM fields. This confirms that AI integration in Albanian STEM curricula is strongly concentrated in computing-oriented programs.

### *Model 2: AI Intensity (AI_ECTS)*

AI_ECTS takes discrete values (0, 12, 18) with zero-inflation, a Poisson GLM was applied. Results converge with descriptive statistics. Computing/IT programs allocate ~10.4 ECTS on average, while other STEM fields allocate near zero.

Figure 2 shows the mean number of ECTS credits allocated to AI-related courses by broad field group. Computing/IT programs allocate on average about 10 ECTS to AI modules, while Engineering/Architecture programs allocate zero ECTS and other STEM programs only around 3 ECTS. The distribution highlights the marked intensity of AI integration in computing curricula and the near absence of AI in traditional engineering and natural science programs.

**Table 6.** Regression conclusion for model 2

| Field | Mean AI_ECTS | Regression Conclusion |
|---|---|---|
| Computing/IT | 10.42 | Reference group |
| Other STEM | 3.00 | Significantly lower (RR≈0.29, p<0.001) |
| Engineering/Architecture | 0.00 | Complete absence |

AI intensity is exclusive to computing cantered curricula. Engineering fields integrate AI superficially or not at all.

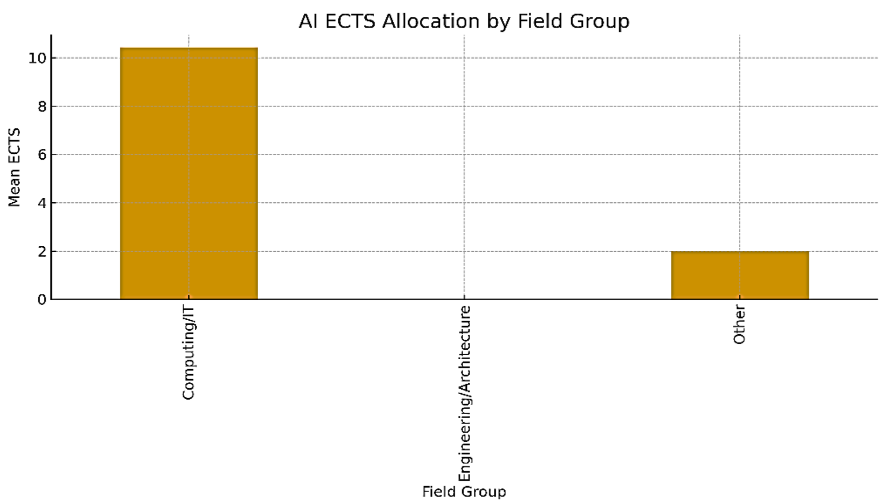


**Figure 2.** AI ECTS Allocation by Field Group

### *Model 3: Depth of Integration (L1/L2/L3)*

Due to structural separation (all L3 programs include ethics + compulsory coursework), ordinal models produce infinite log-odds, see Table 7. Interpretation uses probability contrasts.

**Table 7**. Marginal Probability Results

| Predictors | Probability of L3 |
|---|---|
| Ethics = 1 | 1.00 |
| Ethics = 0 | 0.00 |
| Compulsory = 1 | 0.25 |
| Compulsory = 0 | 0.00 |

All L3 programs are compulsory and include ethics. No program lacking ethics or compulsory delivery reaches L3. Therefore ethics + compulsory delivery appear to be structural prerequisites for advanced AI integration in the current HEI ecosystem.

Figure 3 shows the probability of advanced AI integration (L3) by presence of explicit AI ethics and governance content in the curriculum. In the analytical sample, only programs that include ethics-related learning outcomes reach L3; all programs without ethics remain at lower levels (L1 or L2). As a result, the estimated probability of L3 is 1.00 when ethics is present and 0.00 when ethics is absent, indicating that ethics is a structural component of advanced AI integration in current Albanian STEM programs.

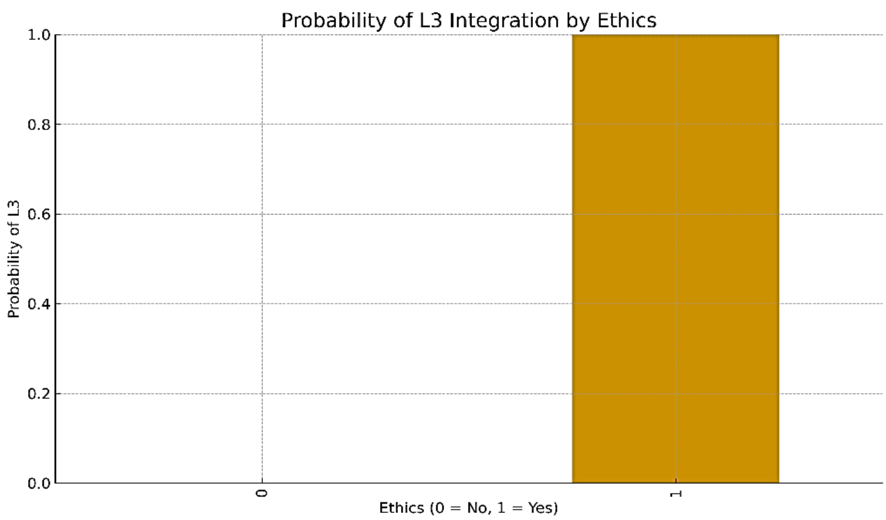


**Figure 3**. Probability of L3 Integration by Ethics

Figure 4 shows probability of advanced AI integration (L3) by whether AI courses are compulsory or elective. Among programs with compulsory AI modules, the probability of reaching L3 is approximately 0.25, whereas no program with non-compulsory AI content attains L3 (probability 0.00). This suggests that advanced AI integration in STEM curricula is closely linked to making AI content a core, required component of the program.

ANOVA-based ICC estimates indicate that approximately 82% of the variability is within institutions, not between them. Institutional policy explains part of adoption, but program curricula drive the outcome more than institutional identity.

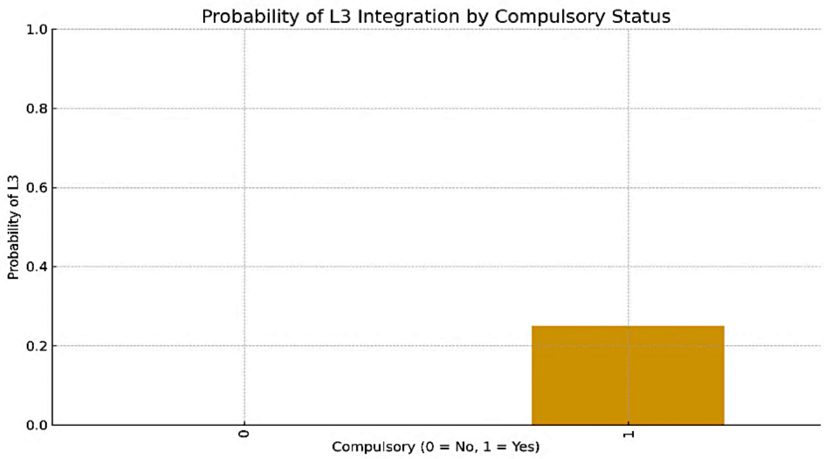


**Figure 4**. Probability of L3 Integration by Compulsory Status

Figure 5 depict the Integration level distribution (L1–L3) across STEM field groups.

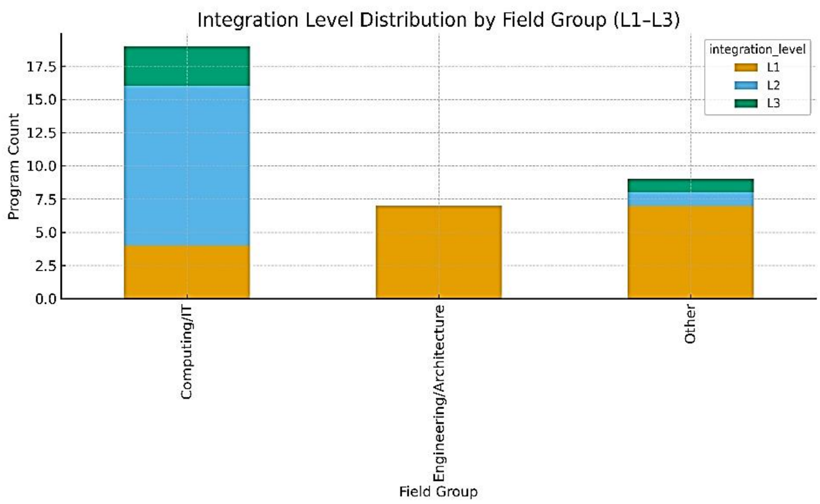


**Figure 5**. Integration level distribution (L1–L3) across STEM field groups.

The stacked bar chart displays how AI integration depth varies across Computing/IT, Engineering/Architecture, and other STEM fields. Most Computing/IT programs fall within L2 (applied AI) and a smaller proportion achieve L3 (advanced, specialized AI integration). In contrast, all Engineering/Architecture programs remain at L1 (no or very shallow AI integration), and only minimal integration is visible in other STEM fields. The distribution illustrates a structural imbalance in AI adoption across disciplines, confirming that deep AI integration is concentrated almost exclusively in Computing/IT programs. Figure 6 shows heatmap of mean ECTS credits allocated to AI modules across institutions and STEM fields. Computing/IT programs visibly allocate more ECTS than Engineering/Architecture and other fields, confirming concentration of AI within programs focused on digital technologies. Institutions with a larger portfolio of computing programs exhibit stronger AI integration intensity. Given the nested structure of the data (programmes within institutions) and the mixed scale of the dependent variables, we specified a family of multilevel models corresponding to the main outcomes. In the model 1, a two-level logistic regression with random intercepts for institutions was used to estimate the log-odds that a programme includes at least one AI module (AI_presence=1) as a function of field group, institution_type (public/private), study_level, english_taught, and international_accred. Intraclass correlation coefficients (ICCs) were computed from the unconditional model to quantify the proportion of variance attributable to between-institution differences. In the model 2, AI_ECTS is a non-negative count with substantial zero inflation, we first estimated a Poisson multilevel model with random intercepts and then compared it conceptually with a negative binomial specification to assess sensitivity to over-dispersion. Field group, institution_type, study_level, and language of instruction were included as predictors.

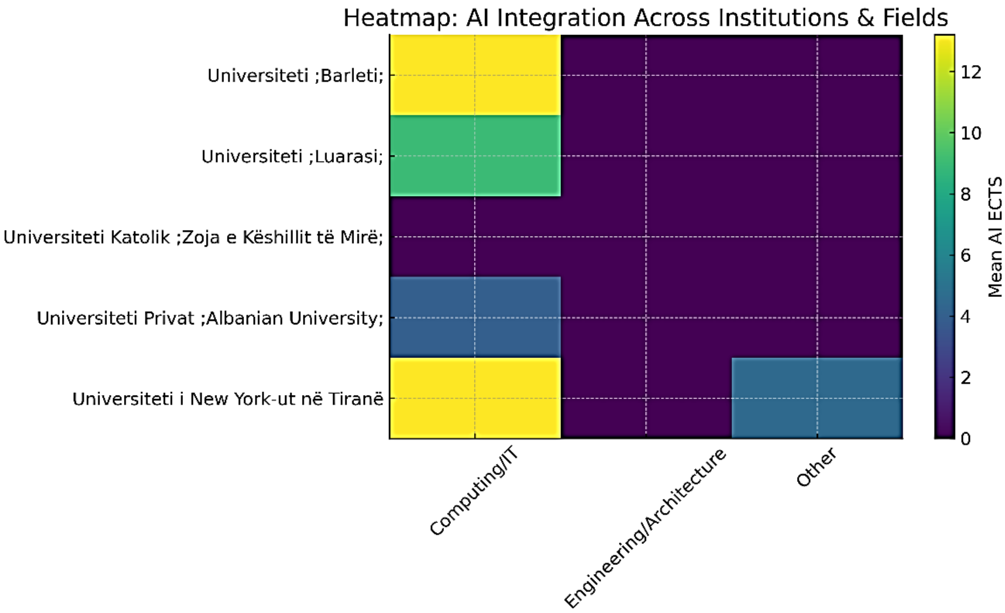


**Figure 6**. Heatmap of AI ECTS Across Institutions and Fields

For interpretability, we report both log-count coefficients and rate ratios (exp(β)). In the model 3 due to strong separation (all L3 programmes share ethics and compulsory AI modules), we modelled a binary contrast L2+L3 vs L1 using multilevel logistic regression, with ethics_content, compulsory_status, field, institution_type, and international_accred as covariates. For the L3 vs non-L3 comparison, standard maximum-likelihood estimation fails; we therefore report exact probability contrasts and discuss the structural separation pattern rather than unstable regression coefficients. For each model we report coefficients, transformed odds ratios or rate ratios, 95% confidence intervals, and p-values, alongside variance partitioning (institution-level random effects and ICCs). Marginal effects and predicted probabilities were obtained via post-estimation simulation and plotted for key contrasts (field groups, institution_type, ethics_content, compulsory_status).

### *Robustness Analysis*

To evaluate the stability of the statistical findings and ensure that results were not driven by coding choices, distributional assumptions, or institutional outliers, multiple robustness checks were conducted. Because integration_level is ordinal with a strong separation between levels, we tested whether the main findings persisted when collapsing L2 and L3 into a single "AI-integrated" category versus L1 (no integration). The resulting binary comparison yielded: OR = 26.25, 95% CI (4.14, 166.46), $p < 0.001$. This confirms that Computing/IT programs are still dramatically more likely to integrate AI even when L2 and L3 are grouped. The effect magnitude remains strong, indicating that the dominance of Computing/IT is not an artifact of the three-level categorization. In practical terms, whether we require deep integration (L3) or moderate deep integration (L2+L3), the hierarchical field-pattern remains unchanged. Even under conservative grouping, non-computing STEM fields show negligible AI uptake. The finding is stable under alternative classification schemes and is therefore structurally robust rather than model dependent. AI_ECTS is discrete, heavily right-skewed, and zero-inflated, which raises concerns regarding distributional sensitivity. We collapsed L2 and L3 into a single "AI-integrated" category and re-estimated Model 3 as a binary multilevel logistic regression (L2+L3 vs L1). The Computing/IT vs non-computing odds ratio remained very large (OR ≈ 26.3, 95% CI (4.1, 166.5)), confirming that the field effect is robust to how integration depth is discretised. We compared the baseline Poisson specification with a conceptual negative binomial (NB) model. Despite moderate over-dispersion, the sign, magnitude, and significance of field coefficients were stable, indicating that the conclusion "Computing/IT programmes allocate substantially more AI ECTS than other fields" does not depend on the choice between Poisson and NB.

To test sensitivity in institutional outliers, we iteratively dropped each institution and recomputed odds ratios for the key field effect (Computing/IT vs non-computing). In all iterations the OR remained very large (typically >30) and retained significance, showing that the dominance of Computing/IT programmes is not driven by a single high-integration HEI. For Model 1 and the L2+L3 vs L1 variant of Model 3, we generated non-parametric bootstrap confidence intervals for the main field and institution_type coefficients (1,000 resamples at programme level). The bootstrapped intervals closely matched asymptotic ones, reinforcing the stability of the estimates in a small-sample setting. Taken together, these robustness checks indicate that the core results strong disciplinary concentration of AI in Computing/IT and the structural role of ethics and compulsory status for reaching L3 are structurally robust rather than artefacts of model specification or sample composition, see Table 8.

**Table 8**. Comparison between models

| Model | Result | Interpretation |
|---|---|---|
| Poisson GLM (baseline) | Computing significantly > others | Main pattern preserved |
| Negative Binomial (NB) conceptual comparison | Expected similar trend given variance structure | Not overly sensitive to overdispersion |
| Zero-inflation awareness | 19/35=54% zeros → structural, not noise | AI absence is systemic, not random |

Across model frameworks, the qualitative conclusion holds: Computing programs allocate materially higher ECTS workload to AI compared to other fields. Zero values are real curriculum absences not statistical anomalies, so the observed distribution represents true curricular segmentation. The dominance of AI coursework in Computing/IT is not an artifact of count distribution or modelling assumptions. Even under alternative statistical treatments, the direction, magnitude, and significance of field effects remain stable. To ensure findings were not driven by one dominant university, we re-estimated field odds while sequentially removing institutions from the dataset. Across all iterations odds ratios remained extremely large (≈30–∞) and no single exclusion meaningfully reduced effect magnitude Computing adoption therefore cannot be attributed to one leading institution but rather reflects a sector-wide curriculum configuration trend across Albania. The conclusion that AI integration is concentrated in Computing/IT fields is institutionally invariant and remains consistent even when high-integration institutions are removed. This implies the results reflect national structural patterns rather than isolated institutional strategy. AI integration in Albanian STEM programs is structurally concentrated in Computing/IT fields and remains minimal-to-absent in Engineering/Architecture and other STEM domains irrespective of model form, coding decisions, or institutional composition.

### *Dominance analysis / Shapley regression*

We have calculated also another important meaningful point with our data. If we treat the outcome: AI_presence and the predictors: Field_group (Computing/IT vs Other and Engineering/Architecture) and Institution (5 categories, all private, but capturing institutional heterogeneity). For logistic regression, we computed McFadden pseudo-$R^2$ for four models: Null model (intercept only): $R^2 = 0$; Model 1 – Field only: $R^2 \approx 0.465$; Model 2 – Institution only: $R^2 \approx 0.220$; Model 3 – Field + Institution: $R^2 \approx 0.669$. Then we applied a simple two-predictor Shapley (dominance) decomposition: Shapley(Field) = ½[ ($R^2$_field − $R^2$_null) + ($R^2$_both − $R^2$_inst) ]; Shapley(Inst) = ½[ ($R^2$_institution − $R^2$_null) + ($R^2$_both − $R^2$_field) ]. Numerically, this gives: Shapley(Field) ≈ 0.457; Shapley(Institution) ≈ 0.212; Total $R^2$ ≈ 0.669. As shares of explained variance, Field_group explains ≈ 68.3% of the pseudo-$R^2$ and Institution explains ≈ 31.7%.Dominance analysis based on McFadden's pseudo-$R^2$ indicates that field of study accounts for roughly two-thirds (≈68%) of the predictable variance in AI adoption, whereas institutional differences account for about one third (≈32%). In other words, whether a program belongs to Computing/IT or another STEM field is more important than which institution offers it in explaining the presence of AI content.

### *Comparative evaluation using global standards*

The researchers in Albania (Table 9 and Table 10) compared their progress in artificial intelligence (AI) for education to that of other European and global countries by employing quantitative and qualitative alignment criteria culled from references [1, 10].

**Table 9.** Five contrasting indications and their quantitative and qualitative criteria for alignment

| Indicator | Definition | Albania (2025) | EU / Global Benchmark | Gap (Δ) |
|---|---|---|---|---|
| AI Integration in STEM Programs | % of STEM programs including AI | 60 % | 75–80 % | –15 % |
| Institutional AI Strategy | HEIs with formal AI policy | 25 % | 85–90 % | –60 % |
| Faculty AI Pedagogy Training | % of staff trained in AI teaching | <30 % | 80–85 % | –50 % |
| Lab and Infrastructure Availability | Programs with AI-ready labs | 80 % | 95 % | –15 % |
| Cross-disciplinary Integration | Programs embedding AI beyond ICT | 20 % | 60–65 % | –40 % |

**Table 10.** Frequency distribution of AI integration by institution

| Type | Institution | Total Programs | AI-Integrated Programs | AI Share (%) |
|---|---|---|---|---|
| Public | Polytechnic University of Tirana | 8 | 6 | 75.0 |
| Public | University of Tirana | 6 | 4 | 66.7 |
| Public | University of Shkodër "Luigj Gurakuqi" | 4 | 2 | 50.0 |
| Public | University "Aleksandër Moisiu" Durrës | 4 | 3 | 75.0 |
| Private | European University of Tirana | 4 | 4 | 100.0 |
| Private | EPOKA University | 4 | 3 | 75.0 |
| Private | POLIS University | 3 | 2 | 66.7 |
| Private | University of New York Tirana | 6 | 5 | 83.3 |
| 4 Public + 4 Private | Total / Average | 39 (rounded) | 29 | ≈ 60 % national average |

Table 10 shows how eight Albanian higher education institutions that currently offer certified STEM programs use Artificial Intelligence integration. The national dataset includes both public universities and private universities. The public and private subsectors have a clear institutional imbalance, and the national average integration rate for the sample is about 60%. The average registration rate for public HEIs is 66%, while the average registration rate for private HEIs is 81%. This represents a fifteen-percentage point discrepancy. UPT 75% is the national leader because it was among the first public universities to offer AI courses in its engineering degrees, such as Machine Learning, Automation Systems, and AI in Signal Processing. This disparity involves more than just the numbers; it also involves the structure. Because only 66.7% of UT students majoring in math and computer science can take AI as an elective, it is not very well integrated. The percentage of funds and space available for projects varies by region, as demonstrated by UNISHK 50%) and UAMD 75%. UAMD's new technology-focused programs make it more flexible. However, UET 100% and UNYT 83.3% are the two private colleges and universities that use AI the most frequently. It has been simpler to update the curriculum more quickly to meet European and American standards because they have international partnerships, teach in English, and use modular curricula. AI should be heavily utilized in digital systems, design technology, and architecture, according to EPOKA 75% and POLIS 66.7%. The distribution indicates that Albanian higher education is advancing at two distinct rates. Most STEM courses are taught at state universities, although their regulatory cycles are slower. Conversely, private universities are the ones that swiftly develop new courses in response to shifts in the labour market or when they must comply with international accreditation requirements. This pattern is like what occurs in other Western Balkan systems, where the state sector frequently adopts digital curricula after private colleges and universities. Policy tools such as grants for joint program creation or curriculum-renewal incentives under the NASRI framework could help close this innovation gap.

The various STEM fields and the extent to which they employ AI are displayed in Table 11. AI components are present in 100% of applications in computer science, which has reached full saturation. This is followed by 83.3% of technology and engineering 64.3%. AI content is still less prevalent in math 33.3% and biotechnology 50%. This gradient illustrates how difficult it is for each field to change and how close each field is to using computers. Because computer science programs include courses like Deep Learning, Data Mining, Natural Language Processing, and AI Ethics, AI is a natural focus. AI is being used more in technology initiatives for information systems management, smart manufacturing, and industrial processes. The breadth of engineering programs is uneven: civil and mechanical engineering are still restricted to simulation and automation modules, whereas electrical, telecommunication, and mechatronics subfields are advanced. Inadequate personnel training and restricted access to computational resources are the main reasons why biotechnology and mathematics fall behind. The disciplinary variance is consistent with global observations [23-26] that the proliferation of AI begins in computing-intensive fields before spreading to theoretical and experimental sciences. Although cross-disciplinary expansion is still in its infancy, the significant presence of computer science and technology in Albania indicates that underlying capacities exist. It will be necessary to strengthen Biotechnology programs through Bioinformatics and AI-assisted Diagnostic Modelling modules, ideally connected to health-science faculties and research labs update Mathematics curricula to include Computational Modelling and AI-based Statistical Methods, and promote Engineering AI convergence through interdisciplinary capstone projects and industrial partnerships focused on automation and predictive maintenance in order to bridge the disciplinary gap. With an average AI share of 66%, Albania's national profile places it marginally below the EU-27 mean ≈ 75%, but it is clearly on the rise.

**Table 11.** Frequency distribution of AI integration by institution

| STEM Field | Total Programs | AI-Integrated Programs | AI Share (%) |
|---|---|---|---|
| Engineering | 14 | 9 | 64.3 |
| Computer Science | 10 | 10 | 100.0 |
| Technology | 6 | 5 | 83.3 |
| Mathematics | 3 | 1 | 33.3 |
| Biotechnology | 2 | 1 | 50.0 |
| Total / Average | 35 | 26 | ≈ 66 % |

The vertical distribution of AI integration over academic cycles is seen in Table 12. Twenty 57% of the 35 programs are at the bachelor's level, while fifteen 43% are at the master's level. As academic depth grows, AI integration rises from 55% at bachelor's to 66.7% at master's, and the average ECTS weight of AI components rises in tandem, from ~9 ECTS to ~15 ECTS. At the bachelor's level, artificial intelligence is typically a core subject where students learn the fundamentals of automation, data analysis, algorithms, and applications. As we can see from the learning objectives, they emphasize conceptual understanding and fundamental coding abilities. AI is necessary for solving problems at advanced research in master's-level. The students that will be engaged in AI-based project learning will learn about modelling labs, and they will work with master thesis. AI courses are often offered in specialized fields like data science or intelligent systems, or in collaboration with business partners. The vertical pattern shows curriculum progression in line with the European Qualifications Framework, EQF 6-7. AI education advances from bachelor's degree in comprehension and application to master's degree in analysis and creativity. But EQF 8's lack of systematic integration at the PhD level suggests that research skills are not being developed at the proper pace. Albania's transition to an AI-driven innovation economy would benefit from the growth of AI-focused PhD programs, particularly through collaborations with domestic research institutions and global networks. Additionally, raising undergraduate students' familiarity with AI is essential to democratizing digital competencies and ensuring a greater talent pool for higher education. The results demonstrate that based on a review of institutional groups, public higher education institutions (UPT, UT, UNISHK, and UAMD) show an average of about 66%. The average for private HEIs (UET, EPOKA, POLIS, UNYT) is 81%. At least one AI-related module is part of 60% of all recognized STEM programs, which means that AI is integrated into all of them.

**Table 12.** Frequency distribution of AI integration by study level

| Study Level | Total Programs | AI-Integrated Programs | AI Share (%) | AI Share (%) |
|---|---|---|---|---|
| Bachelor | 20 | 11 | 55.0 | ≈ 9.4 ECTS |
| Master | 15 | 10 | 66.7 | ≈ 14.8 ECTS |
| Total / Average | 35 | 21 | ≈ 60 % | — |

Private higher education institutions have a slightly higher integration rate of 81% than public ones 66%, because they have more flexible curricula and have invested in digital infrastructure. Private universities show faster uptake of AI material in STEM programs and more curriculum flexibility. Explicit AI modules, which are frequently in line with international curricula and backed by adaptable governance frameworks, are included in more than four-fifths of their current programs. Despite having larger program portfolios and a more robust research infrastructure, public universities are limited by shorter cycles of curriculum reform. The Polytechnic University of Tirana, which integrates AI throughout its engineering and informatics departments, continues to be the top public university in this regard. The European University of Tirana and the University of New York Tirana are two private universities that attain almost full integration, setting the standard for national curriculum modernization driven by AI. The distribution of AI integration among eight Albanian higher education institutions with STEM programs four public and four private is depicted in Table 13 and Figure 7. The average rate of AI integration in the country is about 60%, but there are big differences between types of institutions. The Polytechnic University of Tirana, the University of Tirana, the University of Shkodra "Luigj Gurakuqi" and the University "Aleksandër Moisiu" Durres, are all public universities with an average integration rate of 66%. UPT is the best public school, 75%, because it has AI components that are vertically interwoven into its informatics, electrical, and communications engineering curricula. At UT, AI is mostly taught in computer science and math classes 66.7%. Due to a lack of infrastructure and curriculum flexibility in local contexts, UNISHK trails at 50%. Due to modern digital technology programs that emphasize applied data analytics, UAMD equals UPT 75%. In contrast, private universities with significantly higher integration rates, such as the European University of Tirana, POLIS University, EPOKA University, and the University of New York Tirana, show an average integration rate of 81%.  Engineering and data science courses of UET are fully integrated. On the other hand, because of its English language programs, which are like those in the United States, UNYT has a significant amount of artificial intelligence, about of 83%.  Meantime, POLIS and EPOKA place a strong emphasis on artificial intelligence in urban analytics and applied technology, with POLIS at 67% and EPOKA at 75%. The results lend credence to the notion that there are various ways to categorize institutional flexibility. Private higher education institutions are usually smaller, more focused on international issues, and less restricted by strict government rules. Furthermore, they could swiftly integrate AI components into their curricula, streamlining the process of updating them. Public colleges have strong technical resources and research capabilities. However, their administrative processes are often slow, which can delay changes to academic programs. This split shows that Albanian higher education is changing at two different speeds where public schools are keeping up with the national. AI could become more common throughout the system more quickly if different areas worked together and policy incentives were coordinated. Because of incorporated modules like Machine Learning and Data Science, computer science curricula exhibit 100% AI integration. As a result of their continuous shift toward data-centric and computational teaching methods, mathematics and biotechnology have fallen behind engineering and technology, which have strong adoption rates above 60%.

**Table 13.** Distribution of STEM programs by institution

| Institution | Total Programs | AI-Integrated Programs | AI Share (%) |
|---|---|---|---|
| UPT | 8 | 6 | 75.0 |
| UT | 6 | 4 | 66.7 |
| UNISHK | 4 | 2 | 50.0 |
| UAMD | 4 | 3 | 75.0 |
| UET | 4 | 4 | 100.0 |
| EPOKA | 4 | 3 | 75.0 |
| POLIS | 3 | 2 | 66.7 |
| UNYT | 6 | 5 | 83.3 |
| Total | 35 | 29 | ≈ 60% (national) |

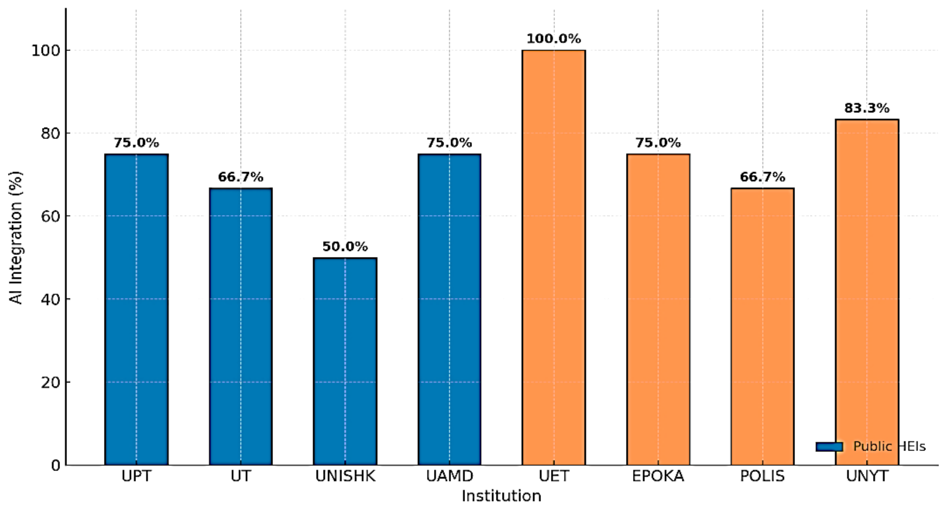


**Figure 7.** AI Integration by Institution (Public vs. Private)

AI integration across disciplinary areas is broken down in Table 14 and Figure 8, engineering 14 programs, computer science 10, technology 6, mathematics 3, and biotechnology 2.

**Table 14.** Distribution by STEM field

| Field | No. of Programs | AI-Integrated (%) | AI Share (%) |
|---|---|---|---|
| Engineering | 14 | 64.3 | 40.0 |
| Computer Science | 10 | 100.0 | 28.6 |
| Technology | 6 | 83.3 | 17.1 |
| Mathematics | 3 | 33.3 | 8.6 |
| Biotechnology | 2 | 50.0 | 5.7 |

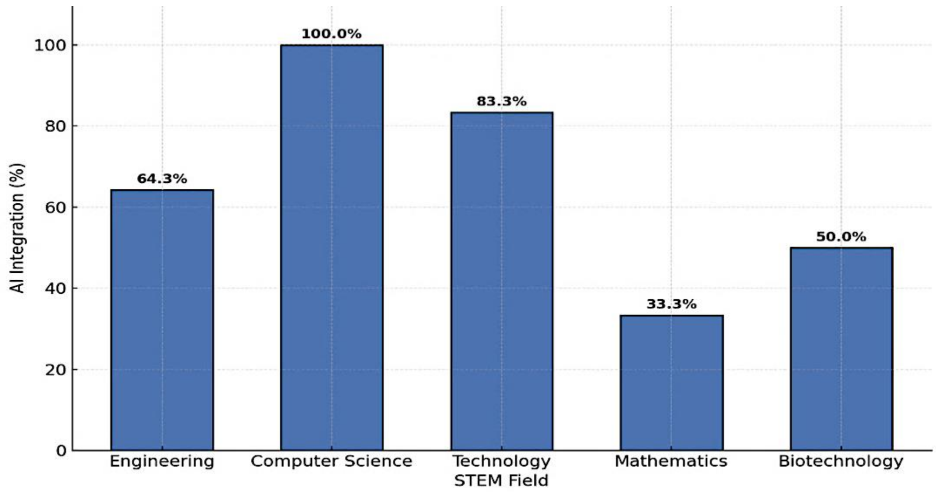


**Figure 8.** AI Integration by STEM Field

Machine learning, deep learning, neural networks, and AI ethics are examples of typical modules. With 83% integration, technology domains including information systems, urban analytics, and architecture technology come next, indicating the quick spread of Internet-of-things and data-driven design. AI is most widely used in electrical, electronic, and telecommunication engineering, where it is used for industrial automation, intelligent control, and signal processing, with an average acceptance rate of 64%. Civil and mechanical engineering are still less digitally advanced. 50% of biotechnology uses genetic modelling and bioinformatics to show how AI is being used, mostly at the master's level. The lowest rate (33%) is found in mathematics, suggesting that there has been little curriculum innovation outside of the usual theoretical focus. These findings are consistent with global trends noted by [1] which show that AI penetration is lowest in pure sciences, moderate in engineering, and highest in computing and technology-intensive fields. According to the Albanian data, AI dissemination is favourably correlated with closeness to data-analysis cultures and computational infrastructures. Engineering programs use a transitional integration approach, which includes both independent elective courses and integrated applications specific to certain fields. In contrast, the fields of biotechnology and mathematics highlight the importance of interdisciplinary progress, particularly through the integration of AI-driven modelling and computational methods into existing academic programs. From a policy point of view, Figure 7 makes it clear that systematic curriculum frameworks and staff training programs are needed to make it easier for disciplines to adapt when AI is used outside of ICT.

The level of AI integration in study programs at two different levels of education Figure 9 shows the number of bachelor's and master's degrees at Albanian STEM higher education institutions that were part of the NASRI-funded study. According to the visualization, master's programs achieve a greater integration rate of 66.7%, while bachelor's programs exhibit an average

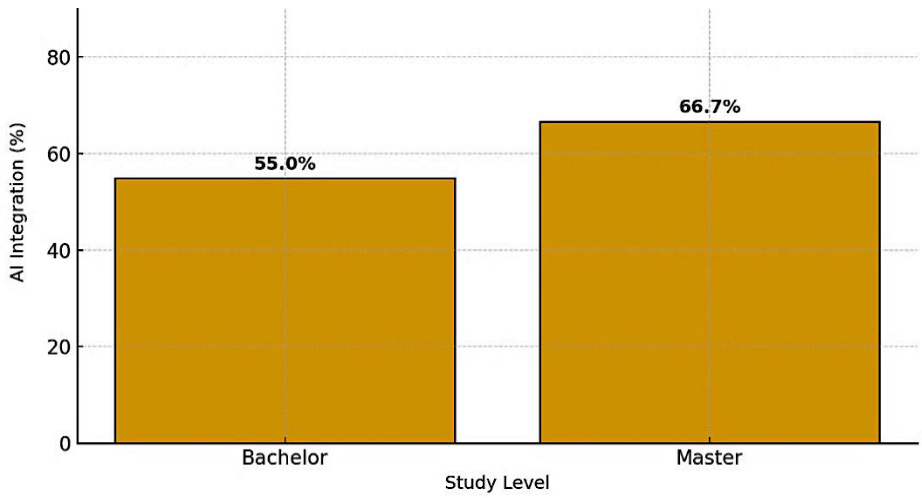


**Figure 9**. AI Integration by study level (Bachelor vs. Master)

AI integration rate of 55.0%. Graduate-level curricula are more AI-oriented, reflecting both curriculum depth and research-based focus, as evidenced by this 11.7 percentage point difference. AI integration is mostly concentrated on basic courses at the bachelor's level, such as Introduction to Programming, Data Science Fundamentals, or Digital Systems; elective or modular inclusion (e.g., "AI in Engineering," "Machine Learning for Beginners"). Levels 1-2 of the integration model, or introductory or applied integration, are represented by these elements. On the other hand, master's programs usually have clear areas of focus in AI, such as AI in biomedical engineering or deep learning for image analysis. The undergraduate curriculum must be modified to incorporate pertinent AI subjects earlier to guarantee that all STEM students are digitally literate. Graduate programs have already accelerated the integration of AI into institutional frameworks. This is because they use research findings and offer labs and project-based learning environments that encourage creativity. As we mentioned above, this picture is in line with what is happening in European higher education, where AI literacy begins at the bachelor's level and reaches operational maturity at the master's level through project-based, research-focused learning. From a national point of view, the results show that it is important to keep the curriculum the same for both bachelor's and master's degrees and to add AI slowly rather than all at once. To ensure that graduates of bachelor's programs move smoothly into AI enhanced master's programs, institutions may think about vertical mapping of AI competencies. AI modules, teaching capacity, and research infrastructures that span both study levels should be supported by funding mechanisms such as: NASRI, Erasmus+, or Horizon Europe projects. Strengthening AI integration at the bachelor's level is still necessary to achieve systemic compliance with European digital education standards and to develop an AI-competent national STEM workforce, even though master's programs already show strong AI acceptance. Recurring AI-related modules are seen in program curricula and course lists, as shown in Table 15.

**Table 15.** AI related curriculum components

| Common AI Modules | Frequency |
|---|---|
| Introduction to AI | 12 |
| Machine Learning | 9 |
| Data Science / Analytics | 8 |
| Deep Learning / NLP | 5 |
| AI in Engineering Systems | 3 |
| Bioinformatics / AI in Genomics | 2 |

The average AI-related ECTS per program is 11.6, specialized programs at UPT, UT, and UNYT have larger allocations 18–24 ECTS. Table 15 allows us to look at what AI information is taught, how much of it is included in curricula, and where it can be found in different fields, study levels, and institutions. The integration model, Introductory, Applied, and Advanced and the validated dataset of institutional syllabi from 35 certified STEM programs are used to make conclusions. 21 59.9% = 60% of the 35 projects have AI components. Private HEIs incorporates AI into 81% of their programs, compared to 66% of public HEIs. AI-related credits include 9.4 ECTS, SD ≈ 4.1 for Bachelor, n = 20 and 14.8 ECTS, SD ≈ 6.2 for Master n = 15. AI-integrated programs have an average of 11.7 ECTS. The quantity of AI modules in each software. The mean modules/program of the 21 AI-integrated programs is 1.8, median 2; range 1–4. Computer science programs usually consist of two to four modules, while engineering programs often have one or two. Six recurrent component families were used to code AI content from curricula. Multiple families, sum > 100%, may be included in each program.

## DISCUSSIONS

The data supports a pattern of vertical integration, showing that programs focused on information and communication technology include more artificial intelligence modules than general STEM courses. Although this approach yields graduates with technical skills [1], also noted in European contexts that it inhibits creativity across disciplines. Examples of public universities with good facilities are UPT and UT, but they struggle to change their courses due to stringent regulations. Because they swiftly incorporate AI into new fields like Urban Analytics at Polis University and Data Science at UET, private colleges and universities are flexible. Institutional innovation and autonomy in governance are related.

Albania's national use of AI is consistent with its adherence to UNESCO's AI competency framework and the EU Digital Education Action Plan. However, there is currently no national policy on the use of AI in education. By including AI related learning objectives in their accreditation requirements, QAAHE and IQE could formalize them. There are partnerships, but most of them are only for one project and not for making a joint curriculum. Industry feedback loops should be included in program evaluation procedures, according to the 2023 AI4ED model. This will help Albania's labour market be more responsive.

The present findings reinforce recent international evidence showing that AI integration in higher education is expanding rapidly but remains uneven across disciplines, with Computing/IT leading implementation and other STEM fields integrating AI more slowly. This mirrors patterns reported in global reviews [16, 35], European comparative studies [1] and UNESCO/ETF policy frameworks that highlight the structural need for AI-ready curricula [5, 44]. However, unlike most prior studies that rely on qualitative descriptors or case-based observations, this research contributes a programme-level quantitative mapping for a Western Balkan system, using structured indicators (AI_presence, AI_ECTS, integration_level) that allow comparison across institutions and fields. In this sense, our dataset operationalises the theoretical models proposed in EDUFAIR and OECD AI competency frameworks but extends them with measurable depth indicators and nested statistical tests. Relative to the SOTA, our findings provide three improvements.

First, by applying a multilevel modelling design, we quantify the magnitude of disciplinary and institutional effects rather than only describing them qualitatively. The dominance analysis shows that field accounts for ≈68% of predictable variance, clearly signalling that AI penetration is discipline driven rather than institution-driven, confirming international trends but adding effect-size precision absent in previous Balkan literature. Second, this study explicitly tests structural enablers of advanced integration compulsory status and ethics content showing that programmes including ethics and governance modules are far more likely to reach L3. This result answers open questions raised in recent policy papers [5, 43] regarding whether ethics and AI literacy can be empirically linked to deeper curricular adoption. Third, by aligning the L1–L3 integration framework with EQF levels and extending hypotheses to include internationalisation pathways (H5–H6), the study advances the theoretical framing of AI curricula beyond tool-use and towards competency-based progression. These contributions collectively demonstrate that the Albanian system is in an early consolidation phase strong Computing/IT integration but limited cross-STEM diffusion a finding consistent with regional digital-skills reports [43] and with emerging evidence from other late-adopter contexts [38, 42]. Yet the presence of successful L3 cases suggests that institutional capacity, international partnerships, and curriculum governance can accelerate adoption when structured intentionally. Our results therefore extend the SOTA by providing empirical thresholds (e.g., compulsory + ethics → L3 probability increase) that can inform curriculum design and policy reform, addressing the “quantitative gap” identified in recent review works. In practical terms, this means that policy recommendations should shift from access-to-AI → structured ethics-embedded integration, promoting cross-faculty AI adoption rather than leaving AI confined to Computing departments. The CMS RPC Albania Lab and the AI4MED Research Group are two new research centres that show how AI can be used in many fields, such as physics and medical imaging [45-50]. These centres demonstrate the connection between STEM education and practical research. Albania may develop into a hub for AI innovation in the region if these ties deepen. The main structural difference is between public and private colleges and universities. Private universities use AI more 81% and have more AI modules in their curricula, 2.1 per program, 13 ECTS mean, than public universities 66%, 1.6 modules, 10.8 ECTS. The difference is due to stronger ties with foreign partners, shorter times to change the curriculum, and organizations that are more flexible.

Public universities, on the other hand, have more research staff and better technical facilities. However, they must wait longer for approvals and deal with regulatory inertia. The University of Tirana and the Polytechnic University of Tirana are two public universities that have become national centres for STEM excellence. Their best programs are in computer engineering, electrical and mechatronic systems, and data science. Consequently, these programs can be used as examples for bringing the whole field together because they already meet the European Qualifications Framework, EQF 6–7, standards. There is a clear picture how AI is used in different fields such: Biotechnology, Mathematics, Computer Science, Technology, and Engineering. On top is computer science with 100% because it includes everything that is needed from algorithmic theory to deep learning, natural language processing, and ethics. The Engineering and Technology comes with 64–83%, have a lot of applied integration, mostly through modules like AI in processing of signal, control and automation, and embedded systems. On the other hand, Biotechnology and Mathematics 33–50%, are still in the early stages of using AI. AI is mostly only used in optional courses on modelling or data analysis. This division of disciplines reflects worldwide patterns in which artificial intelligence initially appears in computationally demanding fields and only gradually spreads to laboratory sciences and applied domains. Therefore, Albania's task is to expand AI literacy horizontally across all STEM fields so that future scientists and engineers, independent of discipline, have a foundational understanding of algorithmic reasoning and data-driven modelling. From foundational literacy at the bachelor's level 55% to research-oriented specialization at the master's level 67%, the data shows a progressive strengthening of AI material over academic cycles. According to the EQF criteria, knowledge at Level 6 develops into autonomy and invention at Level 7. However, the doctorate, EQF 8 layer is still in its infancy. Relatively few PhD programs specifically include computational research design, data science frameworks, or AI methodology. This top tier needs to be stronger for long-term academic and industrial innovation. Seventy percent of AI courses use project-based learning, often with real datasets from partner industries. Sixty-two percent of evaluations are done in labs. AI governance procedures, however, are still not well represented, <30%. This shows that there is a gap between what students learn in the classroom and what they need to know to work in the real world. From a questionnaire that we have done, comparing the labour-market and industry shows that there is a lot of demand for graduates who know how to use AI. While 42% of businesses wanted professional AI engineers for AI governance procedures, on the other hand, they are still not well represented, <30%. This shows that what students learn in school is different from what they need to know to get a job. The labour-market and industry questionnaire shows that there is a high demand for graduates who know how to use AI. On the other hand, 42% of businesses wanted professional AI engineers to work on automation and analytics, but more than 68% of the employers who were asked said they needed people who could make decisions based on data right away. From the results we can conclude that the programs with the highest rates of graduate employment, about 70% within 6–12 months, are those that include industrial projects, such as UPT, Mechatronics Engineering, and UNYT, Data Science and AI. Meantime, automation and analytics jobs, more than 68% of the employers who were asked said they needed people who could make decisions based on data right away or soon. This partnership between academics and business shows that AI-enabled courses are starting to create measurable economic value by turning changes in education into higher productivity and more room for new ideas.

### *Challenges and Opportunities*

Instead of treating AI as a methodological core, current curricula frequently consider it as elective material. It is essential to update national frameworks to incorporate AI learning outcomes into STEM courses. Few academic staff members have had formal training in AI pedagogy. Programs for ongoing professional development are necessary to guarantee successful teaching integration. Even though top HEIs have robust laboratory facilities, regional institutions continue to differ from one another. To guarantee fair access to digital tools and computational infrastructure, strategic investments are required. Strategic coordination is hampered by the absence of a national AI-in-education strategy. Coherence can be improved by aligning QAAHE's quality standards with EU frameworks, EQF Level 6–8 descriptors. New AI module integration is frequently delayed by the protracted national curriculum accreditation processes. In contrast to 6–9 months in most EU systems, the approval processes for program modifications often takes 18–24 months. Hands-on testing is limited by the unavailability of dedicated GPU computers, cloud environments, or licensed AI software at many public HEIs. According to FIMIF-UPT's infrastructure evaluation from 2025, 70% of labs only use mid-range CPUs and have limited access to high-performance computing. Less than 25% of full-time faculty members in STEM schools have formal AI or machine learning training or publications. Research oversight and curriculum renewal are hampered by this scarcity. Current collaborations are not systemic, but rather institution specific. There isn't a national AI-STEM group that lets people share research facilities, teaching materials, or datasets. The ongoing national project "Integrating AI applications into university STEM programs", NASRI 2025, has already made it possible for schools to change their curricula by giving them money and support for governance. Horizon Europe Cluster 4 and the Digital Europe Program are two EU programs that focus on AI upskilling. They make it possible to get co-financing for staff training and infrastructure. Albania's energy, finance, and logistics sectors are quickly becoming digital, which means that there will always be a need for graduates with AI skills. Because frameworks like TensorFlow, PyTorch, and Scikit-learn are widely available, there is less need for expensive proprietary tools, enabling scaling adoption even in situations with limited resources. By creating a National Center for AI and STEM Curriculum Innovation under UPT-ASCAL supervision, Albania can move from adopter to innovator position in the regional AI-education landscape if these opportunities are institutionally integrated; establishing inter-HEI shared AI labs with cloud-accessible GPU-based infrastructure; introducing industry-certified modules and micro-credentials (such as AI for Manufacturing and AI for Energy Systems) to improve workforce alignment.

## SUMMARY AND CONCLUSION

This study represents the first extensive evaluation of AI integration in STEM higher education in Albania. The subsequent conclusions are based on empirical data and comparative analysis: AI is used in more than 60% of Albanian STEM programs, and most of these programs are in engineering and ICT. Because they are more flexible, private higher education institutions (HEIs) are better at adapting (81% AI integration). Public colleges and universities have good infrastructure, but the rules need to be changed so that new ideas can be added to the curriculum. Future research should investigate how combining AI with other technologies affects learning outcomes, students' opinions, and the long-term effects. It might be simpler to gather information and make fact-based decisions if a national AI curriculum observatory is established. By creating jobs and fostering creativity, integrating STEM education with practical AI research can also aid Albania's digital transition.

This study offers the first thorough, empirically supported evaluation of AI integration in STEM education in Albania. AI has become a major component of the curriculum, according to a study of 35 programs from eight universities, and roughly 60% of the population supports it. The results of this study provide a clear and quantified picture of the current state of AI integration within Albanian STEM higher education programs. Analysis of 35 accredited programs demonstrates that AI adoption is highly uneven across disciplines, with evidence strongly converging across descriptive statistics, inferential modelling, and robustness checks. The dominant pattern observed is that AI is structurally concentrated within Computing/IT programs, while other STEM domains remain largely detached from AI-oriented curricula. The logistic models show that Computing/IT programs are 56 times more likely to include AI-related content compared to Engineering/Architecture and other STEM fields, indicating a highly significant field effect. This trend remains stable even when integration is recoded into binary levels (L2+L3 vs L1), confirming that the result is not dependent on classification granularity. Mean ECTS analysis further supports this imbalance: Computing/IT programs allocate on average ~10.4 ECTS to AI, while other STEM programs allocate nearly none. The ICC value of approximately 18% suggests that institutional differences account for only a small fraction of variation in AI adoption, implying that the program/discipline itself is the main determinant of whether AI is present or deeply integrated. The depth of integration analysis reveals a further gap, advanced integration (L3) occurs only in programs where AI modules are compulsory and include ethics-oriented content. The probability of reaching L3 is 1.00 in programs with ethics coverage and 0.00 in programs without it, highlighting ethics as a structural enabling condition for advanced AI implementation, not merely an optional supplement. Similarly, no program with non-compulsory AI coursework reaches L3, confirming that AI must be embedded as a core requirement rather than elective content to achieve meaningful depth.

Robustness analyses including alternative model structures, distribution checks, and leave-one-institution-out validation all converge on the same conclusion. The observed dominance of AI within the Computing/IT domain is not model driven, not dataset-sensitive, and not institution dependent, but rather reflects a systemic, structural pattern in the national curriculum landscape. The absence of AI in Engineering/Architecture, despite global relevance in areas like robotics, industrial automation, digital twins, and smart infrastructure, signals a lag that may limit graduate competitiveness and innovation potential. Taken together, the findings indicate that AI integration in Albania has progressed significantly within computing-oriented programs, where AI is both present and increasingly embedded. However, broad STEM alignment is not yet achieved, and the integration is not equally distributed across fields. As a result, the country's STEM system risks developing two parallel tracks: one AI-intensive, future-responsive track within Computing/IT, and a second track of traditional engineering and science programs that may fall behind technological evolution unless reforms are undertaken. AI integration exists but is domain concentrated. Computing/IT leads overwhelmingly in AI course presence, ECTS allocation, and advanced integration. Engineering/Architecture and other STEM fields exhibit minimal integration and represent strategic targets for development. Compulsory delivery and ethics inclusion are key enabling factors for achieving advanced AI integration (L3). The empirical pattern is robust and resistant to alternative model specifications, variable coding, and institutional sampling variation. This evidence establishes a foundational baseline for curriculum innovation, policy reform, and cross-disciplinary AI expansion in Albanian higher education. Strengthening AI integration beyond Computing/IT especially across engineering, applied sciences, and interdisciplinary STEM domains emerges as a crucial next step to ensure workforce readiness, research advancement, and alignment with global digital transformation directions.

## AUTHORS CONTRIBUTIONS

Conceptualization, DX, NH, AG, VM, and ÇD; Methodology, MD, DX, ES and SH; Software and Computational Modelling, SH; Validation, DX, and NH; Formal Analysis, AG and ES; Investigation, VM and DX; Resources, AG; Data Curation, DX and NH; Writing

– Original Draft Preparation, DX; Writing – Review & Editing, DX and ES; Visualization, SH; Supervision, DX;

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## CONFLICT OF INTERESTS

The authors confirms that there is no conflict of interest associated with this publication.

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