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Aligning Academia with Industry: An AI-Powered Curriculum Intelligence Platform for STEM

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Abstract

Although higher education aims to establish a lifelong foundation in STEM principles, the rapid transformation of the industrial landscape has resulted in a perceived readiness gap among new graduates. To contextualize this issue, this study conducts a foundational literature review of 20 articles selected from an initial pool of 50 examining the STEM skills gap across various disciplines. Building on this review, the research investigates the misalignment between academic preparation and the immediate expectations of the contemporary workforce at the entry-level hiring stage. The methodology employs a comparative content analysis of two distinct datasets: public STEM course syllabi and a curated sample of 279 entry-level job postings. This analysis utilizes a Keyword Grouping framework to categorize required competencies into three domains: Technical (tool-specific proficiency), Analytical (theoretical foundations and logic), and Communication (interpersonal and professional skills). By calculating an alignment score, the study evaluates the hypothesis of a "Category Mismatch," wherein academic institutions prioritize analytical foundations while the labor market demands immediate technical fluency. Ultimately, this research establishes the foundational framework for developing an automated, reproducible tool designed to systematically quantify and evaluate the specific skill gap between higher education curricula and evolving job market demands, enabling institutions to dynamically incorporate market-driven technical tools without compromising academic rigor.

Keywords
Curriculum Improvement, STEM Syllabi, Workforce Readiness, Skill Gap Tool, Career-Ready.

1. Introduction

The Fourth Industrial Revolution (4IR) is rapidly altering the occupational needs of the STEM workforce (Yamada 2021; Hassan et al. 2023). Despite the high demand for STEM graduates, employers report a widening "skills gap," specifically noting that recent graduates lack the dynamic employability skills required by the modern workplace (McGunagle and Zizka 2020; Finley 2023). Although academic programs are highly successful in teaching theoretical and analytical concepts, they often neglect interpersonal communication, teamwork, and immediate technical tool proficiency (Karimi 2020; Daley and Baruah 2020). This creates a severe problem: a "Category Mismatch" between theoretical academic preparation and practical, real-world labor market demands (Amalu et al. 2023; Kersanszki and Nadai 2020). This research is vital because without systematically understanding and addressing this gap, universities cannot adequately prepare graduates to be "industry-ready" for the rapidly evolving 21st-century knowledge economy (Tytler 2020).

1.1 Objectives

The core objectives of this research are twofold:
Quantify the STEM Skills Gap: To evaluate the misalignment between higher education STEM syllabi and entry-level job market demands by employing a comparative content analysis to prove the "Category Mismatch" hypothesis.
Propose an Automated Solution: To establish the conceptual architecture for a 9-layer Curriculum Intelligence Platform that leverages AI and natural language processing to translate real-time labor market signals into actionable educational insights.

2. Literature Review

The literature surrounding the STEM skills gap highlights a growing disparity between academic instruction and the competencies required by the modern workforce. To contextualize this issue, this study evaluates an initial pool of 50 articles, narrowing them down to 20 foundational studies examining this gap across various disciplines. This review categorizes the existing literature into three core areas: the identification of the cross-disciplinary skills gap, early theoretical employability models, and the recent integration of emerging technologies to map labor market demands.
The data from these 20 articles confirmed that the STEM skills gap is a documented, cross-disciplinary issue (Abina et al. 2024; Reinholz et al. 2021; Carter et al. 2021; Villán-Vallejo et al. 2022). To address this, early employability models sought to embed employability and transferable assets into the curriculum (Bennett et al. 2020; Siby et al. 2023; Koromyslova 2021; Daley and Baruah 2020; Kersanszki and Nadai 2020; Finley 2023; Tytler 2020). More recently, researchers have successfully adopted artificial intelligence, big data, and natural language processing to map skills from job portals (Hassan et al. 2023; Chiu and Li 2023; Naseer et al. 2024). These technological approaches work alongside standardized professional frameworks, such as the European e-Competence Framework (e-CF) and the Skills Framework for the Information Age (SFIA), which are used to describe competencies globally (Raj et al. 2021; Davenport et al. 2020; Amalu et al. 2023; McGunagle and Zizka 2020; Karimi 2020; Yamada 2021).

In summary, while existing research extensively documents the STEM skills gap and offers various theoretical models and technological mapping tools, a significant disconnect remains. The literature confirms the need for an automated system capable of translating raw, real-time labor market signals into actionable educational insights. Building upon these foundations, this study aims to quantify this specific "Category Mismatch" to establish the framework for a Curriculum Intelligence Platform.

3. Methodology

The unit under observation for this study is the Higher Education STEM curriculum, which functions as the pipeline preparing students for the 21st-century knowledge economy and the modern workplace. We defined three core problem factors to be evaluated: Technical, Analytical, and Communication competencies. The unit of measurement for each factor is the frequency of specific keywords extracted from unstructured text in academic STEM syllabi versus entry-level job postings. The expected range of change for these factors spans from 0% alignment (a total mismatch between curriculum and industry needs) to 100% alignment (where the curriculum perfectly mirrors the skill frequency demanded by employers).

As our first methodological step, the foundational literature review of 20 articles helped define the three core domains and confirmed the need to investigate the "Category Mismatch" hypothesis (Figure 1).

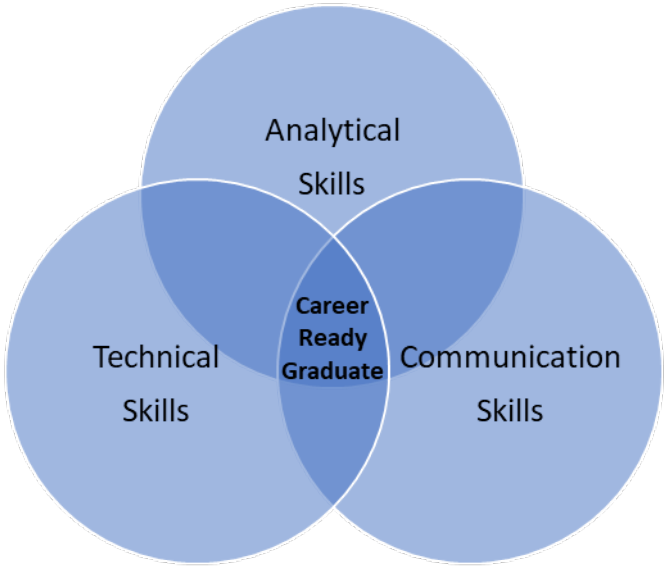

Figure 1: Core domains

4. Data Collection

To establish the baseline for our automated tool, we then conducted a manual comparative content analysis. Our procedure evaluated unstructured text from 21 academic STEM syllabi against a curated sample of 279 entry-level STEM job postings scraped from four major portals (Indeed, LinkedIn, Glassdoor, and ZipRecruiter). Using a defined Keyword Grouping framework, we categorized competencies into three domains:

Analytical Skills: Conceptual bases and logic-based reasoning.
Technical Skills: Tool-specific proficiency required to perform immediate tasks.
Communication Skills: Interpersonal and professional skills essential for teamwork and leadership.

Our data analysis involved using statistical keyword frequency distributions and calculating an alignment score to bridge the gap between academic language and industry terminology. A major lesson learned from this methodology is that unstructured data from job portals is highly complex and fragmented, requiring robust text-extraction frameworks and algorithms to accurately map these competencies, ultimately leading to our proposed systemic solution.

5. Results & Discussion

5.1 Numerical Results

The findings definitively proved the "Category Mismatch". The 21 academic syllabi yielded 186 Analytical keywords, but only 94 Technical and a mere 14 Communication keywords, proving a heavy prioritization of foundational theory. Conversely, the 279 job postings revealed a staggering 860 demands for Technical keywords, 297 for Communication keywords, and 375 for Analytical keywords. Because the job posting sample size is significantly larger, evaluating the relative proportions and per-document averages confirms this disparity, showing that individual job postings demand significantly more technical and communication competencies than individual syllabi provide.

5.2 Graphical Results

The statistical analysis of the Keyword Frequency Comparison chart (Figure 2) visually emphasizes the disparity. While academia provides an abundance of analytical theory, industry strongly favors technical execution and communication, highlighting the specific areas where graduates are underprepared.

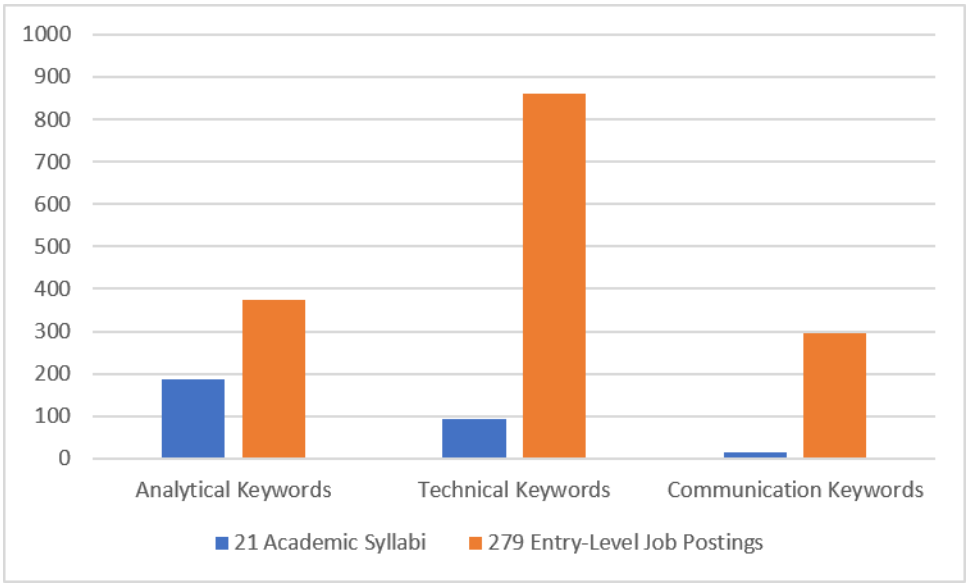

Figure 2: The "Category Mismatch" keyword frequencies in Academic Syllabi vs. Job Postings

5.3 Proposed Improvements

Because graduates lack "industry-ready" skills and curricula do not evolve as quickly as industry demands, this paper outlines a comprehensive 9-layer software architecture to automate curriculum enhancement. Moving beyond basic keyword matching, this platform extracts raw intelligence, standardizes skills using NLP, and passes data through cutting-edge analytical engines to generate actionable academic modules (Figure 3).

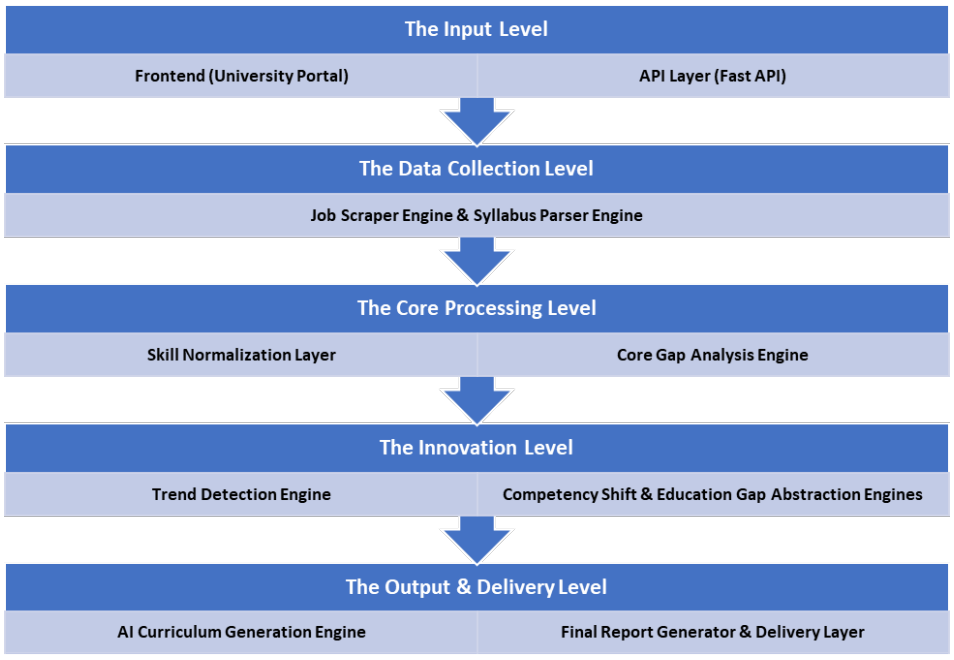

Figure 3: 9-Layer curriculum intelligence platform architecture

Layer 0: User Input (Frontend Layer): University administrators or faculty input the program name, university name, and region. The front end seamlessly initiates the process without exposing backend logic.

Layer 1: Data Collection Layer (Raw Intelligence): This layer utilizes Job Market Mining (scraping real-time demand from portals like LinkedIn, Indeed, and Glassdoor using dynamic tools like Playwright and Scrapy) and Syllabus Mining (extracting academic reality from university websites and course catalogs via PDF parsers).
Layer 2: Normalization Layer (Skill Standardization): Merges messy, unstructured data into a unified skill taxonomy using NLP clustering and sentence-transformer embeddings (e.g., standardizing "ML pipelines" and "model deployment" into "Machine Learning Operations").
Layer 3: Core Gap Analysis Engine: Compares the normalized skill overlap to calculate exact Curriculum Coverage and Industry Alignment scores based on missing vs. covered requirements.
Layer 4: The Innovation Layer (Advanced Analytics): This core layer separates our platform from standard matching tools by providing context:

- ✓ Trend Detection Engine: Tracks and illustrates the real-time surge and growth metrics of emerging technical keywords (e.g., detecting a +241% growth in LangChain over an 8-month period) (Figure 4).

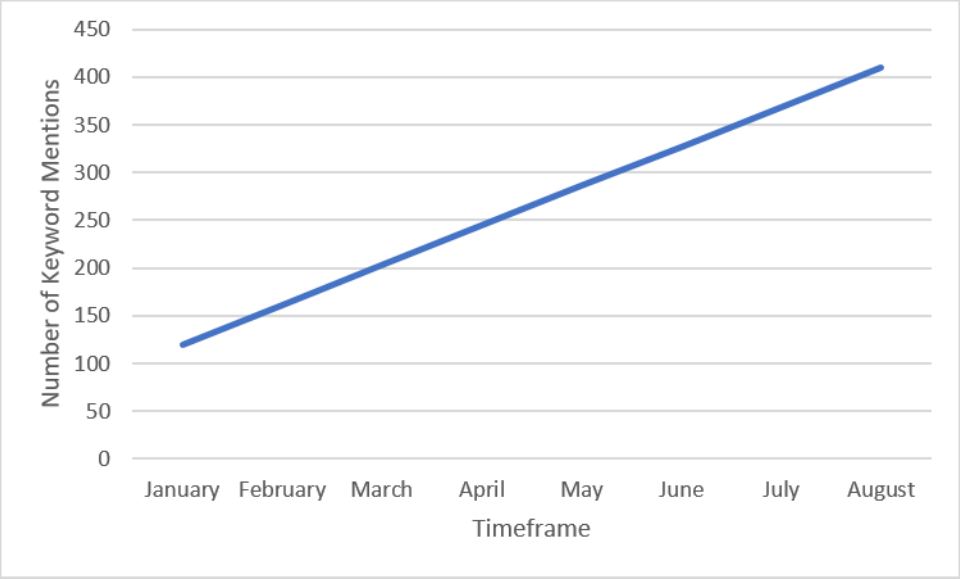

Figure 4: Trend Detection (LangChain Growth)

- ✓ Competency Shift Engine: This layer translates raw job signals into higher-level organizational insights. For example, if the system detects an increase in the phrase "code review required," it logically deduces that the industry is shifting toward "system-level verification" rather than basic coding (Table 1).

Table 1: Competency shift engine translation of raw job signals to educational insights

Raw Job Signal (What the employer asks for)	Abstracted Insight (What it actually means)
"code review required"	Shift to auditing/verification roles
"production deployment"	Infrastructure expectation increase
"open-ended problems"	Agility + ambiguity requirement
"GitHub required"	Portfolio-based hiring trend

- ✓ Education Gap Abstraction Engine: Identifies why a gap exists by abstracting the context. It can deduce that students are trained in structured labs or controlled environments, whereas the industry requires exposure to production-grade systems and ambiguity (Figure 5).

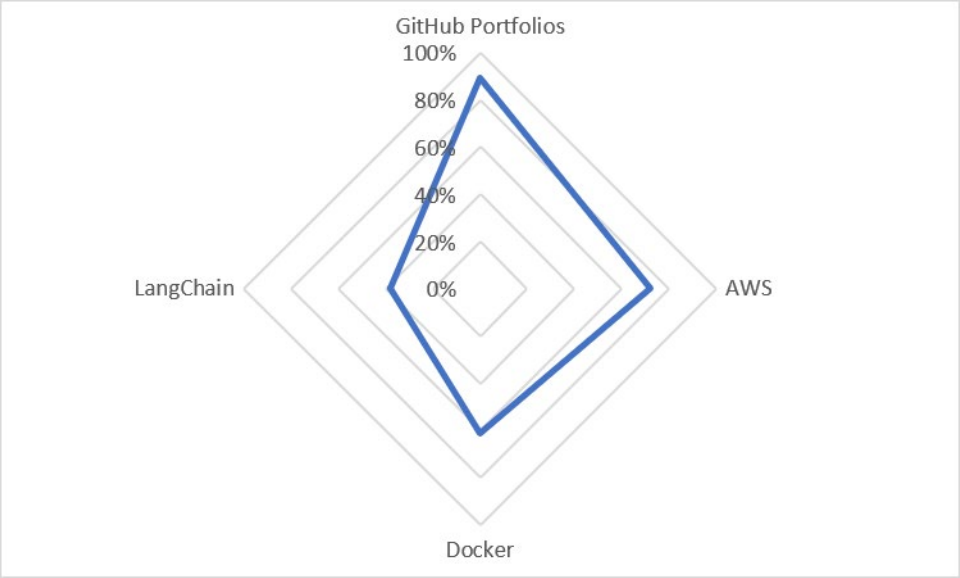

Figure 5: Real-Time Market Demand and Growth Rankings for Emerging Technical Skills

Layer 5: AI Curriculum Generation Layer: Converts accumulated insights directly into academic action. It maps missing skills to automatically generated modules (e.g., suggesting an "LLM Systems and Vector Databases" module), utilizes an Elective Generation Engine to propose entirely new courses (e.g., "Production AI Systems and Deployment Engineering"), and generates specific curriculum upgrade recommendations.
Layer 6: Market Intelligence Layer: Finalizes and outputs concrete data on Skill Demand Rankings, Emerging Skills lists (e.g., LLMOps, AI Agents), and Hiring Preference Shifts.
Layer 7: Final Report Generation Layer: Compiles a university-ready "Curriculum Intelligence Report" detailing the program overview, industry alignment score, skill gaps, emerging trends, industry shifts, and recommended curriculum changes.
Layer 8: Delivery Layer: Delivers the finalized intelligence to the end-user via PDF reports, interactive dashboard views, and optional API responses.

5.4 Validation

At its current stage of implementation maturity, the 9-layer Curriculum Intelligence Platform is presented as an advanced conceptual framework designed to guide future software development. While the fully automated digital infrastructure, including Layer 0's API and Layer 2's NLP clustering, has not yet been built out as a deployed proof-of-concept prototype, the underlying logic of the architecture has been thoroughly validated through a manual pilot study. The comparative content analysis conducted in this research, in which complex, unstructured text from 21 academic syllabi and 279 job postings was manually extracted, processed, and categorized using the Keyword Grouping framework, served as the foundational proof of concept for the system's viability. By successfully identifying and quantifying the "Category Mismatch" manually, this study validates the core methodology and establishes the necessary architectural blueprint to transition this process into a fully automated, AI-driven platform in future development phases.

6. Conclusion

The modern STEM landscape calls for an unprecedented level of agility. This research reveals the severe "Category Mismatch" between academic syllabi and job market requirements, confirming that the true premium in the entry-level job market lies in immediate technical application and dynamic communication. The primary objectives of this research to systematically quantify this skill gap through a comparative content analysis and establish the foundational framework for an automated 9-layer Curriculum Intelligence Platform have been successfully met. A unique research contribution of this work is the proven Keyword Grouping framework that definitively uncovers this "Category Mismatch" between theoretical academic instruction and practical workforce demands. By moving our proven

framework into the scalable Curriculum Intelligence Platform, we provide higher education institutions with an intelligent, data-driven system that explicitly explains how and why education must evolve based on real-time labor market intelligence, guaranteeing that future graduates are completely equipped for the 21st-century workforce.

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Biographies

Sana Bhimani is a graduate of SAU and currently works at SAUTech as an instructor for Data Science. Her academic and professional focus centers on Data Science, STEM, and workforce readiness. Her academic and professional focus centers on Data Science, STEM education, and workforce readiness. Dedicated to bridging the gap between academic preparation and industry demands, she has successfully completed a previous research project in collaboration with Dr. Hayder Zhgair titled "Simulation as a Strategic Decision-Support Tool: A Review of Current Practices and Future Directions." Currently, she is partnering with Dr. Zhgair and Seema Powar on an ongoing study to systematically quantify and evaluate the misalignment between higher-education STEM syllabi and entry-level workforce expectations. Through her instruction and collaborative research at both SAUTech and SAU, she aims to provide higher education institutions with actionable, data-driven frameworks for effectively integrating market-driven tools into theoretical curricula.

Seema Powar is an undergraduate student at SAU pursuing a degree in education with an emphasis on computer science. Her academic focus bridges the gap between STEM education and workforce readiness. She is currently co-authoring research that uses comparative content analysis to examine the misalignment between academic STEM syllabi and entry-level job-market requirements. Her ongoing work contributes to the development of a Keyword Grouping framework designed to systematically quantify the skills gap across technical, analytical, and communication domains. Through her undergraduate research at SAU, she is dedicated to identifying actionable insights that can help align theoretical curricula with the practical, market-driven tools expected of new graduates entering the contemporary workforce.

Dr. Hayder Zghair is an Assistant Professor of Industrial Engineering and the Director of Industrial Engineering Development at Southern Arkansas University (SAU). He earned his Ph.D. and M.S. in Manufacturing Systems Engineering from Lawrence Technological University, alongside a B.S. and M.S. in Industrial and Production Engineering from the University of Technology. Before joining SAU, he served as an Assistant Teaching Professor at Pennsylvania State University and a lecturer at Kettering University. Dr. Zghair's research encompasses Flexible-Automated Manufacturing, Robotics, Sustainability Engineering, Analytical Modeling, Simulation, Optimization, and Industry 4.0/5.0 technologies like AI and IIoT. Currently, he is collaborating with Sana Bhimani and Seema Powar to investigate the STEM skills gap and to develop analytical frameworks to align academic curricula with entry-level workforce demands. An active leader in the engineering community, he serves on the Board of Directors for the ASEE Environmental Engineering Division and is an Affiliate Researcher at the Penn State Institute of Energy and the Environment. He holds professional memberships in ASEE, INFORMS, SAE, and IEOM, and actively mentors students as the faculty advisor for the SAE, SAU Baja, and IEOM student chapters at SAU.