JOURNAL AL-KAUTSAR
KNOWLEDGE ADVANCEMENT IN TEACHING STRATEGIES AND RESEARCH
E-ISSN: 3032-4815

Curriculum–Industry Alignment in Applied Chemistry: A CIPP Mixed-Methods Evaluation at the University of Zawia

Najah Baroud
Chemistry Department, Faculty of Education University Of Zawia, Al-Zawiya Libya

Article Info

Article history:

Received 03 23, 2026
Revised 05 09, 2026
Accepted 05 11, 2026

Keywords:
Applied Chemistry Curriculum, CIPP Model, Industry Alignment, Competency-Based Education (CBE), Digital Literacy, Vocational Education, Zawia Oil Refinery.

ABSTRACT

This study evaluated the alignment between the Applied Chemistry curriculum at the University of Zawia and the technical competency requirements of the Zawia Oil Refinery (ZOR) in Libya. Alignment evaluation is urgently needed because of the widening gap between traditional academic outcomes and the rapid digitalization of high-tech refinery operations. The research adopted an evaluative approach using an exploratory sequential mixed-methods design guided by Stufflebeam's CIPP model. Qualitative interview findings were used to develop quantitative questionnaire items to ensure methodological rigor. Participants included 15 faculty members and 10 senior technical experts from ZOR, selected through purposive sampling. Data collection occurred between 2024 and 2025 to reflect current industrial conditions. Quantitative analysis showed a moderate overall alignment (M=3.01, SD=0.71, 60.2%). The lowest scores were recorded in Process Simulation (M=2.41) and Digital Literacy (M=2.36), indicating that graduates lack critical proficiency in LIMS and simulation software like Aspen HYSYS required for modern refinery work. The study identifies structural weaknesses in laboratory modernization and internship quality. The most urgent recommendation is the establishment of an Industrial Advisory Board to facilitate the integration of industry-standard digital tools and practical training modules.

**** Corresponding Author:***

Najah Baroud
Email: n.baroud@zu.edu.ly

INTRODUCTION

Vocational education in the contemporary era is undergoing a fundamental transformation to respond to the dynamics of a global labor market that is becoming increasingly digitized and specialized. Higher education institutions now bear a significant responsibility to ensure that curricula are directly relevant to operational needs in the industrial sector (Düzgünçınar, 2025; Liu & Paramalingam, 2025). In Libya, this challenge is particularly acute due to the need to reconstruct the economic infrastructure through the strengthening of human capital in technical fields (Dboba et al., 2022). This alignment issue is not merely a policy matter, but a significant perceptual gap between academics and industry practitioners that needs to be measured empirically through systematic evaluation (Nkolika, 2024; Tablatin, 2023). Without such synchronization, university graduates will struggle to adapt to the high-tech systems used in the energy sector.

The oil and gas sector remains the backbone of Libya's economy, making a significant contribution to the national Gross Domestic Product. Reliance on the hydrocarbon sector demands a supply of highly qualified technical workers to maintain production stability. The Libyan government, through the National Oil Corporation (NOC), has set ambitious production targets to reach 2 million barrels per day by 2026 to accelerate national economic recovery. However, the success of these targets heavily depends on the quality of chemical technicians capable of managing refining processes efficiently and safely. Synergy between national energy policy and higher education outcomes is crucial to minimize reliance on foreign experts (Rianto et al., 2022; Underdahl et al., 2023).

The University of Zawia, through its Applied Chemistry program, bears a significant responsibility for preparing experts for the oil and gas industry in western Libya. This program is designed to provide a strong theoretical foundation in chemistry; however, its implementation often lags behind technological advancements in the field. Preliminary observations and initial data suggest a critical technological lag, where graduates possess strong theoretical understanding but lack proficiency in the modern analytical instruments used in the industry (Baroud, 2024). This situation poses a challenge for companies like the Zawia Oil Refinery to recruit ready-to-work personnel. A curriculum redesign oriented toward labor market needs is a logical solution to address this issue (Dubey & Noronha, 2025).

As a strategic facility, Zawia Oil Refinery requires a proficient workforce in specialized technical competencies in petroleum processing. These competencies include precise laboratory analysis, catalyst management, and the operation of complex atmospheric distillation units. Chemical technicians at this refinery must be able to detect process anomalies through digital sensor systems in real-time. In addition to technical skills, mastery of occupational safety (HSE) aspects is an absolute prerequisite in a high-risk operational environment. International standards, especially ISO-based management systems and OSHA safety requirements, now function as essential benchmarks; therefore, curricula should integrate these standards into instructional content (Galatro & Chakraborty, 2025).

The theoretical framework of this study integrates Human Capital Theory, which emphasizes education as a strategic investment in industrial productivity. In the Libyan context, human capital specific to the chemical refining sector holds significantly higher economic value than general skills. Strengthening human capital through appropriate education is key to achieving national energy technology self-reliance. Investment in a curriculum aligned with industry will yield returns in the form of technical innovation and reduced operational costs (Franco et al., 2023).

Failure to achieve this alignment will only result in massive waste of human resources in the future.

The principle of Competency-Based Education (CBE) serves as a functional foundation that interacts closely with the CIPP evaluation model. CBE instruments are specifically utilized to fill the Input and Process dimensions of the CIPP model, ensuring that each learning module is designed based on an actual job task analysis at ZOR. Students must demonstrate proficiency in operating industry-standard laboratory equipment before being declared graduates (Castelló et al., 2023; McMullen et al., 2022). This approach ensures a smoother transition from the academic world to the workplace without the need for lengthy retraining. CBE also provides universities with the flexibility to adapt course content to the latest technological trends.

The CIPP Evaluation Model (Context, Input, Process, Product) provides the overarching comprehensive framework for this program evaluation. Context evaluation is used to assess the alignment of program objectives with the current strategic needs of Libya's energy sector. The input evaluation assesses the readiness of human resources and laboratory facilities at the University of Zawia. Meanwhile, the process evaluation monitors the effectiveness of the implemented learning methods, such as the integration of computer simulations. Finally, the product evaluation measures the competency levels and employment rates of graduates in the downstream oil and gas industry (Suharno et al., 2022).

The integration of digital technology is essential in the applied chemistry curriculum to address the challenges of the industry 4.0 era. The use of simulation software such as Aspen HYSYS is crucial for providing students with practical experience without the risk of real-world accidents. This technology enables students to perform virtual optimization of chemical processes that closely mimic operational conditions in actual refineries. Additionally, proficiency in Laboratory Information Management Systems (LIMS) has become a highly sought-after skill in modern industry. Higher education in Libya must begin adopting virtual laboratories as a solution to existing physical infrastructure limitations (Herink et al., 2022).

The aspects of “Green Chemistry” and environmental sustainability are also key points in the redesign of future curricula. Libya is beginning to integrate renewable energy and carbon management into oil and gas operations to meet international environmental commitments. Graduates in applied chemistry are expected not only to be technically proficient but also to possess an awareness of bioremediation and waste management (Binani et al., 2024; Miladinović, 2024). Integrating sustainability principles into the curriculum will foster the character of technicians who are ethically responsible. This aligns with the Sustainable Development Goals (SDGs), which have now become a global benchmark for the quality of higher education (Mitarlis et al., 2023; Nazneen et al., 2023).

Structural barriers such as bureaucracy and political instability often hinder the modernization of educational facilities in Libya. Delays in procuring specialized chemicals and advanced equipment result in suboptimal student laboratory sessions. In this situation, progressive university leadership is essential to seek alternative funding sources (Elabbar, 2022). Strategic partnerships through CSR schemes with oil companies could provide a solution for laboratory funding (Bhatia, 2025; Dash, 2025). Additionally, international collaboration in the form of expert exchanges and faculty training must be strengthened (Jain et al., 2022). Without breakthroughs in funding, the technological gap between universities and industry will continue to widen.

Cultural factors such as nepotism or “Wasta” have also been identified as barriers to merit-based career development. In this research, the “Wasta” variable is measured within the Context and Process evaluation of the CIPP model to understand its impact on curriculum development and professional integrity. These practices often diminish students’ motivation to achieve academic excellence due to the perception that connections matter more. To address this, the oil and gas industry needs to implement a transparent Competency Assurance Management System in the recruitment process. Improving internal quality standards at universities is the first step toward restoring industry confidence (Mosbah et al., 2022).

Pedagogical transformation through Project-Based Learning (PjBL) is highly recommended to enhance student engagement. PjBL enables students to solve real-world problems drawn from operational cases at the Zawia Oil Refinery. Through this method, students’ critical thinking and teamwork skills can be honed more effectively. The STEM approach within PjBL has proven effective in boosting graduates’ professional confidence (Nkolika, 2024). Instructors no longer act as sole providers of content but rather as facilitators in the process of discovering technical solutions. This paradigm shift is essential for creating a more dynamic learning environment.

Learning from international models such as Germany’s dual system can provide valuable insights for TVET reform in Libya. Germany has successfully created a synergy where students spend the majority of their time learning directly in industry. Although security conditions in Libya are challenging, practical elements of this model can be adopted gradually. The use of the DACUM (Developing A Curriculum) framework can help universities break down technical refinery tasks into precise instructional materials (Kurniawan et al., 2024). This synergy will ensure that what is learned in the classroom is directly relevant to what is done in the field.

The urgency of this research lies in the need to formulate a comprehensive curriculum integration strategy to bridge existing competency gaps. Previous studies have evaluated chemistry curricula, but none have specifically used the CIPP model to measure technical alignment between the University of Zawia and ZOR in the digitalization era. A mixed-methods approach is chosen specifically to capture the depth of qualitative data from refinery practitioners (ZOR) that cannot be captured by statistics alone. Successful curriculum alignment will lead to a reduction in youth unemployment by increasing graduate employability (K. Chen & Khodi, 2025).

As part of the structure of this article, the discussion will begin with an in-depth analysis of the economic conditions of Libya’s downstream oil and gas sector. Subsequently, a comparison will be made between the current curriculum profile and the technical standards in effect at the Zawia Oil Refinery using the CIPP framework. The identification of specific competency gaps will serve as the basis for formulating strategies for integrating digital technology and sustainability principles. Mitigation strategies for social, cultural, and structural barriers will also be explored to ensure the curriculum’s effective implementation. The final section of the article will present conclusions and strategic recommendations for human resource developers in the energy sector.

METHOD

This study employed an evaluative research approach to assess the effectiveness and relevance of the Applied Chemistry curriculum at the University of Zawia against the technical competency requirements of the Zawia Oil Refinery

(ZOR). The research design utilized an exploratory sequential mixed-methods approach. In this design, qualitative data were initially gathered through in-depth interviews to identify key competency issues, which were subsequently translated into quantitative questionnaire items for broader measurement and triangulation (Gierus et al., 2025; Koskey et al., 2023). The point of interface occurred when qualitative findings regarding digital literacy gaps and process simulation were operationalized into specific indicators within the survey instrument. This approach is considered effective in curriculum evaluation research because it enables researchers to combine contextual qualitative insights with broader quantitative validation (Toyon, 2021).

The study adopted Stufflebeam's CIPP (Context, Input, Process, and Product) Evaluation Model as the primary analytical framework. This model was selected for its comprehensive structure in examining curriculum goals (Context), institutional resources (Input), instructional implementation (Process), and graduate outcomes (Product) (Gao et al., 2025; Ratnaya et al., 2022). Operationally, the Context dimension evaluated the alignment of the curriculum vision with industrial strategic needs; Input assessed the readiness of laboratory facilities and staff; Process monitored the effectiveness of practical learning methods; and Product measured the actual work-readiness of graduates in the field. The CIPP framework has been widely recognized as an effective evaluation model for vocational and competency-oriented educational programs because it allows multidimensional assessment of curriculum quality and labor-market relevance (Jiang & Liu, 2021).

Participants were selected using a purposive sampling technique to ensure the representation of key stakeholders within the oil and gas education-industry ecosystem in Zawia. The sample consisted of 15 faculty members from the University of Zawia and 10 technical practitioners from ZOR. Although the total sample size (N = 25) is relatively small, it is considered authoritatively representative because the participating refinery practitioners are senior technical experts or key decision-makers with a minimum of five years of experience in chemical refining. Their inclusion ensured that the study captured practical industrial expectations and current refinery competency standards (Teshome & Oumar, 2023). In addition to primary data, secondary data were obtained through the analysis of Semester Learning Plans (RPS) and the 2024–2025 technical workforce requirement reports from the National Oil Corporation (NOC) of Libya.

Data were collected using a 5-point Likert scale questionnaire specifically developed based on current refinery technical standards. The interpretation criteria for the mean scores (M) were established as follows: 1.00–1.80 = very low, 1.81–2.60 = low, 2.61–3.40 = moderate, 3.41–4.20 = high, and 4.21–5.00 = very high. The questionnaire indicators covered technical competency areas such as instrumental analysis, digital literacy, process simulation, HSE compliance, catalyst management, and green chemistry competencies, which are increasingly emphasized in modern industrial curriculum alignment studies (X. Chen et al., 2024; Gómez-Ríos et al., 2023). To ensure instrument quality, qualitative validity was supported through source and technique triangulation, while the quantitative instrument was tested for reliability using Cronbach's Alpha, yielding a value of 0.84, which indicates high and convincing internal consistency. This reliability level exceeds the minimum acceptable threshold commonly used in educational and vocational research (Chiuariu et al., 2024).

The qualitative data obtained from interviews were analyzed using thematic analysis techniques to identify recurring patterns related to curriculum relevance, industrial competency gaps, and institutional barriers. Coding procedures were conducted iteratively to classify themes according to the Context, Input, Process, and Product dimensions of the CIPP model. Meanwhile, quantitative questionnaire data were analyzed descriptively using mean scores, standard deviations, and percentage distributions to determine the degree of curriculum alignment perceived by respondents. The integration of qualitative and quantitative findings strengthened the interpretative validity of the study through methodological triangulation and enabled a more comprehensive understanding of the relationship between vocational education and labor-market expectations (Kondybaeva & Celletti, 2025; Tena et al., 2025).

RESULTS AND DISCUSSION

Overall Curriculum Alignment with Industry Needs

The results of the CIPP-based evaluation indicate that the overall alignment between the Applied Chemistry curriculum at the University of Zawia and the technical requirements of the Zawia Oil Refinery (ZOR) is categorized as "Moderate" (M = 3.01; 60.2%). While basic theoretical chemistry principles are well-covered, there is a significant discrepancy in applied technical domains. The highest alignment scores were found in HSE Culture (M = 3.56) and Green Chemistry (M = 3.48), reflecting successful integration of safety and environmental awareness. However, the findings point to a critical "Low" alignment in Process Simulation (M = 2.41) and Digital Literacy (M = 2.36). This suggests that despite the industry's move toward digitalization, the curriculum remains anchored in traditional manual methodologies, creating a technological lag for graduates (Bondin & Zammit, 2025; Passalacqua & Alsaba, 2020).

Table 1. Curriculum Alignment between University of Zawia (UZ) Outcomes and Zawia Oil Refinery (ZOR) Technical Standards

Competency Areas	ZU Curriculum Outcomes	ZOR Technical Standards	Mean	SD	Alignment Index (%)	Alignment Status
Instrumene Analysis	GC & HPLC Theory	GC Operation & Troubleshooting	3.18	0.74	63.6	Partial
Process Simulation	Thermodynamics Theory	Aspen HYSYS & Digital Twin	2.41	0.68	48.2	Low
HSE Culture	Lab Safety Basics	ISO 45001 & OSHA Standards	3.56	0.71	71.2	Intermediate
Catalyst Management	Surface Chemistry	Zeolite Deactivation Monitoring	3.09	0.77	61.8	Partial
Digital Literacy	Basic Computer Skills	LIMS & Data Visualization	2.36	0.65	47.2	Low
Green Chemistry	Basic Principles	Bioremediation & Flare Gas Emissions	3.48	0.73	69.6	Intermediate
Overall Alignment			**3.01**	**0.71**	**60.2**	**Moderate**

Note: Using a five-point Likert scale, the mean scores were interpreted as follows: 1.00–1.80 = very low, 1.81–2.60 = low, 2.61–3.40 = moderate, 3.41–4.20 = high, and 4.21–5.00 = very high. Accordingly, the alignment status in this table was categorized as low, partial, or intermediate.

Context and Input Evaluation: Infrastructure and Faculty Readiness

The input evaluation reveals structural weaknesses in the program's physical and human resources. Although faculty members possess high academic qualifications, their direct engagement with the refining industry is limited. This distance results in instructional methods that are heavily exam-dominated rather than competency-based. Furthermore, the state of laboratory facilities at the university is a major bottleneck. Interview data from ZOR practitioners highlighted that graduates often struggle to operate modern analytical instruments such as High-Performance Liquid Chromatography (HPLC) and Gas Chromatography (GC) systems used at the refinery. One senior technician noted, "We often see graduates who can derive complex chemical formulas on paper but are completely stumped when asked to calibrate a digital sensor." This confirms a lack of hands-on preparedness within the current educational input. These findings are consistent with studies emphasizing that vocational curriculum effectiveness depends not only on theoretical content but also on industrially relevant laboratory exposure and technology-enhanced learning facilities (Cordero-Guridi et al., 2022; Fuertes et al., 2021).

Process Evaluation: The Gap in Practical Instruction and Internships

Regarding the learning process, the study identifies a lack of structured pedagogical strategies such as Project-Based Learning (PjBL). The current internship model is perceived as "general exposure" rather than a rigorous skill-acquisition phase. Without a formal logbook system validated by both academic and industry supervisors, the internship fails to satisfy the principles of Competency-Based Education (CBE) (Castelló et al., 2023; Qin, 2024). Moreover, the absence of industry-standard software such as Aspen HYSYS in the classroom means that students have minimal exposure to process optimization simulations before entering the workforce. This lack of simulation-based learning increases operational risks when graduates eventually handle real refinery equipment. Previous studies similarly argue that Industry 4.0-oriented vocational education requires immersive practical training, digital simulation, and competency-based instructional methods rather than purely theoretical assessment (Malhotra et al., 2023; Paszkiewicz et al., 2021).

Product Evaluation: Graduate Work-Readiness and Economic Inefficiency

The product evaluation measures the final competency of graduates and their transition into the workforce. Current data show a significant "Retraining Gap," where new hires from the University of Zawia require an average of six to twelve months of intensive on-the-job training before becoming fully operational. According to Human Capital Theory, this represents a substantial economic inefficiency for ZOR because the refinery must bear the financial burden of corrective education that should have been provided by the university. The relatively high performance in theoretical knowledge does not translate into immediate productivity, indicating that the curriculum currently serves academic interests more effectively than industrial needs (Ekeoma & Okoroafor, 2025; Singh & Dixit, 2025). This finding reinforces previous research suggesting that graduate employability in technical sectors depends heavily on practical readiness, digital adaptability, and operational troubleshooting capabilities (Parilla & Evangelista, 2025).

Qualitative Themes and Curriculum Implications

Five major themes emerged from the interviews: strong theory but weak application, limited digital competence, under-structured internships, general HSE knowledge, and the lack of industry-led updates. To address these issues, the curriculum must introduce Aspen HYSYS, LIMS, and data visualization modules. Furthermore, integrating international standards such as ISO 45001 and OSHA into core courses is essential to strengthen ZOR's compliance culture and operational safety orientation.

Table 2. Summary of Interview Themes and Curriculum Implications

Major Theme from Interviews	Interpretation of Findings	Curriculum Implication
Strong theoretical foundation but limited industrial application	Students understand concepts but struggle to apply them in refinery settings	Expand hands-on laboratory practice, industrial case tasks, and troubleshooting activities
Weak digital and simulation competencies	Graduates are underprepared for digital refinery environments	Introduce Aspen HYSYS, digital twin exposure, LIMS, and data visualization modules
Internship experience is insufficiently structured	Placements do not consistently produce measurable technical skills	Redesign internships around learning outcomes, supervision, and competency checklists
HSE preparation is general rather than operationally specific	Students know basic safety principles but not full industrial compliance culture	Embed ISO 45001, OSHA, and refinery-specific HSE practice into core courses
Curriculum updating lacks regular industry input	Revision occurs, but not through a sustained collaborative mechanism	Establish an Industry Advisory Board involving ZOR and PTQI for periodic review

Toward an Adaptive and Competency-Based Curriculum

The findings support the adoption of a Competency-Based Education (CBE) framework in which learning outcomes are defined in measurable technical terms rather than solely conceptual terms (Franco et al., 2023; Malhotra et al., 2023). Universities must integrate Industry 4.0-oriented technologies, including virtual laboratories, digital twins, and simulation software, to overcome physical infrastructure limitations and improve technical realism in learning environments (Bondin & Zammit, 2025; Hernández-Chávez et al., 2021).

Finally, establishing an Industry Advisory Board (IAB) emerges as one of the most strategic managerial solutions for ensuring periodic curriculum review, strengthening university-industry collaboration, and reducing the influence of non-meritocratic recruitment practices such as "Wasta" by emphasizing technical competency and transparent assessment mechanisms. Without integrating these reforms and technologies, the program risks producing graduates whose competencies are increasingly obsolete within a rapidly transforming refinery industry (Nkolika, 2024; Padovano & Cardamone, 2024).

CONCLUSION AND RECOMMENDATION

This study concludes that the Applied Chemistry curriculum at the University of Zawia demonstrates a moderate level of alignment (60.2%) with the technical competency requirements of the Zawia Oil Refinery (ZOR). While the curriculum provides a credible scientific and theoretical foundation, it remains predominantly academic-centric and is not yet fully responsive to the operational, digital, and safety-related demands of a digitalized industry. The findings specifically reveal that the lowest alignment score in Digital Literacy (M=2.36) represents a significant threat to graduate relevance in the industry 4.0 era, posing a risk of systemic competency degradation. Furthermore, the identified gap between academic achievement and actual workplace readiness results in a substantial economic inefficiency for Libya's energy sector. This is evidenced by the 6–12 month retraining period that the industry must bear, which reflects a low return on educational investment and a form of wasted human capital.

Recommendation. Based on these findings, the study recommends a targeted curriculum redesign grounded in Competency-Based Education (CBE) to ensure that learning outcomes are expressed as measurable technical and professional proficiencies. The university should prioritize the integration of digital simulation tools, such as Aspen HYSYS, and consider utilizing virtual laboratories as a short-term solution to overcome physical infrastructure barriers and equipment procurement bureaucracy. Greater emphasis must be placed on practical laboratory upgrading and refinery-specific HSE training, incorporating international standards like ISO 45001 or OSHA into core courses. Structurally, the establishment of an Industry Advisory Board (IAB) is recommended to facilitate periodic reviews and close the gap between academic instruction and industrial reality. Additionally, the university should explore alternative funding mechanisms, such as CSR partnerships with the ZOR refinery, to support laboratory modernization.

Research Limitations and Future Directions. While this study provides a comprehensive evaluation, its primary focus on the Applied Chemistry program and ZOR limits the generalizability of the findings to other industrial sectors. Future research should conduct comparative studies with other universities in Libya or perform longitudinal impact evaluations after the new curriculum is implemented to observe the long-term effectiveness of the CIPP model. Furthermore, expanding this evaluative framework to other engineering and technical programs would validate the CIPP model's utility more broadly across the university system.

REFERENCES

Baroud, N. (2024). A Systematic Comparison of Students' Attitudes Toward Practical Work in Chemistry Department Faculty of Education, Zawia - University of Zawia. *IJCER (International Journal of Chemistry Education Research)*. https://doi.org/10.20885/ijcer.vol8.iss2.art7

Bhatia, J. (2025). Viksit Bharat and CSR-driven Funding for Industry-Academia Collaboration. *The International Journal of Business & Management*. https://doi.org/10.24940/theijbm/2025/v13/i5/bm2505-017

Binani, S., Reddy, N. V., Patel, M., & Subramanyan, V. (2024). Integrating Green Chemistry in Engineering Chemistry for Achieving Sustainable Development

Goals through Education (JEET). *Journal of Engineering Education Transformations*. https://doi.org/10.16920/jeet/2024/v38is1/24208

Bondin, A., & Zammit, J. (2025). Education 4.0 for Industry 4.0: A Mixed Reality Framework for Workforce Readiness in Manufacturing. *Multimodal Technol. Interact.*, *9*, 43. https://doi.org/10.3390/mti9050043

Castelló, E., Santiviago, C., Ferreira, J., Coniglio, R., Budelli, E., Larnaudie, V., Passeggi, M., & López, I. (2023). Towards competency-based education in the Chemical Engineering Undergraduate Program in Uruguay: Three examples of integrating essential skills. *Education for Chemical Engineers*. https://doi.org/10.1016/j.ece.2023.05.004

Chen, K., & Khodi, A. (2025). Toward Curriculum–Industry Alignment in FinTech Education: A Conceptual Framework Linking Digital Competence and Critical Thinking at Changchun Sci-Tech University, China. *Journal of Information Systems Engineering and Management*. https://doi.org/10.52783/jisem.v10i3.8113

Chen, X., Wang, L., Shao, X., & Wei, R. (2024). An analysis of Chinese chemistry curriculum standards based on OECD Education 2030 Curriculum Content Mapping. *Disciplinary and Interdisciplinary Science Education Research*, *6*. https://doi.org/10.1186/s43031-023-00091-4

Chiuariu, D. A., Babaliga, M. O., & Paleu, V. (2024). TIE-M Plus: Alignment of Higher Education with Labor Market Demands. *2024 IEEE 30th International Symposium for Design and Technology in Electronic Packaging (SIITME)*, 87–90. https://doi.org/10.1109/siitme63973.2024.10814817

Cordero-Guridi, J.-D.-J., Cuautle-Gutiérrez, L., Álvarez-Tamayo, R., & Caballero-Morales, S. (2022). Design and Development of a I4.0 Engineering Education Laboratory with Virtual and Digital Technologies Based on ISO/IEC TR 23842-1 Standard Guidelines. *Applied Sciences*. https://doi.org/10.3390/app12125993

Dash, S. (2025). CSR-Driven Industry-Academia Collaboration: Accelerating Innovation and Sustainability Under Viksit Bharat@2047. *The Social Science Review A Multidisciplinary Journal*. https://doi.org/10.70096/tssr.250307045

Dboba, M., Astiata, W., & Bindra, S. (2022). Science and Quality Education for Sustainability Development in Libya. *INTI Journal*. https://doi.org/10.61453/intij.202218

Dubey, A., & Noronha, M. (2025). Transforming Technical and Vocational Education and Training (TVET) in India: Need for a Longitudinal Study on Industry and Academic Alignment. *International Journal for Multidisciplinary Research*. https://doi.org/10.36948/ijfmr.2025.v07i04.50064

Düzgünçınar, T. (2025). Bridging the Gap Between Industry Needs and Vocational Training Curricula. *Journal of Information Systems Engineering and Management*. https://doi.org/10.52783/jisem.v10i44s.8649

Ekeoma, P., & Okoroafor, E. (2025, October 13). *Navigating Career Entry and Growth Challenges for Young Professionals in the Evolving Oil and Energy*

Sector: Strategies for Success. SPE Annual Technical Conference and Exhibition. https://doi.org/10.2118/227899-ms

Elabbar, A. A. (2022). Repercussions of the Continuous Instability for the Quality of Education in the State of Libya: An Investigational Study within the Faculty of Education, University of Benghazi (UoB). *American Journal of Educational Research*. https://doi.org/10.12691/education-10-10-6

Franco, L., Da Costa, A. C., De Almeida Neto, A., Moraes, Â., Tambourgi, E., Miranda, E., De Castilho, G., Doubek, G., Dangelo, J., Fregolente, L., Lona, L., De La Torre, L. G., Alvarez, L., Da Costa, M., Martinez, P. F. M., Ceriani, R., Zemp, R., Vieira, R., Filho, R., … Suppino, R. (2023). A competency-based chemical engineering curriculum at the University of Campinas in Brazil. *Education for Chemical Engineers*. https://doi.org/10.1016/j.ece.2023.04.001

Fuertes, J., Prada, M., Rodríguez-Ossorio, J., González-Herbón, R., Pérez, D., & Domínguez, M. (2021). Environment for education on Industry 4.0. *IEEE Access*, *PP*, 1–1. https://doi.org/10.1109/access.2021.3120517

Galatro, D., & Chakraborty, S. (2025). *Strategies to Map Education 5.0 and Industry 5.0 in the Context of a Modernized Undergraduate Program in Chemical Engineering*. 1–9. https://doi.org/10.1109/educon62633.2025.11016293

Gao, H., Wang, J., Chen, Z., Guo, P., & Peng, T. (2025, October 24). *Research on Dynamic Evaluation Model of Vocational Education Curriculum Based on CIPP Model and Neural Network*. Proceedings of the 2025 2nd International Conference on Artificial Intelligence and Future Education. https://doi.org/10.1145/3785987.3786104

Gierus, B., Du, T., Maduforo, A., Gilbert, B., & Koh, K. (2025). Prevalence and Quality of Mixed Methods Research in Educational Subdisciplines: A Systematic Review. *SAGE Open*, *15*. https://doi.org/10.1177/21582440251335171

Gómez-Ríos, D., Ramírez-Malule, H., & Marriaga-Cabrales, N. (2023). Mesocurriculum modernization of a chemical engineering program: The case of a high-impact regional university in Colombia. *Education for Chemical Engineers*. https://doi.org/10.1016/j.ece.2023.06.002

Herink, T., Bělohlav, V., Jirout, T., & Belohlav, Z. (2022). Opportunities of experiential education in chemical technology and engineering. *Education for Chemical Engineers*. https://doi.org/10.1016/j.ece.2022.08.003

Hernández-Chávez, M., Cortés-Caballero, J., Pérez-Martínez, Á., Hernandez-Quintanar, L., Roa-Tort, K., Rivera-Fernández, J., & Fabila-Bustos, D. (2021). Development of Virtual Reality Automotive Lab for Training in Engineering Students. *Sustainability*. https://doi.org/10.3390/su13179776

Jain, N., Thomas, A., Gupta, V., Ossorio, M., & Porcheddu, D. (2022). Stimulating CSR learning collaboration by the mentor universities with digital tools and technologies – an empirical study during the COVID-19 pandemic. *Management Decision*. https://doi.org/10.1108/md-12-2021-1679

Jiang, H., & Liu, Y. (2021). Construction of Teaching Quality Evaluation System of Higher Vocational Project-Based Curriculum Based on CIPP Model.

International Journal of Information and Education Technology, *11*, 262–268. https://doi.org/10.18178/ijiet.2021.11.6.1521

Kondybaeva, S., & Celletti, D. (2025). Evaluating The Alignment of Higher Education Systems with Contemporary Labor Market Requirements: An Analytical Perspective. *Farabi Journal of Social Sciences*. https://doi.org/10.26577/fjss20251131

Koskey, K., May, T., Fan, Y., Bright, D., Stone, G., Matney, G., & Bostic, J. (2023). Flip it: An exploratory (versus explanatory) sequential mixed methods design using Delphi and differential item functioning to evaluate item bias. *Methods in Psychology*. https://doi.org/10.1016/j.metip.2023.100117

Kurniawan, A., Abikusna, R., Muspiroh, N., & Firmansyah, B. (2024). Synergy Between Education and Industry: A Competency Development Model for Graduates at Islamic Universities in Cirebon. *Eduprof : Islamic Education Journal*. https://doi.org/10.47453/eduprof.v6i1.297

Liu, H., & Paramalingam, M. (2025). Aligning Vocational Education with Emerging Industry Trend. *Journal of Neonatal Surgery*. https://doi.org/10.52783/jns.v14.2242

Malhotra, R., Massoudi, M., & Jindal, R. (2023). Shifting from traditional engineering education towards competency-based approach: The most recommended approach-review. *Education and Information Technologies*, *28*, 9081–9111. https://doi.org/10.1007/s10639-022-11568-6

McMullen, J., Arakawa, N., Anderson, C., Pattison, L., & McGrath, S. (2022). A systematic review of contemporary competency-based education and training for pharmacy practitioners and students. *Research in Social & Administrative Pharmacy : RSAP*. https://doi.org/10.1016/j.sapharm.2022.09.013

Miladinović, S. (2024). Green analytical chemistry: Integrating sustainability into undergraduate education. *Analytical and Bioanalytical Chemistry*, *417*, 665–673. https://doi.org/10.1007/s00216-024-05680-4

Mitarlis, M., Azizah, U., & Yonata, B. (2023). The integration of green chemistry principles in basic chemistry learning to support achievement of Sustainable Development Goals (SDGs) through education. *Journal of Technology and Science Education*. https://doi.org/10.3926/jotse.1892

Mosbah, A., Cowton, C., Drake, J., & Teviotdale, W. (2022). Preparing students for the workplace in developing countries: A study of accounting education in Libya. *Accounting Education*, *31*, 184–212. https://doi.org/10.1080/09639284.2022.2032220

Nazneen, A., Elgammal, I., Khan, Z., Shoukat, M. H., Shehata, A., & Selem, K. (2023). Towards achieving university sustainability! Linking social responsibility with knowledge sharing in Saudi universities. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2023.139288

Nkolika, C. J. (2024). Bridging the Gap Between Curriculum, Innovative Pedagogy, and Evolving Industry Demands for Future-Ready Graduates. *JURNAL ILMIAH MAHASISWA*. https://doi.org/10.22373/jim.v2i2.722

Padovano, A., & Cardamone, M. (2024). Towards human-AI collaboration in the competency-based curriculum development process: The case of industrial engineering and management education. *Comput. Educ. Artif. Intell.*, *7*, 100256. https://doi.org/10.1016/j.caeai.2024.100256

Parilla, E., & Evangelista, J. (2025). From Campus to Career: A Qualitative Exploration of Graduate Employability and Workforce Readiness in Ilocos Norte. *Advanced Qualitative Research*. https://doi.org/10.31098/aqr.v3i1.2818

Passalacqua, H., & Turki I Alsaba, M. (2020). Energy Transitions: An Academia Take on Shaping the Future Professionals of Oil and Gas. SPE Annual Technical Conference and Exhibition?, https://doi.org/10.2118/201593-MS.

Paszkiewicz, A., Salach, M., Dymora, P., Bolanowski, M., Budzik, G., & Kubiak, P. (2021). Methodology of Implementing Virtual Reality in Education for Industry 4.0. *Sustainability*, *13*, 5049. https://doi.org/10.3390/su13095049

Qin, C. (2024). Discussion on the Curriculum Design and Implementation of Competency-Based Vocational Education. *Journal of Modern Educational Theory and Practice*. https://doi.org/10.70767/jmetp.v1i2.357

Ratnaya, G., Indriaswuri, R., Widayanthi, D. G. C., Atmaja, I., & Dalem, A. (2022). CIPP Evaluation Model for Vocational Education: A Critical Review. *Education Quarterly Reviews*. https://doi.org/10.31014/aior.1993.05.03.519

Rianto, J., Kamil, M., Putry, W. A., & Bahri, S. (2022). The Relevance of the Higher Education Curriculum in the Development of the World of Work and the Industrial Sector: The Case of Universitas Islam Syekh-Yusuf. *Society*. https://doi.org/10.33019/society.v10i1.408

Singh, D., & Dixit, P. (2025). Bridging Higher Education and Industry: An Academic Evaluation of Curriculum Effectiveness in Skill Development for Employability. *International Journal of Scientific Research In Engineering and Management*. https://doi.org/10.55041/ijsrem52820

Suharno, S., Pardiman, P., Harijanto, D., & Ashar, A. (2022). Monitoring Strategy and Evaluation of Education and Training Program with The CIPP Method. *Nazhruna: Jurnal Pendidikan Islam*. https://doi.org/10.31538/nzh.v5i3.2566

Tablatin, C. L. (2023). Academic Community and Practitioner Perceptions on Information Technology Competencies: A Gap Analysis. *WSEAS TRANSACTIONS ON INFORMATION SCIENCE AND APPLICATIONS*. https://doi.org/10.37394/23209.2023.20.36

Tena, B., Motuma, F., Denekew, M., Bekele, A., Abebe, G., Binalf, K., Mengistu, M., Woldekidan, S., Zewdie, S., & Nano, T. (2025). Enhancing Graduate

Competency and Workforce Alignment in Ethiopian Higher Education. *Kotebe Journal of Education*. https://doi.org/10.61489/30053447.pb(1).20

Teshome, A., & Oumar, J. (2023). Engineering Graduates' Skill Acquisition and Employers Skill Need as applied to Science Education in Ethiopia. International Journal of Research in STEM Education, 5(2), 46–60. https://doi.org/10.33830/ijrse.v5i2.1607

Toyon, M. A. S. (2021). Explanatory sequential design of mixed methods research: Phases and challenges. *International Journal of Research in Business and Social Science (2147- 4478)*. https://doi.org/10.20525/ijrbs.v10i5.1262

Underdahl, L., Akojie, P., Magabo, M. A., Reed, R. R., Haynes, S., Marzano, M., Navarro, M., & Patterson, M. (2023). A Framework to Enhance Graduate Employability. *International Journal of Doctoral Studies*. https://doi.org/10.28945/5090