COLLABORATION BETWEEN INDUSTRY AND ACADEMIA: A PANACEA FOR ENHANCING PRACTICAL CHEMISTRY AND TECHNOLOGY TRAINING IN NIGERIAN TERTIARY INSTITUTIONS

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Abstract
Recently, Academia-Industry collaboration has attracted studies from scholars in higher educational systems in Nigeria due to the deficiency or lack of proficiency of many graduates of our tertiary institutions, mostly in the natural sciences of chemistry and technology. Consequently, industries and agencies of government who are the employers of labour view this challenge as one of the causes of unemployment, and an obstacle to achieving corporate goals and a serious obstacle to national development. There seems to be a gap between theoretical instruction and practical competency in Nigerian tertiary institutions. Mostly, Nigerian tertiary institutions tend to present essential theoretical principles without complementary laboratory practical experiences; thereby producing graduates who are cognitively filled but lacks rudimentary practical skills, especially among chemistry and technology graduates. Skill gaps in job performance of university graduates indicate a mismatch between university output and labour market needs. Also, a minimal industrial interaction with the students while in school, limits possibilities for larger experience and skill learning, reducing academic competences. A synergistic relationship known as collaboration between the academia and industries can achieve university goals through research, industrial training for students, support for development projects, and joint curriculum development. This paper analyzes options for improving practical chemistry and technology training in Nigerian higher education, by providing a framework of understanding and collaborations between Nigerian higher institutions(academia) and relevant industries for national industrial development. Using current literature, and descriptive case studies, the paper suggests a multi-stakeholder model that prioritizes co-designed curricula, industrial internships, research partnerships, infrastructure sharing, patent development, marketing, communication and continuous assessment of competency outcomes, between the academia and the industries. The paper concluded that systematic collaborations produce mutual benefits. The paper therefore, recommends actionable legislative reforms, long-term funding methods, and collaboration for effective incorporation of industrial demands into academic practice.
Keywords: industry, academia, collaboration, practical training, chemistry, technology training

Introduction

Globally, tertiary education provides varying opportunities for academic graduates to acquire knowledge and skills for self-reliance and relevance in the world of work. The core mandate of tertiary institution, resides in the inculcation of knowledge and skills and production of skilled manpower relevant to the needs of the industries and labour market (Eniola-Arigbe et al., 2022). Akinola, (2021) opined that the heart and brain of industrial production and development of any nation reside in the ability to do science and convert this to technology and the beneficiation of the scientific materials through aggressive scientific innovation. This is crucial since the bedrock of any industrialization and development is science and technology innovation (Akinola, 2022).

For these innovations to occur and thrive, there must be a symbiotic partnership of industry-academia synergy. Also, because the knowledge in science and technology drives innovation and development, it is only pertinent to ensure a sustainable aggressive collaboration between industry and academia (Omonijo et al., 2019). Industry-academia collaboration serves as a catalyst for driving innovation, fostering talent development, and addressing real-world challenges. By bringing together academic expertise and industry insights, collaborations between universities and businesses create synergies that benefit students, faculty, and industry partners alike. From co-creating curriculum and conducting joint research to facilitating internships and industry placements, industry-academia partnerships enhance the relevance, quality, and impact of higher education while promoting economic growth and competitiveness (JIMS, 2026)

Abdallah and Hridoy (2023) in addressing academia-industry collaborations opined that one major component in this synergy is creating the environment for Industry and academic institutions to collaborate intensely. For the national goals of education and industrial development to be achieved there is a need for Academia-Industry collaboration by all means. For this academia-industry collaboration to take root and survive, certain prerequisites must be put in place. a country that does not have a thriving industry, manufacturing enterprise, cannot talk of innovation talk less of industry-academia collaboration, or benefits derivable from it (Hublink, 2025). The level of development a country enjoys is intertwined with the degree of industrialization, manufacturing of its economy. This in turn, greatly influences the level of human development index. Therefore, for a nation to survive developmentally, the institutions must prepare a curriculum that is tandem with the developmental need of industries. When this is done, the goals of the academia will align with the goals of the industries and the collaboration between the academia and industries will begin to yield needed results (Ajile, Abiye and Njoku, 2026)

Chemistry which is the study chemical properties of matter is one of the major sciences that will enable industrial technology and development. Effectively applying chemistry and technology principles in industrial situations, graduates must be both intellectually and practically competent through the acquisition chemistry knowledge, practical skills and technological knowhow (Okeke, 2023). In Nigeria, the workforce in industries such as petrochemicals, pharmaceuticals, environmental management, and manufacturing is increasingly demanding specialists who can solve real-world issues. However, the dominant teaching method at higher schools is frequently theoretical, with little industry applicability (Onwuchekwa & Ajoku, 2020; Okeke, 2023). The gap shows as graduates lacking crucial practical skills, prompting businesses to invest extensively in remedial training upon hire (Bello & Farombi, 2022).

Ejilah, et al, (2025) opined that collaboration between industry and academia offers a possible option to address this divide. Institutions may ensure that curricula reflect developing technological trends while also providing employers with access to a competent personnel pipeline through collaborations that include industrial experience into academic programs. This research investigates ways for strengthening such relationships, particularly for practical chemistry and technology training in Nigerian tertiary institutions (Zanua, Appiah and Amegbanu, 2024).

So, this paper therefore, is a wakeup call into a deep `introspection on the issues that constitute fundamental challenge to the implementation of Industry-Academia collaboration; and how to overcome the barrier of poor educational program implementation in the sciences especially chemistry as a subject and technology which may hamper development of skill and scientific consciousness for national economic development.

Chemistry and Technology Training in Nigeria

Universities, polytechnics, research, colleges and educational institutes make up Nigeria's tertiary education system. Chemistry and technology programs at these tertiary institutions are designed to develop learners with requisite knowledge and skills through practical training and models to generate graduates who can contribute to scientific research, industrial operations, and technological innovation. However, institutions of higher learning seem to fall short of the standards expected of them. There are many reasons for the above, which include, low population of chemistry teachers, lack of good 21st century skills inculcation to teacher trainee. Low population of students in chemistry and chemistry related subjects. Poor funding of science and technology. Use of improper curriculum, lack of efficient laboratories and laboratory facilities. Corruption, lack of motivation for

chemistry and technology teachers, excessive strikes and stoppage of academic progrmes, low patronage of science graduates, bad government policies etc. Others include;- insufficient access to contemporary laboratories, lack of qualified teachers of chemistry, language of chemistry teaching, poor industry information on academic needs, outdated curricula, and limited industrial interaction reduce the effectiveness of practical training (Oladipo et al., 2022; Adewale & Oladimeji, 2023).

Lack of manipulative Skill for work

The discrepancy between educational outputs and industry needs has been well established. This is because certain graduates leave school without acquiring the right skills for work. The problem emanates from the distance between industry needs and academic curriculum. When industry needs are distant from academic curriculum, the products do not align with the needs of industries leading to many graduates roaming the streets (Adewale & Oladimeji, 2023). Also because poor scientific and mathematics foundation, from primary school there is the incident of phobia for science and mathematics exacerbated by teaching methods and over theorisation of science leading to rote memorization of science. Therefore, chemistry and technology graduates frequently demonstrate inadequacies in laboratory procedures, instrumentation, process optimization, and problem-solving abilities (Ojo & Oyeniran, 2021). As a result, many businesses believe Nigerian graduates are unprepared for technical positions (Nwachukwu, 2019). To overcome this, collaborations that include industry inputs into the educational process are essential, to model a curriculum that will suit industry needs, train the teachers that will implement the curriculum and produce the graduates who will in turn employ the graduate prepared for work. By doing this public confidence will grow and more people would want to study to be employed or enter as entrepreneurs.

Industry-Academic and globalisation

Academia-industry collaboration acts as a global engine for innovation, bridging theoretical research with practical application to foster economic growth of nations. It enhances curriculum relevance, drives research and development efficiency and addresses complex global challenges. Globalisation accelerates cross border knowledge transfer in science, technology, ICT and innovation added to international partnerships. Academia-industry collaboration enhances innovation and development, knowledge transfer, cultural harmony and transfer, curriculum relevance and employment, global research network, reduced research and development costs, effective partnership between institutions and international companies for improvement. Unfortunately, some international laws of citizenship like disparate cultures, risks of industrial aversion and potential conflicts over

intellectual patents and properties.

The major drivers of academia-industry collaborations include;-

1. *Information and communication technology and ICT*: This plays a crucial role in enabling global virtual collaborations between remote industries and indigenous universities.
2. *International alliances*: Cross boarder alliances are increasingly essential for sharing expertise and tackling complex global scale problems.
3. *Competitive advantage*: Active participation in global networks is critical for maintaining academic relevance and industrial competitiveness.

Also, industry-academia collaboration models have expanded to include co-operative education, work-study programs, and industrial fellowships. Germany's dual education system combines classroom instruction with work-based training (Euler, 2013), whereas the United States has established cooperative internships for STEM students (Knight & Yorke, 2020). Such models have resulted in better graduate outcomes and stronger innovation environments.

Collaboration between industry and academia in Nigeria

In Nigeria, there are many forms of collaborations between industries and academia. One of the notable one is the student industrial work experiences (SIWES) this is a method where within the curriculum a student must go and have an interface in a work place in his chosen career, schools post students to these industries, private enterprises or agencies of government, there students get first hand experiences on the job skills and come back to finish their educational programs. Although some researchers have argued that a of problems from poor implementation, poor monitoring and others have failed to improve the system (Omonijo, et al., 2019). Others, include when government invites company and industry executive to be part of the curriculum formation and drafting bodies. Other ways is when higher institutions partner with industries in carrying out special projects and researches to provide academic answers to societal problems. Also, industries are called on to supervise special projects and help develop patents on researches carried out by students.

According to Bello and Farombi, (2022), relations between academia and industry are infrequent and mostly informal. Existing collaborations usually comprise guest lectures or isolated research initiatives that have little impact on curriculum design or student practical experience (Bello & Farombi, 2022). Because of this lack of participation, academic programs frequently fall behind industrial technical breakthroughs.

Models of Industry-Academia Collaboration

Academia-Industry collaboration is deeply embedded in an institution's vision and mission and correlates to what the institution wants to achieve as its goals when is collaborates with any industry. Key components of its industry-academia collaboration initiatives according to JIMS (2024) include:

- **Curriculum Co-creation**: It collaborates with industry partners to co-create and update its curriculum, ensuring alignment with current industry trends, technologies, and practices. Industry representatives serve on curriculum advisory boards, provide input on course content and learning objectives, and offer insights into the skills and competencies needed for workforce readiness.
- **Guest Lectures and Workshops**: The higher institutions invite industry experts, executives, and thought leaders to deliver guest lectures, workshops, and seminars on campus. These sessions provide students with valuable insights into industry best practices, emerging trends, and real-world applications of theoretical concepts, enriching their learning experiences and expanding their professional networks.
- **Internships and Industry Placements**: Facilitates internships and industry placements for students to gain practical experience and apply classroom learning to real-world projects. Through partnerships with companies and organizations, students have the opportunity to work on live projects, gain exposure to diverse industries, and develop industry-specific skills, enhancing their employability and career prospects.
- **Collaborative Research and Innovation**: Engages in collaborative research and innovation projects with industry partners to address pressing challenges and explore new opportunities. Joint research initiatives, technology transfer programs, and innovation hubs foster knowledge exchange, promote technology commercialization, and drive regional economic development.

Others include The industry-academia collaboration initiatives have yielded numerous benefits for students, faculty, industry partners, and the broader community. Some of the key outcomes include:

- **Enhanced Employability**: Industry-academia collaborations provide students with valuable industry exposure, practical skills, and professional networks, enhancing their employability and readiness for the workforce.

Internships, industry placements, and project-based learning experiences equip students with the hands-on experience and industry-specific knowledge needed to succeed in their careers.

- **Industry-Relevant Curriculum**: Collaboration with industry partners ensures that the curriculum remains relevant, up-to-date, and responsive to industry needs. By incorporating industry insights, case studies, and best practices into the curriculum, the college prepares students to tackle real-world challenges and make meaningful contributions to their respective fields upon graduation.
- **Knowledge Transfer and Technology Commercialization**: Collaborative research and innovation projects facilitate knowledge transfer between academia and industry, leading to the development of new technologies, products, and services. Technology transfer initiatives, patent filings, and spin-off companies contribute to economic growth, job creation, and societal impact, driving innovation and entrepreneurship in the region.
- **Enhanced Faculty Development**: Industry-academia collaborations provide opportunities for faculty members to engage in applied research, industry consulting, and professional development activities. By collaborating with industry partners, faculty gain exposure to real-world challenges, access to industry data and resources, and opportunities for knowledge exchange and collaboration, enriching their teaching and research endeavors.

Collaborations of Academia-Industry and the way to go

As Higher Institutions continues to strengthen its industry-academia collaboration initiatives, they must remain committed to fostering mutually beneficial partnerships that drive innovation, enhance student learning, and contribute to economic development in the following ways:

- **Expand Industry Partnerships**: There is need to expand its network of industry partners and deepen existing collaborations across sectors. By forging strategic partnerships with a diverse range of companies and organizations, it will broaden students' exposure to different industries, enhance research opportunities, and facilitate technology transfer and commercialization.
- **Foster Innovation Ecosystems**: It must establish innovation hubs, incubators, and accelerators that bring together academia, industry, and

government to support entrepreneurship and innovation. By providing infrastructure, funding, mentorship, and networking opportunities, these ecosystems will catalyze the development of startups, spin-offs, and technology-driven ventures that address societal challenges and drive economic growth.

- **Promote Lifelong Learning**: They must promote lifelong learning and professional development among students, faculty, and industry professionals through executive education programs, continuing education courses, and industry-academia partnerships. By offering flexible learning opportunities that cater to diverse needs and interests, the college will empower individuals to stay relevant and competitive in today's rapidly changing world (JIMS, 2024).

Benefits of Industry-Academic Collaboration

Effective collaborations between higher education institutions and industry stakeholders result in multiple benefits for teaching, research, innovation, and graduate employment.

1. **Curriculum Modernization and Relevance:** Collaboration allows for periodic curriculum reviews that reflect current industry trends, technological breakthroughs, and labour market needs. Industry professionals provide practical insights that help to align theoretical education with workplace requirements this ensures that course content reflects emerging technologies. Students acquire industry-relevant competencies skill mismatches between graduates and employers are reduced. It also strengthens the knowledge-production model described in the Triple Helix framework developed by Henry Etzkowitz and Loet Leydesdorff, which emphasizes university–industry–government interaction in driving innovation.
2. Access to Industry-Standard Equipment and Facilities: Many tertiary institutions, particularly in underdeveloped countries, confront infrastructure challenges. Partnerships allow Shared access to current laboratory equipment, exposure to cutting-edge industrial tools and software, and hands-on training with real-world technologies all promote practical competence and close the gap between classroom simulations and genuine industrial operations. Students graduate with familiarity with the tools they will use in the workplace, which increases productivity and adaptability.
3. **Joint Research and Innovation:** Collaborative research fosters

innovation by integrating academic knowledge with industrial experience. Benefits include: Market-driven research solutions are developed, research outputs are commercialized, funding opportunities are increased through joint grants, and applied research culture is strengthened. Industry benefits from problem-solving expertise, while institutions gain practical research directions and funding sustainability. This symbiotic relationship strengthens national innovation systems and promotes economic development.

4. **Expanded Internship and Industrial Attachment Opportunities:** Structured internship programs provide experiential learning opportunities for students. Apply theoretical knowledge in real work settings, improve professional skills (communication, teamwork, time management), and build professional networks. Internships also function as a recruiting conduit for employers, lowering hiring risks. Evidence suggests that graduates with structured industrial exposure have higher employability and workplace preparation (Etzkowitz & Leydesdorff, 2000; Eze & Obi, 2022).

Improved Graduate Employability and Career Outcomes through Collaboration: Students receive industry-recognized competences, soft skills development is reinforced, and career transitions are easier. Employers profit from lower training expenses, while graduates get jobs faster. Over time, this adds to lower unemployment rates and a better institutional reputation. Institutions with significant industry ties attract more students, gain research funds, form international partnerships, and improve their ranking and visibility. This results in a sustainable environment in which education, innovation, and economic progress reinforce one another.

Challenges in Practical Training

Many institutions lack the contemporary laboratories and analytical instruments necessary for industrial-level training (Oladipo et al., 2022). Curricula are frequently out of date and do not reflect current industrial practices or technologies (Adewale & Oladimeji, 2023).Existing industry attachments are frequently ad hoc, with no specific learning objectives or assessment systems (Nwankwo, 2021).University research rarely tackles real-world industry concerns or engages industrial partners (Eze & Obi, 2022).

Strategies for Enhancing Collaboration

Industry input is required during curriculum creation to incorporate practical

competences such as advanced analytical techniques, process safety, and digital instrumentation (Bello & Farombi, 2022). Advisory committees made up of industry specialists might assist revise syllabi on a regular basis. Internships should be formalized with defined learning targets, assessment criteria, and co-supervision by academic and industrial mentors. This gives students with ongoing exposure to real-world industry settings. Shared research facilities and centres of excellence help to facilitate technological transfer and applied research. Industries and universities can collaborate to fund laboratories in important areas such as green chemistry and materials science (Okoro & Musa, 2023). Industry-led workshops assist instructors stay up to date on developing technology and pedagogical approaches, hence boosting training quality.

The partnership framework is based on structured and ongoing involvement among tertiary institutions, industry players, and government agencies. It is made up of five interconnected pillars that promote structural and operational integration among stakeholders (Etzkowitz & Leydesdorff, 2000). Industry experts serve on curriculum review committees to co-create curriculum. Curriculum co-creation guarantees that academic training meets industrial skill requirements. Establishing permanent Industry Advisory Committees (IACs) within chemistry and technology departments formalizes this relationship. These committees should comprise specialists from the petrochemical, pharmaceutical, agro-allied, environmental, and manufacturing industries, as well as academics and regulatory representatives.

According to research, stakeholder engagement-driven curricular reform improves employment outcomes. Bello and Farombi (2022) discovered that employers in STEM sectors frequently notice deficits in practical laboratory competence and digital instrumentation skills among Nigerian graduates. Incorporating industry experts into curriculum review procedures ensures that emergent competences like green chemistry, process safety, automation, and quality control systems are addressed. Furthermore, Knight and Yorke (2020) argue that when practical skill development and reflective learning are included into curriculum design, employability improves. Regular curriculum evaluation (every 2-3 years) will prevent obsolescence and ensure responsiveness to technological change. This strategy operationalizes the Triple Helix interaction concept, in which academics and industry collaborate to affect knowledge production (Etzkowitz & Leydesdorff, 2000).

Integrated internships are formal industrial placements with evaluation standards. Structured, credit-bearing internships integrated into academic programs are critical for experiential learning. Research shows that well-designed internship programs greatly boost graduate preparation and technical confidence (Nwankwo, 2021).

However, most Nigerian industrial attachments lack standardized assessment frameworks. To solve this, internships should be compulsory and credit-weighted. According to Ojo and Oyeniran (2021), Nigeria's skills mismatch is caused in part by a lack of practical experience during undergraduate studies. Formal industry placements in chemistry and technology programs enable students to gain experience in laboratory analysis, process monitoring, regulatory compliance, and industrial safety practices.

Joint research hubs are collaborative laboratories that address real-world problems. Joint Research Hubs provide a strategic framework for applied research and innovation. These hubs should serve as co-funded research ecosystems in which faculty, students, and industry researchers interact to solve industry-specific problems. Eze and Obi (2022) argue that restricted university-industry research integration in Nigeria reduces innovation output. Similarly, Okoro and Musa (2023) underline the significance of innovation centers in facilitating knowledge transfer and commercialization. Priority areas for chemical and technology research hubs can include Green and Sustainable Chemistry, Renewable Energy Materials, Waste Valorization Technologies, Industrial process optimization Environmental Remediation.

Access to advanced instrumentation and industrial-scale facilities improves research quality and student competency (Oladipo et al., 2022). Furthermore, clearly defined intellectual property (IP) regulations promote commercialization while protecting stakeholder interests. These hubs adhere to the Triple Helix approach by combining knowledge generation (academic), application (industry), and policy support (government) (Etzkowitz & Leydesdorff, 2000).

Resource sharing entails reciprocal access to facilities and expertise. Resource sharing improves efficiency and reduces infrastructural shortfalls in Nigerian tertiary institutions (Oladipo et al., 2022). Formal Memoranda of Understanding (MOUs) allow enterprises to provide access to production units, analytical laboratories, and industrial-scale equipment for training and joint research. In contrast, universities can provide: Consultancy services, laboratory testing and analysis, research knowledge, and ongoing Professional Development (CPD) activities. Onwuchekwa and Ajoku (2020) observe that graduate employability improves when institutions actively participate in industry ecosystems. Shared infrastructure encourages practical learning and builds trust among stakeholders. To ensure long-term viability, formal agreements must specify cost-sharing models, safety protocols, maintenance responsibilities, and intellectual property rights.

Monitoring and evaluation (M&E): Use key performance indicators (KPIs) to track impact on graduate outcomes. Effective collaboration necessitates quantitative

performance metrics. A strong Monitoring and Evaluation (M&E) framework should include Key Performance Indicators (KPIs) such as graduate employment rates within 6-12 months, employer satisfaction ratings, the number of structured internships completed, joint publications and research grants, industry-funded research projects, patents and commercialization outputs, and curriculum revisions influenced by industry. Bello and Farombi (2022) underline the importance of employer feedback in measuring graduate preparedness. Similarly, Okeke (2023) contends that evidence-based appraisal promotes institutional responsibility. Annual performance reviews involving all stakeholders will provide transparency and help lead policy changes. Data-driven monitoring enables ongoing development and long-term sustainability.

Policy Implications

Government Roles: Government intervention is essential for institutionalizing collaboration. The policy measures should include: Tax breaks for businesses that invest in university collaborations (Okoro & Musa, 2023). Accreditation requirements demand evidence of industry interaction for program acceptance (Adewale & Oladimeji, 2023). Dedicated funding plans for collaborative research labs and industrial training programmes (Eze & Obi, 2022). Strategic policy alignment reinforces the national innovation ecosystem and supports economic diversification.

Institutional Governance

Universities should set up specific departments to handle relationships, negotiate Memorandums of Understanding (MOUs), and track outcomes. Industry representatives should participate in governance forums for curriculum and research strategy.

Conclusion

Improving industry-academia partnership is critical for developing competent graduates who can fulfill the demands of Nigeria's dynamic industrial landscape. Tertiary institutions can revolutionize practical chemistry and technology education by using co-designed curricula, structured internships, collaborative research projects, and supportive policies. Strong teamwork not only improves employability, but it also promotes innovation and economic progress. Collaboration between industry and academics is transformative rather than just supportive. It modernizes courses, increases research output, boosts practical training, and dramatically improves graduate results.Structured collaboration frameworks in Nigerian tertiary education can serve as a strategic approach toward workforce readiness and national growth.

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