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Building Collaborative Innovation Platforms for Engineering Education: Government University Industry Nexus

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ABSTRACT

The paper discusses the challenges of co-creating a 21st-century engineering, architecture, and urbanism curriculum in Egypt, emphasising the need for collaboration between the government, industry, and higher education providers. The paper aims to overcome barriers in the Government-University-Industry (GUI) nexus to align and enhance the engineering sector's contribution to Egypt's economic prosperity. The study identifies cultural, educational, and structural factors influencing innovation in Egypt and addresses gaps at the national, university, and program levels. The paper highlights the similarities of innovation landscape with the UK. The authors identified, poor communication and alignment between national goals, industrial strategy, and academic research that hinder engineering innovation in Egypt. The research highlights the inflexibility and lack of clarity in the current engineering curriculum, contrasting the evolving demands and advancements in engineering technology. The paper also refers to the UK Apprenticeship Education Programme as a possible model for improving industrial collaboration and discusses its relevance to Egypt's technical education initiatives.

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1. Introduction

Co-creating Engineering Curriculum for the 21st Century is not a simple task. It requires genuine and deep-rooted collaboration between the government, the industry, and higher education providers. The efforts to improve the engineering curriculum in Egypt also rely on pulling together a number of organisations and integrating disparate and fragmented innovation structures. This has been a key driver behind the CRUISE research project, a collaborative effort between UK and Egyptian partners. The Project identified the similarities and differences between the two countries' innovation landscapes. The project also explored the UK apprenticeship Education Programme as a possible model for co-creating an exemplary cadetship Engineering curriculum featuring industry-driven educational content. Throughout the project,

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several challenges facing the Government-University-Industry (GUI) collaboration in Egypt have been identified.

This paper explains the challenges facing GUI (Government- University- Industry) and identifies the innovation ecosystem to deliver further improvement to the engineering industries that are core to the economic prosperity in Egypt.

Dating back to 1816, Engineering education in Egypt has equipped graduates with key engineering skills across the Middle East and Africa. Over the last 50 years, Egyptian engineers have pushed the boundaries of knowledge, science, and technology. At the same time, the number of engineering graduates has continued to increase, reaching more than 35,000 graduates, with an increase of approximately 300% since the turn of the century. (Elsafty 2020)

It would be possible, sensing the recent rise and improvement in the ranking of a number of Egyptian Universities, to opt for a quiet life basking in previous successes, shrugging off the current challenges, and shirking the need for reform. It would be, however, detrimental to delay the urgent need for transformation as the engineering industry is already changing faster than it has ever done before, and the pace of change will continue to accelerate. Egyptian universities are key to the country's ability to effectively manage change without becoming enmeshed in it. Future success is dependent on better mobilizing the knowledge, imagination, creativity, skills, and abilities of our whole engineering workforce to contribute to national economic prosperity.

The Co-Create Government University Industry Engineering Curriculum for the 21st Century (CRUISE) project, presented in this article, stands as a collaborative endeavour between academic institutions and industry, aiming to develop engineering education in Egypt. The project focuses on narrowing the knowledge gap between academia and industry by jointly crafting a cadetship curriculum tailored to meet industry demands. Throughout the project journey, several pivotal milestones were reached. These include the comprehensive mapping of Egypt's research and innovation landscape, critical comparison between Egyptian and UK innovation landscape, capacity-strengthening workshops, and the development of industry-driven educational content. Central to the project's success was active stakeholder engagement, with workshops and seminars serving as platforms for dialogue among academics, industry stakeholders, and government representatives, addressing crucial aspects such as curriculum development, industry integration, and research innovation. Significant highlights emerged from stakeholder workshops which delved into topics like the UK apprenticeship programmes, fostering industry-university partnerships, and adapting curricula to align with industry standards. Notably, the project emphasised practical experiences and industry engagement, resulting in the adaptation of modules across partner universities to involve industry in the modules' delivery.

2. Literature Review

The transition from higher education to the workplace represents a critical phase for new graduates, where they must navigate the socialisation process within organisations to integrate effectively into their roles. Korte (2008) emphasized the significance of this socialisation process in shaping newcomers' experiences and perceptions of work and the organisation. He suggests that these early experiences not only impact job satisfaction and learning but also have potential long-term effects on turnover and commitment. This underscores the importance of understanding and facilitating the transition for new professionals. In response to the evolving demands of the job market, higher educational institutions are reevaluating their teaching methods to equip students with the necessary skills for lifelong learning and adaptability. Khodeir and Nessim (2020) highlight the challenges posed by '21st Century Competencies' and the imperative for educational institutions to address them. This shift reflects a recognition of the dynamic nature of industries and the need for graduates to possess versatile skills to succeed in their careers. Zeidan and Bishnoi (2020) delve into the gap between academia and industry readiness, particularly in the context of Industry 4.0. Their study investigates the skills and competencies required by

the industry, revealing discrepancies between graduates' abilities and industry expectations. This misalignment underscores the need for collaboration between academia and industry to bridge the gap and ensure graduates are adequately prepared for the workforce.

Achieving successful collaboration between universities and industries presents its own set of challenges. Chen, Lu, and Wang (2020) highlight the complexities involved in university-industry collaboration, including questions regarding timing, contributions from both parties, and achieving mutual benefits. This indicates the necessity for clear frameworks and strategies to facilitate effective collaboration and maximize outcomes for all stakeholders. Furthermore, the implementation of standards-based reform in education requires leadership that can navigate both technical and adaptive challenges. Pak, Polikoff, and Desimone (2020) emphasize the importance of technical and adaptive leadership in aligning curriculum with standards. Without addressing both aspects, they argue, challenges in implementation will persist, hindering the effectiveness of educational reforms.

The literature on academy-industry relations demonstrates a broad spectrum of activities, structures, and concepts facilitating the exchange of resources, ideas, and influence between universities and for-profit entities (Anderson, 2001). Factors influencing university-industry interaction include networking, legal support, facilitating agents, and management practices (B€urger & Fi, 2021). University programs aim to equip students with skills and knowledge for employment, fostering critical thinking and empowerment. However, there is a growing emphasis on aligning programmes with industry needs to enhance graduates' employability (Al Asefer, 2021). Higher education faces the dual mission of preparing graduates for the workforce and fostering well-rounded individuals with qualities of citizenship, responsibility, and professional expertise (Suleman, 2021). Employability skills have been extensively studied, while attributes related to holistic education receive less attention, despite their societal relevance (Suleman, 2021). In the context of Egypt, its higher education system has shown promise, particularly in the establishment of a national accreditation body (Saeed, 2021). Meanwhile, in China, challenges persist in promoting industry-education integration, necessitating comprehensive policies, involvement of enterprises, and a robust evaluation system (Xu, Su, & Hong, 2021). Innovation ecosystems play a crucial role in enhancing university-industry interactions, with factors such as networking, legal support, and management practices influencing the relationship (B€urger & Fi, 2021). Moreover, the importance of hard and soft skills in employability is emphasized, with soft skills increasingly recognized as vital assets in the labour market (Kraja & Begani, 2021).

The implication and significance of industry-education integration have been a subject of growing interest and scrutiny in recent years. Xu, Su, and Hong (2022) examined this discourse and emphasized the importance of constructing a comprehensive system of policies and regulations, coupled with a robust evaluation mechanism. Their study underscores the pivotal role of enterprises in this integration process, suggesting that harnessing the full potential of industry partnerships is crucial for its success. This assertion resonates with the broader consensus in academia, advocating for a symbiotic relationship between educational institutions and industries to address the evolving demands of the workforce. Bae, Polmear, and Simmons (2022) contribute to this discourse by shedding light on the development of employability among civil engineering students. Their findings highlight the multifaceted nature of career preparation, emphasizing the significance of intrinsic motivation, extracurricular engagement, and the role of educators. The study underscores the imperative for academic institutions and management to bridge the gap between theoretical knowledge and practical skills demanded by the industry. Such efforts are deemed essential for enhancing students' readiness for the workforce and ensuring their long-term success in their careers. Bermejo, Eynian, Malmskold, and Scotti (2022) introduce a cooperative model, grounded in the Plan–Do–Study–Act cycle, as a viable framework for industry-academia collaboration in the context of Manufacturing Engineering education. Through a detailed examination of its application in curriculum design, the authors demonstrate the efficacy of this model in aligning educational objectives with industrial requirements. The study advocates for the broader adoption of

such methodologies across various fields of education, emphasizing its potential to bridge the gap between academia and industry effectively.

Wilson, Dyer, and Cantore (2023) provide insights into the evolving landscape of stakeholders in the education sector. Their investigation identifies strategic shifts in stakeholder dynamics, attributing these changes to factors such as the emergence of concepts like the third mission and corporate social responsibility. The study underscores the need for educational institutions to adapt to these evolving stakeholder dynamics, recognizing the shifting influence and salience of various stakeholders. Such adaptability is crucial for fostering sustainable partnerships and ensuring the relevance of educational initiatives in a rapidly changing societal context. Collectively, these studies underscore the multifaceted nature of industry-education integration and the evolving dynamics within the educational landscape. They emphasize the importance of collaborative efforts between academia, industry, and other stakeholders in addressing the challenges posed by the changing demands of the workforce. Moreover, they advocate for innovative approaches and frameworks to facilitate effective collaboration and ensure the continued relevance and success of educational initiatives.

Several efforts have been made to foster the co-creation of engineering curriculum in the United Kingdom. For example, *Connected Curricula* developed by Siemens and adopted in a number of Engineering courses in the UK, are based on round education where academic and industry partners work together to develop the modules. While Siemens is developing and updating the lecture content and adding practical projects around the subject of industrial automation to fit seamlessly into the existing university syllabus, the academics are responsible for delivering this content to students. Siemens also gives technical help and engages with the students in project meetings. Siemens never gets involved in the assessment; students are assessed by university academics. In addition. connected curriculum modules allow students to access Siemens simulation software, NX Mechatronics Concept Design, Tecnomatix Plant Simulation, and PLCSIM Advanced and TIA Portal. Students will also get the chance to learn and apply the digitalisation techniques such as MindSphere and Digital Twins (Salford University, 2019). Table 1 shows the SWOT analysis for possible application of the Connected Curriculum in an Egyptian context.

Table 1: SWOT analysis of the Connected Curriculum. (Source: Authors)

Strength	**Weaknesses**
• Diverse and interactive learning approaches • Upskilling students' capabilities in new technologies • Equipping students with Industry 4.0 skills • High-skilled students' attributes • Fulfil industry needs • Saving budget for buying equipment	• Complexity and difficulty of the software and the hardware • The time constraint • The limitation to specific modules • The non-involvement of the industry in assessment methods
Opportunities	**Threats**
• Academic collaboration with the industry (industry networking) • Universities' competitive value and be aligned with the national Industrial Strategy • Improving reputation • Incorporating blended learning approaches in future curriculum development	• Diminished teacher/student relationship • Less care for the students in the theoretical content • Possible lack of coordination • Ethical challenges • The possible bureaucratic procedures and decision making

3. Gap Analysis Methodology

In Egypt, higher education is offered through different typologies, there are 199 High or technical Institutes containing 454 faculties/ institutes; 27 private universities (209); 10 Technological universities (16); 4 community universities (10); 4 public universities (41 Domain); 12 public universities emanating from governmental universities (122); 4 branches for European universities (14); 2 universities of special nature; 8 Universities, academies and institutes with international and framework agreements; 7 newly approved universities; 4 governmental Academies and institutes; in addition to 199 High or technical Institutes (MOHESR). The total number of enrolled students in all HE institutes in Egypt is about 3.495 million during the academic year 2021-2022 (CAPMAS, 2022).

Engineering education is highly connected to the health and structure of the innovation landscape. The CRUISE project conducted a thorough literature review to gather existing knowledge and insights, related to curriculum mapping, research, and innovation landscape in Egypt. The project has therefore, mapped the Egyptian research and innovation ecosystem. This helped in understanding the current state of engineering education in Egypt at different national, university, and module levels. The project has identified relevant frameworks and best practices. The gap analysis aimed to identify discrepancies between the existing curriculum and industry requirements in Egypt. This involved comparing the skills and knowledge provided by the current curriculum with the skills and knowledge demanded by the industry, using both qualitative and quantitative data sources. CRUISE project employed a comprehensive research methodology and data collection approach as shown in Figure 1. These combine qualitative and quantitative methods to gather diverse perspectives and evidence for informing curriculum development, research landscape mapping, gap analysis, and module development.

3.1. Stakeholder workshops were organised to gather qualitative data and insights from various stakeholders, including academics, industry partners, government officials, and students. These workshops facilitated discussions on curriculum mapping, industry needs, and the research landscape, providing valuable qualitative data for analysis and decision-making.

3.2. Pilot Testing: New modules developed as part of the project were pilot-tested in real-world settings to gather feedback from students, instructors, and industry partners. This iterative approach allowed for continuous refinement and improvement of the modules based on actual implementation experiences.

3.3. Surveys and questionnaires were utilised to gather quantitative data on specific aspects of the project. For example, primary questionnaires were administered to students to gather their opinions and feedback on their experience with the newly developed modules that integrated the industry into the content delivery and evaluation process.

3.4. Expert Consultations: Expert consultations were conducted with academic experts, industry professionals, and policymakers to gather specialised knowledge and insights on curriculum development, industry trends, and research innovation. These consultations helped in refining project strategies and recommendations.

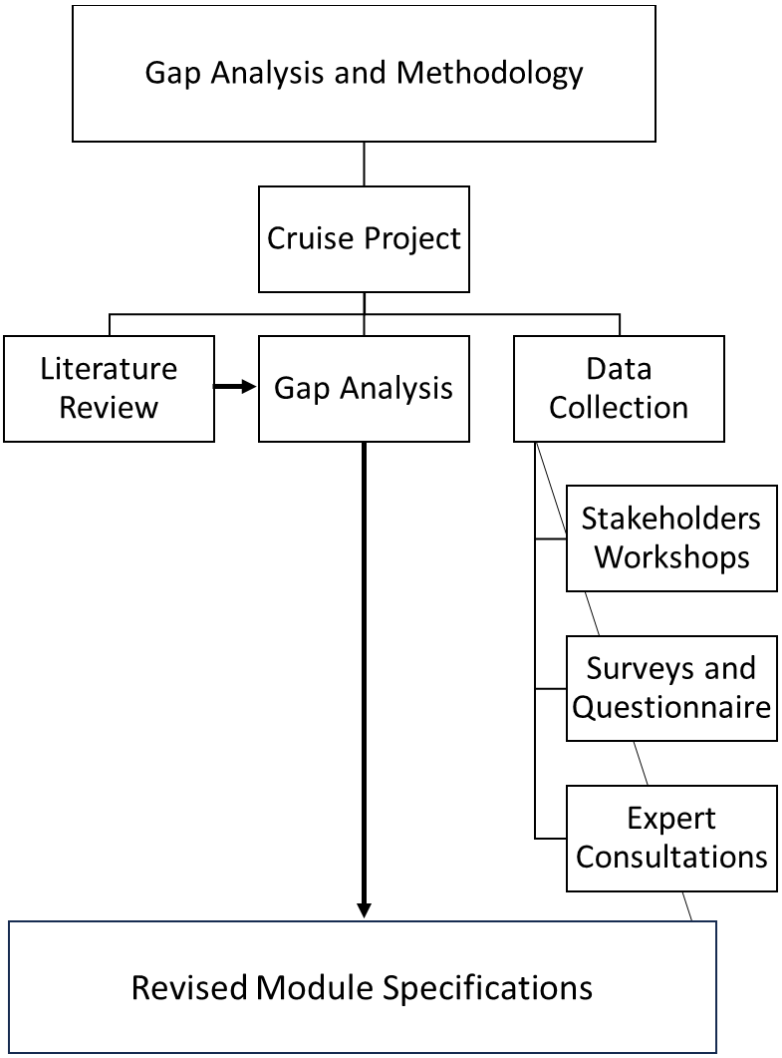

Figure 1. Theoretical framework and methodological process of the study (Source: Authors)

4. Results

Innovation in any country relies on several cultural, educational, and structural factors. Co-creating a new contemporary engineering curriculum could not and should not be separated from those factors. Mapping the innovation landscape in Egypt in this project has revealed several opportunities and exposed a number of gaps, especially when comparing it with its equivalent in the UK as seen in Table 2. The CRUISE project team has tackled those gaps on three different levels; the strategic national level, the universities' missions and structures related to industry engagement, and the engineering programmes level.

Despite the similarities in the innovation landscape in the UK and Egypt shown in Figure 2 and 3, fragmentation, and lack of overall coordination, heightened by poor communication between departments on all levels, seems to halt the acceleration of innovation in Egypt. The project found discrepancies between the objectives of the Egyptian national industrial strategy and research priorities in higher education. The engineering curriculum has neither the flexibility nor the clarity to meet those national goals. Egyptian academics were largely either not aware of the national goals set in the industrial strategy, or under the impression that it is the role of the industry rather than academia to achieve those

goals. Universities' research strategies do not seem to be in sequence with the national strategic cycles. Therefore, research strategies and plans do not reflect the urgency to adapt to the Egyptian national industrial goals.

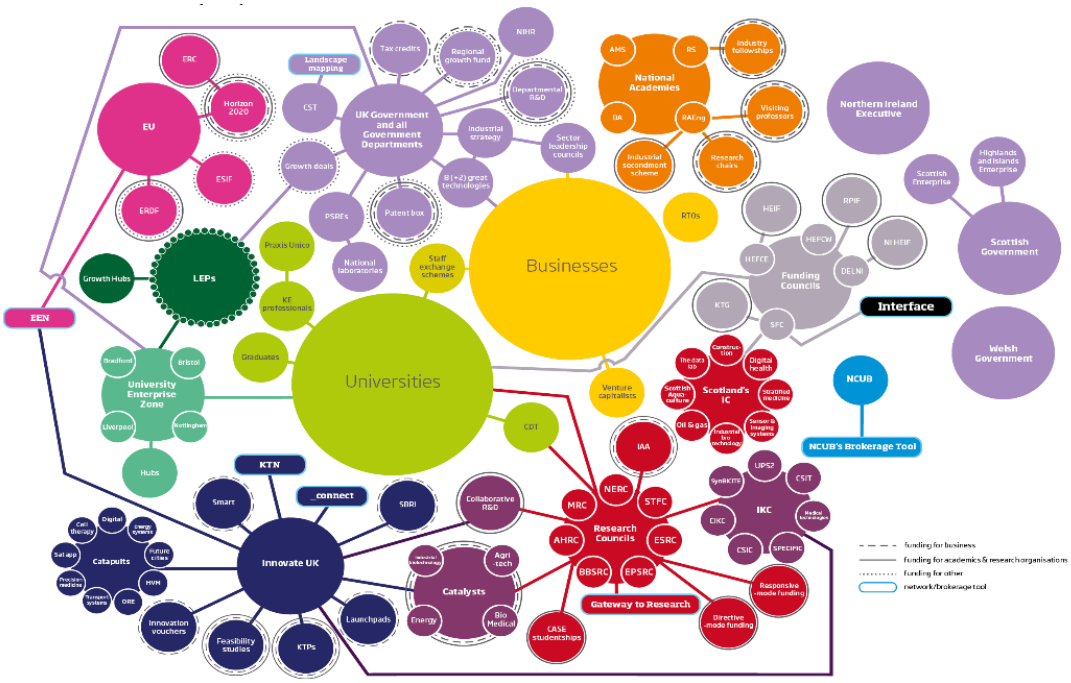

Figure 2. UK innovation landscape (Source: BEIS, 2015)

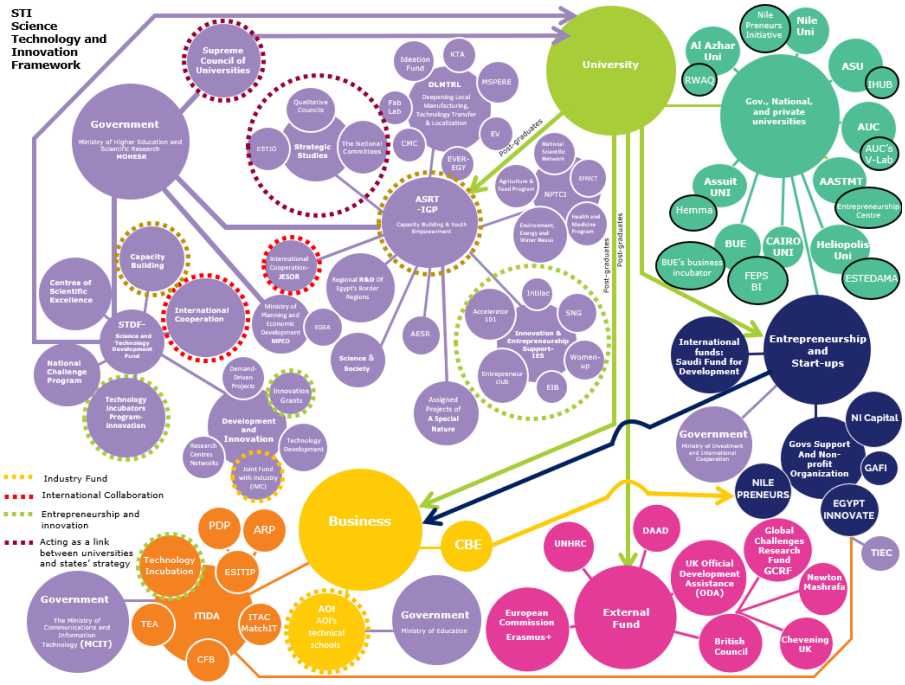

Figure 3. Egypt innovation landscape (Source: Authors)

Egyptian universities are keen to build bridges with the engineering industry. There have been a number of shining examples of successful joint projects. Success has been however limited and heavily relies on personal individual interests and contacts. CRUISE project has provided UK good practices of how to manage and nurture industrial engagement in a more holistic view. Different levels of key accounts need to be identified with clarity of management structure that includes levels of responsibilities and accountability to ensure the sustainability of any industrial collaboration schemes. This would also ensure different levels of engagement that would benefit both universities and the industry including offering opportunities for co-development of course materials and staff development. CRUISE has also made some recommendations on ways to motivate academic staff to prioritise industrial links and collaboration.

Table 2. Comparison between innovation structures in UK and Egypt. (Source: Authors)

Aspect	UK	Egypt
Innovation landscape	Connected and effectiv	Fragmented and less effective
Funding	Funding available	Funding limitations
Visibility	Visible and noticeable	Lack visibility
Organizational Connectivity	Connected	Dotted with broken connections
University Awareness	Fully aware	Aware
Industrial partnerships	Structured and organized	Personal ad-hoc basis
Sustainability	Sustainable	At risk
Incentives	Explicit framework	No explicit framework
Modes of delivery	Flexible	Little flexibility
Curriculum	Sound developed	Well developed
Assessment	Flexible	More effort required

The structure, delivery mechanism, and assessment of engineering curriculum in Egypt have not generally been changed for decades. There have been some welcomed efforts to liberalise modules structures such as the introduction of credit hour framework in several universities. The core of engineering education has however remained unchanged despite the vast technological advances, changes in demands, students' profiles, and nature of contemporary learning methods. CRUISE carefully examined samples of engineering programmes, their structure, contents, delivery mechanism, and assessment methods. The research team investigated, in particular, elements in the examined curriculum related to industrial engagement, knowledge and required industrial skills. While there have been numerous references to industrial input and industrial knowledge, most of these objectives remain theoretical and are limited to efforts to attract guest lectures from the industry and/or limited placement agreements. Almost all the identified, industrial-relevant, intended learning outcomes (ILOs) are not assessed. CRUISE project team has made several recommendations to overcome those challenges.

At the national level, there are numerous efforts to link the university (education and scientific research) and the industry. This is to promote the employability of both fresh graduates and entrepreneurs. Although these efforts may have succeeded in achieving the goals set, these efforts seem like isolated islands. A national-level, comprehensive and integrated regulatory framework that organises these efforts is missing. The absence of this framework might lead to the mismatch of these efforts with the development priorities according to the state's vision, as well as to a lack of clarity in the responsibilities of all the parties involved.

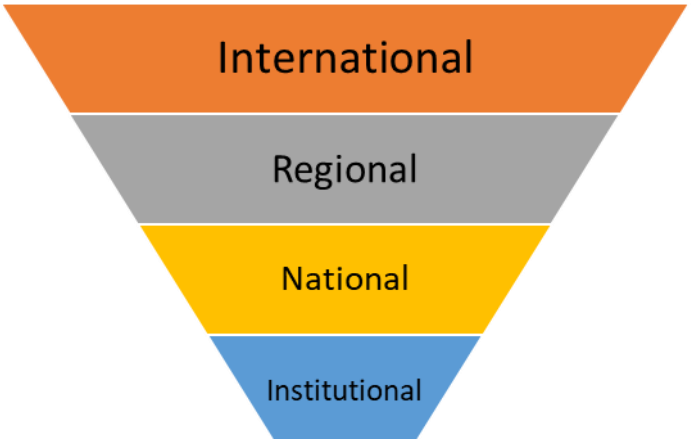

Figure 4. Levels of Government Initiatives Supporting University-Industry Links (Source: Author)

5. Discussion and Conclusions

Egypt boasts considerable potential for fostering research and innovation across various sectors. However, the current research and innovation landscape is fragmented and lacks comprehensive awareness among many staff members. Despite the country's rich pool of talent and resources, there is a need for greater understanding and coordination to harness Egypt's research and innovation capabilities fully. Efforts to consolidate and disseminate knowledge about existing research initiatives and innovation opportunities can significantly enhance collaboration and drive transformative change in the Egyptian research and innovation ecosystem.

5.1. Improved Curriculum Integration: Through stakeholder engagement and collaboration, the project successfully integrated industry-driven content into the curriculum of partner universities. This resulted in modules that better align with industry needs and equip students with practical skills for the workforce, enhancing their employability.

5.2. Enhanced Industry-Academia Collaboration: The project facilitated stronger partnerships between academia and industry, fostering collaboration in curriculum development, research projects, and experiential learning opportunities. This collaboration has the potential to drive innovation and economic growth in Egypt's engineering sector.

5.3. Identification of Skills Gaps: The project identified key skills gaps in the current engineering education system through gap analysis and stakeholder consultations. This insight informed curriculum revisions and provided valuable information for future educational initiatives.

5.4. Positive Student Feedback: These collected during the project indicated a positive reception to the revised curriculum and increased industry engagement. Students reported feeling better prepared for their future careers and appreciated the practical learning experiences provided by the project.

Recommendations for Future Initiatives: Based on the project findings, recommendations were made for ongoing efforts to enhance engineering education in Egypt. These recommendations include continued industry collaboration, ongoing curriculum review, and promoting experiential learning opportunities for students.

The CRUISE project has made substantial strides in enhancing engineering education in Egypt, fostering collaboration between academia and industry, and aligning curricula with industry requirements. Looking ahead, the project's outcomes are poised to continue shaping the future of engineering education,

catalysing innovation, and driving economic growth in Egypt. There are two areas, in our engineering education, that must improve.

First, the expansion of engineering education to respond to the immediate and future needs of the industry in Egypt, the Middle East and North Africa. This would require a genuine closer collaboration to co-create an updated contemporary curriculum with the industry.

Second, we must make better progress in harnessing industrial knowledge as well as the use of cutting-edge digital technology for a step change in the delivery mechanism of the engineering curriculum. We must involve the industry in a more contemporary delivery mechanism that would use digital platforms, reduce reliance solely on university resources, blend working and learning environments, and support our future talented and well-equipped Egyptian engineers.

In conclusion, the CRUISE project successfully improved curriculum integration enhanced industry-academia collaboration, identified skill gaps, received positive student feedback, and provided valuable recommendations for future educational initiatives. The project has laid a foundation for continued progress in engineering education and industry engagement in Egypt.

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The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

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Studies involving animal subjects: No animal studies are presented in this manuscript.
Studies involving human subjects: No human studies are presented in this manuscript.
Inclusion of identifiable human data: No potentially identifiable human images or data is presented in this study.

Conflict of Interests
The Authors declare that there is no conflict of interest.

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