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Bridging Purpose and Practice: A Decade of Technopreneurship Education through PKAS at Universiti Kebangsaan Malaysia

Kalaivani Chellappan[a*], Amitabh Verma[b], Jabar Yousif[c] & Wan Hamidon Wan Badaruzzaman[d]

[a]*Department of Electrical, Electronics and System Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia,*

[b]*Faculty of Business, Sohar University, Oman*

[c]*Faculty of Computing and Information Technology, Sohar University, Oman*

[d]*Faculty of Engineering, Sohar University, Oman*

**Corresponding author: kckalai@ukm.edu.my*

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ABSTRACT

In the context of Malaysia's strategic push toward a digital and innovation-driven economy, traditional engineering education models must evolve to equip graduates with both technical expertise and entrepreneurial acumen. This paper presents the outcomes of a decade-long implementation of the Program Pemerkasaan Kompetensi Akademik Siswa (PKAS), initiated in 2016 at Universiti Kebangsaan Malaysia (UKM). The program focuses on bridging technical and entrepreneurial competencies among engineering students, aligning with Malaysia's strategic national agendas. Through experiential learning, industry collaboration, and startup incubation, PKAS has transformed postgraduate research into real-world applications. This case study evaluates the framework, outcomes, and potential for national replication. Originating as a postgraduate competency initiative, PKAS has expanded across multiple education levels, integrating hands-on innovation projects, industry collaboration, and entrepreneurship development. The study highlights key outcomes such as student start-ups, interdisciplinary innovation outputs, and institutional capacity-building, while drawing lessons on curriculum reform, policy alignment, and sustainable educational design. The paper concludes with policy implications for embedding technopreneurship in national education strategies and calls for broader adoption of experiential, innovation-focused learning in engineering education.

Keywords: Technopreneurship education; engineering curriculum reform; experiential learning; innovation ecosystem; interdisciplinary learning

INTRODUCTION

Knowledge-based and innovation-driven economies prioritize production, distribution, and application of knowledge and innovation as key drivers of growth. This global shift necessitates a redefinition of educational priorities to align with rapidly evolving industry demands. The Triple Helix model exemplifies this evolution by emphasizing the dynamic interplay between universities, industries, and governments in fostering innovation (Magalhães & Veiga, 2019). In line with this, Karpudewan & Huri (2022) argue that education systems must be redesigned to prepare students for complex, interdisciplinary challenges inherent in a globalized, knowledge-based economy. Malaysia's national development strategies MyDIGITAL, the Malaysia Education Blueprint, and the Twelfth Malaysia Plan (12MP) reflect this shift by embedding innovation, entrepreneurship, and digital transformation as core tenets of the country's future workforce agenda. MyDIGITAL promotes digital literacy and entrepreneurial acumen, while the Malaysia Education Blueprint emphasizes STEM education to meet Fourth Industrial Revolution (4IR) demands (Idris et al. 2023). Meanwhile, the 12MP supports inclusive, technology-driven growth by aligning educational outcomes with workforce readiness (Kamaruddin et al. 2021). These policies underscore the urgency for universities to produce graduates who are not only technically proficient but also agile, entrepreneurial, and market ready.

However, there remains a persistent disconnect between theoretical learning and practical innovation in many engineering programs. Traditional models of engineering education often emphasize disciplinary depth and technical rigor at the expense of hands-on, interdisciplinary, and entrepreneurial engagement (Zhao et al. 2023; Bühler et al. 2021). This gap limits graduates' ability to apply their knowledge to dynamic real-world problems and hinders innovation readiness (Barneveld & Ströbel 2018; Terano et al. 2022).

Technopreneurship, the fusion of technology and entrepreneurship offers a compelling solution to this challenge. It enables students to develop dual competencies in technical problem-solving and business innovation, enhancing their capacity to respond to market needs with scalable, tech-driven solutions (Awan et al. 2023; Oladejo et al. 2022). Embedding technopreneurship within engineering curricula fosters innovation through hands-on learning, industry partnerships, and interdisciplinary collaboration (Sulaeman & Wibowo 2024; Rukmana et al. 2023). Nevertheless, many institutions still lack structured programs that systematically link theory with practice.

In response, the Program Pemerkasaan Kompetensi Akademik Siswa (PKAS) was launched in 2016 at Universiti Kebangsaan Malaysia (UKM) to address critical gaps in system engineering competencies among postgraduate students. Initially focused on analytics, modeling, and knowledge design, PKAS evolved into a comprehensive technopreneurship platform by 2018, equipping learners with both technical expertise and entrepreneurial skills. Today, PKAS spans multiple academic levels from undergraduates to secondary students while maintaining a self-funded, sustainable model that supports knowledge application and innovation. Figure 1 illustrates the management structure of the center.

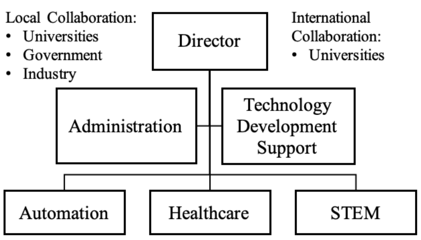

FIGURE 1. PKAS Management Structure

The objective of this paper is to present PKAS as a scalable and practical model for technopreneurship education within higher learning institutions. It aims to showcase how PKAS integrates technical training with entrepreneurial development to address real-world challenges through innovation. The paper focuses on the program's framework, key outcomes achieved over its decade-long implementation, and the lessons learned in bridging academic knowledge with industry needs. It also explores implications for education policy and academic practice, particularly in fostering sustainable innovation ecosystems through student-led start-ups and knowledge co-creation.

BACKGROUND AND RATIONALE

In recent decades, the global transition toward knowledge-intensive and innovation-centric economies has reshaped the role of higher education institutions, particularly in science and engineering domains. Universities are no longer viewed solely as centres for theoretical knowledge transfer but are increasingly expected to function as active contributors to economic development and technological innovation. The Triple Helix model reinforces this shift by advocating for stronger university-industry-government collaboration to generate societal value through innovation (Magalhães & Veiga 2019).

Malaysia's national strategies, such as MyDIGITAL, the Malaysia Education Blueprint, and the Twelfth Malaysia Plan, have placed strong emphasis on aligning educational systems with the digital economy and the demands of the Fourth Industrial Revolution (IR 4.0). These strategic plans underscore the need for digital literacy, entrepreneurial skills, and interdisciplinary problem-solving capabilities across all levels of education (Idris et al. 2023; Kamaruddin et al. 2021). The focus is clear: academic institutions must go beyond conventional pedagogies to develop globally competitive graduates capable of navigating and shaping future economic landscapes.

However, the existing structure of many engineering education models in Malaysia and globally remains heavily rooted in theoretical instruction. This approach often lacks the flexibility and relevance needed to respond to fast-changing industry demands. Studies have shown that the limited exposure to hands-on projects, entrepreneurial thinking, and industry networks within traditional programs contributes to a disconnect between graduate capabilities and workforce expectations (Zhao et al. 2023; Mitchell & Guile 2022; Goldsmith & Willey 2018). Moreover, institutional challenges such as curricular rigidity, resource limitations, and faculty resistance further impede efforts to reform engineering education (Bühler et al. 2021).

In this context, technopreneurship emerges as a transformative educational strategy that combines the innovation potential of technology with the value creation mechanisms of entrepreneurship. It equips students with dual competencies, technical and entrepreneurial that enabling them to ideate, develop, and scale technological solutions that address real-world needs (Oladejo et al. 2022; Awan et al. 2023). Importantly, technopreneurship education fosters an entrepreneurial mindset while encouraging interdisciplinary collaboration, market engagement, and practical innovation through experiential learning approaches (Sulaeman & Wibowo 2024; Murray et al. 2022).

Recognizing the need to bridge this persistent gap between academic training and practical innovation, UKM launched PKAS in 2016. Initially conceived to address system engineering skills among postgraduate students, PKAS quickly evolved into a broader technopreneurship initiative that now spans multiple educational levels. The program integrates core technical training with entrepreneurial development through self-funded, scalable, and industry-relevant modules.

PKAS is positioned not only as a response to national policy imperatives but also as a proactive model for educational transformation. Its evolution over the past decade demonstrates how targeted interventions in curriculum design, stakeholder collaboration, and pedagogical strategy can contribute meaningfully to student readiness, innovation capacity, and economic participation. As such, understanding the rationale and framework of PKAS offers valuable insights for other institutions seeking to implement technopreneurship education as a sustainable response to 21st-century workforce demands.

THE PKAS FRAMEWORK: PHILOSOPHY AND STRUCTURE

PKAS UKM was conceptualized to address persistent and critical gaps in the application of technical knowledge and the overall innovation readiness of engineering students, particularly at the postgraduate level. While engineering curricula often provide a strong theoretical foundation, there remains a significant disconnect between what is taught in the classroom and what is required in professional, interdisciplinary, and innovation-driven environments. One of the primary technical knowledge application gaps lies in the integration of traditional and scientific knowledge. For instance, in fields such as agricultural engineering, indigenous technical knowledge (ITK) developed by local communities covering areas like seed treatment, natural pest control, and sustainable harvesting is often undervalued or sidelined in favour of modern techniques. This disconnect hinders the development of locally relevant, eco-friendly solutions that leverage both traditional wisdom and scientific rigor. Bridging this gap is vital for fostering context-sensitive innovations that are both technically sound and culturally resonant. Another major gap exists in the practical application of technical knowledge in professional contexts. Many engineers, despite their technical competence, struggle to translate that expertise into effective action within organizational or leadership settings. Success in modern engineering roles increasingly requires a hybrid skillset: technical proficiency must be complemented by personal attributes, teamwork, communication, management skills, and an understanding of business or policy environments. However, traditional postgraduate engineering programs tend to underemphasize these dimensions, leaving students underprepared for complex, real-world challenges. A third area of concern is the procedural and legal application of engineering knowledge. In contexts such as forensic engineering or accident investigation, gaps arise when technical expertise is inconsistently applied due to limitations in procedural understanding or inadequate legal frameworks. Engineers are expected to contribute to accurate assessments and decision-making processes, yet many lack training in how to navigate the administrative or legal implications of their technical input.

The concept of innovation readiness is central to PKAS's approach. In this context, innovation readiness refers to a student's or institution's preparedness to successfully adopt, implement, and benefit from innovation. This includes having the right strategies, cultural mindset, leadership engagement, access to resources, and capability development mechanisms in place. Without these foundational elements, even technically sound ideas may fail to materialize into impactful outcomes. Postgraduate students are particularly vulnerable to these gaps because their training often emphasizes narrow specialization and theoretical mastery, with limited exposure to real-world application, interdisciplinary problem-solving, or entrepreneurial thinking. Employers, however, increasingly seek graduates who can contribute from day one who not only understand the science and engineering behind a problem but can also work across domains to deliver innovative solutions.

PKAS responds to this challenge by positioning competency development as more than knowledge accumulation; it is a transformation that enables students to translate learning into technopreneurial action. Through structured interventions, industry linkages, experiential learning, and mentorship, PKAS aims to produce engineering graduates who are not only knowledgeable but also agile, innovative, and ready to lead in a fast-evolving technological landscape.

PHILOSOPHY AND PEDAGOGICAL UNDERPINNINGS

PKAS adopts a competency-based and learner-centred pedagogy, informed by Kolb's Experiential Learning Theory and principles (Kolb, D. A., 1984) of transformative learning as in Figure 2.

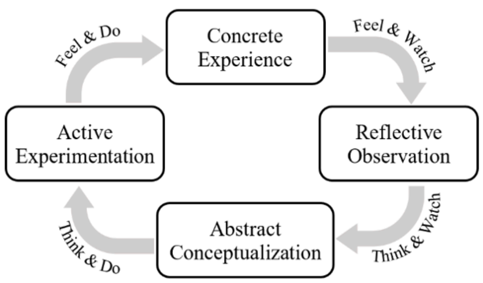

FIGURE 2. Kolb's Experiential Learning Model

The program views students as active agents of innovation, capable of identifying real-world problems, synthesizing interdisciplinary knowledge, and creating technological solutions with commercial and social relevance. Learning is structured around practice-oriented challenges, where students engage in iterative cycles of reflection, experimentation, and solution development. The PKAS framework aligns closely with national education policy priorities by emphasizing technical excellence, entrepreneurial agility, and industry relevance. It reinforces the vision that university graduates should be future-ready contributors to the national innovation ecosystem and capable of launching or supporting tech-based ventures.

CORE COMPONENTS OF THE PKAS FRAMEWORK

The PKAS structure is built upon four interlocking components designed to support holistic technopreneurial development detailed and summarize in Figure 3:

1. Technical Mastery Module: Focused on enhancing foundational competencies in system engineering, analytics, modeling, and digital design. These modules are taught through problem-solving workshops, simulations, and mentorship by subject matter experts.
2. Entrepreneurial Development Module: Embeds entrepreneurial thinking through training in ideation, business modeling, intellectual property, pitching, and venture planning. Real-life case studies, market analysis, and start-up engagement provide applied learning opportunities.
3. Experiential Projects and Innovation Challenges: Students work individually or in teams to solve real-world problems sourced from industry, government agencies, or community contexts. These projects culminate in proof-of-concept demonstrations and are often linked to innovation competitions or startup incubation.
4. Industry and Ecosystem Integration: PKAS is embedded within a broader ecosystem of innovation that includes partnerships with local startups, Small Medium Enterprise, funding bodies, and UKM's research and innovations resources. These collaborations offer networking, mentorship, prototyping facilities, and access to early-stage funding.

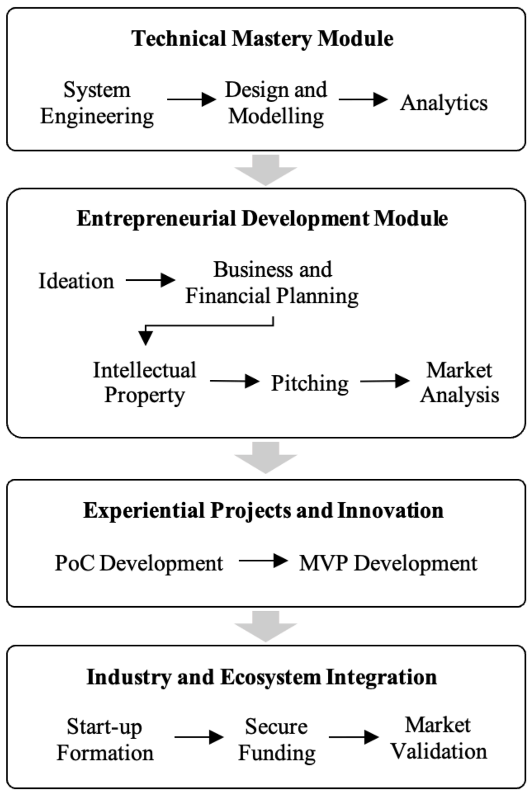

FIGURE 3. PKAS' Technopreneurial Framework Components

EVOLUTION OF THE PROGRAM STRUCTURE

Initially established as a postgraduate upskilling initiative in 2016, PKAS operated as a self-funded model under the System Intelligence Lab (SIL), allowing for flexible curriculum design and resource autonomy. Recognizing the limitations of isolated skills training, the program expanded in 2018 to integrate technopreneurship and innovation culture across other academic levels including undergraduates, diploma holders, and even secondary school students in STEM outreach efforts.

This inclusive expansion restructured the program to be modular, scalable, and adaptive, accommodating varying academic levels while maintaining a consistent emphasis on applied learning and entrepreneurship. The program's flexible architecture also supports customized delivery, enabling integration into coursework, research training, or extracurricular enrichment.

OUTCOMES AND IMPACT: EVIDENCE FROM A DECADE OF IMPLEMENTATION

Since its inception in 2016, PKAS has evolved from a postgraduate competency-building initiative into a national model for technopreneurship education that spans multiple education levels. The program's decade-long implementation offers valuable insights into the measurable impact of integrating technical education with entrepreneurial development in higher learning institutions.

SKILLS TRANSFORMATION AND COMPETENCY DEVELOPMENT

One of the most notable impacts of PKAS has been the significant upskilling of students in system engineering and analytics, particularly in areas such as modeling, simulation, and digital system design. Alumni assessment data reveal improved confidence and competence in applying complex technical skills to solve interdisciplinary problems. These skills have not only contributed to academic excellence but also enhanced students' preparedness for roles in high-technology sectors and R&D environments.

ENTREPRENEURIAL READINESS AND INNOVATION OUTPUT

Since 2018, the inclusion of technopreneurship modules has led to the emergence of student-led start-up projects and innovation prototypes addressing real market needs. Key metrics include:

1. 243 individuals from TVET as stated in Table 1 from various level and institution innovation projects completed, many of which were presented at university and national-level competitions.
2. A significant number of UKM and other both the public and private university students from undergraduate, masters and PhD do participate in various activities related to innovation and product development over the last 10 years as evident in products and talent development.
3. Establishment of three student-founded startups incubated through PKAS's innovation and entrepreneurship ecosystem.
4. Participation of PKAS students in national entrepreneurship programs such as KHAZANAH - SICA, SUPERB, and MRANTI HealthTech Design Thinking Workshop.
5. Increased student participation in grant competitions like CREST Fastrack, CRADLE and MyLab.

TABLE 1. PKAS' Framework TVET Participations

Program	Participants	Projects
Technopreneurship Bootcamp	54 (TVET Trainers & Students)	30 MVP Innovations
TVETpreneurs Program	47 (School & TVET Students)	14 MVP Innovations
Technopreneurship Program	142 (TVET Students)	14 MVP Innovations

These outputs demonstrate the program's success in bridging academic learning with practical application, preparing students to navigate both engineering and business development landscapes.

ECOSYSTEM AND STAKEHOLDER ENGAGEMENT

PKAS has also contributed to strengthening the university's innovation ecosystem. It has fostered long-term collaborations with industry partners, NGOs, and funding agencies. These partnerships have enhanced students' exposure to market realities, mentorship opportunities, and post-graduation pathways in the innovation economy.

1. Collaborations with Newport Technologies Sdn Bhd, BRAINet (M) Sdn Bhd, and CREST have enabled real-world project sourcing.
2. PKAS alumni have continued as research officers, assistants, innovators, and tech consultants under various university-industry linkage programs.

The program has also reached secondary school students and diploma holders through outreach and pre-university interventions, expanding the innovation mindset to younger learners and non-traditional university audiences.

INSTITUTIONAL RECOGNITION AND REPLICABILITY

The sustained outcomes of PKAS have led to institutional recognition at UKM by OpenGov Innovation Award in 2019 & 2022 as a model for disruptive innovation in education.

LESSONS LEARNED AND FUTURE DIRECTIONS

A decade of implementing PKAS at UKM has offered critical insights into both the potential and limitations of integrating technopreneurship within engineering education. These insights can inform institutional strategies and national education reforms aimed at producing innovation-ready graduates.

KEY LESSONS LEARNED

1. Bridging Theory and Practice Requires Intentional Design: PKAS has shown that bridging academic theory with market-driven innovation is possible when curriculum and co-curriculum are intentionally designed for experiential, interdisciplinary, and project-based learning. Passive knowledge delivery must give way to active engagement in problem-solving contexts that simulate real-world complexity.
2. Entrepreneurial Mindset Is Cultivated, Not Inherited: Embedding entrepreneurial competencies across all student levels rather than treating them as niche electives has proven effective in normalizing innovation culture. Students who initially lacked business acumen developed entrepreneurial confidence through structured training, coaching, and applied exposure.
3. Self-Funded, Modular Models Enhance Sustainability: The self-funded origin of PKAS allowed for flexibility, autonomy, and innovation in program design. Its modular, low-cost model also proved scalable and replicable across faculties with varying capacities, suggesting a viable strategy for institutions with budget constraints.
4. Institutional Support and Policy Alignment Are Crucial: Sustaining technopreneurship education demands more than programmatic success, it requires alignment with institutional priorities, national policies, and reward systems. PKAS flourished because it was integrated into UKM's broader strategic initiatives and supported by leadership committed to educational transformation.

FUTURE DIRECTIONS

Scaling to a Multi-Institutional Platform: There is growing interest in adapting PKAS across other Malaysian universities and vocational institutions. Plans are underway to establish a national technopreneurship consortium, where institutions can co-develop, co-deliver, and co-evaluate innovation modules under a shared framework.

Deepening Industry Integration: Future iterations of PKAS will enhance real-time industry engagement through live problem briefs, co-mentorship, industrial sabbaticals for students, and venture acceleration pathways. Stronger alignment with Malaysia's National Technology and Innovation Sandbox (NTIS) and MRANTI is being explored.

Embedding Policy and Curriculum Influence: Insights from PKAS are being used to shape curriculum guidelines and policy dialogues on future-ready education, especially in engineering, computer science, and applied sciences through collaboration between both foreign and local institutions. The program aspires to contribute to the design of national technopreneurship education blueprints by 2030.

Research and Evidence-Based Development: Moving forward, PKAS will formalize its impact measurement framework, incorporating longitudinal tracking of graduate outcomes, start-up performance, and innovation output. This will strengthen evidence-based decision-making and support its potential as a case study in higher education transformation.

CONCLUSION AND POLICY IMPLICATIONS

PKAS offers a compelling case of how technopreneurship can be purposefully integrated into engineering education to meet the demands of a digital and innovation-driven economy. Over the past decade, PKAS has evolved from a postgraduate skills enhancement initiative into a scalable and adaptable model that bridges academic knowledge with entrepreneurial practice, aligning closely with Malaysia's strategic education and economic policies such as MyDIGITAL, the Malaysia Education Blueprint, and the Twelfth Malaysia Plan.

The outcomes of PKAS demonstrate that structured technopreneurship education rooted in experiential learning, interdisciplinary collaboration, and industry engagement can enhance the employability, innovation capacity, and entrepreneurial readiness of graduates. The program's success underscores the need to rethink traditional engineering education, moving beyond theory-based instruction toward dynamic, problem-based learning that fosters real-world impact.

POLICY IMPLICATIONS

Curriculum Reform: Policymakers and university leaders should institutionalize technopreneurship as a core competency within engineering and STEM education, not merely as an elective or add-on. Embedding entrepreneurship within technical disciplines ensures students are equipped to navigate complexity and lead innovation.

Funding and Incentive Structures: Flexible, modular programs like PKAS thrive under sustainable, decentralized funding models. National policies should incentivize innovation-driven, student-led initiatives through micro-grants, innovation vouchers, and performance-based rewards.

Multi-Stakeholder Collaboration: Ministries, universities, industries, and innovation agencies must co-create educational ecosystems that support student innovation pipelines, from idea to incubation. PKAS provides a replicable template for such collaboration, particularly in resource-limited settings.

Evidence-Based Policy: The decade-long implementation of PKAS offers a valuable dataset for policy benchmarking, curriculum innovation, and institutional strategy. Continuous evaluation and longitudinal tracking should guide future investments and reforms in technopreneurship education.

CONCLUSION

In sum, PKAS illustrates the potential of bridging purpose and practice in higher education. Its journey affirms that with visionary leadership, structured innovation pathways, and responsive pedagogy, universities can lead the transformation toward a knowledge-based, innovation-powered future.

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DECLARATION OF COMPETING INTEREST

None.

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