ADVANCING INTEGRATED STEM EDUCATION IN TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING (TVET)

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Abstract

SEAMEO STEM-ED envisions a future-ready workforce in Southeast Asia equipped with STEM (Science, Technology, Engineering, and Mathematics) competencies critical for Industry 4.0, automation, and artificial intelligence (AI). In collaboration with the International Labour Organization (ILO), SEAMEO STEM-ED introduced the Bangkok Statement on Integrated STEM Education in TVET to align Technical and Vocational Education and Training (TVET) systems with evolving labour market demands. At the heart of this initiative is a strong emphasis on curriculum integration, industry collaboration, teacher capacity building, and inclusive STEM education, recognising these as essential pillars for equipping learners with relevant skills. The Bangkok Statement underscores the urgency of harmonising STEM competencies within TVET systems to ensure they remain responsive to workforce needs. Informed by expert discussions, pre-summit webinars, and regional policy frameworks such as the ASEAN Work Plan on Education 2021–2025 and the SEAMEO Strategic Plan 2021–2030, this initiative drives policy alignment, fosters public-private partnerships, and implements innovative pedagogies. Through regional cooperation and best practices, SEAMEO STEM-ED and ILO aim to cultivate a resilient, future-ready workforce that supports sustainable development and economic growth in the digital era.

Keywords: STEM in TVET, STEM Policy in TVET, Policy Recommendations

1. Introduction

The global shift towards automation, artificial intelligence (AI), and the digital economy demands urgent reform in education systems, particularly in Technical and Vocational Education and Training (TVET). Recognising this need, the Bangkok Statement on Integrated STEM Education in TVET presents a comprehensive vision for aligning STEM competencies with industry demands. This article elaborates on the Bangkok Statement's recommendations, supported by insights from pre-summit webinars and expert discussions, to propose actionable strategies for preparing a future-ready workforce in Southeast Asia. These strategies align with key frameworks, including the ASEAN Work Plan on Education 2021–2025 (ASEAN Secretariat, 2021), the SEAMEO Strategic Plan 2021–2030 (SEAMEO Secretariat, 2021), the GEM Report 2023 (UNESCO, 2023), the World Economic Forum's Future of Jobs Report (World Economic Forum, 2023), the World Bank's workforce development initiatives (World Bank, 2023), and SEAMEO VOCTECH's contributions to regional TVET innovation (SEAMEO VOCTECH, 2024).

The ASEAN Secretariat's Work Plan on Education 2021–2025 closely aligns with the Bangkok Statement on STEM Education in TVET (SEAMEO STEM-ED, 2024), which emphasises the integration of STEM (Science, Technology, Engineering, and Mathematics) into TVET to enhance workforce readiness for Industry 4.0. Key initiatives supporting this alignment include the following:

a. **Strengthening Business-Industry Collaboration**:
The ASEAN Future Workforce Council (AFWC), established in 2019, reinforces partnerships between education providers and industries. This directly supports the Bangkok Statement's call for synergising TVET curricula with labour market demands and emerging technologies.

b. **Curriculum Alignment with STEM Competencies**:
The International Labour Organization's (ILO) STEM in TVET Curriculum Guide advances the Bangkok Statement's vision by mapping STEM competencies to TVET programmes. This ensures students gain industry-relevant competencies, fostering regional economic growth and resilience.

c. **Promoting Regional Workforce Mobility**:
The ASEAN-ROK TVET Mobility Programme, funded by the ASEAN-Korea Cooperation Fund, supports the Bangkok Statement by addressing skills gaps and fostering cross-border collaboration. This initiative helps equip learners with digital and STEM skills vital for a dynamic, interconnected labour market.

The World Economic Forum's Future of Jobs Report 2023 (World Economic Forum, 2023) highlights significant shifts in the global labour market, emphasising the critical role of STEM (Science, Technology, Engineering, and Mathematics) competencies in adapting to these changes. The report indicates that technological advancements and the green transition will likely create 69 million new jobs by 2027 while displacing 83 million positions, resulting in a net loss of 14 million jobs.

To navigate this evolving landscape, the report underscores the importance of reskilling and upskilling, noting that 44% of workers' competencies are expected to be disrupted within the next five years (Angela Elzir and Matteo Morgandi, 2024).

This aligns with the Bangkok Statement on STEM Education in TVET by SEAMEO STEM-ED, which advocates for integrating STEM into Technical and Vocational Education and Training (TVET) to equip the workforce with competencies essential for Industry 4.0.

While the World Bank's World Development Report 2023 (World Bank Group, 2024) focuses on migration and its developmental impacts, the World Bank has also addressed the importance of digital literacy and skills in workforce development. A World Bank report (Angela Elzir and Matteo Morgandi, 2024) emphasises that the digital economy is expanding rapidly, necessitating a workforce proficient in digital and STEM skills to meet new job demands.
These insights from the World Economic Forum (2023) and the World Bank (2023) reinforce the objectives of the Bangkok Statement, underscoring the necessity of integrating STEM education into TVET programmes to develop a workforce capable of thriving in a rapidly evolving job market.

2. Insight from Global Perspectives of International Organisation

2.1 STEM Competencies: A Regional Framework for Workforce Readiness

A harmonised understanding of STEM competencies is crucial for effectively integrating them into TVET curricula across ASEAN. Establishing standardised definitions ensures consistency and enhances regional collaboration. The ASEAN Work Plan on Education 2021-2025 emphasises regional cooperation to address skills gaps and foster innovation. Additionally, it underscores the need to harmonise qualifications and skills recognition frameworks across ASEAN to enhance mobility and employability. SEAMEO VOCTECH (SEAMEO VOCTECH,

2024) has been instrumental in developing regional competency standards and conducting baseline studies to identify critical skill gaps, ensuring that STEM education addresses the demands of the Fourth Industrial Revolution. For instance, the ILO's Women in STEM Workforce Readiness and Development Program (International Labour Organization, 2017) demonstrates how targeted capacity-building initiatives can align STEM education with labour market needs.

2.2 Government-Industry Collaboration

Partnerships between governments, educational institutions, and industries play a crucial role in ensuring TVET programmes remain relevant. The World Economic Forum's Future of Jobs Report stresses that partnerships are critical for aligning curricula with emerging skills demands in AI, robotics, and green technologies. SEAMEO VOCTECH's initiatives in establishing public-private partnerships (PPPs) have supported the co-design of training programmes tailored to industry needs, such as apprenticeships and cooperative education models. Work-based learning programmes and internships complement these partnerships by bridging the gap between theoretical knowledge and practical application, thereby enhancing employability (SEAMEO VOCTECH, 2024).

2.3 Teacher Training and Support

Empowering TVET educators through professional development is critical. Teachers must receive continuous training in emerging technologies and pedagogical strategies. Programmes integrating micro-credentials, industry exposure, and mentorship will empower educators to deliver high-quality STEM education. SEAMEO VOCTECH's regional training programmes, which focus on enhancing the digital and pedagogical competencies of TVET trainers, align with the SEAMEO Strategic Plan 2021-2030 and underscore the importance of equipping educators with tools for innovation and inclusion (SEAMEO VOCTECH, 2024).

2.4 Innovative and Inclusive STEM Education

Ensuring equal access to STEM education for disadvantaged groups is essential for inclusivity. Scholarships, gender-sensitive curricula, and targeted mentorship programmes are effective strategies for reducing barriers to participation. The GEM Report 2023 (UNESCO, 2023) highlights the need to address gender disparities in STEM fields through systemic reforms and tailored interventions. SEAMEO VOCTECH's community-based training initiatives (SEAMEO VOCTECH, 2024), which prioritise marginalised groups and underrepresented communities, further underscore the importance of inclusive approaches. Promoting creativity and innovation within TVET curricula enhances students' ability to tackle complex challenges in technology-driven careers. For instance, integrating problem-solving projects and digital simulations promotes innovation while addressing local development challenges.

2.5 Challenges and Best Practices

The 2023 Global Education Monitoring (GEM) Report (UNESCO, 2023) examines the role of technology in education, highlighting both its potential benefits and challenges. The report emphasises that while technology can enhance access to educational resources, particularly for marginalised groups, it also has the potential to exclude individuals from poorer backgrounds if not implemented thoughtfully.

Integrating STEM into TVET presents several challenges, including infrastructure gaps, limited teacher qualifications, and rigid curricula. Addressing these challenges requires:

a. **Infrastructure Development:** Investments in modern facilities, reliable internet access, and advanced equipment are critical for effective STEM training. The World Bank's initiatives on education financing offer valuable insights into overcoming such challenges by focusing on scalable solutions for resource-constrained environments. SEAMEO VOCTECH's support for e-learning platforms and blended learning models provides additional avenues for mitigating infrastructure limitations (SEAMEO VOCTECH, 2024).

b. **Flexible Curricula:** Adaptive curricula that respond to technological changes enable timely updates and skill acquisition. The SEAMEO Strategic Plan also underscores the importance of embedding future-ready skills into curricula (SEAMEO Secretariat, 2023).

c. **Regional Collaboration:** Platforms for sharing best practices foster innovation and cohesion among ASEAN member states. This aligns with the ASEAN Work Plan's emphasis on collaborative capacity-building and shared standards (ASEAN Secretariat, 2023).

In parallel, the International Labour Organization (International Labour Organization, 2016) has released several key messages in 2023:

a. **Global Unemployment Trends**: The ILO reports that global unemployment remained at a historical low of 5% last year and is projected to stay the same through 2025. However, disparities persist, with youth unemployment notably higher at 12.6%. The ILO underscores the need for new approaches to social justice, including investments in education and leveraging migrant remittances to stimulate job creation in developing countries.

b. **Value of Essential Work**: The ILO's "World Employment and Social Outlook 2023" report calls for a revaluation of key workers' roles to better reflect their social contributions. It advocates for increased investment in essential sectors to ensure the sustainability of critical services, especially in light of challenges highlighted by the COVID-19 pandemic.

These insights from the GEM Report and the ILO highlight the importance of integrating technology thoughtfully in education and addressing labour market challenges through comprehensive social policies. Along with the **SEAMEO Strategic Plan 2021–2030** highlights STEM and TVET as critical pillars for regional development. Key statements include:

a. **Programme Excellence and Alignment with SDGs**: The plan emphasises advancing STEM and TVET education to address skills gaps, promote innovation, and align with SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth). This ensures youth are prepared for Industry 4.0 and the rapidly evolving job market.

b. **Digital Transformation for Rapid Change**: The integration of digital technologies into STEM and TVET programmes is prioritised to enhance teaching and learning, bridging the gap between educational outcomes and industry demands.

c. **Strategic Partnerships and Networking**: SEAMEO fosters collaboration with industry, governments, and educational institutions to strengthen STEM and TVET curricula, ensuring they remain relevant to emerging trends and technologies.

SEAMEO STEM-ED and SEAMEO VOCTECH are committed to advancing STEM in TVET to build a future-ready workforce equipped with critical skills for sustainable development and economic growth in Southeast Asia. At the forefront of this effort, SEAMEO STEM-ED and SEAMEO VOCTECH can play a pivotal role by either initiating new programmes or expanding

existing SEAMEO VOCTECH initiatives such as: a) **Regional TVET Leadership** which drives STEM integration into TVET by offering specialised training, research, and consultancy services tailored to the needs of Southeast Asian countries; and b) **SEA-VET.NET** as this platform consolidates best practices and innovations in TVET, emphasising STEM education's role in fostering regional collaboration and knowledge-sharing among policymakers and educators.

This aligns with the SEAMEO Strategic Plan 2021–2030 and directly supports the Sustainable Development Goals (SDGs), ensuring that regional education and workforce development contribute to global sustainability efforts. Key connections include:

SDG 4 – Quality Education:

- SEAMEO STEM-ED's emphasis on integrating STEM into TVET fosters equitable access to quality education that equips learners with the technical and digital skills needed for Industry 4.0.
- SEAMEO VOCTECH's training programmes and SEA-VET.NET platform enhance capacity-building for educators, ensuring inclusive and quality education across Southeast Asia.

SDG 8 – Decent Work and Economic Growth:

- By aligning TVET curricula with labour market demands, SEAMEO supports youth employability and lifelong learning, addressing skills gaps critical for economic growth.
- STEM-focused TVET promotes entrepreneurship and innovation, fostering job creation in emerging sectors such as green technologies and digital economies.

SDG 9 – Industry, Innovation, and Infrastructure:

- SEAMEO VOCTECH and SEAMEO STEM-ED facilitates the development of STEM competencies that drive innovation and industrial advancement in Southeast Asia.
- Digital transformation in TVET aligns with sustainable infrastructure development, ensuring students are prepared for technologically advanced industries.

SDG 17 – Partnerships for the Goals:

- SEAMEO STEM-ED and SEAMEO VOCTECH actively engage in cross-sectoral partnerships with industries, governments, and international organisations to advance STEM in TVET and achieve regional and global education goals.

2.6 The Way Forward

The Bangkok Statement's recommendations (SEAMEO STEM-ED, 2024) provide a roadmapfor advancing integrated STEM education in TVET. Key actions include:

a. Developing a joint regional strategic plan that incorporates baseline research, curriculum development, and resource allocation, reflecting the goals outlined in the SEAMEO Strategic Plan and ASEAN Work Plan. This includes sector-specific plans targeting industries like green energy and ICT.

b. Establishing regional guidelines for STEM competencies to standardise and harmonise practices across ASEAN, consistent with global trends highlighted in the World Economic Forum's Future of Jobs Report. SEAMEO VOCTECH's ongoing efforts in developing competency frameworks provide valuable reference points.

c. Enhancing teacher training programmes and expanding industry partnerships to support the integration of cutting-edge technologies in TVET curricula. Leveraging digital platforms for training delivery ensures wider access and scalability.

d. Promoting inclusive policies to ensure underrepresented groups, particularly women, have access to STEM opportunities, addressing equity concerns noted in the GEM Report 2023 and the ASEAN Work Plan. SEAMEO VOCTECH's community-based initiatives further this goal by delivering tailored training programmes.

3. Conclusion

Integrating STEM into TVET is essential for equipping Southeast Asia's workforce with the skills needed for the Fourth Industrial Revolution. Collaborative efforts among governments, industries, and educational institutions are crucial to overcoming challenges and achieving sustainable development. By implementing the recommendations of the Bangkok Statement and aligning with frameworks such as the ASEAN Work Plan, the SEAMEO Strategic Plan, and global reports, ASEAN countries can build resilient, inclusive, and future-ready TVET systems that drive regional growth and innovation.

Embedding STEM in TVET empowers Southeast Asian learners with future-ready skills, promotes lifelong learning, and strengthens regional resilience in alignment with the SDGs. This strategic focus ensures that education serves as a catalyst for sustainable economic and social development.