

THE SOUTHEAST ASIA SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) EDUCATION LANDSCAPE STUDY

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ABSTRACT

The SEAMEO Regional Centre for Science, Technology, Engineering, and Mathematics Education (SEAMEO STEM-ED) is dedicated to strengthening capacities in STEM education across Southeast Asia. It serves as a regional knowledge repository by conducting high-quality research in STEM education and generating evidence-based practices, solutions, and policy recommendations. The Southeast Asia STEM Education Landscape Study offers an extensive analysis of STEM education in the Southeast Asian region, focusing on key domains such as major roles responsible for STEM education, policies related to STEM education, curriculum and teaching pedagogies, and capacity building programmes. The research also examines various STEM initiatives, projects, and programmes across the region. This study highlights the crucial role of governments, academic institutions, and industries in driving STEM education, emphasising fostering partnerships and collaboration to ensure effective policy implementation, resource allocation, and curriculum development. The study concludes with recommendations for fostering innovation and ensuring that STEM education in Southeast Asia is responsive to global trends, aligned with the Sustainable Development Goals (SDGs), and equipped to meet the challenges of a rapidly evolving technological landscape. By examining the status of STEM education in different countries in Southeast Asia, the study identifies areas for improvement and highlights best practices in STEM education that can be adapted in various contexts.

Keywords: Southeast Asia, Science, Technology, Engineering, and Mathematics (STEM) Education, Landscape Study, SEAMEO STEM-ED

1. Introduction

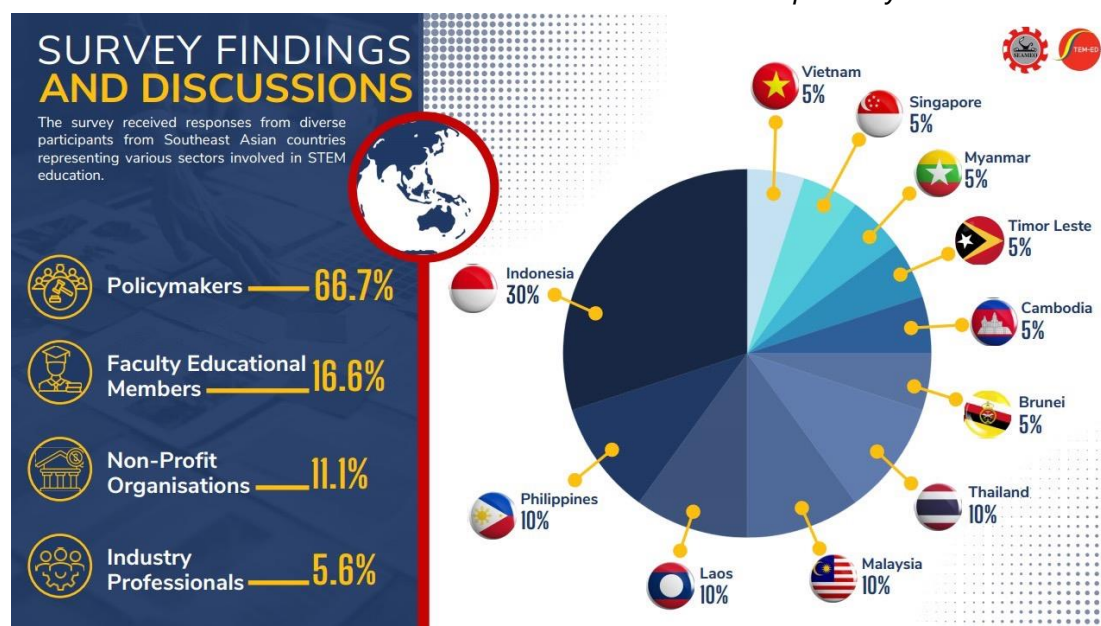
The Southeast Asia region is well-known for its wide range of geographical, political, economic, and religious diversity between and within the countries in the region. Recognising the diverse nature of the STEM education landscape in Southeast Asia, Recognising the varied nature of STEM education across the region, the SEAMEO Regional Centre for Science, Technology, Engineering, and Mathematics Education (SEAMEO STEM-ED) conducted the Southeast Asia STEM Education Landscape Study. This comprehensive analysis explores key aspects such as ecosystem roles, relevant policies, curriculum integration, and the current state of STEM initiatives. The study also delves into the contributions of public-private partnerships and the development of resources to support STEM education. These insights will assist policymakers in amplifying STEM education efforts across diverse regional contexts.

The research methodology involved collecting data from diverse participants, including policymakers, faculty educational members, non-profit organisation members, and industry professionals across Southeast Asia. An online survey was developed and distributed to the Ministries of Education (MOE) of SEAMEO member countries. Each MOE assigned

respondents to complete the survey by providing relevant data and insights. Furthermore, data from SEAMEO centres were utilised as a part of the triangulation technique. By employing this approach, a comprehensive understanding of the STEM education landscape across the region can be achieved.

The survey received responses from diverse participants from Southeast Asian countries representing various sectors involved in STEM education. Policymakers comprised 66.7% of the sample, followed by faculty educational members at 16.6%, non-profit organisations at 11.1%, and industry professionals at 5.6%. Geographically, most participants were from Indonesia (30%), followed by the Philippines (10%), Laos (10%), Malaysia (10%), Thailand (10%), Brunei (5%), Cambodia (5%), Timor-Leste (5%), Myanmar (5%), Singapore (5%) and Vietnam (5%). Figure 1 shows the percentage distribution of respondents included in the study.

Figure 1: The Percentage Distribution of Respondents in the Southeast Asia STEM Education Landscape Study



2. Insights from the Study

2.1 Significant Roles and Countries Policy Related to STEM Education

STEM education in Southeast Asia has experienced significant growth with key stakeholders playing essential roles in shaping and promoting its growth. Government agencies, academic institutions, industry partners, and non-governmental organisations (NGOs) are instrumental in creating an ecosystem that fosters innovation and equips students with the necessary skills for the future. These roles are reflected in the comprehensive policies and frameworks developed across the region to address the demand for STEM professionals, ensure educational inclusivity, and align curricula with global and regional needs. Government agencies play a central role in implementing STEM education programmes, while universities and research institutions contribute through curriculum development and research. NGOs and the private sector offer outreach programmes and real-world learning experiences. From the collected data, countries like Brunei, Malaysia, the Philippines, and Indonesia have developed specific STEM initiatives led by the ministry, often in collaboration with relevant organisations.

Private sectors support STEM education through funding and partnerships with educational institutions to provide real-world learning experiences for learners. Collaboration with industry partners is essential for delivering real-world context and relevance to STEM education. Singapore, Thailand, and Vietnam, in particular, have established frameworks to integrate STEM education across various levels, emphasising cross-disciplinary learning and problem-solving skills with industry partners.

International organisations provide funding, technical expertise, and networking opportunities, fostering regional collaboration. The result is an integrated ecosystem where each role's contributions support the socio-economic development and global competitiveness in the region. International organisations, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the United Nations International Children's Emergency Fund (UNICEF), for instance, provide critical support to strengthen STEM education infrastructure and capacity in several countries, including Myanmar, Cambodia, Laos, and Timor-Leste. This collective effort aims to equip Southeast Asian students with 21st-century skills, ensuring their readiness for the global workforce and fostering innovation-driven economic growth.

A review of STEM education policies across Southeast Asia reveals a strong emphasis on improving standards, capacity building programmes, teacher training, and collaboration with industries to enhance learning outcomes. For instance, Brunei and Malaysia are focusing on comprehensive reforms that integrate STEM subjects into their national education systems, with Brunei incorporating STEAM elements into its National Education System for the 21st Century (SPN 21), and Malaysia's policies, the 60:40 Science/Technical to Arts initiative, aimed at boosting student interest and teacher competency in STEM. The Philippines has integrated STEM into its broader economic and social transformation plans, while Indonesia's *Kurikulum Merdeka* adopts STEM teaching methodologies to promote critical competencies through project-based learning.

In other Southeast Asian countries, STEM education remains a key priority. Singapore's Applied Learning Programme (ALP) and STEM Inc. have been successful in fostering hands-on, practice-oriented STEM learning. Thailand's initiatives, including Thailand 4.0 and the National Education Plan, seek to integrate STEM into early childhood education. Other examples are Cambodia's New Generation Schools framework, which supports STEM education through governance reforms, and Myanmar's National Education Strategic Plan, which aims to increase STEM graduates and enhance curricula for employability. Likewise, Vietnam has progressively introduced the STEM model in its schools, highlighting the region-wide commitment to fostering critical thinking, creativity, and problem-solving skills to prepare students for future challenges in a rapidly evolving world.

2.2 STEM Curriculum Practices and Capacity Building Programme

In Southeast Asia, countries actively develop and implement innovative STEM curriculum practices and pedagogical approaches to equip students with essential skills for future STEM careers. Each country tailors its STEM initiatives to address specific needs and challenges, moving beyond traditional rote learning to embrace hands-on experimentation, interdisciplinary connections, and real-world applications. For instance, Brunei's National Education System focuses on preparing students as creative, innovative citizens, while Singapore's STEM Inc. Programme integrates STEM concepts across multiple subjects, emphasising practical learning experiences. Similarly, Thailand and Malaysia incorporate STEM into their curricula, focusing on project-based and problem-based learning and interdisciplinary approaches that encourage collaboration among science, technology, and mathematics.

The emphasis on STEM education extends across the region, with various countries introducing curriculum reforms and pedagogical methods to foster critical thinking and problem-solving skills. Indonesia's Kurikulum Merdeka simplifies the curriculum to focus on essential competencies through project-based learning. At the same time, the Philippines and Vietnam apply STEM models in primary and secondary education to enhance practical skills and problem-solving abilities. Timor-Leste and Myanmar also advance STEM education by integrating STEM subjects into national curricula and improving educational resources and teacher training. Overall, the region's commitment to a holistic STEM education approach highlights the importance of critical thinking, creativity, and technology skills in preparing students for future challenges.

Capacity building programmes in STEM education are essential for advancing educational development across Southeast Asia. Effective STEM education depends on well-trained educators who can inspire and engage students. To address this need, various programmes and initiatives have been launched throughout the region to enhance teachers' pedagogical skills, content knowledge, and confidence. Governments, educational institutions, and NGOs invest in teacher training programmes, modern pedagogical approaches, and resource access to ensure educators are well-prepared to foster the next generation of STEM professionals. For example, Singapore's National Institute of Education offers comprehensive professional development through its STEM Inc. Programme. Additionally, Brunei's collaboration with Universiti Brunei Darussalam focuses on supporting teachers with practical and real-world STEM applications.

Across Southeast Asia, countries are addressing teacher capacity challenges with tailored programmes. In the Philippines, the ACE Teaching programme enhances STEM competencies through ICT integration and professional development. Malaysia offers various training programmes, including inquiry-based and project-based learning approaches, improving teacher confidence and student engagement. Thailand's initiatives, supported by organisations like the Institute for the Promotion of Teaching Science and Technology (IPST) and the National Science and Technology Development Agency (NSTDA), emphasise hands-on and inquiry-based methods. Meanwhile, Cambodia, Timor-Leste, and Laos face resource limitations but are making strides through international support and localised projects to enhance STEM education in underserved areas. Myanmar is also advancing its STEM education by upgrading teacher training and infrastructure. Overall, these diverse capacity-building efforts highlight the commitment to improving STEM education quality through targeted teacher development and resource enhancement.

2.3 Resources and Development Adoption in STEM Education

Adopting resources and development in Southeast Asia is a critical factor in ensuring the success of STEM education. Access to quality resources, such as digital tools, laboratories, and teaching materials, directly impacts students' ability to engage with the learning process. The availability and accessibility of educational materials, laboratory equipment, digital tools, and online platforms are crucial for delivering a well-rounded STEM education. Various countries in the region have adopted different approaches based on their economic development, educational policies, and infrastructure capabilities. For instance, Brunei has introduced the STEAM Programmes Guidebook to promote inquiry-based learning, while Malaysia uses the Digital Educational Learning Initiative Malaysia (DELIMA) for online STEM learning resources.

Another significant development in STEM resource adoption is the investment by Singapore in STEM resources by the STEM Inc and the programme and interactive centres by the Science Centre Singapore. In addition to these efforts, other Southeast Asian countries have developed specific initiatives to enhance STEM education. In the Philippines, efforts to

enhance STEM education include projects like the Greening Programme in Green Schools Curriculum, training pedagogy, and content for Artificial Intelligence (AI). Indonesia's Merdeka Mengajar Platform offers extensive resources for teachers, encouraging teachers to learn independently from provided materials and improve STEM education quality, including curriculum reform, teacher training, and establishing STEM centres nationwide.

Moreover, Thailand incorporates digital tools and platforms such as ThaiMOOC, which offers free online STEM courses, and DLTV, which provides pre-recorded science lessons and teacher training materials. Cambodia uses the Learning Management System (LMS) to provide online content. Cambodia's STEM education efforts include providing a similar LMS based on *Moodle* of ITC. This initiative helps develop and record online teaching and learning content in the studio and upload it into the *Moodle* platform.

Furthermore, Vietnam's STEM Resource Centre Initiative aims to improve access to educational technology, while Myanmar focuses on integrating modern resources and online learning platforms into its STEM education framework. These digital resources help bridge the gap between theory and practice, giving students hands-on experience with STEM applications, even in resource-constrained environments. The diverse approaches illustrate the region's commitment to improving STEM education by ensuring students and educators access essential tools and resources in a rapidly evolving technological landscape.

2.4 STEM Initiatives, Events, Programmes and Activities

STEM initiatives across Southeast Asia are diverse and aimed at fostering student and educator engagement in STEM fields through various programmes, events, and projects. These initiatives, including competitions, workshops, and hands-on activities, are designed to cultivate a skilled STEM workforce and promote a culture of innovation and entrepreneurship. For example, Brunei's STEM initiatives include national competitions and industry collaborations like the Seria Energy Lab and Malaysia's Ministry of Education organises projects such as the STEM Executive Consultation and STEM Carnival.

Another significant initiative in STEM education is conducted by Singapore to support STEM aspirations through national challenges and awards. Through this competition, students are encouraged to apply their STEM knowledge to develop solutions in areas such as environmental sustainability, healthcare, and technological advancements. It fosters collaboration and cross-cultural exchange among participants, highlighting the importance of innovation and problem-solving skills in addressing the region's challenges.

In addition, the Philippines hosts events, including the National Festival of Talents and supports regional STEM hubs to enhance the STEM education initiatives in the country. Thailand's STEM landscape also features events like the National Science and Technology Fair and the World Robot Olympiad, alongside initiatives like the STEM Ambassadors programme and the FABLAB Thailand project. Integrating digital resources and establishing physical spaces such as Malaysia's Digital Makers Hub and Vietnam's STEM Resource Centres reflect a commitment to enhancing a conducive STEM learning space in the country.

Based on the findings, Southeast Asia has seen a surge in STEM initiatives, events, programmes, and projects to promote STEM education across the region. These efforts are supported by public-private partnerships and collaborations with international organisations, which are crucial for providing quality resources and infrastructure. Overall, these initiatives collectively contribute to enriching STEM education and preparing students for future challenges and opportunities.

2.5 Regional Partnerships and Collaboration in STEM Education

Regional partnership and collaboration are crucial for advancing STEM education across Southeast Asia. Recognising the importance of innovation and educational opportunities, countries in the region actively work with governments, academic institutions, industries, and non-profit organisations. These collaborations enhance the reach and effectiveness of STEM initiatives by pooling resources and expertise. For instance, Brunei's STEAM Outreach programme and its partnership with the University of East Anglia focus on broadening STEM access and developing teacher skills. Collaborations between academic institutions in the region also drive innovation and research in STEM education.

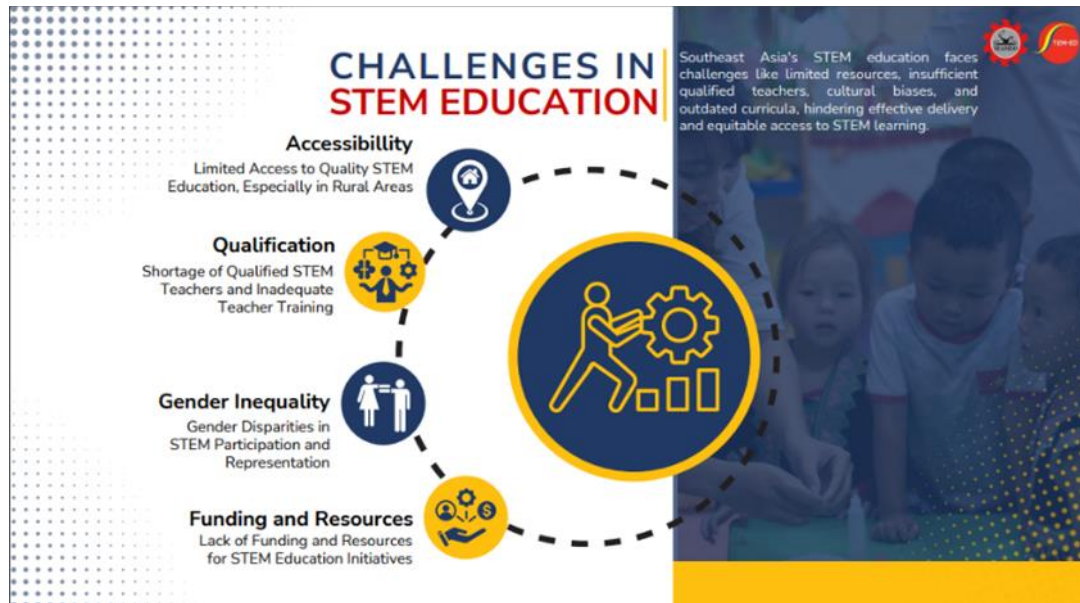
Other countries also demonstrate strong collaborative efforts in promoting STEM education. The STEM4ALL: STEM Street programme conducted in Malaysia, engages various stakeholders to improve STEM education and career guidance, while the Philippines relies on partnerships with industry leaders and NGOs to support equitable access and policy development. Indonesia's partnership with the US Agency for International Development (USAID) aims to develop a new STEM learning model. Singapore's ecosystem benefits from a combination of top-down strategies and grassroots efforts, with active involvement from both industry and non-profit organisations. The partnerships ensure that Southeast Asian students are well-prepared for the demands of the global job market while also fostering innovation and entrepreneurship within the region.

Another collaboration is Thailand's Chevron Enjoy Science project and Cambodia's Cyber University Network, which exemplify regional and institutional collaborations that foster STEM education. *Girls in STEM* programme in Timor-Leste and the industry-academic partnerships in Myanmar further highlight the commitment to inclusivity and practical experience among the countries. A key feature of these partnerships is the exchange of best practices in STEM pedagogy, curriculum development, and teacher training. Vietnam's collaboration with the British Council and initiatives like Proposal A, emphasise the importance of gender inclusivity and adapting successful methods. The collaboration gives access to global expertise that informs the development of locally relevant STEM education strategies. These partnerships strengthen Southeast Asia's STEM education landscape, ensuring a robust, collaborative, and innovative learning environment.

3. Challenges in Southeast Asia's STEM Education

Despite significant growth potential, STEM education in Southeast Asia faces several challenges that hinder its advancement. Figure 2 represents the highlighted key themes of the STEM education challenges in Southeast Asia. One of the primary issues is the disparity in educational resources and infrastructure between urban and rural areas. A major obstacle is the disparity in resources, which affects both funding and equipment. Many schools across the region struggle with limited access to essential resources such as laboratory equipment, computers, and reliable internet connections. The lack of modern technology and well-equipped laboratories restricts students' ability to engage in practical, hands-on STEM activities, leading to an uneven quality of STEM education.

Figure 2: Key Themes of the STEM Education Challenges in Southeast Asia



In addition to resource constraints, Southeast Asia contends with a shortage of qualified STEM teachers and inadequate training for current educators. The lack of sufficient training and professional development in STEM subjects leads to many teachers not fully equipped to deliver engaging and effective lessons. This shortage creates a major issue, preventing the region from meeting the growing demand for skilled STEM educators and further impeding the delivery of quality STEM education. Furthermore, cultural biases and stereotypes, particularly those affecting girls, also discourage certain groups from pursuing STEM careers. Socioeconomic barriers and geographic isolation contribute to limited access to quality STEM education, particularly in rural and marginalised communities.

Another significant challenge is restricted funding, which impacts the ability to enhance STEM education programmes effectively. Many Southeast Asian countries struggle with limited educational budgets, which restricts their ability to invest in modern STEM resources, technology, and teacher training. This lack of financial support can lead to outdated curricula, insufficient teaching materials, and inadequate educator professional development. Securing increased funding from governmental and private sources is crucial for overcoming these limitations and ensuring schools have the necessary resources to deliver high-quality STEM education. By addressing these barriers and encouraging broader participation, Southeast Asia can develop a more diverse and innovative STEM workforce that reflects the region's full potential.

4. Recommendations for STEM Education in Southeast Asia

Several strategic recommendations can be implemented to enhance STEM education in Southeast Asia and address the existing challenges. First and foremost, increasing investment in STEM infrastructure is crucial. Governments and private sector partners should allocate more resources to build and upgrade laboratories, provide modern digital tools, and ensure that schools have access to current teaching materials. This investment should be targeted not only at urban areas but also at rural and underserved areas to bridge the resource gap and ensure equitable access to quality STEM education.

Another critical recommendation is to enhance teacher training and professional development programmes. Educators need ongoing support to stay current with the latest teaching methodologies, technologies, and industry trends. Establishing comprehensive training programmes that include in-service and pre-service training can help teachers effectively deliver STEM content and engage students. Additionally, fostering partnerships with universities and international organisations can provide teachers with access to global best practices and innovations in STEM education.

Updating and aligning STEM curricula with industry needs is also essential. Curricula should be regularly reviewed and revised to incorporate emerging technologies, industry requirements, and real-world applications. Engaging industry partners in curriculum development can ensure that educational content remains relevant and prepares students for the current job market. Furthermore, integrating interdisciplinary approaches and project-based learning can make STEM subjects more engaging and applicable to real-life problems, thus enhancing student motivation and learning outcomes.

Promoting diversity and inclusion in STEM education is another key recommendation. Efforts should be made to address gender disparities and support underrepresented groups pursuing STEM careers. Initiatives such as targeted scholarships, mentorship programmes, and outreach activities can help encourage broader participation in STEM fields. Creating a supportive and inclusive learning environment can also help retain students from diverse backgrounds and foster a more innovative and dynamic STEM community. By implementing these recommendations, Southeast Asia can strengthen its STEM education system and better prepare its youth for future challenges and opportunities.

5. Summary

The Southeast Asia STEM Education Landscape Study provides a comprehensive overview of the current state and prospects of STEM education in the region. It highlights significant investments and initiatives to improve STEM education, including infrastructure development, digital resources, and updated curricula. The study emphasises the critical role of partnerships and collaborations between governments, academic institutions, industry, and international organisations in advancing STEM education. These collaborations help align curricula with industry needs, enhance teacher training, and integrate modern technologies into the classroom. The findings serve as a roadmap for policymakers, educators, and stakeholders to foster a more innovative and inclusive STEM education landscape.

Overall, the study underscores the need for a coordinated approach to strengthen STEM education in Southeast Asia. The region can build a robust STEM ecosystem that prepares students for future challenges and opportunities by enhancing infrastructure, updating curricula, and investing in teacher development. Integrating STEM education with the Sustainable Development Goals (SDGs) can address regional challenges and promote sustainable development by incorporating real-world problems into the curriculum. Promoting diversity, addressing gender disparities, and fostering an entrepreneurial mindset are crucial for maximising the region's talent pool. Southeast Asia can build a robust STEM ecosystem by focusing on digital literacy and innovation, empowering students to become future leaders and innovators. Despite challenges, these strategies offer a path to Southeast Asia's more dynamic and competitive STEM education landscape.