



Research Report (4 September 2024)

The Southeast Asia Science, Technology, Engineering, and Mathematics (STEM) Education Landscape Study

Overview of the Southeast Asia Science, Technology, Engineering, and Mathematics (STEM) Education Landscape Study:

The SEAMEO Regional Centre for STEM Education (SEAMEO STEM-ED) aims to develop, maintain and continuously strengthen capacities in STEM education, serving as a regional knowledge repository and creator through high-quality research in STEM education, both within Southeast Asia and from around the world, in a way that builds evidence of good practices, experiments and demonstrates pragmatic solutions, and guides effective policy formulation and capacity building of policymakers, professionals, and practitioners. This guiding statement was established due to identified STEM challenges in Southeast Asia.

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. The variations and insights from the different contexts will enable insights into how STEM education initiatives have been assessed, adapted, and developed in highly complex and diverse contexts.

The Southeast Asia STEM Education Landscape Study offers an extensive analysis of STEM education in the Southeast Asian region. Recognising the dynamic nature of the STEM education landscape, the Southeast Asia STEM Education Landscape Study offers an extensive analysis of STEM education in the Southeast Asian region by exploring current challenges, opportunities, and trends. Examining the status of STEM education across Southeast Asian countries, the study aims to identify areas for improvement and propose strategies to enhance STEM education. Considering each country's diverse contexts and circumstances, the study aims to uncover common themes, best practices, and opportunities for collaboration in the region.

Consequently, the study's findings will be instrumental in establishing a comprehensive Five-Year Development Plan (FYDP) 2025/2026 – 2029/2030 for SEAMEO STEM-ED, ensuring robust support for the continuous improvement of STEM education in Southeast Asia.

Research Background and Significant:

The Southeast Asia STEM Education landscape study report provides an overview of the status of STEM education in the Southeast Asia region. A strategic plan for the landscape study has been formulated to outline the vision, mission, values and critical themes for each vital issue area and approach. The report also provides recommendations, feedback, and regional support regarding funding, resources, and collaboration among Southeast Asian countries.

The significant insights from the study serve as invaluable guidance for the team responsible for implementing the STEM program in Southeast Asia countries. These findings will aid in crafting a holistic, integrated STEM education curriculum tailored for the educators in STEM education. Moreover, the findings of the research study, underpinned by evidence-based methodologies, furnishes policymakers with a potent approach for amplifying the STEM education landscape and nurturing 21st-century STEM proficiencies among learners.

The research report and its key findings can greatly contribute to the 2nd SEAMEO STEM-ED FYDP 2025/2026 – 2029/2030 by providing valuable insights, evidence-based recommendations, and data-driven strategies tailored to address regional needs and strengthen STEM education in Southeast Asia.

Purpose of the Study:

The Southeast Asia STEM Education Landscape Study provides an extensive analysis of STEM education in the Southeast Asian region. The study aims to develop, maintain, and continuously strengthen capacities in STEM education. It serves as a regional knowledge information and inputs in STEM education, leveraging insights from Southeast Asia countries. This working paper aims to report the Southeast Asia STEM Education Landscape Study findings, which offers an extensive analysis of STEM education in the Southeast Asian region.

Research Objectives:

This study aims to provide a comprehensive overview of the Southeast Asia STEM education landscape. The specific objectives of this study encompass the following dimensions to:

- I. study the current state of STEM education in Southeast Asia
- II. identify significant actors involved in the STEM education ecosystem.
- III. explore the various STEM initiatives, levels of awareness, support mechanisms, and opportunities for STEM education in the region.

Issues to Study:

- I. Major Actors and roles
- II. STEM Curriculum, Integration, and Initiatives

- III. Public-Private Partnerships in STEM Education
- IV. Future Outlook and Recommendations for Regional Cooperation in STEM Education

Research Questions:

The following are the research questions for the Southeast Asia STEM education landscape study:

1. What are the roles and contributions of major actors, including government bodies, educational institutions, industry partners, and NGOs, in promoting STEM education across Southeast Asia?
2. What are the existing policies related to STEM education in Southeast Asian countries, and how do they impact the development and implementation of STEM education programs?
3. How is the implementation and integration of the STEM education curriculum into the educational system?
4. What are the current strategies and programs for building the capacity of STEM educators in Southeast Asia?
5. What are the various STEM programmes, projects, activities, and initiatives implemented in Southeast Asia, and how do they contribute to promoting STEM education and fostering students' interest in STEM education?
6. How are resources developed and adopted to support STEM education in Southeast Asian countries?
7. What are the roles and contributions of public-private partnerships in promoting STEM education in Southeast Asia, and how do they facilitate the development and implementation of STEM initiatives?
8. What are the future trends and challenges in STEM education in Southeast Asia, and what recommendations can be proposed for enhancing regional cooperation to address these challenges and promote STEM education across the region?

Research Methodology:

For this study, a structured questionnaire was designed to collect data on various aspects of STEM education, including significant actors involved in the STEM education ecosystem, STEM curriculum, integration and initiatives, public-private partnerships in STEM education, resources, challenges, future outlook and recommendations for regional cooperation in STEM education. The survey link was shared with educators, policymakers, industry professionals, and other relevant Southeast Asian stakeholders related to STEM education. The survey remained open for responses over eight weeks. Responses were analysed using qualitative methods to identify trends, patterns, and insights regarding STEM education in the region.

Sample Size

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%).

Data Collection:

An online survey was conducted using Google Form and distributed to the Ministries of Education (MOE) of SEAMEO Member Countries. Each MOE assigned two to three respondents who will be requested 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.

Research Instrument:

The research team has created the Southeast Asia STEM Education Landscape Study survey using Google Forms. The research survey encompasses the following domains and survey items:

I. Demographic Information:

1. Which Southeast Asian country are you currently located in?
2. What is the name of your department/institute/organisation?
3. What is your role and responsibility within your organisation?
4. How many years of experience do you have in STEM education?

II. Major Actors in Countries' STEM Ecosystem

- Please provide up to 5 organisations responsible for STEM education in your country.
 1. Please give the name of the organisation.
 2. Please identify the type of identified organisation that plays significant roles in promoting and advancing STEM education and initiatives in your country:
 - a. Government agencies:
 - b. Corporations:
 - c. Foundations:
 - d. Non-government Organisations (NGOs):
 - e. International Organisations
 - f. School/Universities
 3. Briefly describe the roles of each identified agency or organisation in promoting STEM education initiatives in your country.

III: STEM Curriculum, Integration, and Initiatives

1. The implementation and Integration of STEM Education Curriculum into the Educational System

- a. Does your country have a national curriculum that incorporates STEM concepts?
 - b. If yes, please provide details on the subjects covered within the curriculum.
 - c. What pedagogical approaches and teaching methods are employed to instruct STEM subjects in your country? For example, are project-based learning, problem-based learning, or other innovative methodologies utilised?
 - d. Are there any co-curricular or extracurricular activities conducted to complement the core STEM curriculum? Please provide information on these supplementary activities aimed at enhancing students' engagement and comprehension of STEM concepts.
2. Implementation of other STEM education initiatives in your country
- a. **STEM Education Teacher Capacity Building Programmes**
 - What STEM teacher training programmes are currently offered in your country?
 - b. **STEM Resources Development and Adoption**
 - Do your countries develop STEM resources such as textbooks, learning modules, educational technologies, and online learning platforms? If yes, please provide details of the resources.
 - Do your countries adopt STEM resources from external organisations or other countries? If yes, please provide details about the specific resources adopted.
 - How does your country utilise technology and digital platforms in STEM education to enhance the learning experience?
 - c. **FABLAB/Maker Space Establishment**
 - Are there any dedicated facilities, such as FABLABs or Maker Spaces, established to facilitate hands-on learning experiences and promote innovation in STEM?
 - If yes, please provide information about the locations of these facilities and the types of equipment and resources they offer to support STEM education and creativity.
 - d. **Career Aspiration/Inspiration Programme**
 - Are there any programmes or initiatives implemented to inspire and cultivate STEM career aspirations among students in your country?
 - If yes, please provide details about the nature and objectives of these programmes, including any notable outcomes or success stories that have emerged as a result.
 - e. **Competitions**

What STEM events (eg: competitions/ campaigns, etc.) are conducted in your country to encourage student participation and showcase their skills and knowledge? Please provide notable examples of STEM events, including their goals and impacts.

V. Public-Private Partnerships in STEM Education:

1. Are there any existing collaborations between educational institutions and private sector organisations in your country to promote STEM education?
2. What types of support or contributions do private sector organisations provide? (Eg: funding, mentorship, internships, or other resources)

VI: Future Outlook and Recommendations for Regional Cooperation in STEM Education

1. In your opinion, what areas require improvement or changes to enhance STEM education in your country?
2. What suggestions do you have for strengthening collaboration between countries in the region to promote and advance STEM education?

The link to the survey form and QR code is <https://forms.gle/BF1yxEi199qcg15H8>



Research Ethics

In order to protect the participants in the research, the researcher followed the research ethics protocol. Participants were informed about the purpose of the survey and provided their consent before participating. Responses were kept confidential, and no identifying information was collected. Participation in the survey was voluntary, and participants could withdraw at any time without penalty. Measures were taken to ensure data security through Google Forms, including password protection and restricted access.

The study aimed to contribute positively to understanding STEM education in Southeast Asia. Findings from the research may inform educational policies, programs, and practices to enhance STEM education initiatives in the region, ultimately benefiting students, educators, and communities.

This report presents the research process, methodology, and findings transparently and accurately. Any conflicts of interest or biases were acknowledged and addressed. The study's limitations were clearly articulated to provide readers with a comprehensive understanding of the research's scope and implications.

Research Limitations

While this report provides valuable insights into the current state of STEM education in Southeast Asia, it is essential to acknowledge certain limitations that may affect the

interpretation and generalisability of the findings. Firstly, data availability and reliability posed significant challenges. Data availability and consistency varied among countries, which may have influenced the depth and accuracy of the analysis.

The STEM education landscape is dynamic, and it is important to gather the most recent information and insights to accurately understand the current state of STEM education in Southeast Asia. The study's sample primarily consisted of educators, policymakers, and stakeholders who were accessible and willing to participate, potentially introducing sampling bias. This may have limited the representativeness of the findings, particularly if certain groups or regions needed to be represented.

Lastly, while the study examined STEM education policies, it did not delve deeply into the implementation and effectiveness of these policies. Understanding the gap between policy formulation and implementation could provide further insights into the challenges and opportunities in STEM education. Addressing these limitations is essential for accurately interpreting the findings and guiding future research efforts to explore these areas in more depth.

Timeline of Study:

2024								
Research activities/Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1. Concept Note Development	X	X						
2. Research questions development		X						
3. Sharing concept notes and surveys to MOE and SEAMEO Centres			X					
4. Data collection			X	X				
5. Data analysis (Content analysis and triangulation)					X	X		
6. Preliminary key findings (Presentation and discussion)						X	X	
7. Reporting							X	
8. Dissemination								X

Data Analysis

The collected data was analysed using content analysis to extract meaningful insights and patterns related to STEM education in Southeast Asia. This analysis helps identify key themes, challenges, successful practices, and opportunities for improvement in the region.

Results and Discussion on STEM Education Landscape in Southeast Asia:

A: Significant Actors and Roles in Countries' STEM Education Ecosystem

STEM education in Southeast Asia has seen significant development in recent years, driven by various actors and initiatives. Multiple actors play crucial roles in shaping the STEM ecosystem, including governments, educational institutions, industry partners, non-governmental organisations (NGOs), and international organisations in Southeast Asia. These significant actors in each Southeast Asian country's STEM ecosystem collaborate to promote STEM education, research, and innovation, contributing to the region's socio-economic development and global competitiveness.

Based on the findings from the study, government agencies play a crucial role in implementing programs that directly impact education quality, including developing policies, allocating resources, and implementing programs to improve STEM curriculum and teacher training. Educational institutions, including universities and research centres, contribute to improving STEM education standards through curriculum development, teacher training, and research initiatives. Research institutions contribute to advancing knowledge and innovation in STEM education through research and development activities. Professional associations play a role in advocating for STEM education and supporting educators' professional development.

NGOs organise outreach programs, provide resources, and advocate for STEM education, particularly in underserved communities. Additionally, private sector companies support STEM education through funding and partnerships with educational institutions to provide real-world learning experiences for learners. International organisations provide technical expertise, funding, and networking opportunities to support STEM education initiatives in Southeast Asia. Collaboration with industry partners is essential for delivering real-world context and relevance to STEM education.

The Ministry of Education of Brunei takes the lead in driving STEM education initiatives. The Science Technology Environment Partnership Centre (STEP Centre) supports the Ministry in promoting STEAM Education Towards Innovation Through the Implementation of High-Value STEAM Programs. STEP Centre provides STEAM skills and STEAM-related training and coaching for students and teachers. This initiative supports effective STEAM learning and motivates more schools to engage in STEAM-based activities and programs provided by or through the STEP Centre, which collaborates with industry partners to offer STEM programs and research opportunities.

In Malaysia, the Ministry of Science, Technology and Innovation (MOSTI) promotes STEM education and careers through various outreach programs, awareness campaigns, and initiatives targeted at students, parents, educators, and the general public. The Ministry of Higher Education (MoHE) works towards promoting STEM education initiatives within Malaysia's higher education sector to nurture a skilled workforce capable of driving innovation and technological advancements in the country. The Ministry of Education of Malaysia oversees the STEM policies, activities and programmes supported by educational institutions like the National STEM Association (NSA), which provides a

platform for STEM activities that encourage students to engage in STEM education. NSA aims to promote interest in STEM among students at all levels, improve teaching and learning methods in STEM education, foster innovation and creativity in classrooms, recognise excellence in STEM programs and personnel, and support the development of innovative and competitive human capital within the STEM ecosystem.

The Department of Education (DepEd) and the Department of Science and Technology (DOST) in the Philippines, supported by educational institutions including the University of the Philippines National Institute for Science and Mathematics Education Development (UP NISMED), lead STEM initiatives supported by academic institutions collaborating with industries to offer STEM programs and research projects. The Center for Integrated STEM Education, Inc. (CISTEM) is the most representative STEM agency and has significantly organised STEM programmes and initiatives. Industry partners support schools and universities through partnerships to organise STEM activities and programmes and provide resources for educators.

The Ministry of Education, Culture, Research, and Technology of Indonesia plays a central role in promoting STEM education nationwide. Educational centres like the SEAMEO Centres in Indonesia collaborate with industries to offer STEM programs and research projects. The industry partners support STEM education through various initiatives, such as scholarships, internships, resources and opportunities for Indonesian students to pursue STEM education.

The Ministry of Education in Singapore drives STEM education policies, supported by the Multi-centric Education Research and Industry STEM Centre at the National Institute of Education (meriSTEM@NIE). The Centre's work is guided by the Integrated STEM Instructional and Evaluation Framework, used to inform the design of integrated lesson packages for teachers and students. The centre's mission is to enhance the quality of STEM literacy in Singapore through cross-disciplinary research, teaching, and outreach partnerships. The meriSTEM@NIE is the first STEM centre in Singapore to engage in research, research-informed STEM education, and evidence-based STEM education outreach.

The Institute for the Promotion of Teaching Science and Technology (IPST) is important in implementing STEM education in Thailand. IPST define STEM education in Thailand as an educational approach that integrates STEM by focusing on problem-solving in daily life and professional undertaking. IPST states that STEM learning organisations should employ an integrated approach to teaching and learning, link multidisciplinary to real life and work, focus on critically demanded twenty-first-century skills, challenge students, and give opportunities for students to share their ideas. The Southeast Asian Ministers of Education Organization Regional Centre for STEM Education (SEAMEO STEM-ED) serves as a regional knowledge centre for education personnel and embodies a strong commitment to elevating regional education standards through research, experiments, education resources development, and policy advocacy of Southeast Asian STEM education.

In Vietnam, the Ministry of Education and Training directs STEM education policies with the support of higher institutions, which provide opportunities for STEM programmes and research. Industry partners support STEM education through partnerships with schools and universities to organise STEM activities, programmes and competitions for students.

The Ministry of Education of Myanmar drives STEM education policies and offers STEM programs and research opportunities. The Goethe-Institut of Myanmar, the Cultural Institute of the Federal Republic of Germany, the Department of Alternative Education, and the Ministry of Education of the Government of the Republic of the Union of Myanmar to work together towards the development of education multimedia resources and platforms for STEM-Vocational oriented learning in Myanmar.

In Timor-Leste, the Ministry of Education primarily leads the development of STEM education. The Ministry collaborates with educational institutions to develop STEM programs and research opportunities. Additionally, the government is supported by international organisations like UNESCO, which provides funding and expertise to improve STEM education in the country.

The Ministry of Education, the Government of the Republic of the Union of Myanmar, has put forth several key initiatives and strategies to promote STEM education in the country. These include the National Education Strategic Plans (2016-2021) and (2021-2030), which lay the groundwork for enhancing education quality and relevance across all levels. The policy framework outlined demonstrates a clear commitment to advancing STEM education through strategic planning, curriculum development, and targeted goals to enhance the country's STEM education and vocational training opportunities.

In Cambodia, the Ministry of Education, Youth, and Sport (MOEYS) plays a central role, spearheading national strategies to integrate STEM into the curriculum and improve educational standards. Notably, the New Generation Schools initiative by MOEYS focuses on promoting STEM education and research in higher education, aiming to cultivate a new wave of critical thinkers and innovators. The Secondary Resource Schools emphasise project-based learning, engaging students in STEM disciplines through hands-on experiences. NGOs such as STEM Cambodia and organisations like UNESCO and UNICEF support these efforts by providing resources, teacher training, and community engagement programs.

The Ministry of Education and Sports (MOES) of Laos plays a pivotal role in leading national efforts to integrate STEM into the education system, focusing on curriculum development and teacher training to improve the quality of STEM instruction. International organisations like UNESCO and UNICEF provide vital support through funding, resources, and expertise, helping bridge educational infrastructure and capacity gaps. Higher education institutions, including the National University of Laos, are essential in advancing STEM research and offering specialised training programs. Additionally, partnerships with private sector companies and international donors foster innovation and practical learning, equipping students with the skills necessary for the modern workforce.

In summary, the effectiveness of STEM education initiatives in Southeast Asia is influenced by various actors who play key roles in shaping policies, implementing

programs, and fostering collaboration within the STEM education ecosystem. These actors and their respective roles interact within the ecosystem of STEM education in Southeast Asia, contributing to the region's efforts to develop a skilled workforce and promote innovation and economic growth. Together, these actors are working towards equipping Southeast Asian youth with the skills and knowledge needed to thrive in the 21st-century global economy growth.

B: Countries Policy Related to STEM Education

Understanding the content of the Southeast Asia STEM landscape study is aided by a brief review of the policy practices related to STEM education across Southeast Asia. A thorough analysis of the STEM education policy in Southeast Asia countries indicates that a growing emphasis has been placed on developing the standard of STEM education provided to all students, ensuring that STEM education is offered to high standards, and enacting comprehensive reforms. These policies encompass a range of strategies aimed at improving STEM curriculum, teacher training, infrastructure, and industry collaboration.

In embracing the elements of STEM, the MOE of Brunei Darussalam is committed to providing an educational system in The National Education System for the 21st Century (SPN 21) that prepares the young generation for future roles as capable, creative, thinking and innovative citizens who would uphold the local social values inherent in the national philosophy embedded in Brunei's national philosophy *Melayu Islam Beraja* or Malay Islamic Monarch (MIB) concept. Moreover, integrated learning across different subject disciplines focuses on acquiring skills in Science, Technology, Arts and Mathematics (STEAM) and, for example, applying skills obtained through ICT and Science classes to produce output in Design and Technology classes.

Within Southeast Asia, the Malaysian government is committed to ensuring STEM education is on par with other developed countries. It is highlighted in *Malaysia Educational Blueprint 2013-2025* (MEB) with a 60:40 Science/Technical: Arts (60:40) Policy, which projected a 60 per cent Science/ Technical ratio against 40 per cent of Arts. This policy is based on the 1967 Statement Report of the Higher Education Planning Committee, and the agenda aims to strengthen STEM education to boost students' interest and teachers' competency in teaching STEM subjects. The National Science, Technology and Innovation Policy (NSTIP) 2021-2030 is also related to STEM as a continuation of previous policies in utilising and advancing science and technology to drive the growth of an innovation-based economy.

The Philippines STEM education initiatives were spurred by the continuous Philippine Development Plan 2023, a plan for profound economic and social transformation to reinvigorate job creation and accelerate poverty reduction by steering the economy back on a high-growth path. The PDP identifies the role of science, technology, and mathematics in attaining outcomes in three sectors: education, service, research, and development. The Education sector focuses on achieving globally competitive and inclusive higher education and attaining improved study for a broader knowledge economy. To do this, the Philippines designed and implemented TVET programs that are

ready for the future, building on the gains of enhanced science, technology, engineering, and mathematics strands.

In Indonesia, introducing *Kurikulum Merdeka* to emancipate learning: transforming the overambitious curriculum into a more straightforward, emancipating curriculum that adopts the STEM way of teaching, focusing on essential competencies, using differentiated approach, and employing project-based learning. The *Merdeka Belajar* focuses on emancipating learning, empowering teachers, evaluating the system, and engaging with technology. The learning achievement of each STEM subject focuses on scientific reasoning and attitude rather than the content knowledge breadth.

Singapore is renowned for its strong emphasis on STEM education, supported by initiatives like The Applied Learning Programme (ALP), which was started by MOE Singapore in 2013 to promote more authentic and practice-oriented learning experiences for students. The STEM ALP is one of the most popular school programmes, which could cover STEM, languages, humanities, business, entrepreneurship, aesthetics, and other subjects. *The Science, Technology, Engineering, Mathematics Innovation and Creativity, or Incorporation (STEM Inc.)* was established in January 2014 to support STEM education in schools. STEM Inc. was charged with the mandate to ignite students' passion for STEM, and they play a solid supporting role in the STEM ALP in secondary schools. Schools can engage STEM Inc. to conduct STEM ALP lessons in their schools or at the Science Centre Singapore.

STEM education was one of the Ministry of Education's priorities in Thailand. The Thailand government has introduced initiatives to advance STEM education including the Thailand 4.0 policy and the Science, Technology, Engineering, and Mathematics Education Development Plan. Despite these efforts, challenges such as limited funding, bureaucratic obstacles, and a lack of stakeholder coordination remain. Strategic investments, policy reforms, and collaborative efforts are essential to effectively implement STEM education initiatives and maximise their impact. The Ministry of Education prioritised STEM education in the Thai National Education Plan, starting from early childhood education to incorporate science, math, and technology into the curriculum. Various organisations, including corporations, NGOs, schools, and universities, contribute to driving and promoting STEM education in Thailand.

Within the Cambodian context, the STEM Policy in Cambodia (2016) creates suitable conditions to encourage environments for developing students' abilities in science, technology, engineering, and mathematics. The plan provides a framework for developing and implementing science, technology, engineering and mathematics at all levels. Under the new policy defining New Generation Schools, the government can make intensive investments in such schools under conditions that ensure high standards of good governance. New Generation Schools follow precedents in other countries where some public schools receive greater autonomy from the state to stimulate educational innovation.

The Ministry of Education of the Government of the Republic of the Union of Myanmar launched the National Education Strategic Plan (2016-2021) and the National Education

Strategic Plan (2021-2030). The education system applies advanced education technologies to support learning design and delivery and produces graduates from leading-edge STEM programs. One of the aims is to increase the number of graduates from leading-edge STEM programmes and review and improve curricula at Higher Education, Research and Innovation (HEI) to enhance graduate employability through 21st-century competencies and STEM education, research and innovation.

In Vietnam, the STEM education model was officially applied to grade 6 for the first time in the 2021-2022 school year and to grade 10 in the 2022-2023 school year. The STEM education model, a world-renowned early education approach, is now widely applied in Vietnamese schools. The Government of Vietnam has piloted the STEM education program in several provinces and cities since 2017, with many places now officially selecting and widely applying this model.

Overall, STEM education policies often emphasise the integration of STEM subjects into the curriculum from an early age, as well as adopting prioritising student-centred learning, inquiry-based learning, creativity, and hands-on learning approaches to foster critical thinking and problem-solving skills. Furthermore, there is a growing emphasis on including digital literacy and computational thinking in STEM education to prepare students for the digital age. The region's focus on policy in STEM education reflects a commitment to preparing future generations for the challenges and opportunities in STEM education in Southeast Asia.

C: STEM Curriculum Practices and Teaching Pedagogical Approaches

In Southeast Asia, countries actively develop and implement STEM curriculum practices and teaching pedagogical approaches to equip students with the skills needed for future emerging STEM careers. Each Southeast Asian country is shaping its STEM education initiatives to meet the unique needs and challenges of its STEM education system. These initiatives encompass a variety of curriculum practices and teaching pedagogical approaches aimed at fostering critical thinking, problem-solving skills, and creativity among students.

In recent years, Southeast Asian countries have been actively developing and implementing STEM curriculum practices beyond traditional rote learning, emphasising hands-on experimentation, interdisciplinary connections, real-world applications, inquiry-based learning, project-based learning, and collaborative learning. These are just a few examples of the innovative strategies from the responses used to engage students and foster a deeper understanding of STEM concepts.

For example, in 2007, His Majesty of Brunei consented to establishing a vision for the country called *Wawasan Brunei 2035* of the National Education System for the 21st Century (SPN 21). In Embracing the elements of STEM, MOE Brunei is committed to providing an educational system that prepares the young generation for future roles as capable, creative, thinking and innovative citizens who would uphold the local social

values inherent in the national philosophy embedded in the *Malay Islamic Monarchy or Melayu Islam Beraja* (MIB) concept.

One prominent curriculum practice in Singapore is the integration of STEM concepts across multiple subjects, known as interdisciplinary learning. For example, in secondary schools, the *STEM Inc. Programme* integrates STEM concepts into the curriculum, emphasising hands-on learning and real-world applications. Through interdisciplinary projects and activities, students explore connections between different subject areas, such as designing sustainable solutions for environmental challenges in science class, incorporating mathematical modelling, and using technology to simulate real-world scenarios.

Thailand's Basic Education Core Curriculum integrates STEM concepts within science and technology subjects. At the primary school level, it includes biological science, physical science, and earth and space science. At the secondary school level, it incorporates technology indicators. IPST has developed additional STEM subjects for upper primary and lower secondary school levels, with annual instruction at the primary level and semester-based instruction at the secondary level, totaling 40 hours. These subjects aim to enhance students' understanding and application of STEM principles. Pedagogical methods in STEM education in Thailand include project-based and problem-based learning. These methods involve creating scenarios where students use their knowledge of science, mathematics, and technology to solve problems, often focusing on issues within their own communities.

Malaysia's STEM curriculum emphasises interdisciplinary learning and problem-solving skills. The curriculum encourages collaboration between science, mathematics, and technology subjects. The Design and Technology subject is offered to primary and secondary school students. This subject focuses on four domains: design appreciation, technology application, product manufacturing, and product design assessment. Students apply their knowledge and skills through design activities and produce meaningful products. The learning involves the application of STEM knowledge, skills and values to solve problems in the context of daily life, society and the environment.

In the Philippines, primary education consists of four interrelated STEM fields, with three learning areas: science, mathematics, technology, and livelihood education. The Engineering component is represented by the Engineering Design Process, which is articulated in various learning standards where learners are expected to apply different concepts to solve real-world problems. Though *Science, Mathematics and Technology and Livelihood Education* (TLE) are distinct and separate, they are interrelated. The STEM Technical-Vocational-Livelihood (*STEM-TVL*) hybrid curriculum enables learners to navigate science and engineering courses. This track calls out to eligible students with subjects focused on job-ready skills.

Introducing *Kurikulum Merdeka* to Indonesia's curriculum emancipate learning, the initiative transforms the curriculum into a simpler, more emancipating one that adopts the STEM way of teaching: focusing on essential competencies, using a differentiated approach, and employing project-based learning. *Merdeka Belajar* focuses on four main

elements: Emancipate Learning, Empower teachers, Evaluate the System, and Engage with Technology. Currently, the curriculum is offered as optional to schools, and schools in Indonesia are opting to adopt the curriculum at three different implementation levels. The learning achievement of each subject focuses on scientific reasoning and attitude rather than the content knowledge breadth.

The Applied Learning Programme (ALP) was started by the MOE Singapore in 2013 to promote more authentic and practice-oriented learning experiences for students in Primary (Grades 1-6, aged 7-12) and Secondary schools (Grades 7-10, aged 13-16). Among the ALP, which could cover STEM, languages, humanities, business, entrepreneurship, aesthetics, and so on, STEM ALP is one of the most popular programmes in schools. STEM Inc. was charged with the mandate to ignite students' passion for STEM, and they play a solid supporting role in the STEM ALP in secondary schools. They have STEM lesson packages that can be used in the classrooms during the STEM ALP lessons. Schools can engage STEM Inc. to conduct STEM ALP lessons in their schools or at the Science Centre Singapore.

The government of Myanmar acknowledges the significance of STEM education in advancing sustainable development objectives. In recent years, the government has shown an increased awareness of this fact, demonstrated by increased funding and robust support for STEM initiatives. Spearheaded by the MOE, initiatives aimed at improving the STEM landscape in the country include upgrading laboratories to meet contemporary standards, providing modern teaching tools, and implementing comprehensive training programs for educators.

In Vietnam, the STEM education model, a world-renowned early education approach, is widely applied in Vietnamese schools. The STEM education model was officially applied to grade 6 for the first time in the 2021-2022, and to grade 10 in the 2022-2023 school year. The Government of Vietnam has piloted the STEM education program in several provinces and cities since 2017, with many places now officially selecting and widely applying this model.

Recognising that a strong foundation in STEM education is vital for the nation's development, Timor-Leste is taking proactive actions. The Ministry of Education, Youth, and Sports (MEYS) of Timor-Leste is taking steps to integrate STEM subjects into the national curriculum, recognising their importance for the country's future growth.

In general, STEM education is more than just a set of subjects; it is a holistic approach to learning that fosters critical thinking, problem-solving, and creativity. Most of the curriculum incorporates hands-on learning, inquiry-based methods, real-world application and interdisciplinary integration to reinforce theoretical STEM concepts. This approach aims to cultivate critical thinking, problem-solving, and collaboration skills among students. Additionally, there's a growing focus on digital literacy and computational thinking, reflecting the region's recognition of the importance of technology in today's world. The curriculum integrates technology, such as computer programming and robotics, from the elementary level. Teachers are encouraged to use technology, with resources such as online simulations and virtual laboratories. Moreover, the pedagogical

approaches employed by educators vary widely, reflecting a diverse range of teaching philosophies and methodologies in the Southeast Asia region.

D: STEM Education Teacher Capacity Building Programme

Teacher capacity building in STEM education is crucial to educational development in Southeast Asia. Effective STEM education relies on well-trained and equipped teachers who inspire and empower students to excel in these fields. Across Southeast Asia, various capacity-building programmes aim to enhance teachers' pedagogical skills, content knowledge, and confidence in delivering STEM education. Governments, educational institutions, and NGOs in the region are investing in various initiatives to improve teacher training programs, pedagogical approaches, and access to resources to ensure educators are well-equipped to inspire and educate the next generation of STEM professionals.

Singapore has been at the forefront of teacher capacity building in STEM education. The National Institute of Education (NIE) offers professional development programmes for teachers, such as the *STEM Inc. Professional Development Series*. These programmes provide hands-on training, resources, and best practices for integrating STEM concepts into the curriculum. Additionally, the programme equips teachers with advanced knowledge and skills in STEM pedagogy. There are project-based approaches and some integrated STEM activities that focus on STEM thinking in subjects. Students also have opportunities to take up independent projects at different levels.

In Brunei, in 2013, a four-year Universiti Brunei Darussalam (UBD) and MOE research-practice partnership focused on Twenty-First Century Teaching and Learning (21CTL) was initiated with the support of a significant grant from the Brunei Research Council (BRC) to cultivate teachers' engagement with SPN21. This teacher development project, working with consultant SRI International, engaged 150 teachers in developing approaches to teaching that could support the aims of the new national curriculum. Through partnerships with industry stakeholders and universities, the programme provides teachers with hands-on experience and exposure to real-world applications of STEM concepts.

Another notable initiative addressing the need for teacher capacity building in STEM education is the Philippines' Advancing Competence for Effectiveness in Teaching (ACE Teaching), focusing on Mathematics, Languages, and Science Enrichment of competencies, including the ones for STEM across the curriculum in all key stages. The teachers' training includes teaching and learning materials development training of national, regional, and divisional trainers on providing teachers with relevant, up-to-date, and appropriate content, pedagogical knowledge, and instructional strategies and levelling Up ICT Competencies through an ICT-Enabled Teaching (LICIT). The program aims to empower teachers through workshops and policies on using and integrating Information and Communications Technology (ICT) in teaching and learning.

In Malaysia, Inquiry-based Science Education, Inquiry-Based Mathematics Education, STEM Executive Consultation, Project-Based Learning, Coding Programs for Design and Technology Subject teachers, and Implementation Guide For Science, Technology, Engineering And Mathematics (STEM) In Teaching And Learning, MOE (2016) are several teachers training programmes and had a profound impact on both teachers and students. These capital-building programmes provide professional development opportunities for teachers to enhance their pedagogical skills and content knowledge in STEM subjects. As a result, participating teachers reported increased confidence and motivation in teaching STEM, improving student engagement and performance. Moreover, the programmes have facilitated the implementation of innovative teaching practices and project-based learning approaches, which have sparked students' interest in STEM careers.

Similarly, the Multi-centric Education Research and Industry STEM Centre at the National Institute of Education (meriSTEM@NIE) in Singapore plays a crucial role in teacher preparation and the provision of professional and school leadership development programmes. meriSTEM@NIE is a research centre within NIE. The centre's mission is to enhance the quality of STEM literacy in Singapore through cross-disciplinary partnerships in research, teaching, and outreach so that future generations of educators, learners, and citizens can harness relevant STEM knowledge and skills in addressing current and emerging challenges for themselves and others.

Thailand focuses on improving teacher capacity in STEM education through various initiatives. This programme provides intensive training in STEM pedagogy, curriculum design, and assessment strategies. Teachers learn to implement hands-on activities, design inquiry-based lessons, and integrate technology into their teaching. Main teacher training programmes are provided by Institute for the Promotion of Teaching Science and Technology (IPST), Office of the Basic Education Commission (OBEC), and National Science and Technology Development Agency (NSTDA), and some trainings are collaborated with private sectors or NGOs such as IAFSW, CONNEXTED, and Chevron. An example is the *Power of Ten STEAM Education Program*, which targets primary and secondary levels, aiming to train teachers to transfer their knowledge and skills to students and support other teachers within the network.

Countries like Cambodia, Timor-Leste and Laos face significant challenges in delivering quality STEM education due to limited resources and infrastructure. In rural areas of these countries, access to essential educational facilities and resources for teaching STEM subjects is often limited. However, initiatives such as the STEM Education Model project, funded by The British Council in Vietnam, started with an intensive training course to provide school leaders and teachers an understanding of STEM education to make practical preparations for introducing this approach to their schools. The aim is to improve the quality and accessibility of STEM education in remote areas through teacher training and curriculum development.

The Timor-Leste MOE, with support from international organisations such as UNESCO, is focusing on improving teacher training and infrastructure to enhance STEM education. Initiatives like the STEM Education Capacity Building Project aim to train teachers in

STEM pedagogy and equip schools with necessary resources, including laboratory equipment and educational materials.

In recent years, the government of Myanmar has shown an increased awareness of this fact, demonstrated by increased funding and robust support for STEM initiatives. The *Strengthening Pre-Service Teacher Education in Myanmar* (STEM) project is a crucial component of this transformation, aiming to elevate the quality of pre-service teacher education from a two-year diploma program to a four-year degree program. The teacher capacity building programme aims to equip teachers with the knowledge, skills, and confidence needed to deliver high-quality STEM education by providing professional development opportunities, resources, and support networks. Spearheaded by the MOE, initiatives aimed at improving the STEM landscape in the country include upgrading laboratories to meet contemporary standards, providing modern teaching tools, and implementing comprehensive training programs for educators.

These examples demonstrate the diverse range of teacher capacity-building programmes in Southeast Asia, each tailored to meet STEM education's specific needs and challenges in their respective countries. Teacher capacity-building initiatives in Southeast Asia's STEM education landscape encompass a range of strategies, including professional development workshops, specialised training courses, and technology integration into teaching practices. Furthermore, partnerships between educational institutions, industry stakeholders, and international organisations are providing opportunities for teachers to gain practical experience and exposure to emerging trends in STEM fields.

E: STEM Resources and Development Adoption

As governments and educational institutions recognise the importance of STEM skills for economic development and global competitiveness, there is a growing emphasis on providing adequate resources and infrastructure to support STEM learning in the Southeast Asia region. The adoption of STEM resources and development in Southeast Asia varies across the region and is influenced by factors such as economic development, educational policies, and infrastructure. From educational materials and laboratory equipment to digital tools and online platforms, the availability and accessibility of resources are critical factors in ensuring that students receive a well-rounded STEM education that prepares them for future careers.

Brunei's Ministry of Education has implemented initiatives like the STEAM Programs Guidebook and STEAM for Future (Training Modules) for secondary and primary levels to promote inquiry-based learning and innovation in schools. The programme emphasises hands-on activities and project-based learning to enhance students' understanding of STEM concepts. Additionally, this guidebook provides several resources that serve as school references.

Malaysia's educational institutions and organisations create specialised learning modules focused on STEM topics. These modules often include interactive content, hands-on activities, and multimedia resources to engage students and enhance their understanding

of STEM concepts. In addition to the mentioned modules, Malaysia also offers specialised modules focused on the professional development of STEM teachers. The digital learning platform, the Digital Educational Learning Initiative Malaysia (DELIMa), is used for online learning purposes, including STEM learning. The platform is a repository of digital resources such as e-textbooks, videos, interactive simulations, and educational games that support learning across various subjects and disciplines. DELIMa also supports teachers and educators by offering teaching materials, lesson plans, assessments, and professional development resources to enhance their teaching effectiveness.

Singapore invests heavily in developing STEM resources and infrastructure to support its world-class education system. The country's "STEM Inc. Programme" provides schools with resources such as robotics kits, laboratory equipment, and STEM-based curricular materials. Additionally, the establishment of the "Science Centre Singapore" and the Singapore Discovery Centre" offers students and educators interactive exhibits, workshops, and educational programmes to supplement classroom learning. Maker Space is used for coding activities and other digital resources and platforms. In addition, the Singapore Science Centre also offers some access to these facilities.

In the Philippines, efforts to enhance STEM education include projects like the Greening Program in Green Schools Curriculum, training pedagogy, and content for Artificial Intelligence (AI). The Philippines' STEM government and private organisations also offer scholarships, research opportunities, and STEM outreach programs for talented students to engage them in STEM fields.

Indonesia's Ministry of Education, Culture, Research, and Technology of Indonesia has been upgrading from conventional training to developing the *Merdeka Mengajar* Platform. This initiative encourages teachers to learn independently from provided materials or each other's shared learning resources and improve STEM education quality, including curriculum reform, teacher training, and the establishment of STEM centres across the country. The resources allow the teachers to teach with more than 2000 resources and a tool to assess students' understanding, to learn with access to quality training materials and inspiring videos to empower oneself and to create and build a portfolio of creations to inspire and collaborate with other teachers.

In Thailand, STEM resources developed by Institute for the Promotion of Teaching Science and Technology (IPST) include manuals, online resources, applications, games, articles, videos, and a teacher learning platform. These resources are supplemented by other organisations developing their own materials. Thailand embraces technology to boost STEM education through platforms like ThaiMOOC, which offers free online STEM courses, and DLTV, which provides pre-recorded science lessons and teacher training materials. Digital tools such as simulations, educational games, and virtual labs are integrated into classrooms to make STEM concepts more engaging. The FABLAB Thailand project, supported by King Mongkut's Institute of Technology Ladkrabang and other organisations, offers schools the opportunity to have STEM labs, providing hands-on experience to support STEM education.

Cambodia's STEM education efforts include providing a learning platform called the Learning Management System (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. Students use technological devices, including smartphones, desktops or laptops, to access uploaded online content and learn at their own pace. Students complete online assignments, quizzes, exams, fieldwork, or practice at laboratories to improve STEM learning.

Vietnam prioritises the development of STEM resources and infrastructure to meet the demands of its rapidly growing economy. The *STEM Resource Centre Initiative* aims to establish resource centres in schools and communities, providing access to STEM kits, textbooks, and educational technology. Furthermore, the government invests in developing digital resources and online platforms to support STEM teaching and learning, especially in remote and underserved areas.

In Myanmar, to keep up with the dynamic nature of STEM disciplines, efforts go beyond physical spaces, providing up-to-date textbooks, cutting-edge software applications, and integrating online learning platforms. By fortifying the foundational elements of STEM education through improved infrastructure and a wealth of resources, Myanmar is fostering an environment conducive to hands-on learning and empowering its educational community with the tools necessary for success in a rapidly evolving technological landscape.

Access to quality resources and infrastructure is crucial for effectively delivering STEM education. The research responses illustrate the diverse approaches taken by Southeast Asian countries to enhance STEM resources and development, aiming to provide students and educators with the necessary tools and facilities to excel in STEM education.

F: STEM Initiatives/Events/Programmes/Activities/Projects

STEM initiatives across Southeast Asia encompass a variety of programs, events, activities, and projects aimed at fostering interest and proficiency in STEM fields among students and educators. These STEM initiatives across Southeast Asia contribute to developing a skilled STEM workforce and foster a culture of innovation and entrepreneurship in the region. These initiatives inspire the next generation of problem solvers who will drive socio-economic progress in Southeast Asia and beyond by providing platforms for hands-on learning, collaboration, and creativity.

Brunei's Ministry of Education hosts STEM competitions, including the National STEM and Innovative Design Challenge (NSIDC), which is adapted from the Formula One in schools, Students in STEAM, and R.E.A.L. Learning; outreach activities like STEAM Outreach Program; Support and training like Green Schools Initiatives (GI), Green School Gardening (GSG) and STEAM for Future (Training Modules) to enhance STEM initiatives among school students. STEM forums, workshops, STEAM programs awareness and roadshow visits, consultancy, training and coaching are also conducted where educators and students engage in hands-on activities and workshops related to STEM. These

initiatives engage students with hands-on activities and workshops related to STEM with access to tools and resources for prototyping and innovation.

Moreover, collaboration with industry partners in STEM projects, such as establishing the Seria Energy Lab (SEL) in Brunei, is a flagship initiative established by Brunei Shell Petroleum to promote scientific literacy throughout the nation. Engaging in this activity facilitates the development of forward-thinking abilities and provides an immersive learning and exploration experience.

Malaysia's MOE organises the STEM Executive Consultation (STEMEC) project, which aims to provide meaningful, integrated STEM learning experiences to every student in a conducive learning environment. It focuses on leadership for school leaders and Integrated STEM Project-Based Learning (PBL) for students. The project guides schools in implementing Teaching and Learning using the Integrated STEM PBL. Other STEM initiatives include the Mentor-Mentee Program, STEM Carnival, STEM Digital Games Teaching & Learning Multimedia Training Module, and STEM Leadership Program.

In Singapore, programmes or initiatives implemented to inspire and cultivate STEM career aspirations among students in the country are part of the Career Guidance programmes in schools. National competitions further stimulate interest in STEM fields. The National STEM Challenge encourages students to apply their STEM knowledge to real-world problems, fostering innovation and creativity. Additionally, the Tan Kah Kee Young Inventors' Award recognises young inventors who create innovative solutions to everyday problems, encouraging ingenuity and practical application of STEM skills. Singapore also organises various science and mathematics competitions which provide platforms for students to showcase their mathematical and scientific prowess.

The Malaysia Digital Economy Corporation (MDEC) Digital Makers Hub (DMH) is a physical space established to promote digital creativity, innovation, and skills development in Malaysia. It brings the school and community members, including students, educators, parents, and industry experts, together to encourage the activity of digital making. DMH is equipped with diverse tools, materials, and learning resources for the public to embark on digital-making projects.

The Department of Education in the Philippines organises the Annual Conduct of National Festival of Talents (NFOT). Many STEM-related contests are conducted during the NFOT (STEMazing). The aim is to develop learners' ability to obtain scientific and technological information about issues from diverse sources with a significant local, national, and global impact. Science investigations, Science fairs, and educational tours are other activities to enhance STEM skills in processing information and extracting relevant data to address and solve a specific problem effectively. Additionally, the regional STEM hub has been built to address the immediate need for technical testing and analysis of student research.

Thailand also hosts various initiatives, such as the National Science and Technology Fair, World Robot Olympiad (WRO) Thailand, and Thailand STEM Festival, which aim to engage students, teachers, and parents in STEM activities through interactive exhibits, workshops, and competitions, fostering interest in STEM disciplines and facilitating

networking among educators, industry professionals, and students. Institute for the Promotion of Teaching Science and Technology (IPST)'s STEM Ambassadors program and career camps like *Dare to Drone and Food for Fun* inspire students to explore aviation and food technology, respectively. Collaborations between Chevron and SEAMEO STEM Education Centre run STEM career academies to equip underprivileged students with necessary skills, and virtual exhibitions like Enjoy Science Career further promote STEM careers. The FABLAB Thailand project, supported by King Mongkut's Institute of Technology Ladkrabang and other organisations, offers schools the opportunity to have STEM labs, providing hands-on experience to support STEM education.

Therefore, based on the findings, access to quality resources and infrastructure is crucial for effectively delivering STEM education. Adopting STEM resources and development initiatives facilitates innovative teaching practices and enriches students' learning experiences. Educational institutions invest in procuring facilities, equipment and materials to enhance hands-on learning opportunities in STEM learning. Integrating digital resources, such as interactive simulations and online learning platforms, expands access to STEM education, particularly in remote and underserved areas. Finally, public-private partnerships and collaborations with international organisations drive the development and dissemination of high-quality STEM resources, further enhancing Southeast Asia's STEM education ecosystem.

G: Regional Partnerships and Collaboration in STEM Education

Regional partnership and collaboration are vital elements driving the advancement of STEM education in Southeast Asia. With a diverse and dynamic landscape, countries in the region recognise the importance of working together to promote innovation, enhance educational opportunities, and prepare students for future challenges. Partnerships between governments, academic institutions, industries, and non-profit organisations foster collaborative work supporting Southeast Asian STEM education initiatives.

The MOE of Brunei actively seeks partnerships to broaden participation and leverage expertise across various stakeholders. A prime example is the STEAM Outreach program, which aims to expand access to STEM education for the wider community, particularly students. In addition to this, the program fosters collaboration with relevant strategic partners. These partners, often government agencies or industry leaders, bring their expertise and resources to the table, assisting the STEP Centre in delivering and running engaging STEM activities. This collaborative approach ensures a broader reach and a richer learning experience for participants.

Another notable collaboration is the partnership between Sultan Hassanal Bolkiah Institute of Education (SHBIE) at Universiti Brunei Darussalam and the University of East Anglia. Based on the UK-Brunei Partnership on Teaching and Learning Workshop, this partnership focuses on developing primary school teachers' skills in incorporating practical STEM projects into their classrooms. Through a combination of workshops and research projects, this collaboration aims to equip educators with the knowledge and tools to deliver a more engaging and effective STEM curriculum.

Malaysia's MOE actively engages diverse stakeholders, fostering a powerful synergy to strengthen STEM education. Malaysian universities contribute academic expertise, while professional bodies offer real-world industry insights. This collaborative spirit is evident in programs like STEM4ALL: STEM Street, which tackles two crucial aspects simultaneously. By working with strategic partners, the MOE increases student enrolment in STEM fields through engaging programs and equips guidance counselors with the necessary knowledge of STEM careers. This collaboration empowers counselors to effectively guide students towards exciting career paths in the ever-evolving world of STEM.

The Philippines cultivates a robust STEM education landscape through collaboration. The government works with industry leaders for real-world application, universities provide expertise and training, and NGOs ensure equitable access. UNESCO fuels this growth by supporting policy development, teacher training, and best practice sharing, ensuring the Philippines leverages international knowledge to empower its future generation in STEM.

Indonesia is actively forging partnerships to strengthen its STEM education landscape. A prime example is its collaboration with the United States Agency for International Development (USAID). Through this partnership, Indonesia is embarking on developing a new STEM-based learning model. This collaborative effort aims to equip Indonesian students with the necessary skills and knowledge to thrive in the future workforce, ensuring a well-equipped generation prepared for the demands of a science and technology-driven world.

Singapore's flourishing STEM education ecosystem thrives on a powerful partnership between top-down and bottom-up initiatives. The ground-up efforts of private and public organisations further bolster this strong foundation. Industry partners and companies play a proactive role by collaborating with schools, offering scholarships, and even developing engaging STEM learning modules. Additionally, non-profit organisations actively develop programs and workshops, providing alternative learning spaces that complement traditional classroom instruction.

This dynamic partnership between government agencies and enthusiastic organisations creates a robust and multifaceted learning environment, ensuring that Singaporean students have access to a rich tapestry of STEM education experiences that prepare them for the challenges and opportunities of the future.

Thailand's STEM education landscape benefits from a collaborative spirit. Thailand actively participates in regional initiatives like the Chevron Enjoy Science project, a collaboration between Chevron Thailand and SEAMEO STEM-ED. Now in its second phase, this eight-year project prioritises innovation and inclusivity, fostering a love for STEM in students beyond traditional science majors. These collaborations show Thailand's commitment to a robust and accessible STEM education ecosystem. Collaboration among stakeholders, strategic investments, and sustained commitment to

STEM education are key to realising Thailand's aspirations for a prosperous and technologically advanced future.

The Cambodian Cyber University Network (CCUN) unites universities to share knowledge and develop curricula in Cambodia. NGOs like Kampuchea Action to Promote Education (KAPE) bridge the gap by implementing projects and research across all education levels. This teamwork ensures a unified and accessible approach to STEM education for Cambodian students.

Timor-Leste is also fostering collaboration in STEM education, mainly focusing on inclusivity. A significant example is the "Girls in STEM" pilot program, carried out by the Centre for Study Science and Mathematics (SESIM) of the Timor-Leste National Commission for UNESCO from 2018 to 2019. By collaborating with schools and potentially other local organisations, the SESIM program offered these girls dedicated learning experiences to spark their interest and equip them with the skills and confidence to pursue STEM subjects. This initiative exemplifies Timor-Leste's commitment to ensuring equitable access to STEM education and empowering girls to become future leaders in science and technology.

Myanmar's STEM education thrives on a dynamic partnership between industry and academia. Corporate companies demonstrate their commitment to education by sponsoring academic institutions, providing internship opportunities, and organising seminars for educators in STEM education. This industry engagement goes beyond basic training. Collaborative research projects allow students to tackle real-world problems alongside professionals, fostering innovation in both academic and corporate spheres. By providing resources, practical experience, and cutting-edge knowledge, private companies play a crucial role in preparing Myanmar's future generation for the demands of the STEM workforce.

Vietnam cultivates a collaborative STEM education environment, leveraging international partnerships. The British Council partnered with the Ministry of Education and Training (MOET) to pilot a project adapting successful UK STEM teaching methods to the Vietnamese context. Additionally, organisations like Kenan VN address gender disparity through Proposal A, which is a collaboration with the government. This initiative, piloted in Bac Ninh province, empowers female STEM teachers to inspire girls and integrate them into green technology clubs and activities. These partnerships showcase Vietnam's commitment to improving STEM education through collaboration and fostering inclusivity for all students.

The STEM partnership and collaboration initiatives encompass a wide range of activities, including joint research projects, teacher training programs, and the development of STEM-focused curricula. Governments collaborate with industry partners to align education with workforce needs and promote STEM career pathways. Educational institutions form partnerships with businesses and non-profit organisations to provide students with hands-on learning experiences and access to cutting-edge technology. Furthermore, regional collaborations between Southeast Asian countries facilitate the

sharing of best practices and resources, strengthening the overall STEM education ecosystem in the region.

H: Bridging the Gap: Challenges in Southeast Asia's STEM Education

Despite the growth potential, several challenges hinder the advancement of STEM education in Southeast Asia. Limited resources, including funding and equipment, pose significant obstacles for many regional schools. While some schools can offer a comprehensive and engaging STEM experience, others need help to provide a basic foundation. This disparity disengages students and fosters educational inequities, limiting Southeast Asia's capacity to reach its potential in STEM education.

One of the most significant challenges lies in resource constraints impacting funding and equipment. Many Southeast Asian schools lack the necessary resources, such as laboratory equipment, computers, and internet access, hindering effective STEM education delivery. For example, many schools still need more computers to provide access to simulations, educational software, online learning platforms, and coding tools, and worse, they have outdated models that can't support modern STEM learning resources. Besides, the absence of well-equipped laboratories with essential tools and materials restricts students' ability to conduct experiments, hindering their practical engagement with scientific concepts.

Additionally, a lack of grants and funding for STEM activities and programs further restricts schools' ability to provide enriching experiences and resources for students. This limits their ability to provide resources beyond textbooks, like inviting guest speakers from STEM fields, organising field trips to scientific institutions, or running robotics clubs. These stimulating experiences are necessary for students to gain opportunities to apply their knowledge in real-world scenarios, fostering a disconnect between theory and practice.

Another challenge faced by most Southeast Asian countries is a shortage of qualified STEM teachers, and existing educators often lack sufficient training in STEM subjects. This challenge creates a situation where there aren't enough educators to meet the growing demand for STEM education. On the other hand, many existing educators, while passionate, often need more training in STEM fields. This knowledge gap can hinder their ability to deliver engaging and practical lessons, utilise technology effectively, or adapt to the ever-evolving nature of STEM fields. This shortage of qualified and well-trained teachers creates a bottleneck, hindering the region's ability to fully capitalise on its potential in STEM education.

Cultural biases and stereotypes also discourage certain groups, particularly girls, from pursuing STEM education and careers. Moreover, access to quality STEM education is often limited in rural and marginalised communities due to geographic location and socioeconomic status. Girls and students from lower socioeconomic backgrounds are frequently underrepresented in STEM fields due to various social and cultural barriers, including gender stereotypes and limited access to educational opportunities.

The issue in STEM education is also compounded by outdated curriculum, which need to sufficiently equip students for current STEM careers, thereby generating a gap between academic achievements and industry demands. The existing curriculum may need to be aligned with the needs of the 21st-century workforce, lacking emphasis on critical thinking, problem-solving, and hands-on learning experiences.

Southeast Asia may realise its full potential in STEM education by tackling these issues and acting, producing a new generation of innovators and future leaders prepared to prosper in the rapidly changing fields of science and technology. By doing so, the region can cultivate a new generation of innovators and future leaders well-equipped to succeed in the rapidly evolving fields of science and technology.

I: Recommendations for STEM Education in Southeast Asia

According to this study's findings, infrastructure investment is crucial for advancing STEM education in Southeast Asia. Governments and stakeholders should prioritise investment in STEM infrastructure, including experimental laboratories, equipment, and digital resources, to provide students with hands-on learning experiences and access to up-to-date technology. Investing in digital resources like advanced software, virtual reality simulations, and online learning platforms allows students to explore cutting-edge technologies that might not be readily available in traditional classrooms.

Additionally, comprehensive teacher training programs are another highlighted area that ensures educators have the necessary skills and knowledge to teach STEM subjects effectively. Curriculum enhancement is also crucial; updating and adapting STEM curricula to be more relevant, engaging, and aligned with industry needs will better prepare students for the future workforce. Continuous professional development opportunities should also be provided to keep educators updated on the latest teaching methods and content.

The findings also indicate that promoting diversity and inclusion in STEM fields through targeted initiatives and public awareness campaigns can encourage participation among underrepresented groups, fostering a more inclusive and dynamic STEM community. Efforts should be made to raise awareness and promote interest in STEM careers among students, especially girls and underrepresented minorities. Partnerships between schools, industry, and community organisations can provide students with real-world exposure to STEM professions.

Moreover, STEM education should be integrated across various subjects, emphasising interdisciplinary connections and real-world applications. This approach fosters critical thinking, problem-solving skills, and creativity among students. Imagine a history lesson exploring the engineering marvel of the Great Wall of China. This approach integrates history and engineering, encouraging students to understand the scientific principles behind its construction and the technological advancements that made it possible. Similarly, an art class could explore colour theory using scientific light and wave

propagation principles, creating a bridge between art and science. By making these connections, students gain a deeper understanding of each subject and how they work together.

By weaving real-world applications into lessons, STEM becomes more engaging and relevant for students. For example, a mathematics class could delve into calculating the optimal trajectory for a rocket launch, integrating mathematics and physics while sparking an interest in space exploration. A literature class might analyse the ethical considerations surrounding artificial intelligence in science fiction, fostering critical thinking skills and a deeper understanding of literature and technology. This approach shows students how STEM concepts are used to solve real-world problems, making them more invested in learning.

The study reveals a dynamic landscape of STEM education in Southeast Asia, supported by partnerships between governments, universities, private companies, and NGOs. This collaborative spirit and initiatives promoting inclusivity and real-world applications pave the way for a brighter future. By implementing the recommendations outlined in this study, Southeast Asia can nurture a thriving STEM ecosystem that empowers its youth to become the innovators and leaders of tomorrow.

J: A Synergy Path Forward and Future Direction on STEM Education

Moving forward, partnerships and collaboration are essential for addressing the challenges of and advancing Southeast Asia's STEM education. Collaboration between academia, industry, and government would help advance the region's STEM education initiatives. Partnerships with industry could provide insights into emerging trends and skills required in the job market, ensuring that STEM curricula remain relevant and responsive to industry needs. Moreover, collaboration with government agencies can facilitate allocating resources and implementing supportive policies to promote STEM education in the country. By working together, stakeholders can create a supportive ecosystem that nurtures innovation, fosters talent development, and drives regional economic growth.

Shifting towards inquiry-based learning approaches that encourage curiosity, critical thinking, and problem-solving skills among students is essential. Promoting lifelong learning initiatives will ensure individuals have access to continuous education and skills development opportunities. Finally, fostering global engagement through international collaborations and exchanges will enable Southeast Asia to learn from best practices in STEM education and contribute to cross-cultural understanding and cooperation worldwide. Embracing emerging technologies such as virtual reality, augmented reality, and online learning platforms can enhance accessibility and effectiveness in STEM education.

The research findings highlight that artificial intelligence applications present significant opportunities to enhance STEM education in Southeast Asia. Through AI-driven tools and technologies, educators can personalise learning experiences, provide adaptive

feedback, and facilitate immersive, hands-on learning through virtual simulations and experiments. By leveraging AI, educators can cater to the diverse learning needs of students, promote active engagement, and cultivate critical thinking and problem-solving skills. Moreover, integrating AI into STEM curricula can better prepare students for the AI-driven workforce of the future, equipping them with the knowledge and skills necessary to thrive in a rapidly evolving technological landscape.

Future directions for STEM education in Southeast Asia should be closely aligned with the Sustainable Development Goals (SDGs) to tackle regional challenges and promote sustainable development. Integrating SDGs into STEM curricula is essential to instil in students an awareness and understanding of global issues and the role of STEM disciplines in addressing them. By incorporating real-world problems related to environmental sustainability, healthcare, poverty alleviation, and more, educators can inspire students to develop innovative solutions that contribute to achieving SDGs. This approach fosters a sense of responsibility and equips students with the skills to impact their communities.

Furthermore, these research findings underscore the importance of future directions for prioritising inclusion and diversity in STEM education for Southeast Asia. Efforts should be made to address gender disparities and ensure equal access to STEM education for all students, regardless of socioeconomic background. By promoting diversity in STEM fields, Southeast Asia can harness the full potential of its talent pool and foster a culture of innovation and creativity. Additionally, emphasis should be placed on fostering an entrepreneurial mindset among students, encouraging them to apply their STEM skills to create solutions to local and global challenges.

Despite challenges, there is optimism about the future of STEM education in Southeast Asia, with an emphasis on digital literacy and innovation. The research provides valuable insights into Southeast Asia's current STEM education landscape. Addressing the identified challenges and building on existing strengths can contribute to the region's development and competitiveness in STEM education. Further research and collaborative efforts are recommended to ensure sustainable progress in STEM education.

In conclusion, by embracing these principles, Southeast Asia can build a robust STEM ecosystem that empowers learners to become future leaders, innovators, and change-makers in a rapidly evolving world. By analysing the key themes in this Southeast Asia STEM education landscape study, identifying existing challenges, and exploring how these can be addressed for further discussion and recommendations, this study aims to provide valuable insights for policymakers, educators, stakeholders, and communities invested in cultivating a generation of future innovators and leaders in STEM education.

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