Capacity Assessment and Development of STEM High School Model: The Case of Kampong Speu Province

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LIST OF ABBREVIATION

APhO	Asian Physics Olympiad
APMO	Asia Pacific Mathematics Olympiad
APT-JSO	ASEAN Plus Three Junior Science Odyssey
ESP	Education Strategic Plan
HEIs	Higher Education Institutions
IBL	Inquiry-Based Learning
ICT	Information and Communication Technology
IMO	International Mathematical Olympiad
IOAA	International Olympiad on Astronomy and Astrophysics
IPhO	International Physics Olympiad
IJSO	International Junior Science Olympiad
MoEYS	Ministry of Education, Youth, and Sport
NEA	National Employment Agency
NGS	New Generation School
PISA	Programme for International Student Assessment
SDGs	Sustainable Development Goals
SEAMEO	Southeast Asian Ministers of Education Organization
SEIP	Secondary Education Improvement Project
SMC	School Management Committee
SMET	Science, Mathematics, Engineering, and Technology
SSYS	The Search for SEAMEO Young Scientists
STEM	Science, Technology, Engineering, and Mathematics
TIMSS	Trends in International Mathematics and Science Study

EXECUTIVE SUMMARY

Education is always a vital pillar in all forms of social and economic development for human evolution history. Without proper education for all, it will be hard to attain all seventeen goals of Sustainable Development Goals (SDGs), a quite ambitious ideal set out by the United Nations. A good education system of a nation has led its way to a sustainable and inclusive growth as well as socio-political and economic development. Investment in educational development endeavor needs long-term commitment and planning from national, institutional and individual levels. By and large, the development of a nation would be going in dark pathways if education for young generation is not in priority agenda of a country. Conceptually, the general education from kindergarten to secondary education is established to shape the citizens in a particular community, while higher education is established to serve socio-economic development. However, bridging these two remains a turning task for educational policy makers since the context could be different from one to another. The recent trend seems to value the importance of education in Science, Technology, Engineering and Mathematics (STEM). At the same time, common understanding among policy makers also sees the relevancy of STEM in socio-economic development.

The ideal philosophy of education has been shaped for national interests and security. Thus, STEM education is of great attention among emerging economy nations viz Cambodia. Even though the complex relation between economic development and STEM education is hardly understood, nascent nations generally view the necessity to invest in science related subjects among general education schools. Particularly, the upper secondary education school, equivalent to Grade 10 to 12 for Cambodia, is the top targeted level among policy players. Students at this level are generally having sufficient critical thinking to prepare themselves for future life either entering the labor market directly or continuing to higher education once there is proper guideline from their instructors. However, direct supervision with well-designed content of STEM education model remains the backbone to ensure proper linkage of education and this future life path for long term development of a nation.

Cambodia’s vision for STEM education is for this reason. STEM education policy was endorsed by Minister of Education, Youth and Sport in 2016 with the aims to improve education system to serve socio-economic development of Cambodia to become an upper-middle income country by 2030 and high-income country by 2050. Nationwide, various STEM education model has been piloting, including New General School, E2STEM, and possibly others. The model has been generally applauded by the public. However, educational policy makers as well as educational philosophers are convinced that a model with more practical approach based on local context is critical for Cambodia. Thus, Kampong Speu province, having favorable geographical condition for industrial development, is chosen for the study to link STEM education to addressing local needs, particularly in industrial sector.

The objective of the study is to find the most practical STEM education model for Kampong Speu province where existing conditions are sufficient to propose a model, potentially expanding nationwide. Conceptually, the study aims at preparing skill graduates for the skill-based workforce, especially for the industrial zones and for post-secondary education with a strong background in STEM for future socio-economic development. The direct points of this report are to provide a model for STEM high schools suitable for Kampong Speu province, to recommend one high school in Kampong Speu to be transformed into STEM high school to become a leading school of the country in STEM education and to provide a recommendation for the transformation process in term of preparation and implementation. This study employs a mixed method of desk reviews, questionnaires for teachers, semi-structured interviews for school principals and school management team, and fieldwork assessments of the site, including the evaluation and observation checklist for overall physical infrastructure in five selected schools in Kampong Speu province.

Stemming from the findings, the concept of Integrated STEM Education is proposed as a model for the context of Kampong Speu province. The ultimate goal of the model is to have skill-based human resources in order to fill in the requirement of future innovative industries in the context of Industrial Revolution 4.0 (IR 4.0). This model requires mingling of teaching and learning approaches from the general concept of inquiry-based learning, project-based learning, and problem-based learning. In addition, mathematics and sciences are taught as embedded subjects in the content and serve as a tool to solve matter facing industrial sector demand as well as future high-skilled formation. This is because high school graduates' qualification for higher education is additionally the important pillar in the proposed model. The reform of teaching and learning contents, qualifications of teacher, infrastructure, governance structure, managerial structure, and financing are the foundation of this Integrated STEM Education. The detailed reform elements are proposed in the study.

The study concludes that the Integrated STEM Education is the most suitable approach for implementation in Kampong Speu Province. It is likely that the current STEM model could be costly, thus hardly far-reaching as far as equitable access, which appear as the points of concern. Another challenge that the current STEM model is facing is its linkage to the local context. The proposed model in this study is viewed to be more flexible in terms of its implementation. Among the five selected high schools, Kampong Speu High School is the best choice for piloting the model since precursor conditions are already available.

1. INTRODUCTION

1.1. Context

For as long as history has been documented, mankind has relentlessly sought to improve living conditions. However, the systematic study of these efforts as an academic discipline called 'development studies' emerged just seven decades ago after World War II. Although development involves many aspects — social, political, and cultural — economic growth is considered the key as it provides resources for promoting and accelerating other aspects of development. Since the 1950s, countless studies have attempted to investigate the causes of economic development in particular countries and between countries within the same continent and countries across continents in a quest to find answers to why, in the long run, some countries had performed better than the others.

Various disciplines provide a wide range of possible explanations on the underlying causes of economic development. Still, the most prominent studies have stressed the role of financial institutions (macro-economic stability, a well-defined system of property rights, and openness of the economy) and business-friendly environment, such as attractive incentives for investors and good governance, as the fundamental causes of differences in economic performance (Benhabib and Spiegel, 1994; López et al., 1998; Easterly, 2001). Although these factors are necessary for economic development, they are not sufficient conditions to ensure a prosperous economy.

Arguably, investment in human capital in terms of education is one of the fundamental factors in a prospering economy. The role of education is manifested clearly in the successful experience of East and Southeast Asian countries such as China, Singapore, Taiwan, South Korea, Hong Kong, Malaysia, Indonesia, and Vietnam. Although these countries have different degrees of quality of economic institutions, business-friendly environment, and good governance, they share a common factor contributing to their prosperous economy—a strong interest in investment in education (Economist, 1991; Morris, 1996).

Educational development, however, is a complex issue, especially when it is developed with the ultimate objective of contributing to the overall economic development. It consists of multiple sub-sectors such as primary, secondary, and higher education in different orientations. Contextually, secondary education is increasingly important as it is the level of education from which most students either enter the labor or is the foundation for higher education where highly skilled workforces can be effectively and efficiently trained.

In Cambodia, Un et al. (2014) found out that about 20% of high school graduates decided to work right after finishing high school. The survey conducted by NEA (2018) also reveals that the majority of the job market in Cambodia required only secondary education, where the job market is classified into four broad occupation groups such as highly-skilled, skilled non-manual, skilled manual, and unskilled. In addition, a comparative analysis across countries and regions suggests that the quantity of education or schooling corresponds to long-term economic growth (Burnett, 2013; Hanushek & Kimbo, 2000; Hanushek & Wößmann, 2007). At the turning point of the millennium, the most critical cognitive skills needed to boost economic development are those related to science, technology, engineering, and mathematics (STEM), as evidenced in East and Southeast Asian countries.

1.2. STEM Education: Global and Cambodian Context

In 1957, the former Union of Soviet Socialist Republics (USSR) succeeded in launching Sputnik 1, the first artificial Earth satellite. This was a technological milestone that started the "Space Race" between the USA and the former USSR. In order to catch up with the former USSR, President John F. Kennedy, in 1961, raised the stakes by setting a goal of "landing a man on the Moon and returning him safely to the Earth". The National Science Foundation was, therefore, tasked to promote education and research in the field of Science, Mathematics, Engineering, and Technology, known as SMET. The term SMET education is typically used to address an education policy or a curriculum choice in schools.

In 2001, the term STEM, a rearrangement of the word SMET, was introduced. At the time, the USA saw the new context for reforming the education system and STEM education to challenge the emerging Asian powers. It is believed that the rise of Asian powers is due to the increasing role of STEM education in promoting their economic power, especially since the 1990s. This is reflected in the lower position of the USA in the international tests such as Trends in International Mathematics and Science Study (TIMSS)[1] and Programme for International Student Assessment (PISA)[2] , a triennial assessment of knowledge and skills of 15-year-old as seen in Table 1, and Table 2.

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[1] Along with the overall students' achievement data, TIMSS comprehensive assessments include data on student performance in various mathematics and science domains (algebra, geometry, biology, chemistry, etc.) and on performance in the problem-solving challenges in each of these contexts.

[2] The Programme for International Student Assessment (PISA) is a worldwide study by the Organization for Economic Co-operation and Development (OECD) in member and non-member states intended to evaluate educational system by measuring 15-year-old school pupils' scholastic performance on mathematics, science, and reading.

Table 1: Top Ten Countries in Math on PISA (Score is indicated after each country's name)

No	2003	2006	2009	2012	2015	2018
1	Hong Kong 550	Taiwan 549	Singapore 562	Singapore 573	Singapore 564	China (B-S-J-G) 591
2	Finland 544	Finland 548	Hong Kong 555	Hong Kong 561	Hong Kong 548	Singapore 569
3	South Korea 542	Hong Kong 547	South Korea 546	Taiwan 560	Macau 544	Macau (China) 558
4	Netherlands 538	South Korea 547	Taiwan 543	South Korea 554	Taiwan 542	Hong Kong (China) 551
5	Japan 534	Netherlands 531	Finland 541	Macau 538	Japan 532	Taiwan 531
6	Canada 532	Switzerland 530	Switzerlan d 534	Japan 536	China (B-S-J-G) 531	Japan 527
7	Belgium 529	Canada 527	Japan 529	Switzerland 531	South Korea 524	South Korea 526
8	Switzerland 527	Macau 525	Canada 527	Netherlands 523	Switzerland 521	Estonia 523
9	Macau 527	Japan 523	Netherlan ds 526	Estonia 521	Estonia 520	Netherlands 519
10	Australia 524	New Zealand 522	Macau 525	Finland 519	Canada 516	Poland 516

Source: Compiled from different years

Table 2: Top Ten Countries in Science on PISA (Score is indicated after each country's name)

No	2006	2009	2012	2015	2018
1	Finland 563	Finland 554	Hong Kong 555	Singapore 556	China (B-S-J-G) 590
2	Hong Kong 542	Hong Kong 549	Singapore 551	Japan 538	Singapore 551
3	Canada 534	Singapore 542	Japan 547	Estonia 534	Macau (China) 544
4	Taiwan 532	Japan 539	Finland 545	Taiwan 532	Vietnam 543
5	Japan 531	South Korea 538	Estonia 541	Finland 531	Estonia 530
6	Estonia 531	New Zealand 532	South Korea 538	Macau 529	Japan 529
7	New Zealand 530	Canada 529	Vietnam 528	Canada 528	Finland 522

8	Australia 527	Estonia 528	Poland 526	Vietnam 525	South Korea 519
9	Netherlands 525	Australia 527	Canada 525	Hong Kong 523	Canada 518
10	South Korea 522	Netherlands 522	Germany 524	China (B-S-J-G) 518	Hong Kong (China) 517

Source: Compiled from different years

Cambodia has not officially participated in any of these international assessments, although its recent participation in the 2018 PISA-D, a trial PISA assessment for development, was seen. It should be noted that those countries having top scores in the above-mentioned assessments are among highly developed countries. For Cambodia, the results from the 2018 PISA-D showed that only 8% of the 15-year-old students achieved a minimum proficiency level 2[3] or higher in reading, and approximately 10% achieved a minimum proficiency level or higher in mathematics. In science, it is even lower; particularly, only 5% achieved this level of proficiency. The findings seem to reflect the situation on the ground. Employers' perspective is an indicator of several challenges facing high school graduates seeking for first-time entry to the workplace. Employers based in Cambodia generally consider that the skills acquired in formal secondary schooling do not meet their demands. Cambodian education is too supply-driven and insufficiently linked to demand from employers. The results of the survey conducted by Burnett (2013) revealed that only 13% of employers believed that graduates have all or most of the skills needed for labor market. The mismatch is mainly caused by the limited capacity of the secondary education system to provide the necessary skills at an adequate level of quality and relevant to employers' needs. This was revealed by CAMFEBA (2008) that high school students believed in more skills needed for them to find a job if they entered the employment sector right after high school education. This finding was further validated by Un et al. (2014), where more than 50% of Cambodian respondents expressed that their high schools had not adequately equipped them with skills needed for employment.

In addition to skill shortage, there is also a skill gap, i.e., the existing staffs cannot perform up to the level required by employers. The survey conducted by NEA (2018) indicated that about one-third (29.2%) of the establishments interviewed declared to have encountered the issue of skill gaps (fairly decreased if compared to the previous 2015 survey, which was at 39.4%). More alarmingly,

[3] The score at 410 or above suggests that the students have a minimum proficiency level (Level 2) in line with the competency level that is the goal of Education SDG 4. Level 2 is the baseline competency level out of the 6 levels of PISA-D or PISA.

despite the willingness of the employers to set up the workforce development program to fill in the skill gaps, many of them find it very difficult to organize the training. The reason for the difficulty is showing a vicious cycle of skill shortages and skill gaps where 35.6% of employers reported that there is none, or a lack of courses and trainers available. About 27% of employers reported low quality of courses on offer or low quality of trainers while 20.4% of employers reported no or poor information on courses/trainers among other reasons (NEA 2018).

The enrollment of STEM-related subjects at higher education institutions also reflects the readiness of secondary schooling, for that matter. Since 2010, MoEYS has implemented a streaming system where all Grade 11 students must choose either science or social science stream. While the focus of the former stream is on science subjects (Physics, Chemistry, Biology, and Earth Science) and Mathematics, that of the latter is on Khmer Literature, History, Geography, and Moral Studies. Kao and Shimizu (2020) showed that there has been a decline in the number of students taking science stream, though the share remains substantially higher than those taking social science stream. What is even more interesting is that despite the high percentage of students taking science stream at secondary school, the higher education level sees a completely opposite trend, as seen in Figure 1. This indicates a poor quality as well as the tasks to make STEM appears more interesting. What is more interesting and very concerning to note is that despite the introduction of STEM policy and new STEM school model since 2016, the percentage of high school students who take social science stream continues to increase, and by 2019-20 academic year, reaching almost equal number to science stream as seen in Figure 1.

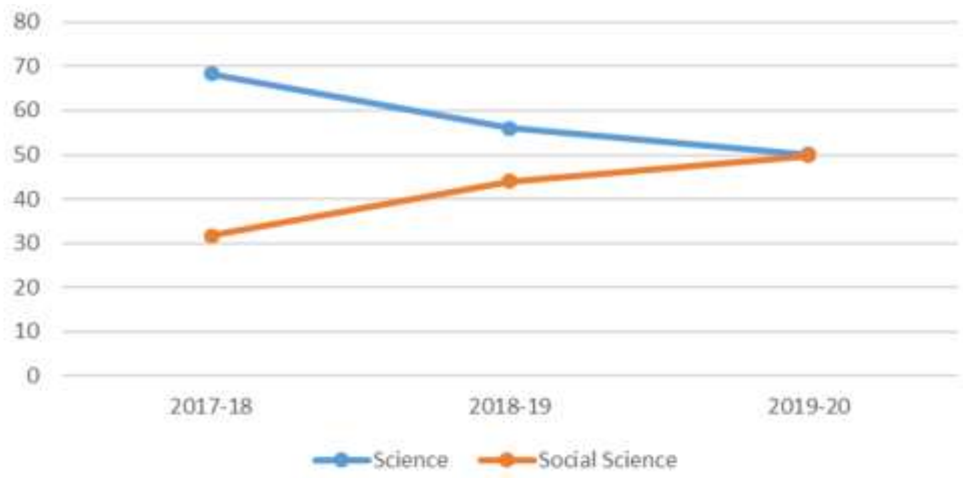

Figure 1: Percentage of students in different streams.
Source: Author's compilation

Since the 1990s, there has been a constant increase in the number of higher education institutions (HEI), i.e., from less than 10 to 118 and the number of students from less than 10,000 to almost 250,000. Amongst them, there are 52 institutions currently providing STEM-related majors, but fewer than 20% of students major in engineering and science (Kao & Shimizu, 2020).

Cambodia has entered a dramatic demographic change due to the baby boom after the Khmer Rouge genocide. The population under the age of 35 accounts for approximately 68.0% of the total population in 2018. An analysis by NEA (2018, p. 11) boldly pointed that “this young and dynamic population continues to play important roles in the future and can have various socio-economic consequences. It can be a good resource or a burden for Cambodia, depending on how they can be transformed into good human capital for the country’s development”. The report also highlighted that this golden age of demographic change will decline gradually starting from 2030. In addition, workforce will start to experience a negative balance from 2045 onward. Therefore, the timeframe to utilize this golden age of demographic change lies solely in the country's education system, the right reform between 2022 and 2033 before it becomes too late, especially in the areas of STEM education, which can foster not only productivity growth but also economic diversification through innovation and creativity.

With relative success in laying down the economic and physical infrastructure, at the first cabinet meeting of the newly elected government in 2008, the Cambodian Prime Minister identified the shortage of skilled workers and the low quality of educational provision at all levels of the 17 challenges as a significant challenge for the country’s economic development. To continue to improve its human capital, in 2018, the Royal Government of Cambodia prioritized human resource development, which is one of the pillars stipulated in the Rectangular Strategy Phase IV (2018-2023), as well as to lay down the investment program in the National Strategic Development Plan. These strategies and development plans guide strategic planning at the sectoral level across all government ministries.

In response to the concern and vision of these strategies and development plans, since 2008, the MoEYS has introduced three Education Strategic Plans (ESP) (2009-2013, 2014-2018, 2019-2023) and other related policies and project interventions related to STEM education, addressing three broad policy objectives: 1. Access & Equity (supply-side expansion & disadvantaged group), 2. Quality & Relevance (regional/international & private sector) and 3. Governance & Finance (effectiveness & efficiency) of the education system[4]. Interventions related to STEM education aim to facilitate Cambodia's visionary transformation into an upper-middle-income and high-income country by 2030 and 2050, respectively, after graduating from a low-income to a lower-middle-income country in 2015.

It is worth pointing out that STEM education and related activities are popularized with several extracurricular activities such as STEM festivals and STEM buses. These events have been organized by STEM Education Organization for Cambodia in cooperation with MoEYS since 2005, aiming to increase the students' interest in getting into STEM-related majors and STEM-oriented higher education. In collaboration with the British Embassy in Cambodia, MoEYS has recently published a STEM Career Booklet listing potential STEM careers and Higher Education Institutions (HEIs) offering STEM-related majors in Cambodia. This affords upper secondary school students a better orientation and helps them make more well-informed choices in matriculating into STEM fields. At the international stage, since 2005, MoEYS also supports strategic teaching and learning preparation for international competitions such as the Asian Physics Olympiad (APhO), International Physics Olympiad (IPhO), International Olympiad on Astronomy and Astrophysics (IOAA), the Search for SEAMEO Young Scientists (SSYS), International Mathematical Olympiad (IMO), and the Asia Pacific Mathematics Olympiad (APMO), amongst others.

Finally, in 2016, the MoEYS introduced the STEM education policy, a new innovation aiming to link the contents of STEM to the normal living practices of citizens by focusing on nurturing and applying the 21st century skills. STEM education policy preparation is a necessity and urgency for strategies and roadmaps for all activities related to STEM education. In the same year, the operationalization of the new policies started. MoEYS piloted a new school model called 'School in a School' wherein one creates a new structure within an existing school, an innovative educational experiment, to address systemic challenges under the technical coordination of one local NGO known as KAPE. First, it started with one upper secondary school through the creation of the autonomous system named New Generation School (NGS), which receives higher funding to spend on teaching and

[4] Other ministries also introduce policies related to STEM fields such as National Policy on Science, Technology and Innovation (STI) (2020-2030), Cambodia's STI Roadmap 2030, Education Strategic Plan (ESP) (2019-2023), and Technical and Vocational Education and Training (TVET) policy (2017-2025).

learning as well as management and professional development program[5] linked to new standards of accountability and governance as well as professional standards. Through this investment and reform, MoEYS's policy emphasizes that this education system will "…effectively compete with other education systems in the ASEAN region where there is an urgent need for a workforce with 21st century skills." This is understood as a call to increase skill levels in STEM subjects.

Thus, more precisely than the normal/traditional upper secondary school, NGS intensifies capacity building in educational technology, problem-based learning methodologies, and a strong emphasis on STEM-related subjects. Evidently, the teaching hours for mathematics, science subjects (physics, chemistry, biology), and technical education have been increased from 16 hours to 20 hours per week (MoEYS, 2016). This ultimately aims to provide skills needed for the labor market when graduates go directly to work and increase more students' enrollment in STEM-related fields in higher education. Over the years, NGS has been expanded not only to other provinces and also across the educational levels. Until recently, NGSs have expanded to 10 sites, including four primary schools, one lower secondary school, and four high schools have been established in 4 different provinces such as Kampong Speu, Kampong Cham, Svay Rieng, and Kandal, in additional to the pilot school in Phnom Penh (ThmeyThmey News, Oct. 2019).

One year later, in 2017, another STEM-based school known as E2STEM was created to be piloted at Preah Yukunthor High School. This model presents the five focuses of training on English, E-learning, Science, Technology, and Mathematics. Some educational theorists see that 21st-century education must address not only pure STEM subjects but also subjects related to liberal arts, social science, humanity, history, and education for addressing inclusiveness and innovation (Reiter, 2017; Radcliffe, 2015). Given those facts, modern STEM education of higher quality and better cost-effectiveness should receive more attention and endorsement from the government, development partners, and relevant stakeholders because it is a driving force that can shift Cambodia from a labor-intensive economy to a knowledge-based one. This quality standard must reach a level that is comparable with that of top schools in neighboring countries. However, its sustainability is put into question, as recently, there has been a report that its resource mobilization could not meet the planned operating budget due to its high

[5] Unit cost of approximately $290 USD per student per year (Chea & Chen, 2021) compared to about $120 USD per student in normal school, according to the personal conversation with people who worked closely in the field.

cost of operation. An informal conversation indicates that this school is asking the government to channel some budget from NGS fund to support its operation[6].

Other schools with a focus on STEM education have also been founded with highly expensive investments but provided varying results, though it is too early to evaluate the recent reforms in this area. For example, a study by Chea and Chen (2021) revealed three interesting observations related to the introduction of NGS. First, they questioned the sustainability and scalability of this new model due to the large investment needed to operate these schools and the limited government budget. Secondly, NGS' locations are in urban areas where community's involvement could help in mobilizing resources, but they are concerned that there is a limit to how much poor households can voluntarily contribute. Finally, the true effectiveness of the NGSs has not yet been empirically evaluated, although descriptive statistics have demonstrated some signs of success. Still, evaluation methods are shallow by relying solely on national examinations, plus there might be a bias as students are recruited to NGS through a very competitive model. Further, its linkage to the industries is also put into question as there is nothing much of the reform and content revision in terms of curriculum and its extra-currcular activities. By this time, Cambodia has not made a clear and strategic vision to nurture and grow talents in the STEM fields. Against this backdrop, this report aims to create a STEM high school model for Kampong Speu province that can lead to an expansion in a wider scale in Cambodia.

1.3. Why STEM High School in Kampong Speu?

1.3.1. Contextual Background

Kampong Speu is a province located about 50 km from Phnom Penh, with a total population of 877,523 (452,421 females) as of 2019. It borders Kampong Chhnang and Pursat to the North, Kampot and Takeo to the South, Phnom Penh to the East, and Koh Kong to the West along the highway leading to Cambodia's largest and deepest seaport Sihanouk Ville. This strategic location has transformed Kampong Speu from one of the poorest provinces in Cambodia into the hub of the industrial zone in recent years. As of 2021, Kampong Speu houses 226 large industries and 1,640 SMEs. The large industry in Kampong Speu, similar to that of national level, is dominated by garment factories, that is accounting for about 70% of industry types, while another 30% could be for a STEM-based workforce (Figure 2).

[6] The attempt to gather detailed specific information for this research was not successful as the questionnaires are not welcomed by the management team of E2STEM school.

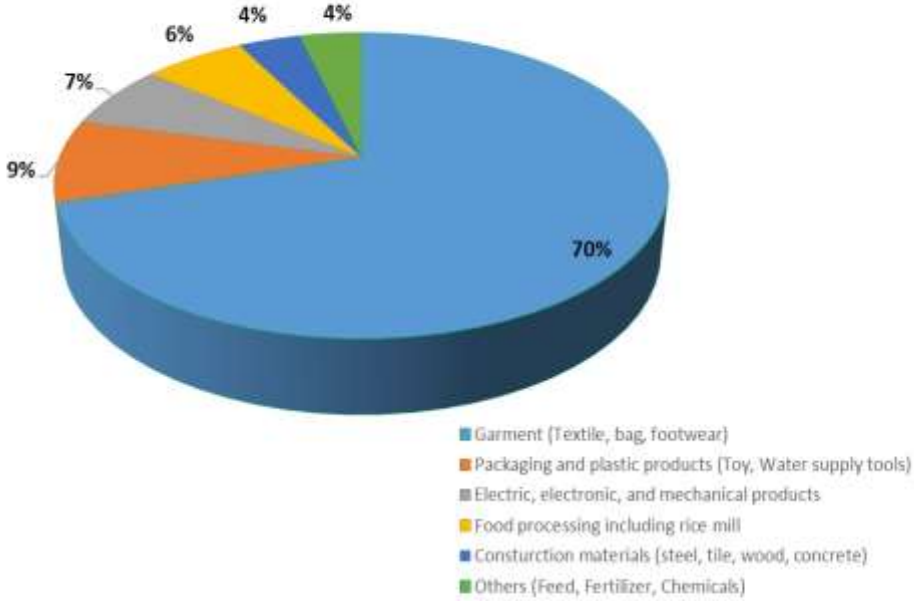

Figure 2. Types of Industry in Kampong Speu province
Source: Author's compilation and analysis

Taking into account the current context of having STEM education as an emerging interest among players, 30% of around 200 industries are obviously on demand for STEM graduates. Specifically, it is seen that engineering and science majors, including construction, packaging technology, materials science, food processing, electric, electronics, and mechanical engineering, are currently important and will be more critically on demand if the industrial expansion follow the trends projected up to 2030.

Relating to SMEs, Figure 3 reveals a promising projection that STEM-based education is on-demand. For instance, factories producing construction materials and food processing display a high percentage, while garment factory ranks third. General view from more than 60 SMEs in the province suggests the need for skill-based human resources from STEM-oriented institutions. Figure 3 indicates that 76% of SMEs fall in the domain of construction materials, food processing, chemicals, plastic, papers, and others. The nature of these SMEs, thus, needs graduates having engineering and science-related backgrounds.

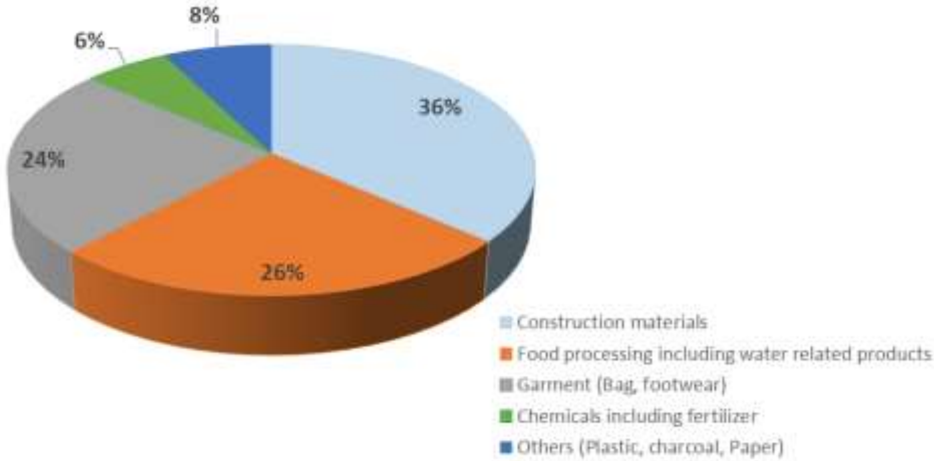

Figure 3. Types of SMEs in Kampong Speu Province
Source: Author's compilation and analysis

In 2016, there was an interesting assessment report made by Jayavarman Center for Development (2016) entitled "Industrializing Cambodia: Making a Roadmap to Construct Core Industrial Clusters in Kampong Speu". The report proposed the following industrial clusters for Kampong Speu: Agro-Industry, Semiconductor Industry, and ICT and Related Infrastructure Development with the investment model for social and physical infrastructure development. With all of these backgrounds, STEM education will improve the productivity of the existing industries as well as actualize the construction of the core industrial clusters in Kampong Speu. This is not an elusive vision; for example, in 2019 alone, thirty-five major Chinese companies interested in investing in Kampong Speu and three international firms planned a total of approximately USD 500 million International Theme Park in Kampong Speu[7], making Kampong Speu the most appropriate province for new STEM model to be introduced.

1.3.2. Human Capital in Kampong Speu

Although the population of age above 15 are relatively high, that is 89.3% (Census, 2019), the literacy rate achievement beyond lower secondary school is underwhelming. For instance, 35.9%, 37.3%, and 23.4% of those who are literate attained only some primary schooling, finished primary school, and lower secondary school, respectively. Only 2.0% and 1.4% of those who are literate

[7] Sen, D. (2019). Education Ministry to create more New Generation Schools. Khmer Times. https://www.khmertimeskh.com/670675/education-ministry-to-create-more-new-generation-schools/

attained upper secondary school and post-secondary school, respectively. This is reflected in the low gross enrollment rate at high schools in Kampong Speu, with about 25.5%.8 In terms of quality measured solely based on high school national examination passing rate, out of the total number of 3,197 students, only a small portion of 6, 53, and 188 students achieved Grade A, B, and C respectively. There rest obtained Grade D and E.

As of 2020, Kampong Speu has 24 high schools, with two being the resource schools. It also has five private high schools, which indicates a demand for quality high school education in this province as parents believe that private school provides a better quality of education. The total number of student enrollment at high school from Grade 10 to 12 is 15,615, of which 8,341 are female. There is an absence of technical high schools, though it has one branch of private university in this province.

According to the Congress Report 2020 made by the Provincial Department of Education, Youth and Sport, there is a teaching program focusing on STEM, though concentrated in a few urban schools. That program focuses on the availability of laboratories for teaching the four science subjects, namely Chemistry, Biology, Physics and Earth Science. There is also a life skills program focusing on Computers and Entrepreneurship.

The challenges reported in the report included low transition rates from lower to upper secondary school, at about 68%, and high rates of dropout at the high school levels. Though the high dropout rates are likely attributed from poverty, several studies revealed that the low quality and the irrelevance of educational content to the current labor market needed, especially for rural and remote areas, significantly caused school dropouts. Related to this finding, Bredenberg (2003) found that lower secondary school pupils expressed skepticism about the value of the education they received in terms of its pertinence to their daily lives. Similar perceptions were also revealed by parents "who do not appreciate that there is a real benefit to their children or themselves in investing precious time and money in education. They see little evidence that education will result in employment opportunities different from those available to uneducated children" (Nock & Bishop (Eds.), 2008, pp. 58-59).

An additional issue reported in the Congress Report 2020 is related to the capacity of the teachers where only about 72% of them meet national qualification standard (12+2), not to mention BA+1 as stated in the preference in MoEYS's policy, and the availability of the physical infrastructure to implement the newly reformed curriculum, especially STEM education where only 2% of high schools have access to ICT to support teaching and learning. There are also reports on the shortage of teachers in certain subjects and school counselors and instructors in life skills programs. Development partners and donors' support to the education sector in Kampong Speu is also limited, as the existing Secondary Education Improvement Project supports only five schools in this province[8].

Currently, there is only one NGS-style primary school, namely "Preah Reach Akka Morhesey (ព្រះរាជអគ្គមហេសី) Primary School" in Oudong, Kampong Speu province. Although the MoEYS planned to increase the number of NGS's to about 150 countrywide, it is not clear whether more NGSs type of school would be established in Kampong Speu among those 150 schools planned. The drawback is a lesson learned from the implementation of NGSs is seen to be a dilemma for teachers to train the student for "teach to think" or "teach to test" (Reimers, 2020). More importantly, the limited quality of education in terms of STEM and its linkage to local industry in Cambodia, even within the new STEM education model, is still observed in comparison with gifted schools in the region (Bo, 2020). For this reason, the study was carried out in Kampong Speu.

1.4. Aim and Objectives

Our conceptual STEM model of high school for Kampong Speu is mainly based on the results of a case study in this province, the insightful knowledge of existing STEM educational models for high schools, and an integration of extra activities suitable for the Cambodian context to improve STEM-based learning outcomes. This mainly aims at:

- preparing graduates for the workforce, especially for the industrial zones, and
- preparing graduates for post-secondary education with a strong background in STEM for future economic development.

The objectives of this study are threefold:

- To provide a model for STEM high schools suitable for Kampong Speu.
- To recommend one high school in Kampong Speu to be transformed into STEM high school.

[8] A summary being translated from the Congress Report on The Education, Youth And Sport Performance In The Academic Year 2018-2019 and Goals for Academic Year 2019-2020 by the Department of Education, Youth and Sport in Kampong Speu (in Khmer).

- To provide a recommendation for the transformation process in term of preparation and implementation in order for the school to become a leading school of the country in STEM education.

1.5. Scope of Work

The research team reviewed existing key documents about high school education in Kampong Speu, as well as existing and accessible documents about NGSs, and available NGS policy from MoEYS. Additionally, high school assessment indicators and other necessary documents were also reviewed. More importantly, data collections were done by using semi-structured interviews, fieldwork, and site visits as methods to evaluate five representative schools (Grade 10-12) in Kampong Speu.

The results from this study are translated into a proposal of new STEM educational model for Grades 10-12 that is appropriate for implementation in a selected school in Kampong Speu and for being further shaped to become a suitable model for more schools in Cambodia in the long run.

2. RESEARCH APPROACH

This study employs a mixed method of desk reviews, questionnaires for teachers, semi-structured interviews for school principals, and fieldwork assessments of the sites, including the evaluation and observation checklist for overall physical infrastructure in five selected schools in Kampong Speu.

2.1. Sample and Selection

Five high schools in different districts out of the twenty-four in Kampong Speu were selected for this study. These included Kampong Speu High School in Chba Morn District, Chan Thnal High School in Udong District, Oral High School in Oral District, Slab Leng High School in Bor Set District, Teab Meanchey High School in Korng Pisei District. These schools represent three geographical spatial of Kampong Speu and the economic background of the community where the schools are located. Among those schools, one is in Chba Morn, the heart of this province, which is located in the North-East of Kampong Speu, two are located in the South-East of Kampong Speu, and the other one is located in the rural area of the North-Western part of Kampong Speu. In this study, a total of 66 teachers, out of whom 67% are STEM-related teachers and 33% are non-STEM teachers, engaged as respondents. The selection of those teachers was made by using a mixed sampling method, involving simple random selection and a convenient sampling process. Table 3 summarizes the school names, districts where the schools are located, and the number of teachers who were considered key respondents.

Table 3: The Name of High Schools and the Number Of Teachers Participate During the Fieldwork

No.	Name of School	Location	No. of Key Teachers Selected for the Study
1	Oral High School	Oral District	11
2	Kampong Speu High School	Chba Morn district	16
3	Slab Leng High School	Bor Set district	24
4	Chan Thnal High School	Udong District	8
5	Teab Meanchey High School	Kong Pisei district	7

Two to four school principals and top management team members from each high school were selected for face-to-face interview (Table 4). The team members include administrators and finance officers. The purpose of having the principal and management team involved in the study is to gain insight knowledge of educational programs and other special programs available, how the schools are running, what strengths, weaknesses, opportunities and threats are, what challenges the schools have had, how the schools have overcome them, what good lessons were learned, and so on. Besides, several more questions were asked to the school principal and top management team of each participating school in order to get general information about the statistics of staffs, facilities, school development plans, if available, and evidences supporting the STEM teaching approach. The followings mainly indicate school names and the number of school principals and top management teams selected in the study.

Table 4: Number of Participated School Principal and Management Team

No.	Name of School	Location	No. of School Principal and Management Team
1	Oral High School	Oral District	2
2	Kampong Speu High School	Chba Morn district	2
3	Slab Leng High School	Bor Set district	4
4	Chan Thnal High School	Udong District	3
5	Teab Meanchey High School	Kong Pisei district	4

2.2. Data Collection

2.2.1. Pen and Paper Surveys

The pen-and-paper survey form was designed, in part, to understand personal and educational background of the respondents, the perceived knowledge and skills they have acquired in relation to the implementation of the STEM teaching approaches and challenges they have to overcome in order to ensure the success of the STEM education implementation.

2.2.2. Policy and Secondary Literature Analysis

For desk review, the study looked into the existing STEM education model being implemented in Cambodia such as that of the NGS, and systematic selection of school models implemented regionally and internationally. Taking into account the educational dimension and government development initiatives, the reviewing team looked into curriculum, hardware infrastructure, human resources, governance, planning, as well as management and finance.

2.2.3. Semi-Structured Interviews

A semi-structured interview with school principal and management team was conducted in each selected school to find out high school history, capacity building programs available in each school, relevant partners/collaborators, recruitment and appointment processes, training schedule for laboratory and practicum, and so on. Furthermore, the capacity and competence of the management team, including leadership, administration, and finance team, were investigated in addition to the available academic activities, staff professional development, facilities maintenance, service, safety, and professional ethics required in each school. To get more information related to the implementation of the curriculum, hardware infrastructure, human resources, governance, planning, management, and finance, several more questions were also asked. It is worth mentioning that another objective of the interview with the school principal is to seek for their perceptions about the future direction towards applying the STEM education model in teaching and learning, and their views about (1) knowledge of contents and pedagogy among their teachers and in which areas of improvement is needed, (2) skills in assessment of student learning, classroom management, understating students' behaviors and attitudes and (3) what should be the future capacity development program in order to ensure that all teachers are more professionally trained.

2.2.4. Field Observation

An observational checklist by the research team was used to record the availability and conditions of the physical infrastructure, movable and immovable materials that are the potential resources in assisting the implementation of STEM education.

2.3. Data Analysis Method

Primary data includes that from the survey forms, recorded interviews, and observational checklist received from five high schools in Kampong Speu. The analysis of the survey and observational checklist is done by using descriptive statistics. The recorded audios from the interviews with the studied high schools were extracted and incorporated in the analysis results to be partially used for recommending the STEM model. Aside from these results, insightful analysis of the accessible key documents about representative NGSs was done additionally, and then served as partial contribution in the recommendation for Kampong Speu, besides criteria for existing STEM models.

3. ASSESSMENT OF TARGETED HIGH SCHOOLS IN KAMPONG SPEU

The following section will show the situation of the five targeted high schools in Kampong Speu province. The focus is on 1) basic infrastructure that supports teaching and learning, 2) basic infrastructure that supports school-community relations, 3) governance 4) management and support staff, 5) funding/financial resources, 6) STEM teachers and teacher qualification, 7). perceived knowledge and skills possessed by teachers.

3.1. Basic Infrastructure that Supports Teaching and Learning

This sub-section shows the basic infrastructure that supports teaching and learning from the five high schools. According to Table 5, the number of buildings available in those five schools ranges from 2 to 5, in which Kampong Speu High school and Teab Meanchey High Schools have a total of 5 buildings mainly for classrooms. In contrast, Oral High school and Slab Leng High School have only 2, and Chan Thnal High School has 3 buildings. Among those schools, Kampong Speu High School, located in the city, has up to 25 classrooms, whilst Oral High School has only ten classrooms.

The number of Grade 10 students per classroom is 36 at Oral High school, and 68 persons at Kampong Speu High School, whilst Grade 11 students per classroom are a total of 41 at Slab Leng High School and 70 at Kampong Speu High School. Not so different from Grade 10 and 11, the numbers of the Grade 12 students per classroom are 37 students at Oral High School and 60 students at Kampong Speu High School.

The libraries at the five schools share similar descriptions. They are small, old, and not functioning well with limited and out-of-date textbooks. Moreover, there are only a few available seats, which are messy and not well arranged for visitors. The science laboratories for physics, chemistry, biology, and earth sciences at all four schools (except Oral High School) are similarly not in good condition and are not responsive to learning needs today, particularly if STEM education is applied. The computer rooms and the current number of computers as well as ICT facilities are not available or not enough to meet the actual number of students in the target schools, including internet connection, LCD-projector, and e-whiteboard for the smart classroom. Among the selected schools, only two schools have a meeting room, Kampong Speu High School and Slab Leng High School; further, not all schools have study rooms and workshop spaces.

Table 5: Basic Infrastructure of the Five Targeted High Schools (Grades 10-12)

Physical Infrastructure (Grade 10-12)		Oral High School	Kampong Speu High School	Slab Leng High School	Chan Thnal High School	Teab Meanchey High School
General Info.		No.	No.	No.	No.	No.
Building		2	5	2	3	5
Classroom		10	25	10	11	17
Students per room	Grade 10	36	68	49	51	50
	Grade 11	59	70	41	56	46
	Grade 12	37	60	40	54	43
Lab	Biology	0	1 (Combined)	1	1 (Combined)	1
	Chemistry	0		1		1
	Physics	0	1 (Combined)	1 (Combined)		1 (Combined)
	Earth Science & Environmental Science					
	Computer	0	2	1	1	1
	English	0	0	0	0	0
ICT Facility	Internet	0	0	0	0	0
	LCD Projector	0	2	0	0	1
	e-whiteboard	0	0	0	0	0
Library		0	2 (Limited books & lack of proper management)	1 (Limited books & lack of proper management)	1	1
Study Room		0	0	0	0	0
Meeting room		0	1 (Max. capacity of 100 people)	1 (Max. capacity of 80 people)	0	0
Workshop		0	0	0	0	0

3.2. Basic Infrastructure that Supports School-Community Relations

Table 6 shows the basic infrastructure that supports school-community relations. According to this table, each school has an office for the management team, teaching, and non-teaching staff, but no room for security, cleaning and eating lounge.

Office for the management team for all schools is in good condition. But only Kampong Speu High School and Slab Leng High School have quite a well-organized office ready to welcome non-teaching staff, though they are small and not well equipped with all necessary equipment.

For infrastructure outside the building, there is no biodiversity garden in the targeted schools except Chan Thnal High School. But that biodiversity garden at Chanthnal High School also needs to be renovated or upgraded for STEM education purposes. On the contrary, all selected high schools have canteens, except Chan Thnal High School, though they are not in good quality and hygiene. All schools have good space for sport area and garden. All schools have very good infrastructure and easy access for toilet and sink units, parking areas, trash bin, water supply, and electricity access to the national grid. However, the parking area at Slab Leng High School is very small.

This study also invited teachers to evaluate the quality of physical facilities of their schools, including buildings, classrooms for teaching and learning, science laboratory, operation of the library, computer labs, teacher rooms, administration office, and terrace. In general, the building and classrooms for Kampong Speu High School, Slab Leng High School, Chan Thnal High School, and Teab Meanchey High School are in good shape, but the quality of the building of Oral High School is very poor. The observations by the research team and teachers reflected that the resource building is in a very good condition compared to other buildings on the campus. There are also rooms that teachers can use.

At Chan Thnal High School, although there is a laboratory, the quality is very low, but the researcher observed that there is no laboratory at Oral High school. The quality of the laboratories at Kampong Speu High School, Slab Leng High School, and Teab Meanchey High School is in moderate condition in terms of space and fundamental laboratory infrastructure. However, the quality of laboratory equipment and materials are very poor and may not be used at full capacity for STEM teaching and learning.

Table 6: Physical Infrastructure of Each Selected High School

Physical Infrastructure (Grade 10-12)	Oral High School	Kampong Speu High School	Slab Leng High School	Chan Thnal High School	Teab Meanchey High School
General Info.	No.	No.	No.	No.	No.
Admin. Building					
Office for Management Team	1	1	1	1	1
Office for Non-Teaching Staff	1	1	1	0	0
Office for Teaching Staff	1	1	1	1	0
Eating Lounge for Staff	0	0	0	0	0
Room for Security and Cleaning Staff	0	0	0	0	0
General Info. on Outside Building					
Garden of Biodiversity	0	0	0	1	0
Canteen	1	1	1	0	1
Sport Area	1	1	1	1 (Volleyball court)	1
Garden	1	1	1	1	1
Toilet & Sink Unit	1	1	1	4	1
Parking Area	1	1	0	1	0
Trash Bin	1	1	1	1	1
Water Supply	1	1	1	1	1
Electricity Access to National Grid	1	1	1	1	1

In addition, the science laboratory equipment and substances are not properly stored according to laboratory conditions. Libraries and learning resources at Kampong Speu High School, Slab Leng High School, and Chanthnal High School are in moderate conditions; however, they do not have a library management system yet. The quality of libraries at Oral and Teab Meanchey High School is very low.

The quality of computer rooms at Kampong Speu High School, Slab Leng High School, and Chanthnal High School is moderate, while the quality of computer rooms at Teab Meanchey High School is very poor. The ICT infrastructure for all the five targeted high schools is insufficient, including the unstable internet connection.

3.3. School Governance

This sub-section shows the information on school governance to reflect on how the five targeted high schools function in the general governance context, in particular its board function. It is observed that not all five high schools have school boards. Even if they do have, there is no clear Terms of Reference observed, suggesting the lack of participation from important players that make school's function works, particularly the involvement of the community and private sector. This also reflects a missing function of the School Management Committee (SMC) in pushing schools to become autonomous and accountable in the context of the current education reform towards an effective school-based management model.

All schools claim to have strategic plans, yet a clear vision, mission, and goal are not available, except for Kampong Speu and Slab Leng (schools under Secondary Education Improvement Project [SEIP]) that have the vision, missions, and goals written and spelled out clearly in their strategic plans and other documents. All the five targeted high schools have a clear school organizational structure. However, the evidence of the process used in developing them is not found and the core activities to improve school management, teaching and learning and mechanisms to monitor and evaluate the realization of the missions and goals, as well as a proper functioning according to the structure, are not clearly defined. Educational leadership and governance are two closely interrelated elements that have a significant impact on the operation of the schools and other educational organizations. The findings from the interviews suggested that the governance teams at the five high schools have limited leadership skills, although their commitment to perform their work is unquestionable.

3.4. Management and Support Staffs

Table 7 mainly reveals the information about management and support staff. According to this table, each school has one principal and two/three deputy-principals depending on how big the school is. Although a full picture of school qualification is not fully available, from the data the research team collected, two school principals earned Bachelor's degree (Oral High School and Teab Mean Chey High School), one has a Master's degree (Chan Thnal High School), whereas the deputy principals of four schools have received Bachelor's degrees (Oral High School, Kampong Speu High School, Chan Thnal High School, and Teab Meanchey High School). In general, each school holds one meeting every month with their staffs and other top management team. According to the interview with school principals, the meetings are mainly to focus on a school development plan, infrastructure enhancement, finance, and management-related activities, as well as on general academic matters. However, professional in-service training is hardly found to be implemented in all targeted schools.

For administrative and finance staff, each school usually has one or two, except Chan Thnal high school that has seven administrative staff, and Oral high school has no staff responsible for administration and finance at all. On the other hand, the majority of the school has not considered having any staff working on public relations, except Teab Meanchey High School that has answered to have staff working on public relations. It is very interesting to note that none of the targeted high schools have staff responsible for academic affairs, except Chan Thnal High School that appoints three staff working for academic affairs.

In terms of a laboratory assistant, Table 7 indicates that Kampong Speu High School has two assistants, while Slab Leng and Chan Thnal High School have one each, and the rest have none. With regard to the school counseling committee for the non-academic affairs, it is interesting to see that the structure of the school counseling consists of 7 student members. For school counseling committee on the academic affairs, it consists of the school principal, deputy-principals and the heads of technical group for each subject but not all schools set up this kind of school counseling committee and secretary as it could only be found at Oral High School, Kampong Speu High School, and Teab Meanchey High School, but not at Chan Thnal and Slab Leng High School.

Table 7 additionally shows that none of the schools has recruited nurses to work at the school, possibly due to limited budget or the common practice available in schools in the whole country. For cleaning staff, only Kampong Speu High School recruited one staff to work on the cleaning of the whole school, while the others do not. According to the interview, the common practice is that students clean their classrooms, and the other parts of the schools are cleaned on a weekly basis by students. Finally, in terms of skills upgrading for staff, almost every school's representative expressed that they have a regular activity that leads to skills upgrading of management team members and staffs, although which specific skills have been upgraded need to be revealed.

Table 7: Top management team, their qualifications, and other related information

Management and Staff Qualifications		Oral High School		Kampong Speu High School		Slab Leng High School		Chan Thnal High School		Teab Meanchey High School	
Management		Qualification	No.	Qualification	No.	Qualification	No.	Qualification	No.	Qualification	No.
Principal			1	-	1		1		1		1
Principal's Qualification		Bachelor's degree		-		-		Master's degree		Bachelor's degree	
Deputy-Principal			2	-	3		2		3		2
Deputy-Principal's Qualification		Bachelor's degree	-	Bachelor's degree	-	-	-	Bachelor's degree		Bachelor's degree	
Personnel Office	Admin staff	-	-	-	2	-	1	-	7		1
	Finance Staff	-	-	-	1	-	1	-	2		1
	Public Relations staff		0		0		0		0		1
	Academic Affairs staff		0		0		1		3		1
	Lab. Assistant		0		2		1		1		0
	Others	Secretary	1		0		0		0		0

School Counselling Committee	Others	7 student members	7	7 student members	7		0		0	7 student members	
	Academic Affairs	• Principal • Deputy-Principals • Heads of technical group of each subject • Secretary	6		0		0		1		0
Number of Security	In-School				1		0	Gaurd	1		0
	Front-Gate	Take turn (student)	6/da y		0		0	Take turn (student)			0
Nursing			0		0		0		0		0
Cleaning			0		1		0		0		0

3.5. Funding/Financial Resources

Table 8 illustrates that in addition to the government budget, all five targeted schools received a substantial amount of support from other sources to support school operations, infrastructure development, and the teaching and learning process. Except for Kampong Speu High School, other high schools such as Oral High School, Slap Leng High School, Chan Thnal High School, and Teab Mean Chey High School received additional support from the development partners. 2021's information indicated that among the schools that received support from the development partners, only Teab Meanchey received up to 11,916,900 riels. More interestingly, Kampong Speu High School received higher additional funds from students' parents than other high schools, amounting to 8,000,000 riels. It is an excellent example of parents' participation in supporting school operations and infrastructure improvement. According to the interviews with school principals, the community has also voluntarily contributed to the school infrastructure development and other purposes, whether through the call for support by the principal or a request to the local pagoda assistance.

Table 8: 2020's Annual Budget Received from the Government and Other Sources in Each High School

Governance and Management		Oral High School	Kampong Speu High School	Slab Leng High School	Chan Thnal High School	Teab Meanchey High School
Annual Budget Source		Amount (Riels)	Amount (Riels)	Amount (Riels)	Amount (Riels)	Amount (Riels)
Government		32,724,000	116,000,000	78,466,800	65,900,600	53,022,000
Others	Partners	616,000	0	10,150,000	4,950,400	11,916,900
	Students' Parents	0	8,000,000	0	0	0
	Community	0	0	1,000,000	2,000,000	0

3.6. STEM Teachers and Their Qualifications

According to Table 9, the number of teachers assigned for the subjects such as Biology, Chemistry, Physics, Earth Science & Environment, Math, Computer is between 1 and 4. For instance, there are four teachers for Biology and Chemistry subjects at Kampong Speu High School and Chan Thnal High School, whilst Oral High School has only one teacher for this subject. For physics subject, only Chan Thnal High School has four teachers, whilst Oral High School has only one, and Slap Leng has two. Only Kampong Speu High School reserves three teachers for

Earth Science and Environment, and other schools have only one or two depending on the number of students. Interestingly, Kampong Speu High School and Chan Thnal High School have seven teachers for Math subject, while Oral high school has only two teachers for this subject. All selected schools, except Oral High School, have two teachers reserved for a Computer subject.

The majority of teachers who teach Grade 10-12 hold a Bachelor's degree, while few of them have received Master's degree. Interestingly, Kampong Speu High School has seven staff with Master's degree, among whom are the heads of technical team leaders for Math and Physics. The majority of teachers at the targeted school have a lengthy experience in teaching, at an average of more than ten years. However, in-service training is rather limited across all targeted schools.

Table 9: Number of Teachers of STEM-Related Subjects and Their Qualifications

Teacher		Oral High School	Kampong Speu High School	Slab Leng High School	Chan Thnal High School	Teab Meanchey High School
		No.	No.	No.	No.	No.
Number of Teaching Staff	Biology	1	4	2	4	2
	Chemistry	1	4	2	4	4
	Physics	1	3	2	4	3
	Earth Science & Environment	1	3	2	2	2
	Math	2	7	4	7	3
	Computer	0	2	2	2	2
Qualification of Technical Team Leader by Subject	Biology	0	1 (Bachelor)	0	1 (Bachelor)	1 (Bachelor)
	Chemistry	0	1 (Bachelor)	0	1 (Bachelor)	1 (Bachelor)
	Physics	0	1 (Master)	0	1 (Bachelor)	1 (Bachelor)
	Earth Science & Environment	0	1 (Bachelor)	0	1 (Bachelor)	1 (Bachelor)
	Math	1 (Bachelor+1)	1 (Master)	1 (Bachelor)	1 (Bachelor)	1 (Master)
	Computer	0	1 (Bachelor)	0	1 (Bachelor)	2 (Bachelor)

Due to an unequal student-teacher ratio with a small number of teaching staff, teaching hours per week among teaching staff are very high and, in some cases, exceed the ministry's requirement. We found that the average teaching hours for science teachers at Slab Leng High School, Chan Thnal High School, and Teab Meanchey High School are at 14 hours per week at Kampong Speu High School, 18 hours per week, and at Oral High School, 25 hours per week. We also can see that 6% of science teachers at Kampong Speu High School teach 29 hours per week (Table 10). Combining with other obligations such as preparation for lesson plans, technical group meetings, and other school-related activities, the teacher's workload at these targeted high schools is quite heavy.

Table 10: Workload of Teachers

Variable		Oral High School	Kampong Speu High School	Slab Leng High School	Chan Thnal High School	Teab Meanchey High School
Teaching hour per week	Mean	25.27273	18	14	14	14.57143
	Minimum	23	16	6	12	9
	Maximum	28	29	20	16	18

3.7. Perceived Knowledge and Skills Possessed by Teachers

As long as pedagogy is concerned, the teaching of STEM subjects is problematic. At a macro or policy level, the fight is between student-centered learning and teacher-centered learning. In STEM education approaches, teaching methodologies such as 5Es instruction model, scientific method, inquiry-based learning (IBL), concept-based teaching, project-based teaching, and problem-based teaching are the keys for the success of the STEM education implementation where student-centered learning approach is highly used in the classrooms. This will assist the moving from content-based teaching that relies on teacher-centered learning approach to a competency-based teaching, which focuses basically on measurable outcomes in three aspects: knowledge, skills, and attitude that rely on student-centered learning.

In this research work, STEM teachers were asked to use a 5-point Likert scale to assess their knowledge and skills in relation to those methods/approaches. Below is a summary of what teachers have to say about their knowledge and skills related to STEM subjects and STEM teaching and learning:

- All science teachers claim they have good knowledge about the lessons they teach.
- Most teachers have moderate to good knowledge about the students they teach and classroom management skills.
- Teachers claim they have moderate skills in lesson plan preparation
- Most teachers claim to have good strategies to teach students to be independent learners.

However, the findings suggested that most teachers have low to moderate skills in ICT (in particular, internet use), English language, project-based learning, creating innovative activities for students, curriculum use, counselling, developing teaching materials, writing for academic purposes and skills in using the laboratories.

Even though teachers claimed that they are likely to be aware of these new teaching and learning approaches but in practice, they never do it due to the lack of sufficient and appropriate teaching and learning materials as well as laboratory to support the implementation of such new approaches for teaching and learning. Other factors such as not having a strong school culture to maintain teaching, learning and assessment that promotes STEM education, and supportive school management that promotes an active working environment are the barriers for teachers to enhance knowledge and skills on STEM teaching and put it in everyday classroom practices. The data above from teachers, therefore, seems to suggest that teachers need to be trained more on how to use new teaching methods such as inquiry-based teaching, project-based teaching, and how to maneuver ICT- and lab-based activities in everyday classroom teaching and learning.

3.8. Curriculum

The curriculum in the targeted schools in Kampong Speu province followed the ministry's curriculum policy framework provided by MoEYS as seen in Table 11. There are two streams, the science stream and the social science stream, and the contents taught in these two streams are different. The science stream is more advanced in terms of STEM education than the social science stream, but the two streams follow solely the textbooks developed by the ministry. What is interesting to note among the five targeted school is that only Kampong Speu High School has a special science class (one class for Grade 12) for talented students who are preparing to achieve Grade A in the high school national examination. This group of students is the potential group to transfer to the STEM-oriented education in the future. This will be discussed more in the recommendation section later.

In addition to the current curriculum, MoEYS developed the new curriculum in 2015 to equip learners with knowledge, skills, and attitudes to support their daily lives and further studies. More importantly, this new curriculum framework seeks to improve the quality of education in response to the changing world and to the demand of the Rectangular Strategy of the Royal Government of Cambodia, which aims to move Cambodia to become an upper-middle income country by 2030 and a high-income nation by 2050. The new curriculum framework also sets a new context for MoEYS to focus more on the quality and relevance of education delivered to students to ensure there is enough qualified workforce for economic growth and for its improved competitive capacity ready for moving into the global market. This is well evident as more teaching hours are allocated to core subjects such as Khmer Literature, Mathematics, Physics, and Foreign Languages, one way or another, to build the foundation of STEM education. However, this new curriculum is still not implemented at the school level.

Table 11: Grade 10-12 Curriculum

No.	Subjects	New Curriculum (Grade 10-12)	Current Curriculum (Public school) Grade 10-12
1	Khmer Literature	5	3
2	Mathematics	6	5
3	Foreign Languages	6	2
4	Physical Education and Sports	2	1
5	Home Economics	1	2
6	Physics	4	3
7	Earth-Environmental Science	2	2
8	Chemistry	3	3
9	Biology	3	3
10	History	2	2
11	Geography	2	2
12	Moral-Civics	2	2
13	ICT	1	0
14	Health Education	1	0
15	Technical Education (Elective)	0	2
Total Weekly Hours		**40**	**32**

4. STEM HIGH SCHOOL MODEL

In terms of curriculum, this proposed STEM high school model follows the MoEYS's new curriculum framework for general education and technical education developed in 2015 that was a good direction, as mentioned earlier. The implementation approach of the proposed STEM curriculum is called the Integrated STEM Education approach, and it is focusing on teaching and learning approach and content. Furthermore, the substance of the approach is the integration of STEM education, particularly, scientific and technological contents based on local context and available resources into Science and Mathematics. However, it is important to note that this proposed model maintains sufficient distribution of subjects and study hours as shown in the Table 12.

Table 12: Distribution of Subjects and Study Hours (Grade 10-12)

No.	Subjects	Integrated STEM Education (Grade 10-12)	Current Model (Public school) Grade 10-12
1	Khmer Literature	4	3
2	Mathematics	6	5
3	English	6	2
4	Physical Education and Sports	2	1
5	Home Economics	1	2
6	Physics	5	3
7	Earth-Environmental Science	2	2
8	Chemistry	3	3
9	Biology	3	3
10	History	2	2
11	Geography	2	2
12	Moral-Civics	2	2

13	ICT	1	0
14	Health Education	1	0
15	Technical Education (Elective)	0	2
Total Weekly Hours		**40**	**32**

Note *- 6 days a week, 4-7 study hours a day, and 1 study hour has 50 minutes.*

In search of an appropriate model that is cost-effective and cost-efficient with the focus of not only improving STEM cognitive knowledge but also linking STEM education to local context and solving local issues and global trends, our STEM education model will focus on changing teaching and learning approaches to connect STEM teaching and learning to everyday life and future innovative industry inquiries. In this regard, the new model will emphasize on an experiential and project-based education model in and outside the classroom that allows students to work on assigned tasks or their own inquiries through problems or projects of their interests while teaching students to integrate the use of educational technology into their learning processes.

To implement the new proposed model, three integrated STEM education approaches are applied, namely interdisciplinary, multidisciplinary, and transdisciplinary approaches with three proposed teaching strategies: 1). Inquiry-Based Learning Strategy[9], 2). Problem-Based Learning Strategy[10], 3). Project-based Learning Strategy[11] to achieve the learning outcomes as presented in Table 13.

[9] Learning with a question or issue and, thereby, engaging learners in constructing new knowledge and understanding.
[10] The real-world problems are used as the vehicle to promote student learning of concepts and principles.
[11] Students work on a project for a period of time, which engages them in solving a real-world problem.

Table 13: Proposed Learning Strategies and Expected Learning Outcomes

Contents	Proposed STEM Learning Strategies	Expected Learning Outcomes
60% for Teaching Science and Mathematics as scientific inquiry	Inquiry-Based Learning or Lab-Based Learning Strategy [Using blended learning methods]	Scientific, technological and know-how knowledge Skills acquired responding to demand of society and being a citizen of 21st century and beyond
10% for Teaching Science and Mathematics as integrated subjects, including engineering and technology contents	Problem-based Learning Strategy Project-based Learning Strategy	Content Knowledge 21st century interdisciplinary themes Applied Knowledge 21st Century Skills
10% for Lab-based Education	Inquiry-Based Learning Strategy having combination of disciplines are built in place. Structure of human resources and facilities are built in place.	Knowledge is made to solve a particular problem of the local or community. Skills are made through collaboration, communication, critical thinking, team work, and research. Attitude is made through passion, curiosity, built-system, respect, ethics, and morality.
20% for Extra-Curricular activities: - Science Fair - Industrial Visits - Equity Programs - Scientific Competition - Internship Programs	Problem-based Learning Strategy Project-based Learning Strategy Outreach programs Culturing liberal arts	Content Knowledge 21st century interdisciplinary themes Applied Knowledge 21st Century Skills

- STEM Excellence Award - Self-Directed Learning - Study Clubs - Entrepreneurial projects or local problems/local solutions, Industrial-based oriented projects		

Applying these different ways of teaching and learning strategies is called the Integrated STEM Education approach, in which the activities are linked to multidisciplinary contents and everyday life. It is focused on 21st century skills and on the use of a scientific approach and technology for teaching and learning. The core of this Integrated STEM Education approach is the Inquiry-based learning strategy, where inquiry is defined in Figure 4. As mentioned in the previous session, around 30% of the SMEs in Kampong Speu needs a STEM-based workforce in the field of engineering and science majors, including construction, packaging technology, materials science, food processing, electric, electronics, and mechanical engineering. These industries are strongly related to Mathematics and Physics skills. Therefore, more numbers of project-based learning will be linked to Applied Physics than to Applied Chemistry and Biology.

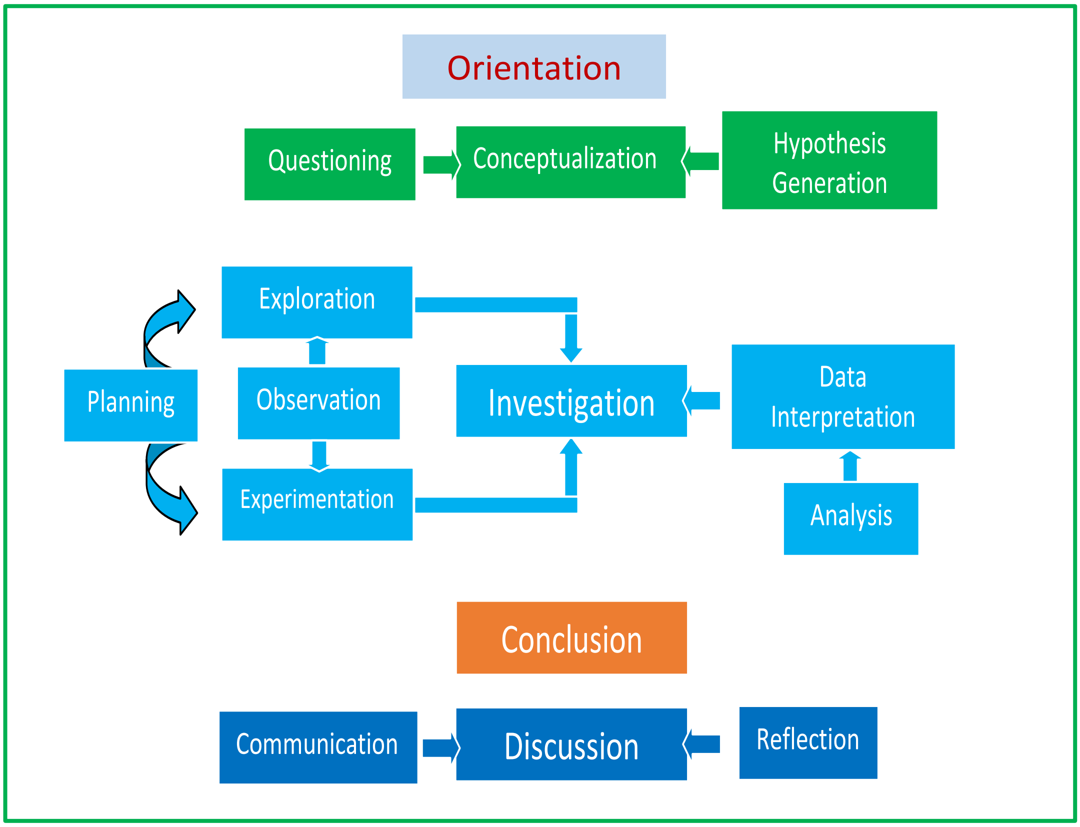

Figure 4: Visualization of the Process of Inquiry Activities was Merged into Five General Inquiry Phases (Margus Pedaste et al., 2015).

Schematically, although the Integrated STEM Education approach does not require a substantial change in the curriculum, the model needs to emphasize the following key activities to ensure that an effective implementation and that the model has added values against other existing STEM school models in Cambodia. These include:

- The whole curriculum promotes an experiential education modality, which requires students to directly work on local issues or STEM projects linked to everyday life or potential industrial application (e.g., ICT skills such as computer coding, web/app development, digital/graphic design, food processing, agricultural skills, packaging technology or electric, electronic, and mechanical engineering design);
- Teaching emphasizes problem-, inquiry- and project-based activities;
- Self-directed learning together with STEM study clubs are promoted as the extra-curricular activities;

- The way students are assessed needs to be implemented differently. Basically, the performance-based assessment is to be implemented alongside the summative assessment that is clearly establishing toward a higher-order thinking skills using the Bloom's Taxonomy at level 3 or above, in the design of everyday learning tasks;
- School-based STEM events or competitions are established;
- STEM projects owned by students with supervision from teachers and/or STEM graduate students to generate income at school is institutionalized.

To implement this Integrated STEM Education approach effectively and efficiently, the research team proposed to have the following guideline in terms of physical and human resources and institutional organization with regard to governance and management.

4.1. STEM Teacher, Their Qualification and Workload

Table 14: Student-Teacher Ratio and Teacher's Qualifications by Subjects (Grade 10-12)

Teacher		Student-Teacher Ratio	Description
STEM Subjects	Biology	30/1	The available resources both facility and human direct the approach to limit this student-teacher ratios to 30-1. In principle, the school could be flexible to accommodate lesser students to around 16 for an ideal case. With 30 students per class, teachers could group them to conduct group works, class practices, project-based learning and others.
	Chemistry	30/1	
	Physics	30/1	
	Earth Science & Environment	30/1	
	Math	30/1	
	Computer	30/1	
Teacher		**Degree**	**Description**
STEM Subjects	Biology	BSc. in Biology plus One	STEM teachers must have the minimum qualification of Bachelor's degree of Science in STEM-related fields plus pedagogical certification (NIE) and must join regular professional development on new content knowledge and teaching methodologies such as Inquiry-Based Approach, Problem-Based Approach, Project-Based Approach, Lab-based
	Chemistry	BSc. in Chemistry plus One	
	Physics	BSc. in Physics plus One	
	Earth Science & Environment	BSc. in Env. Science/Physics/Geography plus One	
	Mathematics	BSc. in Mathematics plus One	

	Computer	BSc. in Computer Science/IT-Engineering plus One	Learning, classroom management, and continuous capacity building on understanding on future technological needs.

Table 15: Teacher's Workload (Grade 10-12)

Teacher's workload	Number of Hours per week	Description
Teaching	15 to 18	Teaching for 3 hours per day
Preparation teaching and learning materials	10 to 12	Preparing teaching and learning material for 2 hours per day
Content-based development and Lab Skills development	5 to 6	Self-development: Content knowledge, Lab Skills, and Applied Research. Also, discussion with other teachers on teaching and learning approach and knowledge sharing
Participating in Extra-Curricular Program and Professional Development on the Integrated STEM Education approach	5 to 6	Involving in the project-based learning activities, supervise students and industrial linkage activities, local problems/local solutions, technological changes, technological demand by industries
Total working hours per week	35 to 42	Total working hours are 7 to 8 hours per day?

4.2. Basic Infrastructure that Supports STEM Teaching and Learning

Consideration on availability of resource in schools it is suggested to have 30 students per lab class.

Table 16: Basic Infrastructure Supporting STEM Teaching and Learning Processes

Physical Infrastructure (Grade 10-12)		Model	
General Info.		Number	Description/Detail Equipment/Requirements
Student classroom ratio	Grade 10	30	30 students per class is ideal to implement STEM education
	Grade 11	30	
	Grade 12	30	
Lab	Biology	1	General Biology Lab equipped with lab furniture such as glassware storage cabinet, cabinet for chemical storage, basic sample preparation and experimentation space, refrigerator, basic experimentation tool for experimentation, microscope, and basic equipment for biology from Grade 10-12
	Chemistry	1	General Chemistry Lab equipped with lab furniture such as glassware storage cabinet, basic chemicals for experimentation e.g., natural base or natural acid, glassware for basic chemistry experimentation, basic fab lab for project-based learning, and other basic chemistry tool for Grade 10-12
	Physics	1	General Physics and Earth Science Lab equipped with lab furniture and basic equipment for Physics and Earth Science & Environmental Science from grade 10-12. Some basic equipment can be one screen for virtual observation which content that can be from YouTube or others. Basic physics tools for earth observation, observatory equipment of the nature, natural interpretation through technology, and others
	Earth Science & Environment al		
	Computer	2	One ICT lab for teachers and students training and training. One Computer Lab for class practices
	English	1	English Lab for both students and teachers.
ICT Facility	Internet	1	One internet system for the whole campus
	Smart TV	3	Need 7 Smart TVs for all classrooms, meeting rooms and study rooms

Library	1	Equip with STEM-related books and a library management system and establish a sound system of librarying to get a favorable environment for students to conduct research or self-studying. School librarian could be trained continuously by professionals.
Study Room	2	Self-study rooms (one for teachers and one for students)
Multipurpose Room	3	Three meeting rooms for discussion, parent consultation, student performance assessment meeting, project work, and meeting
Workshop	1	Workshop room for engineering and technology development

4.3. Basic Infrastructure that Promotes a Supportive School Environment

Table 17: Basic Infrastructure Promoting a Supportive School Environment

Physical Infrastructure (Grade 10-12)		
General Info.	**Number**	**Description/Detail Equipment/Requirement**
Admin. Building		
Office for Management Team	1	Office for School principal and two deputy school principals
Office for Non-Teaching Staff	1	Office for Administration staff, Finance staff, Public Relation staff, discipline management staff, and person in charge of Academic Affairs
Office for Teaching Staff	1	Room-teaching staff used during break and waiting time with basic facilities to have favorable environment
Eating Lounge for Staff	1	Lounge: breakfast, tea, coffee, and lunch for staff and visiting guests
Room for Security and Cleaning Staff	1	Room for security staff and cleaners
Outside Buildings		
Botanical Garden	1	Botanical garden is the outdoor science lab that students and teachers can use for Biology, Chemistry, Physics, and STEM project activities and research. Furthermore, the refreshing mind recreation serves as potential project-based learning for students practicing biology.
Hygiene Canteen	1	Common hygiene canteen for the school, in which students, teachers, and management team can have breakfast, lunch and coffee. The proper waste cleaner and food service provider is established in place.
Sport Area	1	Sport area can be used for multi-purpose sport activities and outdoor class activities. Some simple sport activities are suggested for building health, communication, and attitude. The basic sport could be football, table tennis, volleyball, running tournament court.
Garden	1	The garden is equipped with an integration system for smart monitoring and Industry 4.0 concept with the Internet of

		Things (IoT) for green and clean campus and STEM education.
Waste Management, Toilet & Sink Unit	2	In addition to the toilet in the building, there are two separate toilets (one for male and one for female) and two sink units on campus for students, staff, and visitors for outdoor activities. In principle, there should have no waste at school. Plastics or other forms of waste are not encouraged to be used at canteen or elsewhere. The waste management should be made and segregate at source (one container for plastic and drive trashes and another container for wet waste). In addition, there must be waste management site for incineration or service contract.
Parking Area	1	Parking area for bike, motorcycles and cars
Clean Water Supply	1	Drinking water support from official supplier
Electricity Access to National Grid	1	Stable electrical system that is connected to grid system (EDC)

4.4. Management and Supporting Staffs

Table 18: Management and Supporting Staffs

Management Team	Number	Description/Detail Equipment/Requirement
Principal	1	Minimum Bachelor's degree (with at least five years' experience in school and preferably having STEM background) and trained in school management and have experience at high school level
Deputy-Principal	2	Minimum Bachelor's degree (with at least five years of experience in school) and trained in school management and have experience at high school level
Management Team Meeting per year	12	Conduct weekly meetings for M&E of day-to-day work activities, to be led by principal
Capacity building of Management Team per year	1	School management system, finance, administration, and public relations courses

Skill-upgrading of STEM Teachers		1	Establish skill-based capacity building to STEM teachers in relation to inquiry-based learning, project-based learning, or lab-based learning, science clubs
Meeting between Management Team and Academic Staffs per year		4	Quarterly meeting on achievements, plan for next, mechanisms to achieve the deliverable, output-based orientation
Personnel Office	Admin staff	1	Minimum Bachelor's degree, preferably in educational management, who can be responsible for all administration tasks at school
	Finance staff	1	Minimum Bachelor's degree, preferably in accounting, who can be responsible for all finance, accounting and cashier
	Public Relation staff	2	Minimum Bachelor's degree, preferably in public relation, who can be responsible for communication and connection to outsiders such as community, parents, industry and development partners
	Academic Affair staff	1	Minimum Bachelor's degree with training on educational counselling who can be responsible all students' performance, transcripts and others related study activities
	Lab. Assistant	4	Minimum Diploma degree in science or engineering which was working closely with STEM teachers to help students on lab experiments and scientific activities
School counselling committee	Non-academic affair	1	Other issues of students such as career pathways, living, accommodation, physical and mental health
	Academic affair	7	Manage and organize all student study clubs activities
Number of Security	In-School	2	One working outside the building and one inside the building and exposure visits
	Front-Gate	1	Working at the front gate
Nursing		1	First-aid task should have students or staffs in-charge and should collaborate with the Red Cross or local health center.

Cleaning	2	One working outside the building and one inside the building. Additionally, it is important to have calendar in place for all staff, teachers, and students, including management level to have self-time table for cleaning the school. E.g., environmental day and/or save the earth day once per year to collect plastic or waste in or out campus or in community.
Meeting Regularity between Management Team and Support Staff every 6 months	12	Monthly meeting for M&E of day-to-day work
Regularity of Skill-Upgrading of Support Staff per year	1	One per year during the school vacation

4.5. Governance and Terms of Reference for School Board

Table 19: Governance and Terms of Reference for School Board

Governance		Number of Members	Description
Board	Number of Board Members	7	MoEYS, local government, school management, private sectors, community representative, parents' representative, and pagoda (monk)
	Number of Meetings per year	4	Quarterly meeting
Terms of Reference			Oversight budget, fund raising, public communication, contextual-based resolution to a particular problem, peering the performance of school, strategic plan and performance of school reviewing

4.6. Funding/Financial Resources

Table 20: Funding/Financial Resources

Annual Budget Source		Number	Description
Other Sources	Government	-	Existing support, with the open possibility towards new infrastructure development
	Development Partners	-	Can support new infrastructure as well as capacity development program, especially through study tour and exchange of teachers
	Students' Parents	-	Supplement for school operation, including recurrent spending and supplement salary
	Community	-	Supplement for school operation, including recurrent spending and supplement salary
These staffs need extra support to perform the new proposed model	Management	3	Principal and deputy principals
	Staff	9	Admin staff, Finance staff, Public Relation staff, Academic Affairs staff, Lab. Assistant
	Teaching Staff	-	All teachers in the science stream at high school
	Nurse	1	Contracting from local health center
	Security	3	Private security
	Cleaning	2	Professional cleaners
	Advisory Board	7	Student volunteers with small support from school

5. CONCLUSION AND RECOMMENDATIONS

The development of STEM education in Cambodia is seen in positive efforts and views nationwide. However, a unified and uniform STEM education definition should be addressed, particularly on STEM education approaches. The concerns as to what is most interesting, what kind of resource mobilization strategy is appropriate to implementing STEM education remain open for best answers. After having reviewed some high school models that claim to promote STEM education, we come to the conclusion that the existing STEM model is seen to be costly and have moderate link of its content to the local context. Most of STEM high school model has shown evidence of efforts regarding practical activities and quality improvement; however, its STEM education program linking to local industries or solving local issues remain unclear as there is nothing much of the reform of the curriculum and its teaching strategy (teach to pass the exam), and there are insufficient extra-curricular activities that provide the added values of STEM education to the future career of students. Furthermore, its high cost might not be suitable to scale up the STEM education nationwide to produce a critical mass of STEM literacy for the future development of the Cambodian economy and industry.

5.1. Rationale for Selecting a High School to be STEM High School

Against this backdrop, we propose to transform Kampong Speu High School to be STEM high school by applying more for science stream students starting from Grade 10. Furthermore, we propose to recruit only 90 students for three classes. Our rationale for selecting Kampong Speu High School out of the five targeted schools to be a STEM high school with the highest possibilities of successful implementation is based on the following conditions:

1. Readiness of the infrastructure (investment needs range from low to moderate);
2. Access to electricity, water, and internet;
3. The distance of its location to the different industrial zones;
4. Teacher, teacher’s qualifications and competency, especially the use of ICT in education and life;
5. Readiness of school management and its competency;
6. Existing practices from participation of community and parent;
7. Location that is easily accessible by all students from Kampong Speu;
8. A strong school culture that is better suited to STEM teaching and learning.

5.2. Recommendations to Transform High School to be STEM High School

5.2.1 Preparation Stage

Investment and capacity building

In order to provide a better supporting mechanism for better implementation of STEM education at the targeted school, the research team provides the recommendation as followings:

1. Redesign the contents to fit the curriculum standard by identifying the set standard, available resources and key concepts; and developing teaching and learning standards for clear teaching and learning assessments and teacher guidebooks for IBL, in general;
2. Provide professional development based on individual teacher's needs and provide all supporting teaching and learning materials based on the newly designed content standard proposed above;
3. Transform the existing pedagogical practices into IBL, such as the IBL instruction models for teaching and learning, competency-based curriculum. In return, teachers are also given financial support and a platform so that their achievement of IBL implementation can be shared electronically or physically in the forums/conferences;
4. Enhance teaching and learning environments such as classroom facilities, science laboratory infrastructure with materials and consumables, favorable environment of skill development, and ICT infrastructure. These facilities will enable teachers and students to conduct prior laboratory activities to promote active learning and arrange post laboratory activities to encourage 21st century skills;
5. Establish extra-curricular for students such as Academia-Industries Program, Science Fair, Exposure Visits to STEM-related activities, linkage to university research graduate, Special Programs, STEM projects and Science Competition in order to provide more chances to students and teachers to learn and apply their knowledge and skills in the real world through scientific investigation, discussion, report writing, presentations, and reflections. Self-directed learning and STEM study clubs on major science subjects and reading need to be implemented to increase learning opportunities for students and to enhance student competence in 21st century skills and ICT use in addition to the normal classroom practices.

Table 22: Recommended General School Infrastructure (Grade 10-12)

<table>
<tr><th colspan="2">Physical Infrastructure (Grade 10-12)</th><th>Existing Infrastructure at Kampong Speu High School</th><th>Ideal Infrastructure for STEM High School</th><th>What needs to be done</th></tr>
<tr><th colspan="2">General Info.</th><th>Number</th><th>Number</th><th>Description</th></tr>
<tr><td rowspan="6">Laboratories</td><td>Biology</td><td>1</td><td>1</td><td>Need to renovate and equip lab furniture and responsive equipment</td></tr>
<tr><td>Chemistry</td><td>1</td><td>1</td><td>Need to renovate and equip lab furniture and responsive equipment</td></tr>
<tr><td>Physics
Earth Science & Environmental</td><td>1</td><td>1</td><td>Need to renovate and equip lab furniture and responsive equipment</td></tr>
<tr><td>Computer</td><td>1</td><td>2</td><td>The current computer room needs to be upgraded with facilities, including computers, internet connection and relevant software. Also, one more computer lab is needed.</td></tr>
<tr><td>English</td><td>0</td><td>1</td><td>Need to establish one English language lab</td></tr>
<tr><td>Internet</td><td>0</td><td>1</td><td>Need one system for whole campus</td></tr>
<tr><td>ICT Facility</td><td>Smart TV</td><td>0</td><td>13</td><td>9 smart TVs for all classrooms and 4 meeting rooms</td></tr>
<tr><td colspan="2">Library</td><td>1</td><td>1</td><td>The existing library is good but needs to add new STEM-related books and upgrade</td></tr>
</table>

Study Room	0	2	Two self-study rooms (one for teachers and one for students)
Meeting room	0	4	Four meeting rooms for discussion, project work and meeting
Basic Fab-lab	0	1	Establish one workshop room for engineering and technology development

Table 23: Recommended Human Resources

Physical Infrastructure (Grade 10-12)	Existing Infrastructure at KampongSpeu High School	Ideal Infrastructure for STEM High School	What needs to be done
Admin. Building	**Number**	**Number**	**Description**
Office for Management Team	1	1	Re-arrange the working space and condition
Office for Non-Teaching Staff	1	1	Upgrade office furniture and ICT infrastructure
Office for Teaching Staff	1	1	Upgrade office furniture and ICT infrastructure
Eating Lounge for Staff	0	1	Establish one new lounge for staff
Room for Security and Cleaning Staff	0	1	Establish one new room for securities and cleaners
Outside Buildings	**Number**	**Number**	**Description**
Botanical garden	0	1	Establish one biodiversity garden for learning and outdoor lab
Hygiene Canteen	1	1	Need hygiene protocol
Sport Area	1	1	Already in good condition
Garden	1	1	Already in good condition
Waste Management, Toilet & Sink Unit	1	2	Already in good condition

Parking Area	1	1	Already in good condition
Tables and Chairs arrangement and overall aesthetics	1	10	Already in good condition
Water Supply	1	1	Already connected
Electricity Access to National Grid	1	1	Already connected, but may need to upgrade in order to meet the new requirement

In the initial stage, a small-scale development is recommended. As presented above, the research team proposes the emphasis on the science stream with three classes put in the plan. Both hard and soft infrastructure for the development and implementation of the proposed STEM program needs to be invested in the same manner. Basic physical infrastructure and classroom facilities to support a new model of teaching and learning, especially the self-directed learning and STEM study clubs that can lead to the implementation of STEM projects to potentially generate income led by students and STEM competition are what should be invested in the first place. The more focus on science stream is rational, given the situation of budget support to the schools in the provinces in Cambodia. Also, it will be easy to be evaluated for its effectiveness and efficiency as well as the possibility to scale up province-wide or so.

A short- and medium-term capacity building for teachers is needed during this phase. Teachers do need some skill trainings to be able to deliver the STEM education with high quality both in and out of the classrooms. The Royal University of Phnom Penh can provide the training and keep mentoring those teachers to implement the problem, project- and inquiry-based learning in the classroom and, particularly, to implement STEM study clubs and STEM projects that lead to potential income generation. Therefore, in addition to the investment in school and classroom facilities that support teaching and learning, the investment in teacher training is critical in the first phase, necessary during the pilot, and continue to be important during implementation phase.

Table 23: Recommended Teachers and Teachers' Qualifications in STEM Subjects

<table>
<tr><th colspan="2" rowspan="2">Teacher in STEM subjects</th><th colspan="2">Existing STEM teachers at Kampong Speu High School</th><th>Ideal Staff for STEM High School</th><th>Requirements</th></tr>
<tr><th>Qualification</th><th>Number</th><th>Number</th><th>Description</th></tr>
<tr><td rowspan="6">Teaching staff</td><td>Biology</td><td rowspan="6">Bachelors' degree and two got Master's degree</td><td>4</td><td>2</td><td rowspan="6">Total numbers of teaching hours for 9 classes (Grade 10-12) by subjects are 54 hours for Mathematics, 36 hours for Physics, 27 hours for Chemistry, 27 hours for Biology and 18 hours for Earth Science and Environment.

Since the number of teaching hours per week per teacher is 15 hours, therefore, the required STEM teachers are:
Mathematics teachers = 4
Physics teachers = 3
Chemistry teachers = 2
Biology teachers = 2</td></tr>
<tr><td>Chemistry</td><td>4</td><td>2</td></tr>
<tr><td>Physics</td><td>3</td><td>3</td></tr>
<tr><td>Earth Science & Environment</td><td>3</td><td>2</td></tr>
<tr><td>Mathematics</td><td>7</td><td>4</td></tr>
<tr><td>Computer</td><td>2</td><td>2</td></tr>
</table>

					Earth Science and Env. teachers = 2 All teachers need professional development on new content knowledge and teaching methodology, especially how to integrate engineering and technology into science and math. Linkage of project or problem to local context is necessary as a case study for students to use science and technology to solve that particular issue.
Qualification of Technical Team Leader by Subject	Biology		1	1	Send technical team leaders to get their Master's degree in the country to get more knowledge and skills
	Chemistry		1	1	
	Physics		1	1	
	Earth Science & Environmental		1	1	
	Mathematics		1	1	
	Computer		1	1	

Governance and Management

The governance structure provides operational semi-autonomy to school principals and management teams to administer and ensure the high professional implementation of curriculum in innovative approach and quality of teaching and learning.

Table 24: Recommended School Board and Terms of Reference

Governance		Existing at Kampong Speu High School	Ideal Number	Description
Board	Number of Board Members	7	7	Membership of the Board should be diverse and the representative of teacher should be a Board member
	Number of Meetings per year	12	4	Number of meetings can be reduced, but need to improve on aspects like having a clear agenda and record of the meeting
Terms of Reference		1	1	Improve M&E skills among the school's Board members to oversight budget, strategic plan and performance of school

Table 25: Recommended Management Team and Relevant Staffs

Management team	Existing at Kampong Speu High Schoo	Ideal Number	Description/Detail Equipment/Requirement
Principal	1	1	School principal receives training on strategic leadership and, especially, training in fund raising skills
Deputy-Principal	3	2	Clearer tasks assignment among existing school deputy principle should be arranged
Management Team Meeting per year	12	12	Need to improve on aspects like having a clear agenda and record of the meeting, peering process to make better system, record what was discussed and discuss what was written

Skill-upgrading of Management Team per year		0	1	Training should focus on school management system, finance, administration, disciplines, and public relations courses
Meeting between Management Team and Academic Staff per year		12	4	Number of meetings can be reduced, but need to improve on aspects like having a clear agenda and record of the meeting
Personnel Office	Admin staff	2	1	Clear division among existing school deputy principle should be arranged
	Finance staff	1	1	Bachelor's degree, preferably in accounting, who can be responsible for all finance, accounting and cashier
	Public Relation staff	0	2	Two staffs that hold Bachelor's degree, preferably in public relation, who can be responsible for communication and connection to outsiders such as communities, parents, industry and development partners
	Academic Affairs staff	0	1	Staff with Bachelor's degree with training on educational counselling, who can be responsible all student's performance, transcript and others related study activities
	Lab. Assistant	2	4	Two lab assistants with minimum diploma degree in lab management and utilization, who will work closely with STEM teachers to help students on lab experiments and scientific activities
School counselling committee	Non-academic affairs	7 students	1	Professional counselor to work on these issues
	Academic affairs	0	1	Teachers who are trained in academic counselling should be appointed as academic counselor

Number of Security	In-School	0	2	Two guards should be hired to make sure clear are safe, especially at night
	Front-Gate	0	1	One guard should be hired to work at the front gate
Nurse		0	1	One nurse should be hired for first aid task
Cleaner		1	2	One cleaner should be hired to make sure that all school space is cleaned
Meeting Regularity between Management Team and Support Staff per year		12	12	Need to improve on aspects like having a clear agenda and record of the meeting
Regularity of Skill-Upgrading of Support Staff per year		0	1	In-service training on respective professional tasks

In order to implement the proposed Integrated STEM Education Model, Kampong Speu High School needs to have a partnership agreement with a university that have strong experience in training students in STEM-related subjects in order to provide professional development on new content knowledge and teaching methodology and how to integrate engineering and technology into science and math subjects as well as sharing human and research infrastructure resources in STEM fields. This partnership also helps to upgrade technical team leaders to study their Master's degree to gain more knowledge and skills as well as to receive mentorship programs. This new working strategy will provide the best connection for general education and higher education to work together in order to produce human resources with the right skills and knowledge for their higher education study and connection to work skills. If successfully implemented, the lesson learned from this partnership can be scaled up nationwide.

A broad-based school Board needs to be developed, which involves invited universities, the local authority, community representatives and private sector, particularly the Special Economic Zone in the province or nearby region. This school Board will play a vital role in providing directions for school development and in supporting school to link to the local industry and beyond.

A clear assignment of school management who will be in charge of the implementation of the STEM program is required. Meanwhile, it is important that experienced STEM teachers be selected and incentivized if student learning outcomes are evident from the program intervention.

5.2.2 Implementation Stage

To implement this Integrated STEM Education Model successfully, all stakeholders (MoEYS, relevant departments at the provincial level, school management team and teachers, communities, ...etc.) must agree on the proposed activities and governance structure and wholeheartedly commit to implement and support those activities. Therefore, the following stages of implementation are provided as followings:

1. The STEM education will apply for the science stream only, starting from Grade 10;
2. Establishment of the oversight Board and Terms of Reference;
3. Assignment of committed school management and STEM team;
4. Development of a strategic plan for investment in content development and curriculum implementation;
5. Experienced trainers will provide a professional development program;
6. Development of the standard operating procedures for monitoring and supporting mechanisms such as:
    a. Admission and Enrollment Guidelines
    b. Teaching and Learning Standard
    c. Lab Operation Procedures
    d. STEM Club Guidelines
    e. Project-based Development Guideline
    f. Procedures for Accreditation (Internal Quality Assurance)
    g. Fund Raising Strategy and Its Accountability
    h. Incentive Scheme and Resource Management
    i. School Monitoring Tool

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