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Improved STEM Education in Cambodia through Spatial Analysis of Secondary Resource Schools

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Abstract

In Cambodia, the establishment of the secondary resource schools has played a very important role in promoting STEM education. In this article, we aim to determine approaches to enhance STEM education in Cambodia through spatial analysis for appropriate location of secondary resource schools. The paper, in particular, focused upon: contribution of resource for promoting STEM education, spatial distribution of secondary resource schools, appropriate location for secondary resource schools, as well as problems and constraints in managing the seoncary resource schools. In our detailed study in Kompong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh we found that: establishment of the secondary resource schools has contributed in a promotion of STEM; but school networks were not sufficiently beneficial due to insufficient transportation cost, limited capacity; weak operation and management. (1) Since 2004, the Ministry of Education Youth and Sport (MoEYS) and Asian Development Bank (ADB) have been the funder of establishing secondary resource schools through three different projects: the Second Education Sector Development Project (ESDP II), the Enhancing Education Quality Project (EEQP) and the Upper Secondary Education Sector Development Program (USESDP). (2) There are now 50 secondary resource schools established across Cambodia. The research confirms that the number of secondary resource schools was passively and strongly correlated to the number of students, the number of secondary schools and the number of school network. (3) An average distance between secondary resource school and school network was 4.2 kilometers ranging from 2.0 and 9.4 kilometers; it was the furtherest in Kratie and the nearest in Bonteay Meanchey. (5) The spatial analysis reveals that the existing secondary resource schools are not central which leading to be difficult to being accessed by school nextworks; (4) Samdach Ov or Serey Sophoan Upper Secondary Schools for Bonteay Meanchey as well as Boeng Trabek Upper Secondary School and Santhor Muk Upper Secondary for Phnom Penh are likely to optimize the distance between the secondary resource schools and school networks for future construction. (5) There are five key problems and contrasints in challenging to manage the secondary resource schools more effectively; they included social norm, capacity, operation, and management.

Keywords: Science, Technology, Engineering and Mathematics (STEM), Spatial Analsysis, Secondary Resource Schools, Cambodia

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Introduction

In 2015, STEM or Science, Technology, Engineering and Mathematics was introduced when the First Cambodia's Science & Engineering Festival (CSEF) organized with a agreat achievement of 10,000 audienaces[1]. Moreover, the Industrial Development Policy of Cambodia (2015-2025) prioritized STEM as a multi-dimensional strategy in preparing the students of today to become successful individuals of tomorrow with a focus of science and mathematics education (CDC, 2015; MoEYS, 2016). It is the fact that STEM education addresses a practice of knowledge to real-world problems for economic growth and social development based on creativity, pronlem-solving, and critical thinking, problem-solving (Machuve & Mkenda, 2019). As the result, STEM has supported a high demand of skills adapted into the fourth industrial revolution (Armbrecht, 2016) and economic growths (Engler, 2012, Kaing, 2016). According to Pimthong and Williams (2018), each discipline of STEM does not exist alone; but, complex and multidimensional problems are combined together. An integration of STEM concepts and processes among young people through participation in multidisciplinary situations help to prepare people for future life and the workforce (English, 2017).

Today, Cambodia has prioritized STEM for supporting economic growth and social development. In 2015, Cambodia has been re-classified as a lower-middle-income economy by the World Bank Group; its Gross Net Income (GNI) per capita was then $1,070 (World Bank, 2016). A strong institutional support of the Royal Government of Cambodia through the Ministry of Education Youth and Sport (MoEYS) is clearly described in Teacher Policy Action Plan lunched in 2015 that all teachers will have at least a Bachelor's degree by 2020 to ensure their capacity to educate the next crop of professionals (Blanquat & Associates, 2016). In promoting STEM education, the MoEYS has worked at various levels and measures by formulatimg school streams: science vs. social science (Kao 2013). In the same time, necessary infrastructure and resources are equipped at secondary schools and at universities for students to support majors in the fields of STEM (MOEYS, 2018). Education is also believed to give further support in reaching its ambition to transition from a lower-middle income country to being an upper-middle income country by 2030 and a developed country by 2050 (MoEYS, 2014). Clearly stated in the government strategy, STEM education is supposed to increase sectors which requires skilled labor among young learners and professionals (Blanquat & Associates, 2016). As one of the 10 country members in Association of Southeast Asian Nations (ASEAN), Cambodia is striving to expand employment markets for young Cambodians to be an advantage under ASEAN Economic Community through an access to STEM careers and reduce its economic dependency on garment and tourist sectors (Anonymous, 2015).

In general, science and mathematics education are delivered from primary to secondary schools worldwide, but engineering field of study is included at higher education (Holmlund et al., 2018). While technology course is provided by vocational education, it is also somehow included at secondary level (National Science Board, 2015). In these recent years, teachers at secondary school has engaged in innovative new models and include more STEM education in their classrooms. As the result, a high quality of science education at secondary level contributes to developing scientific literacy and understanding by brinding students to pursue the enabling

[1] See detail at http://www.stemcambodia.ngo/

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sciences and engerneering at university. In the other word, generating higher levels of participation in science-related studies at university is associated to the improvement of science education at secondary schools (Ainley et al., 2008). However STEM education has been today integrated at school curriculum from primary to secondary level; there are still many cconstraints in promoting literacy of STEM. Those challenges include insufficient contents to be integrated into national curriculums, lacks of resources and facilities, inadequate compentant teaching staff for science and engineering and students' perception as too difficult subjects. According to the Minstery of Eductaion Youth and Spory (MoEYS) in 2015, subjectives of science, math, and technology have been provided at secondary level; but nationally-required curriculum does not exist.

For example, the lack of engineering concepts in the secondary schools' curriculum may be a contributing factor to the low rates of students resigersted for this field. Among countries in ASEAN, the low number of students enrolling engerneering field of study in Cambodia has become a significant concern in this region (ASEAN Secretariat , 2007). Morover, secondary schools are facing with lacks of facilities, resources and highly-qualified teachers to support STEM education to be aligned with regional and international standards for curriculum, instructional practice (USAID, 2010). For students' prospective, STEM education are considered as difficult subjects because there were no much opportuntiies for sudents to engage in application, practices and experiment. Today, there are too many number of business graduates, creating a surplus in job seekers in that sector and STEM sectors are a deficiency skill (Kaing , 2016).The availability of resources, experiment and teaching approach do not yet attract students' attention and make them easily understand and perform well at classes (Recayi et al., 2012).

According to Goldstone & Sakamoto (2003), the world has become a complex place and scientific problems need abstract reasoning about systems to appreciate their intricacies. The Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas suggests that students at secondary level require opportunities to engage in laboratories, or scientific investigations (Achieve, Inc., 2013). At secondary school, laboratires and practice at secondary level are criucal (Luft et al., 2011) because students involve in improving scientific skills (Suleiman, 2013), communicating their ideas to others (NRC, 1996), and establishing the accuracy of their beliefs (Angus & Keith, 1992). Teaching method at class toom alone is not enough; the improvement of learners' understanding and remembering of information through experiment and practice help developing problem-solving and critical thinking skills (Kigali Institute of Education, 2011). Moreover, the provision of necessary equipment for experiment and practical actitivities in science is a necessary to be aligned with the daily life of the students (Ogunmade, 2005). With the demonstration of teachers, the experiments and observational exercises are carried out by the students to apply for theoretical knowledge with practical activities done in the laboratory, classroom, field work (Tytler, 2007). Sandifer & Haines (2009) believe that hands-on activities are the best strategy for effective science teaching and learning.

The Global Competitiveness Report 2017–2018 presents that the quality of math and science education in Cambodia is at the ranking 111 among 124 countries.

During the first mandate, the Minister H.E. Dr. Hang Choun-Naron has made a significant move towards educational development. The establishment of secondary resource schools have been one of his efforts to deliver well-rounded education services to the communities. In early

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2011, Asian Development Bank (ADB) funded under Education Sector Development Project II (ESDP II) to build 18 secondary resource schools in Cambodia. Today, 50 secondary resource schools have been constructed throughout the country; each secondary resource school has a network of up to eight secondary schools for sharing resources with the seconday resource school. A primary outcome of the project is to improve quality and equity of education in Cambodia with more effective secondary education, improved teacher competencies, and stronger education management systems. In aiming to make secondary resource school to be a place for learning and teaching resources for excellent education; they are equipped with computer labs, library, science labs, meeting rooms, and teachers' room. In particular, secondary resource school has played very important roles in promoting STEM education by proving opportunity for students to engage in experiment and practical work to link between theories learned in class room and practice at secondary resource schools[2]. Accordingly, the paper aims explore to approaches to enhance STEM dducation in Cambodia through doing spatial analysis for appropreciate location of secondary resource schools by focusing on its contribution, spatial distribution of secondary resource schools, sppropriate location for secondary resource schools, and problem and contraints in mananagment of seoncary resource school.

Research Methodology

This study employs both exploratory and descriptive approaches to examine the research questions. This research was primarily qualitative data; however, it was substantiated by quantitative information. The research design includes case study, social and participatory approaches for collecting qualitative data and information. Moreover, raw data from secondary sources were also collected for statistical analysis to back up with qualitative ones. In addition, Measure Distance Map App was also used to collect latitude and longitude data of each school location for the spatial analysis. During the field work, semi-structured questionnaires were applied to collecting qualitative data from school management team at hosted school of secondary resource schools and school netwok in Kompong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh. In each study province, one secondary resource school and three school network (at least) were selected for the interview (Table 1). The interview focused upon how secondary resource schools are locating, operating and managing. In addition, the interview also investigate on how secondary resource schools are beneficial to STEM education of hosted school and school network. Key informants were made by using unstructured questionnaire to collect qualitative data from the Ministry of Education Youth and Sport, and the Provincal Deparmnt of Education Youth and Sport. The interview was held to explore about the policy and programme intervention regarding to the management of secondary resource schools. Furthermore, the interview helps to understand about the roles of MoYES in supporting the operation and magment of the secondary resource schools from national to sub-national levels.

Both quantiatiev and qualitative analysises were applied; they included desk review, problem analysis and problem analysis. Desk review is an important part of the assessment by collecting, organizing and synthesizing available reports and previous assessment and raw data of the projects. The researcher gained an understanding of the context and result produced by

[2] See detail at https://moeys.gov.kh/images/moeys/Projects/259/SRC%20Brochure-Eng.pdf

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the operation of secondary resource school. The desk review also helps to identify problems and gaps faced by the secondary resource schools. As for problems and situation analysis; they facilitated exploration of the general position or context in which the secondary resource schools and school network schools or institutions operated and managed. The findings elicited from using this technique provided the context and knowledge for assessing the implementation of secondary resource school.

Table 1. List of respondents for interviews and key informants

No.	Institution		No.
Unstructured questionnaire for key informants			
1	Ministry of Education Youth and Sport	Department of Secondary School	1
2	Provincial Department of Education Youth and Sport in Banteay Meanchey	Provincial Office	1
3	Provincial Department of Education Youth and Sport in Phnom Penh	Provincial Office	1
Semi-structured questionnaire for interview			
4	Provincial Department of Education Youth and Sport in Kompong Thom	Provincial Office	1
5	Porng Tek Lower Secondary School	Management team	1
6	Hun Sen Krong Kep Lower Secondary School	Management team	1
7	Bun Rany Hun Sen Chakriya Vong Upper Secondary Scool	Management team	1
8	Hun Sen Chamkar Dong Upper Secondary School	Management team	1
9	Hun Sen Khlar Koun Upper Secondary School	Management team	1
10	Tek Thlar Lower Secondary School	Management team	1
11	Sandech Ov Upper Secondary School	Management team	1
12	Serey Sorphorn Upper Secondary School	Management team	1
13	Chbar Ampeouv Upper Secondary School	Management team	1
14	Hun Sen Prek Pra Lower Secondary School	Management team	1
15	Bun Rany Hun Sen Phsardeounthkov Upper Secondary School	Management team	1
16	On Chanh Lower Secondary School	Management team	1
17	Kratie Krong Upper Secondary School	Management team	1
18	Damrei Chorn Khlar Lower Secondary School	Management team	1
19	Hun Sen Balang Upper Secondary School	Management team	1
20	Stung Sen Upper Secondary School	Management team	1
21	Panha Chi Lower Secondary School	Management team	1

In the quantitative analysis, ANOVA was to test whether there was significant difference between the means of distance between secondary resource schools and school network in the five study areas , and the correlation analysis to test the association of two numberic variables between the number of resource schools, number of secondary schools and number of network. ArcView software was applied to map secondary resource school and school network in

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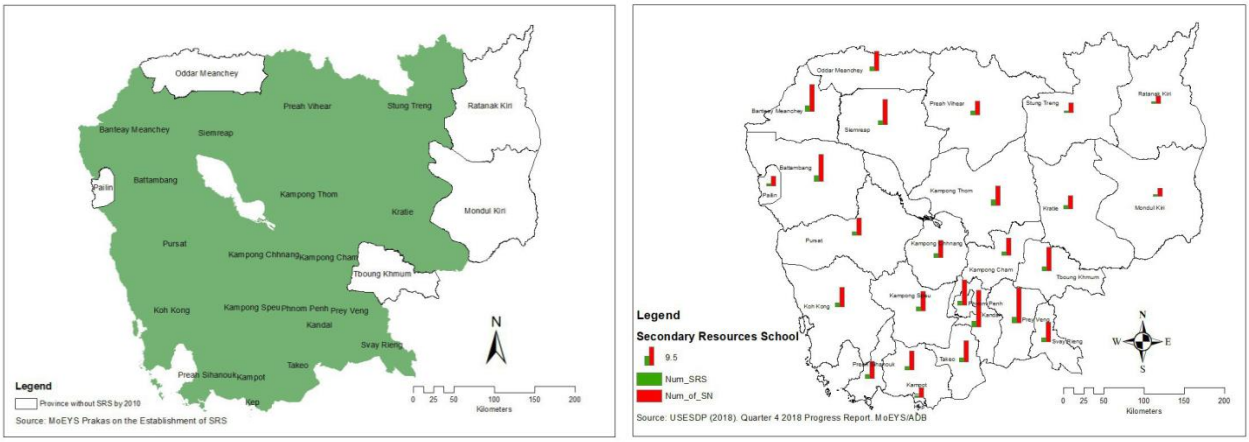
Cambodia and explore appropriate location of resource school in Bonteary Meanchey and Phnom Pen.

Results and Findings

Contribution of seconrday resource schools in promoting STEM education

In 2004, seconday resource schools was initially initiated by the MoEYS and the Asian Development Bank (ADB). Contruction and operation of secondary resource schools have been funded by ABD in three different project aiming to improve the quality of secondary education through building educational facilities. The projects include the Second Education Sector Development Project (ESDP II), the Enhancing Education Quality Project (EEQP) and the Upper Secondary Education Sector Development Program (USESDP). Under the ESDPII (2004−2008), the project constructed 18 resource schools which was then known as Secondary Resource Centers. The main purpose of the project was to increase resource mobilization for the education sector by constructing 24 model school buildings for teacher development in Science, Maths and ICT or Information Communication Technology. In spreading more resource schools across the country, ADB provided further fund under the EEQP (2008-2014) to construct other 18 secondary resource schools in Cambodia.This project primarily focused on education system management, teacher professional development, and enhancing secondary education. Between 2016 and 2021, ADB has still continued to fund 14 more secondary resource schools under the USESDP project. The project has targeted to improve the quality of human resources at supper secondary education for sustaining Cambodia's economic growth and social development. By the end of December 2019, there were 50 resource schools recorded in Cambodia (Figure 1).

Figure 1. Mapping secondary resource school and school networks in Cambodia



Today, secondary resource schools are converted in all the 25 provinces and cities across the country; but the number were varied due to the demand and the availability of funds from ADB. In average, two resource schools were established in each province or the capital city with a maximum of 3 and a minimum of 1. While provinces, i.e., Banteay Meanchey, Battambang, Kampong Thom, Kandal and Prey Veng hosted upto three secondary resource schools; the ADB only funded one secondary resource school each in Mondulkiri, Kep, Pailin, Ratanakiri and Stung Treng. Other provinces hosted two secondary resource schools in each. The analysis by using

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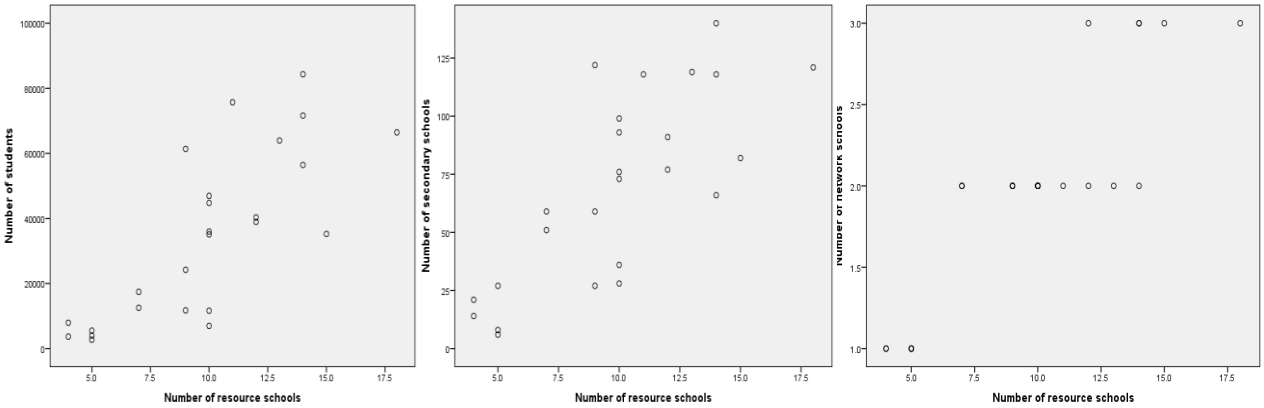
correlation analysis illustrated in Figure 1 proves that the number of resource schools were posively and strong correlated to number of students (P-value=0.000), to number of secondary schools (P-value=0.000) and number of network (P-value=0.000). With this confirmation, the construction of secondary resource schools in Cambodia were directly responded to the real need of students at hosted schools and school network for promoting STEM education. The higher number of students and secondary schools reflects to the higher number of secondary resource schools estabishoed.

Figure 1. Association among resource schools, secondary schools and network schools



R^2= 0.777, P-value = 0.000 R^2= 0.763, P-value = 0.000 R^2= 0.880, P-value = 0.000

According to the Department of Secondary School at the MoEYS, the secondary resource schools have been established to increase the opportunity to access experiment and practice of science subjects. The secondary resource school is established in city center or provincial town. A secondary resource school covers several upper secondary or lower secondary schools within 20 kilometers to the east, west, north and south. Teachers and student at the school networks are able to access facilities of the secondary resource schools for doing experiment and practice [Pers. Comm. MoYES]. While hosted schools have been funded with annual budget for operation of the secondary resource school, the purchase of materials and equipment; and, scholarship scheme for poor students; students and teachers at school networks received only butdget to cover their transportation and the purchase of materials and equipment. The interview of a secondary resource school at Chbar Ampeouv Upper Secondary School reveals that 'My school has received around 35 million Cambodian Riel per year to pay for water, electricity, equipment and renovation of the infrastructure. As I know the fund was previously from ADB. From this year, it is now allocated by the MoEYS under Public Budget (PB). I get additional 5 million Camboidna riel, so it is now totally 40 million Cambodian Riel.' [Pers. Comm. Chbar Ampeouv USS]. Since 2019, the MoYES has allocated the annual budget for operation of secondary resource schools after completing EEQP project. To increase the use of secondary resource schools, the USESDP budget is designed to provide an annual budget for transportation and purchases of experimental materials and equipment. Both hosted schools and school network are now annually funded with 500 US dollars to pay for transportation of teachers and students and buy chemicals required for their experiment at resource schools [Pers. Comm. MoYES]. A school principal expressed that:

> 'I think the secondary resource school is very useful because it gives opportunity to my students to do experience and practice including earth science, physics and biology. Through MoEYS, ADB

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> are funding my school with 500 US dollars. The amount may be very small for other schools but it is much for my school. With the support, I can bring my students to practice at Hun Sen Khlar Koum secondary resource school for 10 times per year. I think other schools could do only between 4 and 6 times. I spend more on transportation cost than the purchase of experiment materials or chemicals because the available budget is not enough. Also, experiment equipment or materials are not abilable around my school.' [Pers. Comm. Serey Sorphorn USS]

In principle, a secondary resource school is functioning with support by four staff: one staff for laboratories, two staff for Information Technology (IT) and two constract staff to support other work required at the secondary resource school. The building has facilities and equipment to promote STEM education for hosted schools and school networks especially physics, chemistry, earth science and biology [Pers. Comm. PDoEYD in Phnom Penh]. The operation of resource schools across Cambodia have been very beneficial for students at secondary schools when they enroll at university. Students are familiar with the courses from the experiences of experiment and practice made at the secondary resource schools. As the result, the Ministry has gained more positive feedback from students and parents because students are able to use resource schools to get clearer understding of theories learned in classrooms. In addition, students form poor families are also granted with scholarship to support their studies [Pers. Comm. MoYES]. Under the USESDP project, the ADB stated to provide scholarships for students; each secondary resource school is granted with 15 scholarships. A student receivs 200 US dollars per year for a period of 2 years. This academic year (2019-2020) was the third year of the scheme [Pers. Comm. PDoEYD in Phnom Penh]. Up-to-date, the MoYES has considered establishment of secondary resource school is the most cost-effective strategy to promote STEM education at secondary school in Cambodia. It is the fact that the MoEYS is not able to equip laboratories, computer labs and libraries at all secondary schools across the countries. 'Only the cost of renovating classroom for a laboratory is roughly 60,000 US dollars and it is excluded the equipments and facilities. How can the Ministry invests in it for 16 students enrollowing at secondary level in some remote areas. They must use the facilities and equipments available at the secondary resource school.' [Pers. Comm. MoYES]. In the same time, parents of students at Kratie Krong Upper Secondary School applauded and was also very optimistic to the secondary resource school. The schools in the reual areas now has modern computer labs, laboratories and libraries for students to practice [Pers. Comm. Kratie Krong USS].

Spatial distribution of secondary resource schools

There are specific criteria for selecting a school to be a secondary resource school. First, the school must be located in a center of the city or province. Second, there must have sufficient teachers to be responsible for all subjects and the school must be equipped with electricity and water utility as the third and fourth criteria. For fifth and sixth criteria, the school is being strongly supported by community and have good management. Having sufficient land for the development is the last criteria [Pers. Comm. MoYES]. When all the schools wish to establish laboratory at their own schools, bias or jealousy about selection of secondary resource school can not be avoided. The officer at the Department of Secondary School explained that 'I used to get reactions and complaints by teachers at remote schools about location selection of secondary resource schools on social media. They are not happy and feel that we [the Ministry] abundant

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the remote schools in promoting science. When I explained about the selection criteria; they agreed to my explanation. At the movement, it is not yet cost-effective to locate a secondary resource school at remote area because of the low number of students and equipment in laboratory are not fully used. ' In Kep, the secondary resource school hosted by Hun Sen Chamkar Dong Upper Secondary School has supported around 1,000 students to do experiment and practice. The secondary resource school has computer lab, laboratories, library and a place for students and teacher to do gathering and provide space to upgrade their knowledge and understanding about science [Pers. Comm. Hun Sen Chamkar Dong UPP]. During the field work, school principals provide different reasons of why their schools were selected to host secondary resource schools.

> 'If compared to other schools, Hun Sen Khlar Koun Upper Secondary has the best location. My school is near the Provincial Department of Education and have a confortable campus for building a secondary resource school. I don't think other schools here have enough space to build this center like us.' [Pers. Comm. Hun Sen Khlar Koun USS]

While th school princinpal at Hun Sen Khlar Koun Upper had a strong argument about its best location and large campus; it was quite hard for the school principal in Banteay Meanchey to suggest the best location to be conveniently accessible by all school networks. For example, there are four upper secondary schools in this province: Sandech Ov, Serey Sorphorn, Hun Sen Khlar Koun, and O Ambel. I do not see any other good location in this province to be allocated for another secondary resource school. If it is located at Serey Sorphorn Upper Secondary School, it is abit narrow. But it is good to be at Serey Sorphorn Upper Secondary School because the school include all levels from primary to upper secondary schools [Pers. Comm. Sandech Ov USS]. Similarly, the school principal at Hun Sen Chamkar Dong Upper Secondary School seem to not agree to the best location is the only main option for selection of secondary resource school in Kep province.

> The main reason of selecting this school as a secondary resource school because it was then the only upper secondary school available in town. Also, our school has big campus. Moroever, the school has the highest number of students enrolled at that time. We have five school networks; they are coming to use our secondary resource school. [Pers. Comm. Hun Sen Chamkar Dong UPP]

In Kampong Thom, Hun Sen Balang Upper Secondary School was the most well-known in terms of good results of national examination at Upper Secondary School, outstanding students and enforcement of morality. At first, this school was planned to host the New Generation School (NGS); but it later came up with the establishment of secondary resource school. The MoEYS ascterted that Hun Sen Balang Upper Secondary School did not fulfill the criteria to host NGS scheme yet [Pers. Comm. Hun Sen Balang USS]. The equipment and facilities available at secondary resource schools are managed by hosted schools; but they are being shared for the usage by school networks. The school nerworks prepared schedules for bring students to practice and do experiment at laboratories equipped at the secondary resource schools.

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Figure 2. Location of resource school in Kep

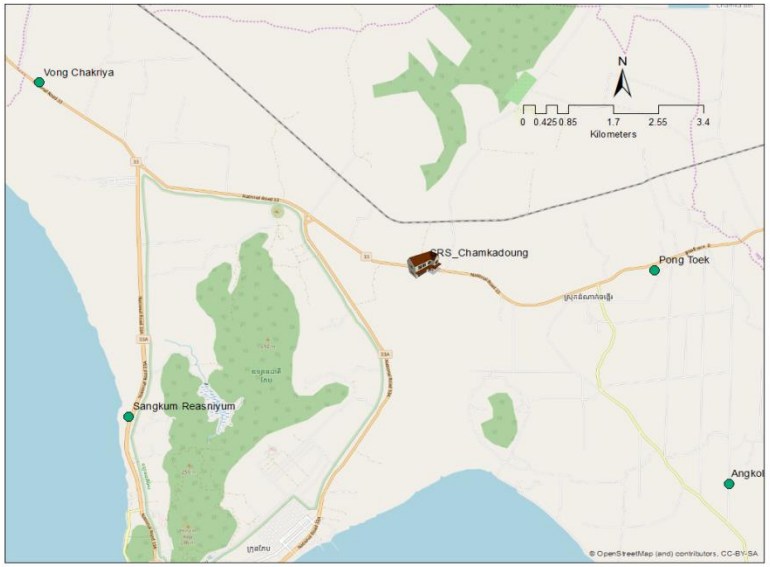

Figure 3. Location of resource school in Kampong Thom

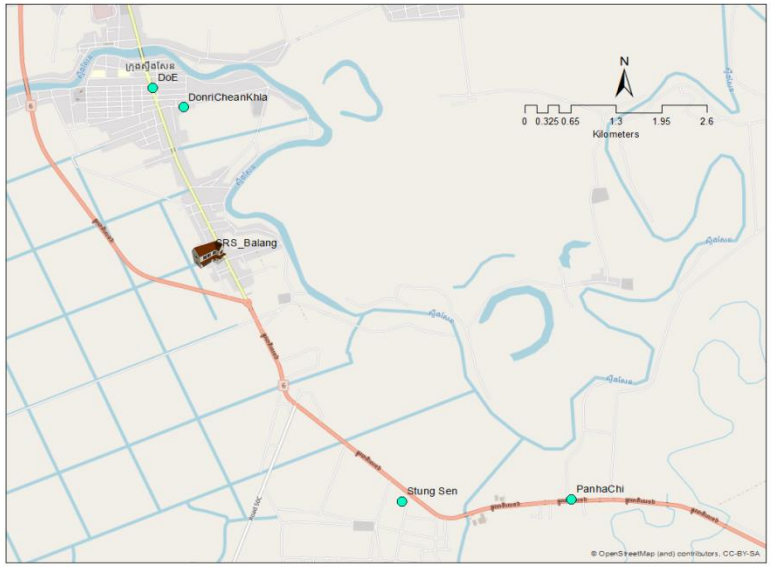

Figure 4. Location of resource school in Kratie

Figure 5. Location of esource school in Manteay Meanchey

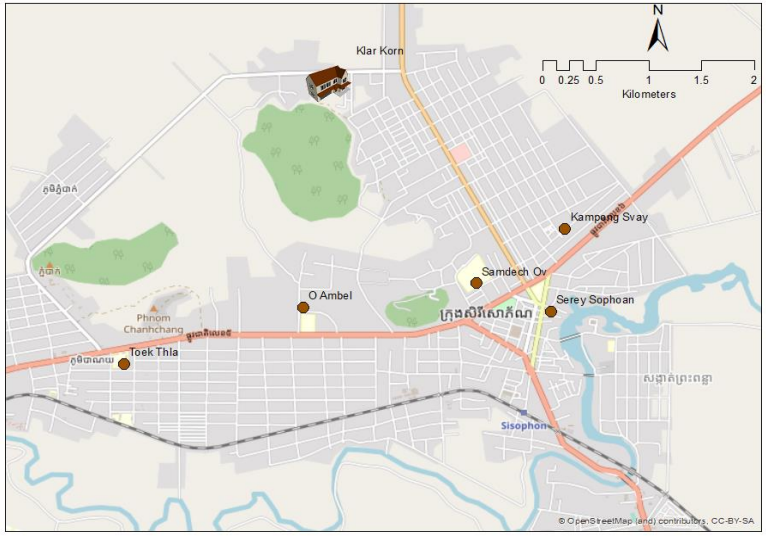

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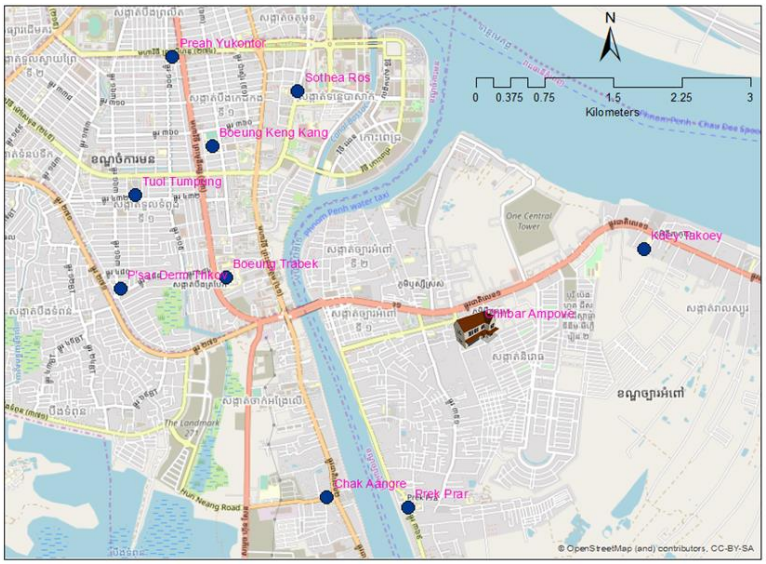
Figure 6. Location of resource school in Phnom Penh



According to sptial analysis of the existing secondary resource schools in Kompong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh, there are some challenges related to the distance between secondary resource schools and school networks (Figure 2, Figure 3, Figure 4 and Figure 5). However secondary resource schools are mainly located in proncial or city center; many schools were not able to access because of far distance. In the same time, all of the school networks wished to have their own laboratories. School networks at remote area did not have means to transport their students to the secondary resource schools. Moreober, secondary resource schools tended to already being fully used by the hosted schools [Pers. Comm. MoYES]. Figure 6 illustrates an average distance from the secondary resource schools to school networks was 4.2 kilometers ranging from 2.0 and 9.4 kilometers. According to ANOVA test show that Kratie was the furthest (7.1 killometers) and Banteay Meanchey was the nearest (2.8 killometers) (P-value = 0.000). In Kratie, there was one seconday resource school called Kratie Krong Upper Secondary School and included only two school networks, i.e., On Chanh Lower Secondary School and Ka Po Lower Secondary School. As On Chanh Lower Secondary School is located 9.4 kilometers away from Kratie Krong Upper Secondary Schhol; the distance of Ka Po Lower Secondary School to resource school is 4.9 kilometers.

The distance from Hun Sen Chamkar Dong Upper Secondary School to its school networks[3] is fairly central. Given that it is unlikely that the furthest school would find it very hard to take students to the secondary resource school except they have to spend the whole morning or afternoon session to cover the experiment period. The average distance to secondary resource schools is as far as 6.0 kilometers; it was up to 7.8 kilometers for Bun Rany Hun Sen Chakriya Vong Upper Secondary Scool and 7.1 kilometers for Hun Sen Angkorl Lower Secondary School. The school principal at Hun Sen Krong Kep Lower Secondary School provided both adanatages

[3] Sangkum Reas Niyum Lower Secondary School, Hun Sen Krong Kep Lower Secondary School, Bun Rany Hun Sen Chakriya Vong Upper Secondary Scool, Porng Tek Lower Secondary School, and Hun Sen Angkorl Lower Secondary School

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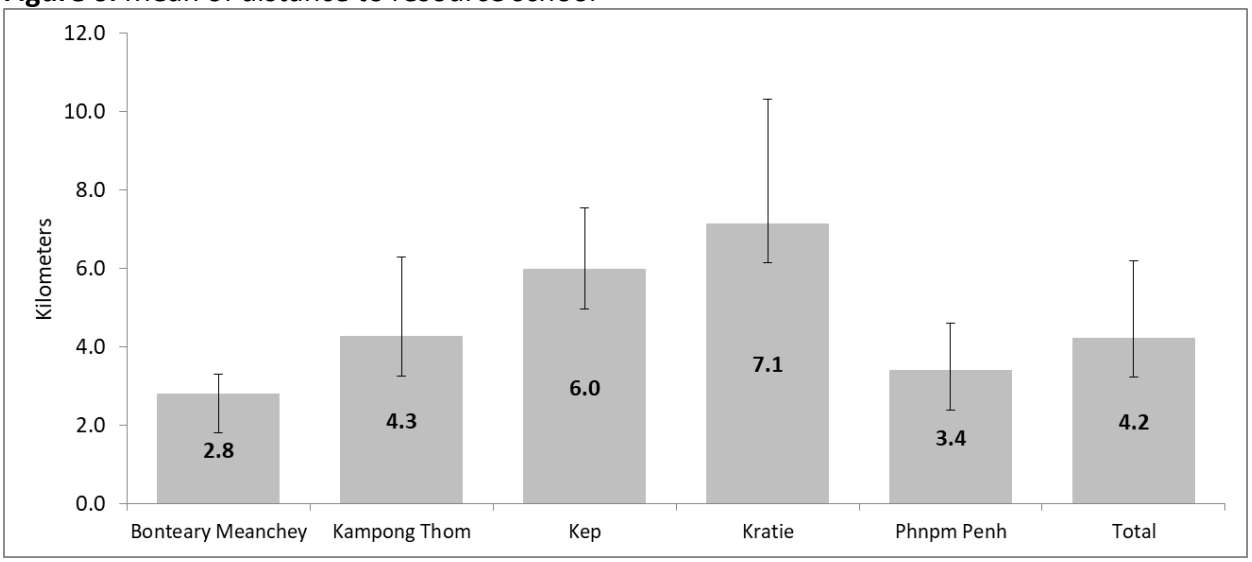
and disadvantages in sending students to secondary resource school. The students are able to do experiment and practice of what they have learn from theories but it is not safe for students to travel far from home [Pers. Comm. Hun Sen Krong Kep LSS]. Similiarly, the school principal at Bun Rany Hun Sen Chakriya Vong Upper Secondary School raised a concern about far distance and student are required to travel by their own to the secondary resource school. The school can not be responsible for any incident of students and teacher during their travel. The school principal complained that 'it is waste a lot of time to travel to secondary resource school. We still need to bring our own equipment, materials and chemicals. So why do we need to go to resource school? and why don't we have a room for it at our school.' [Pers. Comm. Bun Rany Hun Sen Chakriya Vong USS]

Figure 6. Mean of distance to resource school



Note: P-value = 0.000 of ANOVA among the five geographical areas and P-value = 0.000 of T-test for average distance of 10 kilometers.

For Kampong Thom, the location of Hun Sen Balang Upper Secondary School is best suit; but, there could be some challenges for Pangha Chi Lower Secondary School. This school is located as far as 8 Kilometers away from the secondary resource school. Since the secondary resource school is used among the school networks, Damrei Chorn Khlar Lower Secondary School had the best access compared to the other two. The distance from Damrei Chorn Khlar Lower Secondary School to Hun Sen Balang Upper Secondary School is only 2.15 kilometers. As the result, the school principal at Pangha Chi Lower Secondary School satisfied secondary resource school very much. After having opportunity to do experiments, the performance of students were positively changed if compared to before [Pers. Comm. Panha Chi LSS]. In constrast, the school pricinple at Damrei Chorn Khlar Lower Secondary School identify as a high risk of far distance and long trip to travel by students to the secondary resource school. The principale clarified 'I do not think it is worth to send my students to the secondary resource school because there are insufficient facilities and equipment for students and teachers to use. It is not very easy to bring our students to use facilities at other schools. When we arrive at the resource school, people in charge are not there. It is also such a waste of time and money to spend on

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transportation with little results from practice and experiment. If we do at our school we can make better quality of experiment and practice.' [Pers. Comm. Damrei Chorn Khlar LSS]. The Provincial Department of Education Youth ad Sport shared similar views that 'it is not so effective because of late arrival of either students, teachers, and people in charge of laboratory. In the sametime, some students missed the session because of various reasons such as no transportation or laziness [Pers. Comm. PDoEYD in Kompong Thom]

Among all the five geographical areas, an everage distance between the secondary resource school and school networks in Kratie (7.1 kilomters) was the furthest as shown in Figure 6. At Kratie Krong Upper Secondary School, parents were very delight that their children have a chance to study at a school where laboratories, computer lab and library are well equied. More and more parents are keeping sending their children to study at Kratie Krong Upper Secondary School because students they can practice after learning from class room. Some students from nearby district also transfered to this school because they want to have better quality of education [Pers. Comm. Kratie Krong USS]. When the location of On Chanh Lower Secondary School is located as far as 9.4 kilometers away from the secondary resource school, students only had little opportunity to take part in doing experiment and practice. Under the support from the MoEYS with 500 US dollar per year, the school is able to send students to do practice at the secondary resource school for around 5 or 6 time per year. From my school to provincial center, it is quite far and hard for transportation [Pers. Comm. On Chanh LSS].

The average distance of the secondary resource schools in Phnom Penh (2.8 killometers) and Banteay Meanchey (3.4 Killometers) were the shortest if compared to three other areas (Figure 6 and Figure 5). In Banteay Meanchey, Hun Sen Khla Koun Upper Secondary Schoolis is off the urban central. There given that it is not very far from the rest of school networks. For Chbar Ampov Upper Secondary School, the schools was located in more central of Phom Penh; but, it still find very hard to commute to the secondary resource school, especially Preah Yukuthor Upper Secondary School. There are three resources in Phnom Penh; but, only Hun Sen Champouvorn Upper Secondary School and Chbar Ampeouv Upper Secondary School are operating now. The resource school at Entrak Tevy High School is under construction and it is not operating yet [Pers. Comm. Chbar Ampeouv USS]. The new construction is expending more coverage of school networks in Phnom Penh. The school principal at Chbar Ampeouv Upper Secondary School welcomed all students, teachers and researchers per requested to use the secondary resource school for the purpose of study and research. Some private schools and local NGOs also used the resource school for doing experiments and organizing the meeting [Pers. Comm. Chbar Ampeouv USS]. With sapce for construction of laboratory at Hun Sen Prek Pra Lower Secondary School [Pers. Comm. Hun Sen Prek Pra LSS] and no resource for construction of laboratory by Tek Thlar Lower Secondary school [Pers. Comm. Tek Thlar LSS], the available secondary resources has provided a long-term support to many secondary schools such as Hun Sen Prek Pra Lower and Tek Thlar because they did not have space for construction of its own facilities for their students to do experiment and practice.

Appropriate location for secondary resource schools

The available public budget for education in Cambodian remains as low as 5.5 US dollars per capita per year; the figure is relatively low if compared to its neighboring Vietnam of 90 US

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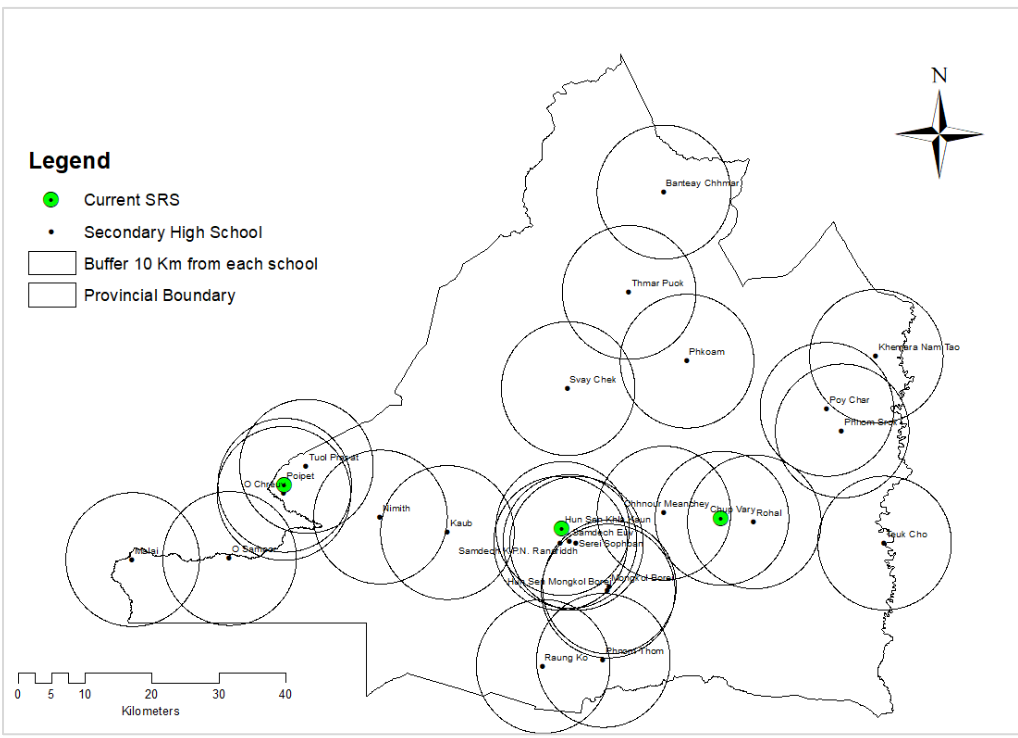
dollars per capita per year. In promoting STEM education, facilities are very important because all science subjects requires doing experiment and practice. Due to limited government budget, contruction of laboratories and facility equipment for experiment at all secondary schools in Cambodia have been quite hard; the construction of lower secondary in city or provical center would remain a choice even in the next 10 years. However the distance of school network coverage were likely to gradually reduce from 20 km to 10 km around the resource schools [Pers. Comm. MoYES]. In order to reduce burdens of the secondary resource schools, the Ministry also allocate budget to some network schools to construct their small-size laboratories [Pers. Comm. Bun Rany Hun Sen Chakriya Vong USS]. In the future, spartial analysis is useful to be used for analyzing a suitable location which is more conveniently accessible to school networks with appropriate distance. In the section, two different geographical area was selected as case studies of how to identify appropriate location for secondary resource schools among lower and upper secondary schools in Banteay Meanchey (Figure 7) and in Phnom Penh (Figure 8).

Figure 7. Appropriate location of secondary resource school in Banteary Meanchey



In Banteay Meanchey, three secondary resource schools were already constructed at Hun Sen Khlar Koun pper Secondary School, Choub Veary Upper Secondary School and Poipet Krong Upper Secondary School. With spatial analysis as illustrated in Figure 7, an appropriate location is identified for the establishment of future secondary resource school in Banteay Meanchey. Similairly, this spatial analysis can be applied in other provincial towns such as Kep or Kratie because it helps to find more central Upper Secondary School to use the secondary resource schools. Figure 7 shows buffer zones, represented by a cycle around the upper secondary schools represented by a dot in the map in Banteay Meanchey. Let alone the road access, the more the cycles around the dot, it means that it is the more central. For example, Poipet Krong Upper Secondary School has three cycles around it while Nimith Upper Secondary School has two cycles

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and Malai has only one cycle. So far, in Bantey Meanchey, the secondary resource schools has been in a central area (within 10 Kilometers radius). Given that there should have been an secondary resource school inn Mongkol Borei since there were many Upper Secondary Schools. In the future, secondary resource schools can be probably constructed at Samdach Ov or Serey Sophoan Upper Secondary Schools because they are more central and easier to be accessible by school networks.

In the case of Phnom Penh, the buffering radius should be about 5 Kilometers or less so that it would be very easy to commute (Figure 8). If this is the case, the analysis finds that the existing resources were not conviently accessible to school networks. For example, distance between Preah YouKunthor to Chbar Ampeouv Upper Secondary School is ranging between 5.9 and 6.2 Kilometers. While it may take 30 by bus, or less than 30 minutes by motor bike or more than one hour by walk. Locating a resource at Chbar Ampeouv Upper Secondary School helps to improve quality of STEM education in more subburbe area of Phnom Penh; but also create commuting issue of students among network schools. The establishment of the secondary resource school at Chbar Ampeouv Upper Secondary School were likely convenient for students at Hun Sen Chak Ang Re Upper Secondary School, Khdei Takoy Lower Secondary School and Hun Sen Prek Pra Lower Secondary Schoo. But it has caused time consuming for students from Beoung Trabek Upper Secondary School, Bun Rany Hun Sen Phsardeounthkov, Preah YouKunthor Upper Secondary School, Toul Tum Poung Upper Seoncary School, Chea Sim Beoung Keng Kang Upper Secondary School and Sothearos Lower Secondary School. If the school provides transportation to students; it will consume a lot of time for students to commune. In the same time, it could not be safe to let students to go for individual transportation by motor bike or bike cycle. The destination to Chbar Ampeouv Upper Secondary School is one of the most traffic congestion especially during the peek hour. Students may be stuck there for hours if the traffic is heavy and transportation is definitely affected other schedule for network school. Considering traffic congestion, safety reason and wide access to school network, Santhor Muk Upper Secondary School is the most appropriate location for the future construction of resource school. Moroever, Boeng Trabek Upper Secondary School were likely to optimize the distance between school networks. The location of the two school are the most central in Phnom Penh to large network school for transportation.

The establishment of a secondary resource school is to be the main educational center; it is located in the center of a province or a city for providing services to other surrounding network schools. The existing secondary resource schools are only now accessible to school network nearby the provincial or city center. Schools located further 20 kilometers of the provincial center were unlikely to access to the secondary resource schools [Pers. Comm. PDoEYD in Banteay Meanchey]. At Damrei Chorn Khlar Lower Secondary School, the school principale hesitated to send students to the secondary resource school at Hun Sen Balang Upper Secondary School because he feels high risk to travel to far distance [Pers. Comm. Damrei Chorn Khlar LSS]. Accoridng to the Provincial Office of Education Youth and Sport, secondary resource schools have attracted for the transfer of students because parents belive their children would do better performance. For example, students at Phnom Sroc Upper Secondary School loved science course but a laboratory was not available. As the result, many students transferred to other schools with laboratory. However advanced laboratory like resource schools are hard to be

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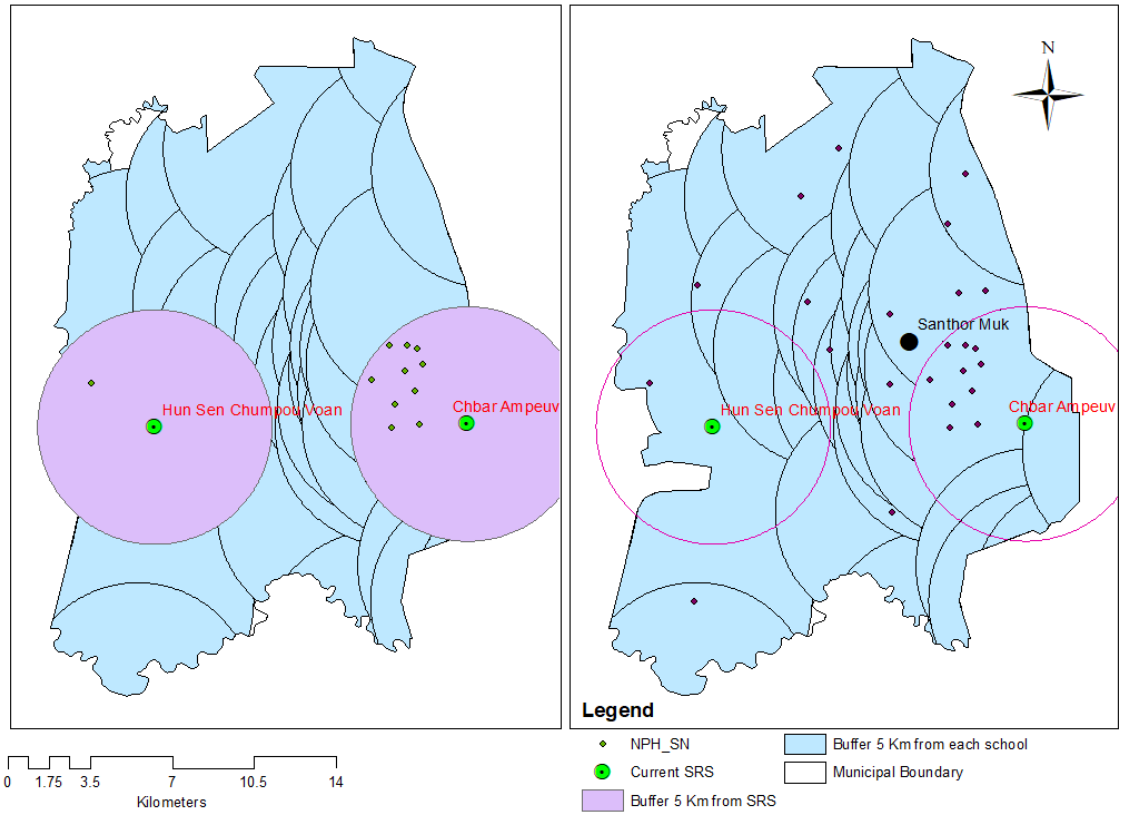
equipped at all schools across the country; a small laboratory at least is important to be established in every secondary school. It is hard for students there to have a deep understanding on physics and chemistry without laboratory [Pers. Comm. PDoEYD in Banteay Meanchey].

Figure 8. Appropriate location of resource school in Phnom Penh



Durng the field work, all the hosted schools satisfied with the establishment of secondary resource schools; but almost all of school networks used the secondary resource school were only because of the instruction of the Ministry and lacking of alternatives. In promoting STEM education, many schools started to develop their small-scale laboratories to enable their students to do experiment and practice. For example, the Porng Tek Lower Secondary School was renovating three rooms for preparing its own experiment center for physics, chemistry and earth science. The Provincial Department of Education Youth and Sport in Banteay Meanchey also agreed that each school should have at least one small laboratory for more effective in teaching. Before the access to electricity and water utility were one of the main criteria; it is now not the problem anymore [Pers. Comm. PDoEYD in Banteay Meanchey]. By having its own laboratory, students had opportunities to do more experiment; but, teachers did not have sufficient capacity for doing experiment. At Porng Tek Lower Secondary School, teachers had only capacity to carry out simple experiment and can do the same things. Many teachers of chemistry can only show students on how to create oxygen; because they did not have any refreshment training for new types of experiment. Lacking of facilities, equipment and chemcals are also the issues. [Pers. Comm. Porng Tek LSS]. At Hun Sen Krong Kep Lower Secondary School, there is no extra rooms

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for establishing its own laboratory, so teacher are buying portable chemical or equipments to illustrate among students in the class room [Pers. Comm. Hun Sen Krong Kep LSS].

Problems and contraints in managing seoncary sesource schools

An ultimate goal of establishing the secondary resource school is to promote STEM education by improving facilities and equipment for practice and experiment of science courses. Accoridng to field work through the interviews with all the key stakeholders including MoEYS, Provincial Office of Eductaion Youth and Sport, school principals and offcers in charge of secondary resource schools; five key problems including social norm, capacity, operation, and management were challnaging to manage the secondary resource school more effectively (Figure 9). However hosted schools claimed that teachers and students from school networks were highly welcome to use the secondary resource schools [Pers. Comm. Hun Sen Khlar Koun USS]; cultural and social norm has affected the feeling of teachers and students from school networks who come to use the secondary resource schools. The school principal at Hun Sen Chamkar Dong confirmed that 'I have never heard any bad words of teachers from school network. They are happy to use the secondary resource school here and thank for our help and cooperation. We have one staff standing by to assis them [Pers. Comm. Hun Sen Chamkar Dong UPP]. In constrast, various negative feedback and reactions were collected from school networs regarding hospitality and support from the hosted school. Experience of teachers at Bun Rany Hun Sen Chakriya Vong Uppser Secondary School was resulted with disatifaction and felt stigmatized when using the secondary resource school. 'I feel hestitate to send my students to the secondary resource school when my students and teachers are not warmly welcome. It is their house and do not like our house. They are already busy with their students; so they have no time for students from school networks. It is supposed to have someone to stand by and assist us, but the officer in charge just locked the door and walked away for all the time. When we ask something, they tended not happily to respond to our questions or request '[Pers. Comm. Bun Rany Hun Sen Chakriya Vong USS]. By treating differently among by hosted schools, school network were feeling guilty to use facilities equipped at the secondary resource schools. In Khmer culture and social norm, people feel something as onwerhsip if it stays under one's authority or management even if it solely belongs to the public. Similiarly, people feel guilty all the time to use the secondary resource schools. The final evaluation of EEQP conducted in 2013 also concluded that school network preferred to have their own experiment [Pers. Comm. MoYES].

The research also discoverd some limitation of professional capacity among teachers at hosted schools and teachers at school networks. The school principal at Chbar Ampeouv Upper Secondary school concerned about capacity of teachers who are using laboratories. 'At every meeting or workshop, I always request for capacity building of people in charge of laboratory. The main problem is instruction of equipment are written in foreign language and no translation into Khmer.' [Pers. Comm. Chbar Ampeouv USS]. In addition, there are no enough equipment for all the students to do practice; but, only available for some of them. When students go to do experiment at the secondary resource schools; some students just go for play because of insufficient equipment. Some other students are not able to catch up what they are doing due to lack of clear explanation. In the past, teachers only drew pictures to explain students about physics. At least, students can now see some demonstration from experiment now [Pers. Comm. Porng Tek LSS]. Teachers at hosted school is responsible for assisting teachers from school

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networks to do demonstraton or do experiment with students. Both of them had limited capacity in using laboratory especially new updated technology and science. The school principal at Hun Sen Chamkar Dong Upper Secondary School admitted that lacking of expertise to support the secondary resource school remained a key issue. Both teachers at hosted school and school networks do not have sufficient skills to use and manage laboratory effectively [Pers. Comm. Hun Sen Chamkar Dong UPP]. Similairly, the school principal at Porng Tek Lower Secondary School commented that the building for the secondary resource school is large enough; but, the availability of equipment and chemicals are very limited. While, teachers from school networks are not able to use the equipment well; teachers from hosted school is not able to provide much assistance [Pers. Comm. Porng Tek LSS].

> We have sufficient teaches; but, we have limited capacity in using laboratory. At my school, we have do not have human resource to manage laboratory equipment well. So we send teachers and students to the resource school because I expect they both learned something from the people in charge. But the people in charge at laborartort only help to arrange equipment and then hand over work to our teachers. I think the teachers who stand by at the secondary resource school also still have limited knowledge and capacity to use all those equipment as well. They just have abit more knwoledege about experiment than our teachers. [Pers. Comm. Sandech Ov USS]

Figure 9. Problems and constraing in managing secondary resource schools

In relation to operation, the budget is not enough for covering the tansporation cost of all the students to the secondary resource schools. At Tek Thlar Lower Secondary School, only 30 or 40 students were selected to go to the secondary resource school. At grade 7 alone, there were more 100 students; only some of them were provided with the opportunity to do experiment [Pers. Comm. Tek Thlar LSS]. At Sandech Ov Upper Secondary School, the available budget was able to send students in particular grade 11 and 12 to the secondary resource schools for few time per year; students were sent to do experiment of four subjects including chemistry,

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biology, physics and earth science. The teachers also did some simple experiment at schools because there were insufficient budget to cover the cost to go ther secondary resource schools for all the time [Pers. Comm. Sandech Ov USS]. Teachers and students were complaining about insufficient support for transportation to resource school. In addition, teachers were hard to manage the transportation of students to the secondary resource school because it is far from school networks [Pers. Comm. Porng Tek Lower LSS]. Furthermore, teachers were worried about high risk to ask students to travel individually to the secondary resoutce schools. The school principal at Damrei Chorn Khlar Upper Secondary School shared his experience that 'there are not enough materials and equipment for students and teachers using during their experiment at the secondary resource school. It was not easy to bring our students to other schools. When we arrive there, people in charge are not there. They waste us a lot of time to wait. I think it is better to allocate fund to each school for doing our own experiment and practice. It is also such a waste of money to spend on transportation and the result from practice and experiment is small. If we do at our school we can make better quality of experiment and practice.' [Pers. Comm. Damrei Chorn Khlar LSS]

Management of the secondary resource school remained a great concern regarding to schedule for experiment and practices of hosted school and school networks, complicated procedure for requesting transportation expenditure, hygiene and clean campus, and quality of building. According to the Department of Secondary School, resource school has tight schedules so school networks were not able to allocate sufficient time to do experiment and practice. For example, each school network can only propose one hour per year for earth science [Pers. Comm. MoYES]. In addition, a laboratory could only accommodate between 20 and 30 students. If there were more students, they were sent to library. But students were not much interested in library because their school also had library [Pers. Comm. Chbar Ampeouv USS]. There were many inconvinent experience faced by school network to request for using the secondary resource school. For example, at Chbar Ampeouv Upper Secondary School, resource schools were always fully booked and it was quite hard to respond to the further request for adding more schedule. This resource school tended to need more building to provide enough services for school networks [Pers. Comm. Chbar Ampeouv USS]. Teachers from school networks had difficulty to arrange financial statement of expenditure after sending students to the secondary resource school. Teachers felt difficulty to deal with this [Pers. Comm. Hun Sen Krong Kep LSS]. Moreover, the management of the secondary resource school required to be improved such as hygienic toilets. The internal regulation of resource schools was also needed to be strictly enforced. The request form for using the secondary resource schools should be fix and not changing all the time; it is wasting of time to learn [Pers. Comm. Hun Sen Krong Kep LSS]. At Hun Sen Balang Upper Secondary School, the building was suddenly broken after the construction. Some rooms were also broken. The school acontacted the Provincial Department of Land Management Urban Planning and Construction for inspection of this mater. The building is fine for use now [Pers. Comm. Hun Sen Balang USS].

Discussion, and Policy Implication

Promoting STEM education through establishing secondary resource schools

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In order to engage more students to learn STEM, they need to access STEM experiences more often and more effectively. Schools, therefore, need to provide facilities, and equipment for students to learn STEM and teachers need to be prepared to teach STEM. Access to equipment and professional development will ensure that teachers can provide motivating and engaging lessons for students to learn STEM. According to the interview with the Department of Secondary School of MoEYS, an establishment of laboratory at each school is a long-term process and it requires a very large government budget. At the movement, the MoEYS has no sufficient budget to establish a laboratory at each school, so the secondary resource schools have been substitutes. Evidences from this research confirms that secondary resource schools do contribute in promoting STEM education in Cambodia. At Hun Sen Chamkar Dong Upper Secondary School, the secondary resource school has been used to host contesting and science exhibition in promoting STEM education. Also, the secondary resource school are providing preparation trainings among outstanding students for the national competition. In 2019, students from Hun Sen Chamkar Dong Upper Secondary School won the third place in science competition. According to the Deaprtment of Secondary School of MoEYS, there were 176 students including 71 female at the 50 resource schools got A at the national examination for upper secondary school; it accounts 37% of nation-wide A. This achievement has clearly approved the increased intests in STEM education by students at secondary school.

In Camboida, public schools have accress restrictions to laboratory for experiment and practice for students and teachers because of (1) highly dependence of government budget and (2) lack of own income generation. Without laboratory, facilities and equipment, it is reducing opportunities for students and teachers to engage in science, this lack of access to appropriate hardware restricts scientist's creativity in experimental designs and contributes to the reproducibility crisis as learners struggle to replicate their peers' work. Under USESDP II, some school networks have been granted with budget for establishing its own laboratory. By doing so, it would not only reduce the burden of the secondary resource schools; but, also increase opportunity for students at the former school network to be able to carry out more experiment and practices. However the secondary resource schools remain useful for school networks because facilities and equipment are much more advanced and sufficient. School networks may consider to bring students to use the secondary resource schools when they require more advanced facilities and equipment. In the same time, other school network may consider to start establish their own simple laboratories for experiment and practice as well. The schools may start from materials or equipment which can be produced by teachers at the school. When each school network has its own simple laboratory, the number of visits at he secondary resource schools are grdaully reduced. As the result, the available budget provided for covering transportation cost to the secondary resource schools can be used for car rental to improve safety of students and teachers.

Alernatively, the operation of mobile laboratory in each province across the country could probably help to spread wider access to school networks or even secondary schools in remote areas. These laboratories on wheels are also used by and for science education to support STEM education at secondary schools. The mobile laboratory travels to schools and provides the schools with educational resources which they otherwise lack. The mobile laboratories is staffed by experts which require for students to practice for example physics, chemistry, biology and

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earth science. The mobile laboratory van is equipped with full-size instruments for an extensive scope of experiment and practice for students at secondary school. The management of mobile laboratory would be similar to the secondary resource schools; but, it would be under the management of the Provincial Department of Education Youth and Sport. The secondary schools are able to request mobilie laboratory van for one week to stand by at their schools; so teachers and experts can work together to support students to do experiment and practice. The choice of operating mobile laboratory van would probably be the most cost-effective in promoting STEM education because the accessibility will be more homogenouly to everywhere accross the country. In addition, the cost of establishment and operation would be cheaper and more affordable.

Recruiting appropriate location of the secondary resource school in Cambodia

The finding of this research clearly conforms that locations of the existing secondary resource schools in Kompong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh are not spatially optimizing. The criteria setting by the MoEYS to locate the secondary resource schools are based on the following criteria: (1) the school is located in the center of the province-municipality or district-khan; (2) there are good school management and good community cooperation; (3) the school size allows for future building expansion; (4) the school is regarded as safe and secure for storage of expensive equipment; and , (5) there are electricity and water supply to provide for computer and laboratory location. The criteria for example the availability of electricity and water utilities does not work anymore because those services are existed everywhere across the country. In addition, the criteria of location would probably weight among the five standards. For example, how much weight is given to criteria 1 and/or other indicators? According the field work, criteria such as the population of students per school, the availability of experts in the fields of science, and good facilitation between hosted schools and school networks should also take into account.

Furthermore feasibility study and spatial analysis are very important to apply for selecting the location of secondary resource schools. When feasibility study help to collect data and information about the perception of students and teachers at both the secondary resource schools and school networks; current issues and problems regarding to social norm, capacity, operation, and management can probably mitigated. Moreover, an implication of Geographical Information Systems (GIS) can be used to identify suitability of a new school location. Social norm, insufficient capacity of teachers and inadequate operation of the secondary resource schools can be mitigated from the results of feasibility study. In addition, the feasibility study and GIS application are useful for planners and project designers to select the right locations which are easier accessible by all school networks. In addition, the feasibility study helps to enhance operation, capacity building and perception of hosted schools and school networks for better management of the secondary resource schools. In general, hosted schools are more beneficial to use the secondary resource schools than those who are school networks because of far distance, insufficient transportation cost and purchase of experimental equipment, and inffective schedule management for using the laboratories.

To identify appropriate locations for secondary resource schools, Phnom Penh and Bonteay Meanchey were selected as example. While the establishment of secondary resource

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schools in Mongkol Borei for Monteay Meanchey as well as Boeng Trabek Upper Secondary School and Santhor Muk Upper Secondary School for Phnom Penh are the most appropriate location for the future construction of secondary resource school. The selection of location for secondary resource schools are very useful because they would help to increase the access by school networks with more affordable transportation cost, less traffic, and more safety for travel by students and teachers. In addition, convenient access to secondary resource schools help to increase more frequency of the visit to the secondary resource schools by school networks. In the future, secondary resource schools may consider to be allocated in the center where there are many lower and upper secondary schools. In helping spartial analysis for appropriate location of secondary resource school, GIS application and feasibility must be made for more better decision of the location.

Policy implication for the establishment of secondary resource school in Cambodia

After participating in experiment at secondary resource schools, students have positive change because they are able to learn more from real demonstration. There is no doubt that it is impossible to promote STEM education without laboratories and it is impossible to make laboratory pssosile at all the lower and upper secondary schools across the countries within this recent years. As the result, the construction of secondary resources are still the choice; but, there is a need to improve the cooperation between hosted schools and school networks. In addition, the effectiveness of operation and management as well as capacity building of teachers at both hosted schools and school networks are also required to be improved. In order to increase more frequent visits and the purchse of equipment of the school networks, the amount of budget (US$500) should be increase. In relation to the management of laboratory, all equipment in laboratory should be labeled into Khmer language that all the teachers and students can understand well. In addition, schedule preparation should be improved in order to attack more attention and usage of the secondary resource schools. The capacity building should be made after the need assessment; so, that the course would be able to respond to the real need of the teachers and students.

Alternatively, small-size laboratories constructed at school network are also reflected to the isses solved in reducing the burden on secondary resource school. However it requires time to build sufficient laboratories accross the country; the current construction help to gradually reduce the current problem. The school networks should also carry out simple experiment and practice at their schools; the schools should only come to the secondary resource schools when they require advanced equipment. In some case, teachers can only simply perform their experiment or let students practice in the class room or libraries that help students to associate theories with practice. The operation of mobile laboratory does not only extand the accessibility of school network; but, it helps to increase the access by schools in remote area. By considering the usage of mobile laboratory would be less expensive then building new secondary resource schools. In particular, it can move from one to another schools in order to equally share the resource even if they are in the remote areas. Moreoaver, mobile laboratories can increase the frequency of experiment or practice applied by students.

Conclusions

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Based on some survey findings at Kompong Thom, Kratie, Kep, Banteay Meanchey and Phnom Penh, supplemented by real situation and insights into the impacts and responses of related nationwide operation, we view that the establishment of secondary resource schools in the 25 provinces and cities has contributed a promotion of STEM education in Cambodia. The secondary resource schools are providing students with opportunities to do experiment and practice in the fields of physics, chemistry, biology and earth science. But, the gaps between hosted schools and school networks were large because the hosted schools already used all the potentials of the secondary resource schools. School networks were much less beneficial because of insufficient transportation cost , limited capacity of teachers at hosted schools and school networks; and, weak operation and management of hosted school. Since 2004, the ADB has been the funder of establishing secondary resource schools through three different projects; they include the ESDP II, the EEQP and the USESDP. Today, 50 secondary resource schools have been already recorded in Cambodia throughout Cambodia.

In average, there were two secondary resource schools established in each province. The research confirms that the number of secondary resource schools was passively and strongly correlated to the number of students, to the number of secondary schools and the number of school network. In order to operate the secondary resource schools and school network; ADB and the MoEYS are also providing them with annual budget for operation of resource school, transportation and material purchase; and, scholarship scheme for poor students. An average distance between secondary resource school and school network was 4.2 kilometers ranging from 2.0 and 9.4 kilometers. Comparatively, Kratie was the furthest and Banteay Meanchey was the nearest. Due to limited government budget, constructions of laboratories and facility equipment for experiment at all secondary schools in Cambodia have been quite hard even in the next 10 years.

As an example, Banteay Meanchey and in Phnom Penh are selected as case studies of how to identify appropriate location for secondary resource schools. In the future, the establishment of secondary resource schools can be probably constructed at Samdach Ov or Serey Sophoan Upper Secondary Schools. In Phnom Penh, Santhor Muk Upper Secondary School, Boeng Trabek Upper Secondary School are likely to optimize the distance between school networks. In managing the secondary resource school, there were currently five key problems; they included social norm, capacity, operation, and management. While, school network felt less hospitality; hosted schools faced great issues regarding operation due to limited annual budget and management of schedules and service to support school network. In particular, hosted schools and school network did not have sufficient capacity in using laboratory effectively and efficiently.

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Appendix. List of interviewees

Code	Organizations	Date
MoEYS	Ministry of Education Youth and Sport	November 2019
Porng Tek LSS	Porng Tek Lower Secondary School	October 2019
Hun Sen Krong Kep LSS	Hun Sen Krong Kep Lower Secondary School	October 2019
Bun Rany Hun Sen Chakriya Vong USS	Bun Rany Hun Sen Chakriya Vong Upper Secondary Scool	October 2019

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Hun Sen Chamkar Dong USS	Hun Sen Chamkar Dong Upper Secondary School	October 2019
PDoEYD in Banteay Meanchey	Provincial Department of Education Youth and Sport in Banteay Meanchey	November 2019
Hun Sen Khlar Koun USS	Hun Sen Khlar Koun Upper Secondary School	November 2019
Tek Thlar LSS	Tek Thlar Lower Secondary School	November 2019
Sandech Ov USS	Sandech Ov Upper Secondary School	December 2019
Serey Sorphorn USS	Serey Sorphorn Upper Secondary School	December 2019
Chbar Ampeouv USS	Chbar Ampeouv Upper Secondary School	December 2019
Hun Sen Prek Pra LSS	Hun Sen Prek Pra Lower Secondary School	December 2019
Bun Rany Hun Sen Phsardeounthkov USS	Bun Rany Hun Sen Phsardeounthkov Upper Secondary School	December 2019
PDoEYD in Phnom Penh	Provincial Department of Education Youth and Sport in Phnom Penh	December 2019
On Chanh LSS	On Chanh Lower Secondary School	November 2019
Kratie Krong USS	Kratie Krong Upper Secondary School	November 2019
Damrei Chorn Khlar LSS	Damrei Chorn Khlar Lower Secondary School	November 2019
Hun Sen Balang USS	Hun Sen Balang Upper Secondary School	November 2019
PDoEYD in Kompong Thom	Provincial Department of Education Youth and Sport in Kompong Thom	November 2019
Stung Sen USS	Stung Sen Upper Secondary School	November 2019
Panha Chi LSS	Panha Chi Lower Secondary School	November 2019